Study questions 1.1 p4

Q1 average speed = $\frac{\text{distance moved}}{\text{time taken}}$

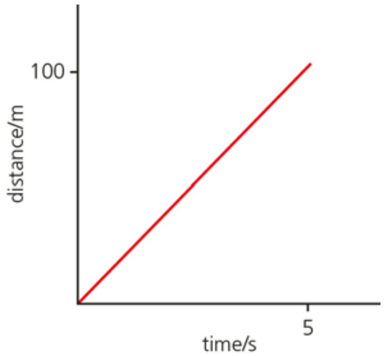
$$= \frac{300\text{ km}}{2\text{ h}}$$

= 150 km/h

Q2 a) 40 s

b) The last part, because the gradient of the graph is steepest.

Q3



Q4

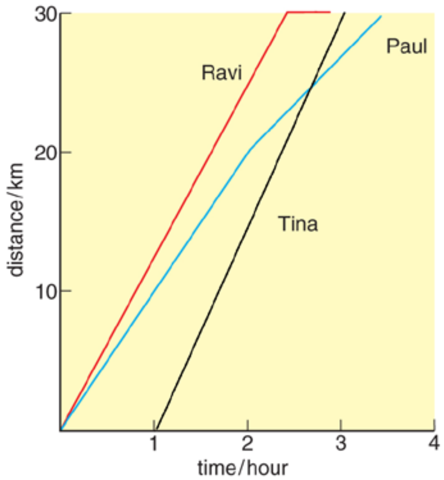
Event	Average speed / m/s	Time
100 m	*10.4*	9.6 s
200 m	10.3	*19.4 s*
400 m	8.9	*44.9 s*
1500 m(1491 m)	7.1	3 m 30 s
10 000 m	*5.7*	29 m 10 s
42.196 km (Marathon)	5.5	2 h 7 m 52 s

Q5 a) Ravi – the gradient remains constant, and the gradient of the graph equals the speed.

b) 8.6 km/h

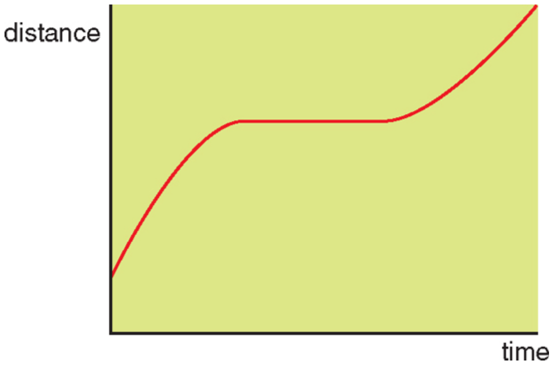
c) Paul slowed down

d)



e) 24 km

Q6



Q7 b) The gradient of the graph is about 10 m/s.

Study questions 1.2 p7

Q1 m/s^2

Q2 Acceleration means that the speed of something is increasing.
Acceleration means that the speed of something is decreasing.

Q3 a) $a = \frac{v - u}{t}$

b) i) $a = \frac{30}{2}$

$= 15\ m/s^2$

ii) $a = \frac{1}{0.001}$

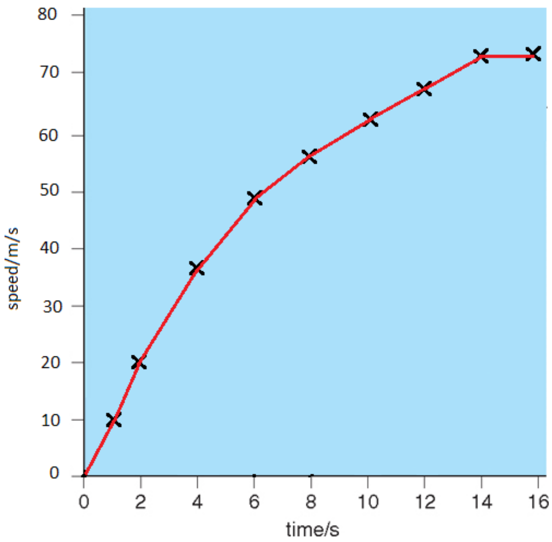
$= 1000\ m/s^2$

Q4 a) $3\ m/s^2$

b) 168 m

c) 8.4 m/s

Q5 a)



b) i) 0 m/s^2

ii) 10 m/s^2

c) approximately 650m

Q6 a) 67 m/s

b) 25 m/s^2

Q7 cheetah – 30 m/s
train – 0.1 m/s^2
aircraft – 60 m/s
car crash – 0.2 s

Study questions 1.3 p10

Q1 You could describe an experiment with light gates or a ticker timer.

i) If the car rolls between two light gates as shown in Figure 3.2, it will take less time to travel through gate A than through gate B. The shorter time means it is travelling faster since:

average speed = $\frac{\text{distance}}{\text{time}}$

ii) or you could attach a ticker tape to the car. The dots get further apart as the car moves thus showing the speed increases.

Q2 a) $a = \frac{20}{1}$

$= 20$ m/s^2

b) $a = \frac{52 - 47}{1}$

$= 5$ m/s^2

Q3 $v^2 = u^2 + 2as$

$60^2 = 2 \times 2.5 \times s$

$s = \frac{3600}{5}$

$= 720$ m

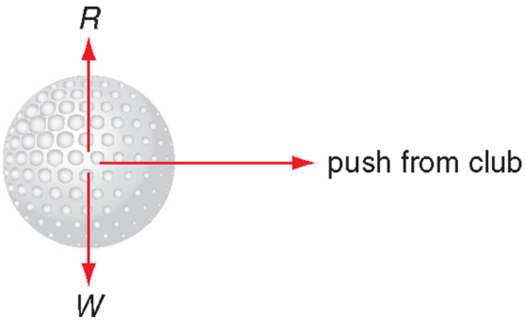
Study questions 1.4 p14

Q1 a) For examples, see (b).
b) Pulling a door open 10 N; pulling a suitcase on wheels 15 N; pulling in a tug-of-war 600 N; pull from a tow truck on a car 1000 N; pushing a heavy table 300 N; pushing a toy car 2 N; pushing on bicycle pedals 400 N
c) Student’s diagram to show size and direction of each force

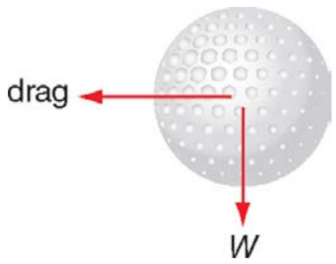
Q2 120 N

Q3 a)

b)



c)



Q4 i) 0
ii) 10 N downwards
iii) 5 N downwards
iv) 5 N to the left

Q5 2200 N

Q6 10 000 N

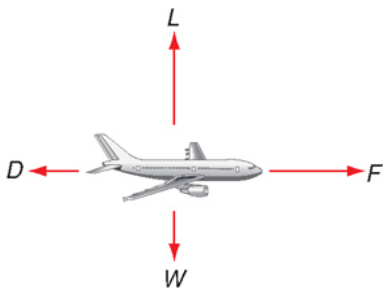
Study questions 1.5 p17

Q1 a) Without friction there is no forwards push from the road on the car.
b) These increase the forwards push on the sprinter, and avoid slipping on the track.

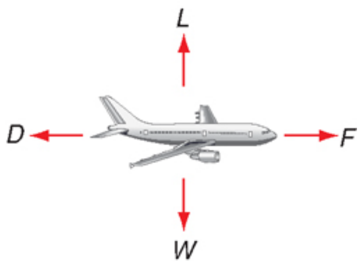
Q2 The parcel has no force acting on it, so it keeps moving until it is stopped by the floor or the front of the car.

Q3 There is an unbalanced force so the car is either accelerating backwards (b) or decelerating while moving forwards (d).

Q4 a)



At take-off, the plane is accelerating upwards and forwards.
So lift L > weight W
Forwards force F > drag D
b)



At a constant speed and height, $L = W$; $F = D$

Q5 The mass of the train is very large, so its acceleration is small. Or, more precisely, the ratio of force/mass is less for the train.

Q6 Accelerate the tins with the same force. The more massive tin accelerates more slowly. (You could push the tins, or start the tins spinning.)

Q7 a) 5 m/s^2
b) 2.5 kg

Q8 a) The trolley is given a small push. If it moves at a constant speed the small pull of gravity balances friction.

This is important to make sure the only force acting on the trolley is the pull of the weights.

b) i) 3 N

ii) 1 kg

iii) $a = \frac{F}{m}$

$= 3\ \text{m/s}^2$

c) i) Average speed = $\frac{\text{distance}}{\text{time}}$

$= \frac{0.294}{0.44}$

$= 0.67$ m/s

ii) $2 \times 0.67 = 1.34$ m/s

The trolley starts from rest, so the average speed is halfway between 0 and the final speed.

iii) $a = \frac{v - u}{t}$

$= \frac{1.34}{0.44}$

$= 3.0$ m/s

d) (i) The force can be varied by changing the number of masses on the hanger: e.g. a 100 g mass provides an accelerating force of about 1 N. Keep the mass constant by keeping spare masses on top of the trolley.

(ii) In the second experiment, the accelerating force is kept constant by always using the same numbers of masses on the hanger. The mass can be increased by adding extra masses on top of the trolley. Now the acceleration can be determined for different masses that are accelerated by the same force.

Study questions 1.6 p21

1 Weight is measured in newtons. His weight is 670 N.

Q2 a) 10 N
b) 1.6 N
c) 0

Q3 The sheet of paper has a large air resistance. The resistance is much less when the paper is screwed up.

Q4 a) Air resistance balances the weight of the red ball; the resultant force is zero.
b) Unbalanced force is 9N. So $a = 9\ \text{N}/1\ \text{kg} = 9\ \text{m/s}^2$

Q5 a) 5 m/s

b) Air resistance is increasing.

c) 1000 m

d) ~~$a = \frac{25}{2} \approx 13$#m/s^2 ($a \approx 22$–25) m/s^2~~- $a = \frac{0-5}{0.5} = -10\ \text{m/s}^2$ deceleration

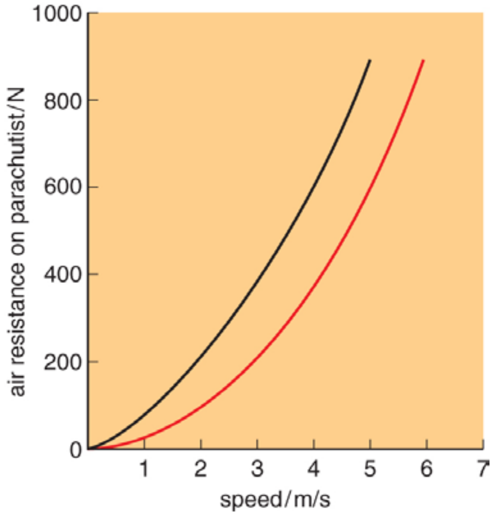
Q6 a) 600 N

b) She is moving at a constant speed so forces balance.

c) i) 4.2 m/s

ii) 6.2 m/s (this is less reliable as you have to predict where the graph goes: 6.0–6.4 m/s is a range of acceptable answers).

d) The curve of the graph lies above the first red line. (To be accurate, you expect the air resistance to be about twice the value on the red line, for the same speed.)

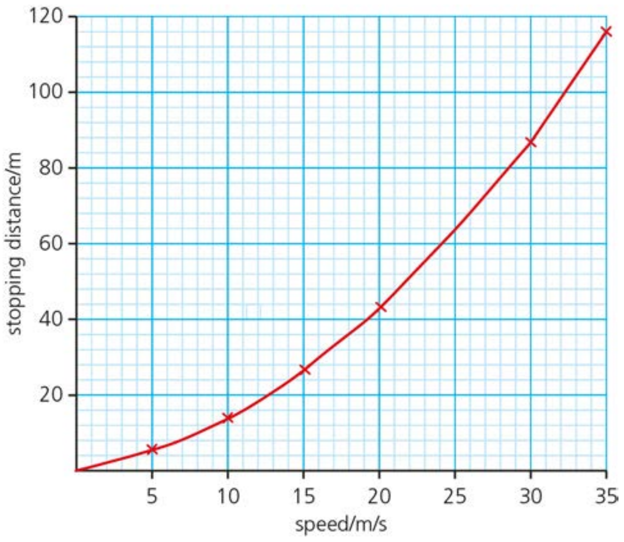


Q7 Choose three answers from the text.

Q8 a) b)

speed in m/s	braking distance in m	thinking distance in m	stopping distance in m
5	2	3	5
10	8	6	14
15	17	9	26
20	31	12	43
25		15	
30	69	18	87
35	94	21	115

c)



d) Stopping distance 63 m
Braking distance 48 m

e) From the graph, the stopping distance is 50 m at a speed of 22 m/s. But in fog it would be wise to travel much more slowly as fog can be patchy, and the visibility can suddenly reduce.

Study questions 1.7 p25

Q1 a) An object deforms elastically if it returns to its original shape after forces that have stretched the object are removed.

b) An object deforms inelastically if it does not return to its original shape after forces that have stretched the object are removed.

Q2 a) 260 mm

b) $k = \frac{F}{e}$

$= \frac{7}{0.26}$

= 27 N/m

Q3 $e = \frac{F}{k}$

$= \frac{600}{20\ 000}$

= 0.03 m

Q4 a) No the rubber band down not obey Hooke’s Law, because the extension is not proportional to the force.

b) The band extends easily for forces up to about 4 N, reaching an extension of 6 cm. Beyond that the extra extension is 3 cm for a force up to 8 N.

Q5 a) The extension is proportional to the force up to an extension of 2.7 cm, when the limit of proportionality is reached. The wire extends elastically up to this point. Beyond the limit of proportionality, the extension is inelastic.

b) The wire obeys Hooke's Law up to point A.

Study questions 1.8 p28

Q1 36 000 kg m/s

Q2 $$\text{force} = \frac{\text{change in momentum}}{\text{time}}$$

a) Bending your legs makes you stop in a greater time. The momentum change is the same however you stop. But the force on you is less when the time is longer.

b) A crumple zone means that a car stops in a longer time in a crash. This reduces the forces on passengers – provided they wear their seat belts.

Q3 If you are not wearing a seat belt in a crash, you keep moving forwards until you hit something – such as the windscreen. You then stop in a short time, so you experience a large force. You can also hit something sharp. A seat belt allows you to take advantage of the time the crumple zone takes to crumple.

Q4 On concrete you stop in a short time, on grass the time is longer.

$$\text{force} = \frac{\text{change in momentum}}{\text{time}}$$

If the time is longer the force is less.

Q5 a) 24 000 N on John
6 000 N on Helen

b) 10 m/s

Q6

- compulsory wearing of seat belts by all passengers
- speed limits
- safety barriers
- speed cameras
- flashing speed warning signs
- pedestrian safety measures, road crossings
- car safety measures – crumple zones, air bags
- penalties for drink driving
- penalties for dangerous or careless driving.

Study questions 1.9 p32

1 Momentum = mass × velocity. Since velocity is a vector, momentum is too.

2 If two objects collide, they have a certain combined momentum. After the collision their combined momentum is the same as it was before the collision. This means momentum is conserved.

Q3 a) Red car 700 kg m/s
b) Blue car 2100 kg m/s
c) The one in the blue car; the force on the driver is larger

4 a) 2.6 m/s
b) 1.0 m/s
c) 2.0 m/s

Q5 a) 180 000 kg m/s
b) 180 000 kg m/s
c) 9 m/s
d) Lorry driver: 80 kg m/s
Car driver: 720 kg m/s
e) Lorry driver: 400 N
Car driver: 3 600 N. Car driver as force on them is far greater.
f) The crumple zone increases the time of the collision, so that the force is reduced.

Q6 a) b) c) All of these depend on the principle behind Newton's Third Law. To every force there is an equal and opposite force. In the gun, an explosion provides the energy to make the bullet move quickly. There is a force from the gun on the bullet (so it goes forwards) and there is an equal and opposite force on the gun, which goes backwards.

Q7 a) +2 000 kg m/s
b) –2 000 kg m/s (the same but in the opposite direction)
c) 2 m/s
d) The recoil from a large gun is very big. The truck and gun recoil, so the truck moves backwards. The truck can then be moved forwards into position.

Study questions 1.10 p35

Q1 a) To increase the turning moment
b) There is a larger turning moment to open the door.

Q2 a) The perpendicular distance from the load to the pivot point of the jib.
b) 26 m
c) 37 tonnes
d) It might not tip the crane, but it might break the ropes

Q3 a) 40 Nm
b) i) 1.6 Nm
ii) The weight of the lid also exerts a turning moment to close it.

4 If the heavy items are close to the bottom they are also closer to the wheel. Since turning moment = force × perpendicular distance, the turning moment of the items' weight is less.

5 You hang the card from each of the 3 holes. In each position you hang the cotton with the weight. Then a line is drawn to show the line of the cotton. You repeat the procedure using the other two holes.

The centre of gravity always lies between the pivot. So where the three lines meet is the centre of gravity.

Study questions 1.11 p48

Q1 a) The counterbalance provides a turning moment in the opposite direction to the turning moment from the load. This helps to prevent damage to the crane, or even the crane tipping over.

b) To the left. The counterbalance would then be further from the pivot so would provide a greater turning moment.

c) 0.9 m to the left of centre.

Q2 a) 60 Nm

b) 80 Nm

c) 140 Nm

d) 280 N

e) The bucket provides a turning moment which counters the turning moment of the weight.

f) Move it so the centre of the ladder is over his shoulder.

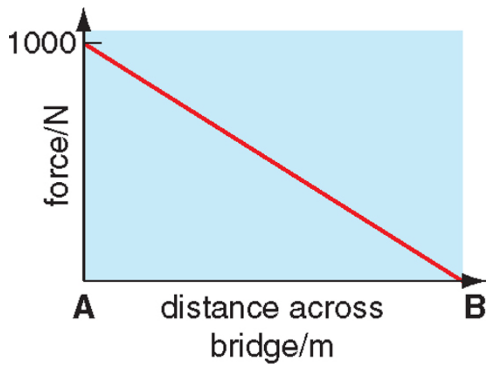
Q3 a) A long handle produces a larger turning moment, because
moment = force × perpendicular distance from the force.

b) It is better at A. A larger force will be exerted at A than at B, because PA is shorter than PB.

c) 35 N

Q4 a) 200 N at A; 800 N at B

b)



c) $F_A = 400$ N
$F_B = 600$ N

Study questions 2.1 p51

Q1 b) An electric fence keeping cattle in a field. Avoid touching this, you might receive a painful shock but it is unlikely to be lethal.
There are dangers near electricity sub-stations. Do not attempt to climb in to retrieve a lost ball, for example.
Overhead lines. People have received a shock when carrying something long such as a fishing rod.
Car batteries. Take care here as while the voltage is low (12 V), a large current can still be delivered which could cause a burn.

Q2 A cell has a store of chemical energy, which is able to do electrical work to push a current round a circuit. As the current passes through the lamp, energy is transferred to the thermal store of the lamp and its surroundings.

Study questions 2.2 p55

Q1 a) Fuses prevent fire and electric shock; they melt ('blow') if there is a surge of current greater than a certain number, for example 3 A or 15 A.
b) A circuit breaker can switch off the power if there is a small leak to earth. Such a small extra current will not always blow a fuse.

Q2 a) To disconnect the dangerous wire.
b) If the fuse rating is much higher, the fuse may not blow if a small extra current flows because of a fault.
c) A metal case conducts electricity, so it needs to be earthed. Plastic cases do not conduct, so there is no advantage in earthing them.

Q3 Brown – live; blue– neutral; earth – green/yellow (UK)

Q4 With a d.c. supply a constant current flows one way. With an a.c. supply the current changes direction.

Q5 The battery has a store of chemical energy, which has the capacity to do work to push a current round a circuit. As current goes through a resistor, energy is transferred to the resistor's thermal store – it heats up.

Q6 a) a.c.
b) 10 V
c) 25 Hz

Study questions 2.3 p57

Q1 a) 60 W
b) 460 W
c) 460 W

Q2 a) i) 0.05 A
ii) 17.4 A
iii) 3.5 A

		iv)	4.0 A
	b)	i)	3 A
		ii)	20 A
		iii)	5 A
		iv)	5 A

Q4 i) 27 820 800 J
ii) 27.8 MJ

Q5 188 370 000 J (188 000 000 J to 3 S.F.)

Study questions 2.4 p59

Q1 a) and b) Student's own circuit diagrams

Q2 a) B and C dim; D bright; E off; F and G normal
b) i) H and I normal, and J off
ii) H, I and J dim

Q3 a) L only
b) K lights; L is off
c) You could draw a circuit with the diode next to K reversed.

Q4 It will get brighter.

Study questions 2.5 p65

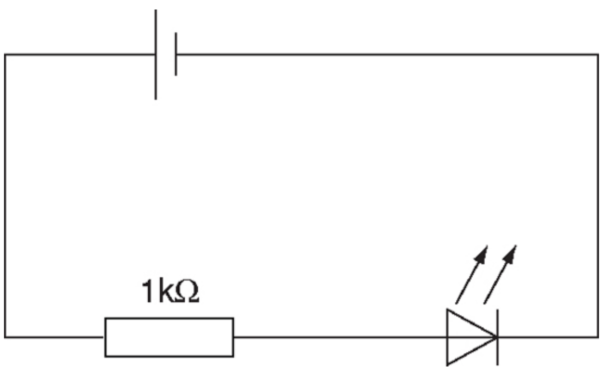
Q1 The current is proportional to the voltage for an ohmic resistor.

Q2 The current decreases as the resistance increases.

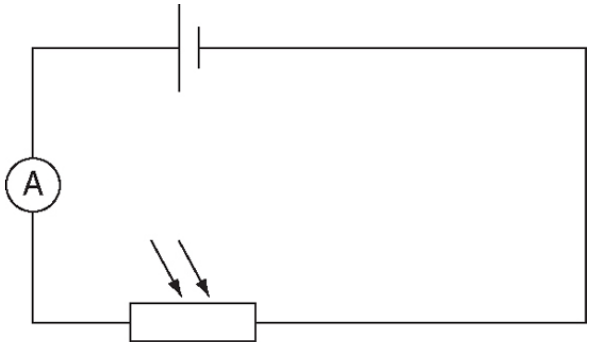
Q3 a) i) 5.0 Ω
ii) 10.3 Ω
b) The resistance rises because the filament has heated up with the larger current, when the voltage is 3 V.

Q4 a) 67 Ω
b) 800 Ω

Q5 a)



b)



Q6 A 30 Ω B 0.17 A C 10 V D 23 Ω E 0.25 A

Study questions 2.6 p68

Q1 a) coulomb, C (b) amp, A (c) volt, V

Q2 a) charge = current × time

b) energy = voltage × charge

Q3 a) $Q = It$
$= 10^{-4} \times 120$
$= 0.012$ C

b) $I = \frac{Q}{t}$
$= \frac{6}{30}$
$= 0.2$ A

c) $t = \frac{Q}{I}$
$t = \frac{7200}{0.5}$
$= 14\,400$ s = 240 min = 4 hours

Q4 a) $E = QV$
$E = 0.8 \times 9$
$= 7.2$ J

b) $Q = It$
$Q = 3 \times 300$
$= 900$ C

$V = \frac{E}{Q}$
$= \frac{6300}{900}$
$= 7$ V

c) $E = QV$
$4000 = 20 \times Q$
$Q = 200$ C

Q5 a) $Q = It$
$= 2.5 \times 80 \times 60$
$= 12\,000$ C

b) $E = QV$
$= 12\,000 \times 12$
$= 144\,000$ J

c) See figure 6.3 on page 67. The positive copper ions move to the negative electrode (the spoon) and coat it. The negative ions (OH^- and SO_4^{2-}) move to the positive electrode.

Q6 $I = \frac{Q}{t}$
$= \frac{0.1}{0.02}$
$= 5$ A

Study questions 2.7 p72

Q1 *p* is the largest; *q* is the smallest

Q2 3A for top figure; 4A, 1A and 1A for lower figure, clockwise from top right

Q3 a) 6.0 V
b) 6.0 V
c) 0.3 A
d) 120 Ω

Q4 a) $V = IR$
b) 5.75 V
c) 57.5 Ω
d) 2300 Ω
e) 23 W

Q5 a) 8 V
b) 10 V
c) 20 Ω

Q6 a) 15 Ω
b) 0.8 A
c) 9.6 W
d) A smaller resistance will allow more current. Then the power will be greater as $P = VI$ and the voltage is still 12 V.
e) More power can be generated as the current will be greater through each element. If one element breaks, 5 can still work.

Study questions 2.8 p74

Q1 R_2

Q2 They have the same current, so R_3 is bigger than R_4.

$R = \frac{V}{I}$, so for the same current, the resistor with the large voltage must be the larger of the two.

Q3 a) $\frac{1}{3}$ A

b) 2.67 W

c) 4 V

d) 12 Ω

Q4 a) 0.5 A

b) 9 V

c) 12 V

Q5 30 Ω

Q6 a) 8 V

b) A_1 = 2A; A_2 = 3A

Q7 a) A_1 = 1 A A_2 = 2 A

b) i) 4 V ii) 4 V

c) 8 W

Study questions 2.9 p78

1 a) The forces are either both positive or both negative.

b) i) They have opposite charges because they attract each other.

ii) Electrons are removed from one material (leaving that positively charged) and transferred to the other (making it negatively charged.)

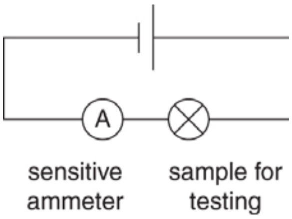
Q2 a) Electrons have left the atoms in the rod and moved to the cloth which rubbed the rod.

b) Electrons have left the atoms in the cloth rubbing the rod, and have moved to the atoms in the rod.

c) As soon as the metal becomes charged, there is a flow of charge through the conducting metal, which neutralises the charge.

Q3 See the text on pages 76–77.

Q4 A circuit could be set up with a sample of material which is connected in turn between 2 points and an ammeter to detect current. If a current is detected, the sample is a conductor. The experiment can be improved by using a very sensitive ammeter that will measure a small current, so that poor conductors can be identified as well. A material that is an insulator will allow no current through at all.



Study questions 2.10 p81

Q1 This discharges the plane, so that it is neutral. If the plane is charged, there could be a spark which ignites fuel.

Q2 See p80 and Figure 10.4 for explanation.

Q3 a) The window gets charged by the duster. The charged window attracts dust. On wet days water vapour in the air discharges the window.

b) As the cling film is unwrapped it becomes charged. Each side of the film has a different charge, so there are attractive forces between pieces of cling film.

Q4 See text on pages 79–81.

Q5 a) 2500 A

b) 500 million J

c) Electrical potential energy in the charged cloud, is transferred to thermal energy. The light that you see and the sound that you hear also transfer energy to the thermal store of the surroundings.

Study questions 3.1 p96

Q1 a) b) See text

Q2 A compression in a longitudinal wave (on a spring) occurs where the coils of the spring are closer together than their undisplaced position. A rarefaction occurs where the coils are further apart than their undisplaced position.

Q3 A pulse going down a slinky can be felt at the far end: this shows that energy is transmitted. You could invent a code to transmit information.

Q4 a) The water moves up and down.
b) The cork moves up and down. (Neither the water nor the cork move sideways.)

Q5 A has a higher frequency and amplitude than B.

Q6 a) The wavelength of the wave.
b) The amplitude of the wave.
c) i) 2 m ii) 30 cm iii) 2.5 m

Q7 a) 4 Hz (b) 100 Hz

Q8 $f = \frac{v}{\lambda}$

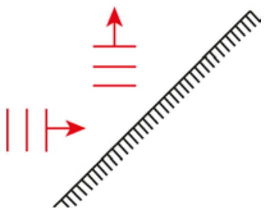
$= \frac{0.4}{0.08}$

$= 5$ Hz

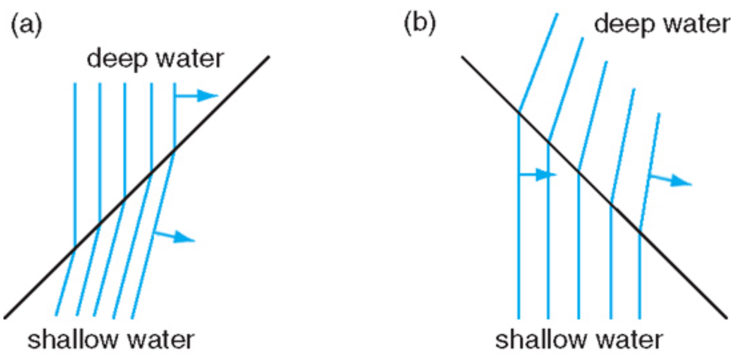
9 See Figure 1.4. The wavelength is the distance between two neighbouring compressions (or rarefactions).

Study questions 3.2 p100

Q1



Q2



3 As the fire engine approaches you, the wavefronts are pushed closer together; this makes the frequency (pitch) of the siren appear higher (see Figure 2.7). As the fire engine passes and goes away, the wavefronts are stretched apart; this makes the frequency appear lower.

Study questions 3.3 p104

Q1 a) X-rays, gamma rays.

b) Infrared, microwaves, radio waves.

Q2 a) To trap the microwaves in the oven so that they cook the food. To stop us being cooked by the waves if we are near the oven.

b) i) Infra-red radiation

ii) Ultra-violet

c) You can find three examples by reading this chapter.

Q3 a)

Type of radio wave	Wavelength / m	Frequency / MHz
Long	1500	*0.2*
Medium	300	*1*
Short	10	*30*
VHF	*3*	100
UHF	*0.1*	3000

b) i) Local radio stations: wavelength of 10 m or less.

ii) UHF for TV broadcast. These ultrahigh frequency waves have very short wavelengths.

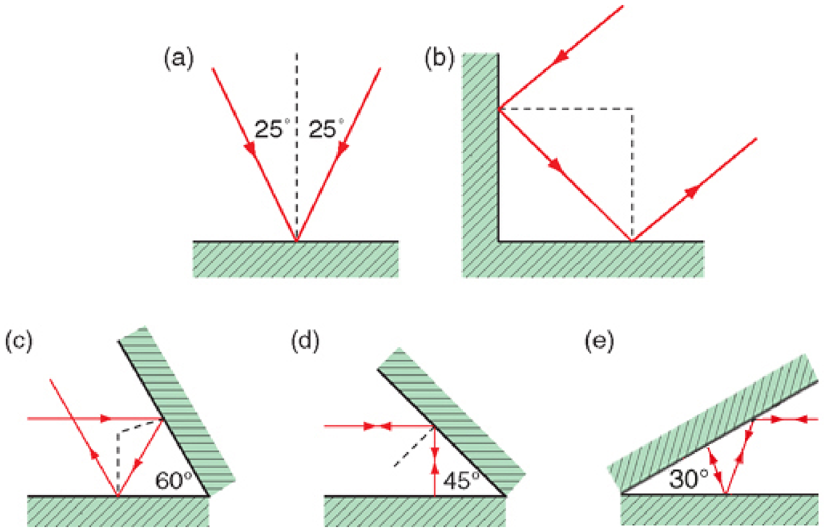
Q4 Microwaves: used for cooking. Potential hazard as uses short wavelength waves that may penetrate our body tissue and damage it by heating, so microwave ovens must be made of metal.
Infra-red rays: used for heating. Hazard if prolonged exposure of the skin to infra-red rays in sunlight as can cause skin burns.
Ultraviolet light: applications in crime prevention, by marking items with materials that fluoresce when exposed to ultraviolet light deters burglary. Ultraviolet light from the Sun can be a hazard as it can damage your skin and cause skin cancer.
Gamma rays: have medicinal applications, for example used in radiotherapy to kill cancer cells in the body. Gamma rays are very hazardous as they have such short wavelengths and so are very penetrating. They can cause cell mutations leading to cancer.

Study questions 3.4 p106

Q1 45°

Q2 10 m/s

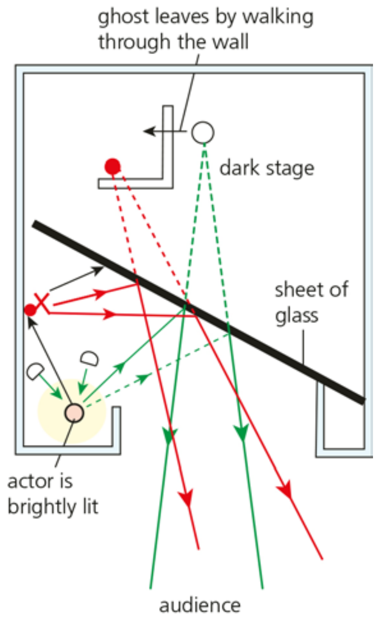
Q3



Q4 a) See Figure 4.2 on page 105.

b) Describe an experiment based on Figure 4.2.

Q5 a)



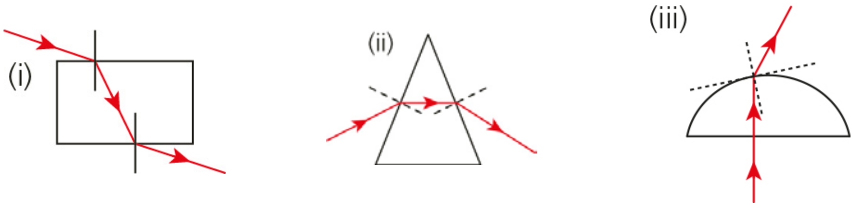
b) He appears to be behind the wall – or he vanishes if he walks into a dark place.

Study questions 3.5 p109

Q1 a) When light travels from air into a medium such as glass or water, the light changes direction. This is called refraction.

b) Refraction is caused by a change of speed: light slows down when it goes into water.

Q2



Q3 a) $$n = \frac{\sin i}{\sin r}$$

$$= \frac{\sin 64}{\sin 34}$$

$$= \frac{0.89}{0.56}$$

$$= 1.61$$

b) The experiment should be repeated several times, with different pairs of the angle of incidence and angle of refraction, to get an average value. A graph of sin i against sin r could be plotted; the gradient is the refractive index.

Q4 $$n = \frac{\sin i}{\sin r}$$

$$1.33 = \frac{\sin 30}{\sin r}$$

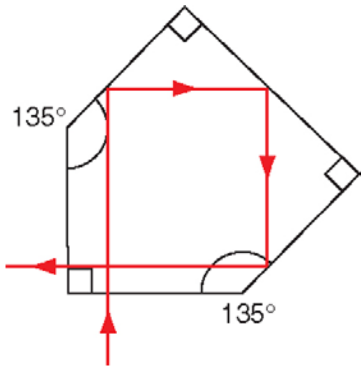
$$\sin r = \frac{0.5}{1.33}$$

$$r = 22^{o}$$

Study questions 3.6 p111

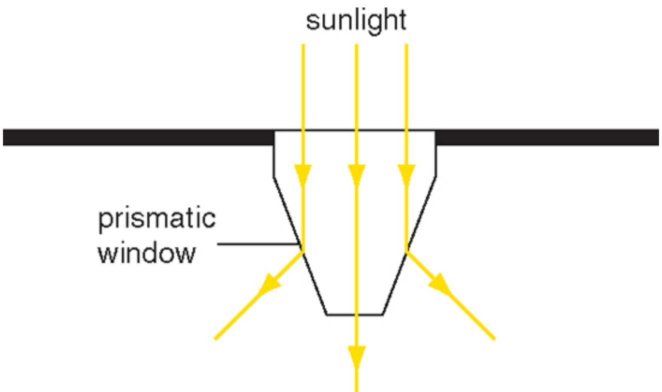
Q1 Glass 42°, water 49°, diamond 25°

Q2



Q3 See text page 111.

Q4 a)



b) So that the light spreads out and illuminates the room more effectively due to the internal reflections and refractions.

Q5 24.6°

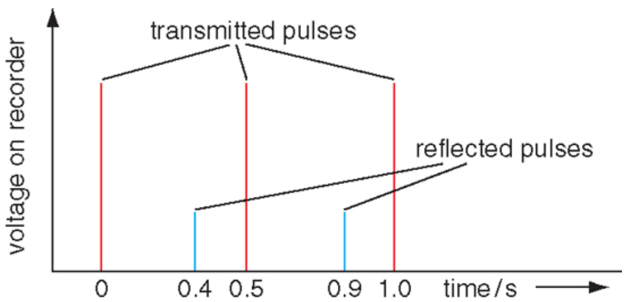
Q6 Base your answer on Figure 6.2. By investigating many angles of incidence using the semi-circular block of glass, you can determine the angle at which all the light is reflected along the blue line.

Study questions 3.7 p114

Q1 a) 1.36 m

Q2 time = 4.2 ms
$d = 340 \times 0.0042$
$= 1.42$ m

Q3 a) 500
b) $v = (2 \times 150) / 0.2$
$= 1500$ m/s
c)



d) The reflected pulse may come after the second transmitted pulse. The reflected pulse also might be of small amplitude.
e) 0.03 m

Q4 You might describe the experiment shown in Figure 7.4. The calculation is based to the measurement of the distance (about 40 m) and the time for the echo to reach you. If you measure 10 echoes in 6.3 s (for example), you can discuss the accuracy. In practice there can be some random errors here depending on the skill and timing of the student doing the clapping.

Study questions 3.8 p116

Q1 1 a) The flute b) The piano c) The flute
d) The piano and violin but the notes have different qualities.

Q2 a) (a) 500 Hz (b) 1000 Hz
b) i) 2000 Hz – you should have 4 waves in the graph
ii) 750 Hz – you should have 1.5 waves in the graph

Q3 i) You should have two complete waves with a peak of 4 squares.
ii) You should have one complete wave with a peak of 2 squares.

Q4 Peak voltage 4 V

$T = 0.0053$ s; $f = \dfrac{1}{0.0053} \approx 190$ Hz

Study questions 4.1 p130

Q1 a) Chemical energy stored in a battery (or in fuel at a power station) is transferred to the load's gravitational store and the thermal store of the surroundings.

b) The firework has a store of chemical energy, which is transferred to its gravitational and kinetic shoes. The explosion transfers energy to the thermal store of the surroundings.

c) Energy is transferred from the car's kinetic store to the thermal stores of the brakes and the surroundings.

d) Energy is transferred from the kinetic store of the car to the thermal store of the tyre surface and road surface. Then energy is transferred to the thermal store of the surroundings.

e) The golfer's muscles have a store of chemical energy. Eventually, when the ball stops moving all the energy has been transferred to thermal stores (in the ball, club and surroundings.) In flight the ball has a store of gravitational energy and kinetic energy.

Q2 Energy cannot be created or destroyed. It can be transferred from one type to another.

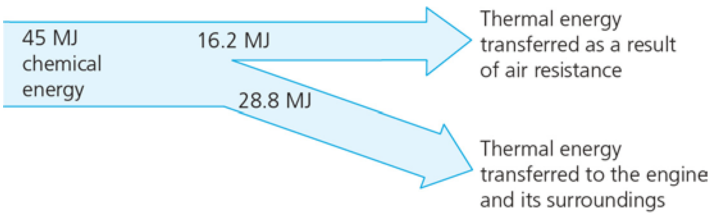
Q3

	KE (J)	PE (J)
A	0	50
B	10	40
C	25	25
D	35	15
E	50	0

Q4 A is more efficient as less energy is wasted for the same input.

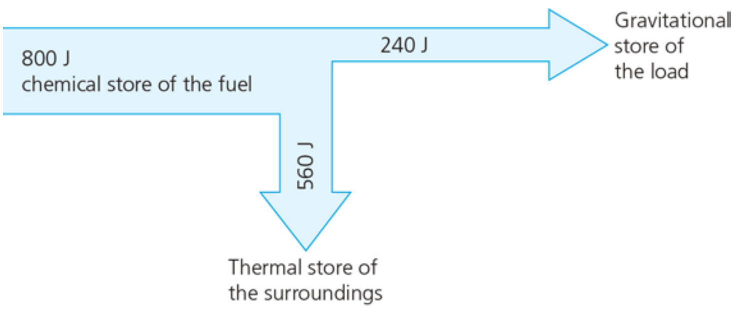
Q5 a) 16.2 MJ

b)



Q6 a) 800 J

b)



Q7 A battery stores chemical energy, which does electrical work to push a current round a circuit.

Study questions 4.2 p135

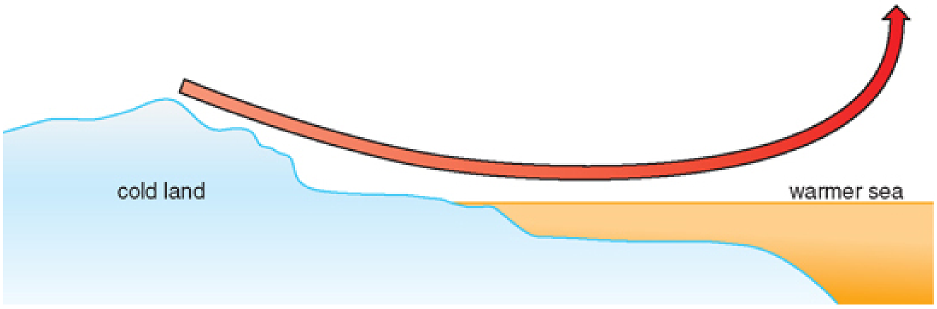
Q1 The tiles are good thermal conductors, so energy is transferred quickly from the girls' feet. The carpet is a poor conductor, so thermal energy is not transferred from her feet.

Q2 The brass under the paper conducts heat away from the flame quickly, so the paper stays cool for longer. The paper over the wood soon gets hot and burns, as the wood does not conduct heat.

Q3 a) Wool traps lots of air between its fibres.
b) The cold metal conducts heat away from your hand and your skin soon freezes. The snowball does not conduct so well.

Q4 Solids do not flow, so convection current cannot happen.

Q5



Q6 a) Hot air rises up the left-hand shaft; cold dense air falls down the right-hand shaft. So a current of fresh air flows along the mine (right to left).
b) This is a bad idea as hot air will go up both chimneys removing all the oxygen. This will make it hard for the miners to breath, and the fires will go out.

Q7 When water is heated it expands, becomes less dense and will rise in colder water. In A hot water boils at the top of the tube leaving colder denser water at the bottom. In B hot water rises to the top and melts the ice. The ice stays at the top as it is less dense than water.

Q8 See text.

Study questions 4.3 p137

Q1 a) White snow reflects radiation. Dark snow absorbs the radiation, so it melts.
b) Black casseroles are good absorbers of radiation from the oven, so food is heated. The heat is inside the kettle; a shiny surface emits less radiation – so wasting less energy.
c) Plastic is an insulator, so it reduces heat loss by conduction and convection. A shiny surface reduces loss by radiation.
d) White houses reflect the radiation from the sun, helping to keep the house cool.

Q2 See Figure 3.5 above and the accompanying text.

Q3 See text.

Study questions 4.4 p140

Q1 a) See text.
b) The joule.

Q2 b) and c)

Q3 a) 40 J
b) 640 J

Q4 10 000 J;
40 000 J, 0.04 litres;
4000 N, 0.04 litres ;
10 m, 60 000 J;
20 000 N, 100 000 J;
3.6 m, 0.09 litres.

Q5 a) 192 N
b) 5760 J

Q6 work = force × distance
So if the drag is greater, more work is done.
Energy is the capacity to do work, so more fuel is used.

Study questions 4.5 p144

Q1 The watt

Q2 $\text{power} = \frac{\text{energy transferred}}{\text{time}}$

Q3 $KE = \frac{1}{2}mv^2$

$= \frac{1}{2} \times 750 \times 15^2$

= 84 375 J or 84 kJ to 2 s.f.

Q4 a) 253 000 J (3 s.f.)
b) 5060 N (3 s.f.)

Q5 $P = \frac{E}{t}$

$= \frac{12\ 000 \times 30}{90}$

= 4000 W

Q6 They develop the same power (900 W).

Q7 a) 50 m

b) 20 m/s

Q8 a) i) 115 200 J
ii) 114 000 J
iii) Not safe
b) Shorten the rope

Q9 a) work = $F \times d$

$= 150\,000 \times 80$

$= 12$ MJ

b) power = 12 MW

Q10 a) 120 m/s^2
b) 0.3 N
c) 0.015 J
d) 0.6 W

Study questions 4.6 p150

Q1 In the text.

Q2 Uranium; non-renewable.

Q3 In the text.

Q4 In the text.

Q5 a) We have two high tides and two low tides each day. We know when these will happen. We do not have the wind blowing every day.

b) It is likely that the wind will be blowing somewhere in the country at any time.

Q6 5000

Q7 a) In the text.

b) PE transferred = mgh

$= 50\,000 \times 10 \times 200$

$= 10^8$ J each second

c) Power = 80% of 10^8 W

or 80 MW

Study questions 5.1 p161

Q1 'lighter' should be 'less dense'; 'heavy' should be 'dense'.

Q2 As the temperature rises, the water expands and becomes less dense. So the floats fall as the temperature rises.

Q3 See text p159.

Q4 osmium – 22 500 kg/m^3
potassium – 850 kg/m^3
titanium – 2250 kg
water – 3 m^3
alcohol – 4 m^3
radium – 1750 kg

Q5 a) 20 ml = 0.00002 m^3

b) $\rho = \frac{m}{V}$
= 0.09 / 0.00002
= 4500 kg/m^3

Q6 a) 0.37 m^3
b) 0.42 m^3

Q7 5000 kg

Q8 It will be less dense than pure aluminium, as lithium has a lower density.

Q9 a) Aluminium and Kevlar have low density and high strength.
b) The strength/density ratio is important. If the ratio is high it means the strength is high and density is low (this keeps the mass of the aircraft low).

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Study questions 5.2 p163

Q1 a) There is low pressure on your thumb – the force acts over a large area; there is high pressure on the point – the force acts over a small area.
b) Skis reduce pressure under our feet
Pads reduce pressure when a ball hits us.
c) A stapler. Scissors. (There are many others.)

Q2

	Weight / N	**Area / cm^2**	**Pressure / N/cm^2**
Amanda	800	4.0	200
Becky	600	2.0	300
Chloe	600	3.0	150 (b)
Debbie	500	2.5	200
Eli	400	1.0	400 (a)

Q3 a) 3.45 N
b) 200
c) Because there are fewer nails supporting him.

Q4 a) b) and c) All these are answered by talking about small areas: $P = \frac{F}{A}$. So when A is small the pressure is large. So the saw and knife cut better with small areas. And the stiletto heel is more likely to do damage to the floor.

d) and e). These are answered by talking about large areas: $P = \frac{F}{A}$. So when A is large the pressure is small. You are less likely to sink into the snow when you wear a snowshoe. The tank tracks provide a large area, so the heavy tank is less likely to sink into mud.

Q5 i) C provides the greatest pressure on the 1 m by 1 m end.

ii) C provides the least pressure on the 5 m by 1 m sides.

Study questions 5.3 p166

Q1 a) Depth; density of the liquid; gravitational field strength.

b) Sea water is denser than fresh water.

c) There is a smaller height of atmosphere above the top of the mountain, so the pressure is less.

Q2 The molecules in liquids (and gases) are free to move in any direction. So when a force is applied to a liquid, (in one direction) the molecules can move in all directions, thus exerting a force in all directions.

Q3 The extra pressure from the sea is 2 Atmospheric pressures, which adds to 1 Atmosphere above the sea.

Q4 a) Gas pressure has gone up.
b) $P = h\rho g$
$= 0.272 \times 1000 \times 10$
$= 2720\ \text{N/m}^2$
c) Height of oil is 34 cm.

Q5 a) i) 200 000 N/m^2
ii) 400 000 N/m^2
b) 8000 N
c) The same pressure acts on both sides of the mask.

Q6 a) 10 000 N/m^2
b) They are at the same depth in the same liquid.
c) Gas can be compressed, so the pressure is not easily transmitted.
d) 800 N
e) 0.2 m

Study questions 5.4 p170

Q1 See diagrams on page 167.

Q2 The molecules in gases are much further apart than they are in solids. So there is less mass per unit volume – less density.

Q3 a) A substance changes from one state of matter to another.

b) i) A solid melts to become a liquid.

ii) A liquid boils to become a gas.

Q4 Melting snow; breaking a match; mixing salt and sugar.

Q5 a) The internal energy increases.

b) The substance (system) being heated could melt or boil.

Q6 a) Energy is required to make the sweat evaporate. When sweat evaporates from our skin there is a decrease in the body's thermal energy, which cools us down.

b) Thermal energy from our bodies is transferred to the water to make it evaporate. This cools us down quickly.

Q7 a) i) It is melting, so the energy supplied causes that change of state.

ii) It is boiling, so the energy supplied causes the liquid to turn to a gas.

b) 150^{o} C

Study questions 5.5 p174

Q1 a) The specific heat capacity is the amount energy required to change the temperature of 1 kg of a substance by 1^{o} C.

b) J/kg ^{o}C

Q2 a) 1 200 000 J (1.2MJ)

b) 22^{o} C

c) 1.5 kg

Q3 a) 250 J/kg ^{o}C

b) i) The heater has had to heat itself and the thermometer.

ii) Thermal energy has also been transferred to the surroundings.

Q4 a) $\Delta Q = mc\Delta t$

$= 0.75 \times 4200 \times 80$

= 252 000 J

b) $E = P \times t$

$t = \frac{E}{P}$

$= \frac{252\ 000}{2000}$

= 126 s or 2 min 6 s

Study questions 5.6 p179

Q1 The molecules of a gas move rapidly in random directions.

Q2 The gas molecules hit the sides of their container and bounce back. Each molecule exerts a force. Thus the molecules as a whole exert a pressure.

Q3 a) As the temperature of a gas increases the average (random) speed of the molecules increases.
b) As the molecules speed up they hit the walls of the container harder and more often. So the pressure rises.

Q4 a) 0.33 l
b) 0.125 l

Q5 a) The lowest possible temperature, molecules stop moving
b) −300°C is below absolute zero

Q6 a) 273 K, 600 K, 100 K, 223 K
b) −263°C, −123°C, 77°C, 127°C

Q7 a) i) 27 kPa
ii) 63 kPa

Q8 20 000 m^3

Q9 a) 100 kPa
b) 600 kPa
c) 350 kPa

Q10 a) 300 K
b) i) 675 kPa
ii) 300 kPa

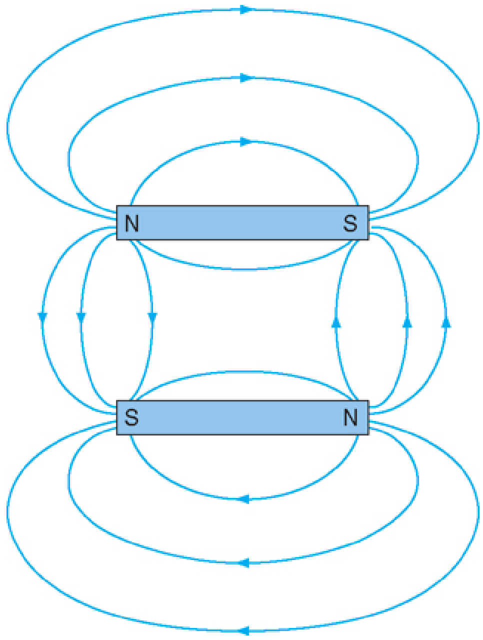
Q11 a) The pressure reduces slightly
b) 318 kPa

Q12 a) The temperature doubles.
b) The temperature rises by a factor of 4. (If v is doubled, v^2 is 4 times larger.)

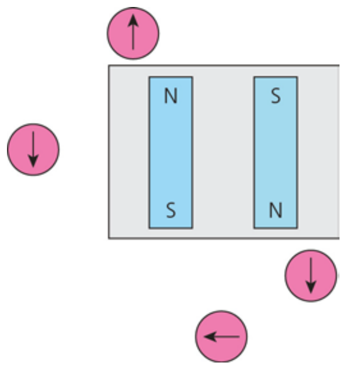
Study questions 6.1 p190

Q1 X is the north pole of the bar magnet so at B and D the plotting compass will have its needle horizontal, arrow pointing right. At C, the plotting compass will point towards Y.

Q2



Q3



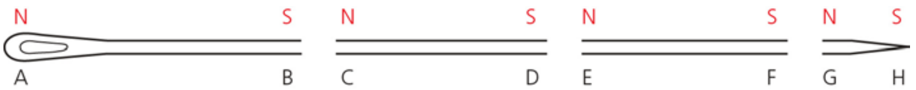
Q4 a) Stronger at the poles. The field lines are close together.

b) The field lies are going down into the earth rather than along the surface.

Study questions 6.2 p238

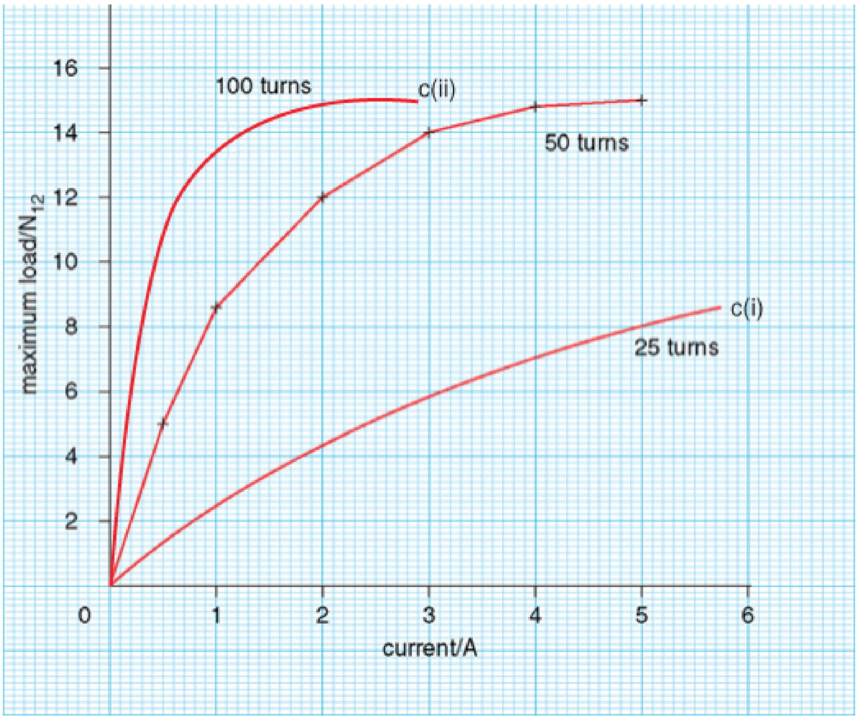
Q1 A magnet is permanent if it can be repelled by another magnet.

Q2 a)



b) The smaller bar magnets help to show the idea that the magnetic needle is made up of smaller regions (or domains). However, the domains will actually be rather smaller than this.

Q3 a)

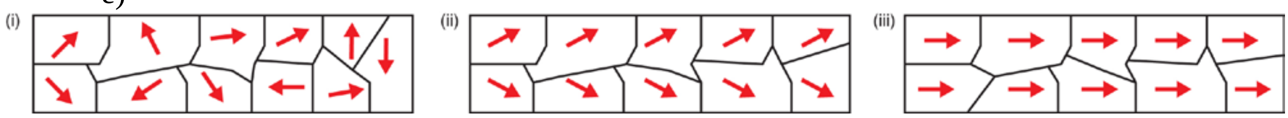


b) i) 10.2–10.3 N

ii) 15.0–15.1 N

d) Now coil X cancels out the magnetic effect of coil Y, so the magnet no longer works.

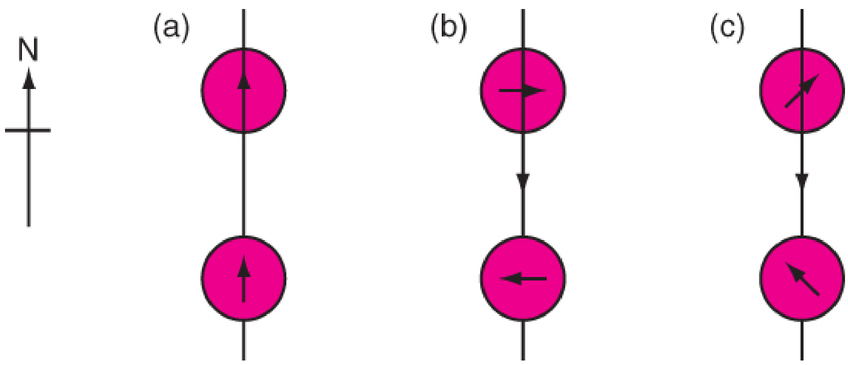
e)



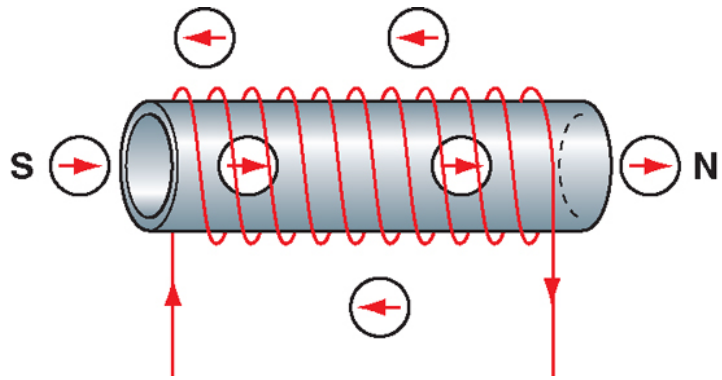
f) When the current reaches 5 A all the domains are lined up. So the iron cannot become any more magnetic. So the magnet has reached its greatest strength.

Study questions 6.3 p195

Q1

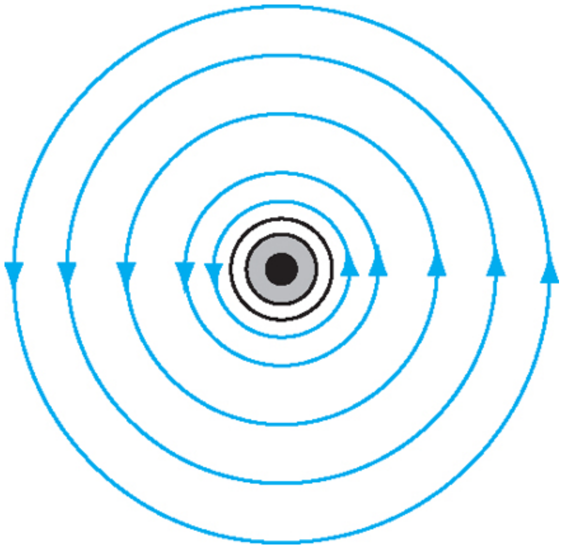


Q2 a)



b) North to the right; south is the left-hand end.
c) If you reverse the current you reverse the direction of the compasses.
d) See Figure 3.6 on p194 (but reverse the direction of the field as the north pole here is at the other end).

Q3



Q4 See Figures 3.3 on page 193 and Figures 3.5 and 3.6 on page 194.

Study questions 6.4 p198

Q1 a) Increasing the current

b) Using stronger magnets

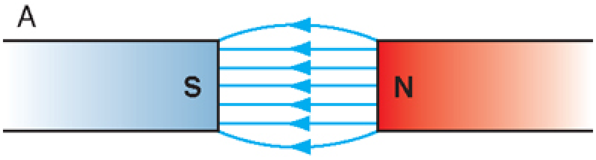
Q2 There is no force when the current is parallel to the magnetic field.

Q3 (a) down (b) down (c) to the right (d) to the right

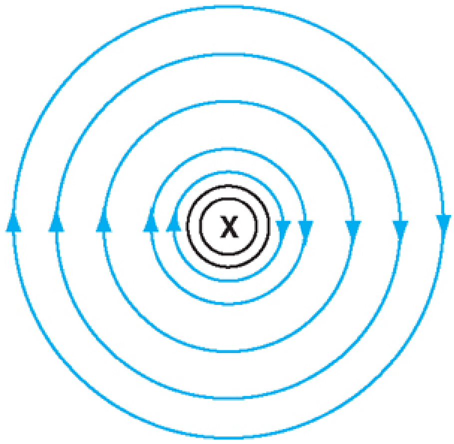
Q4 The current is parallel to the field.

Q5 a)

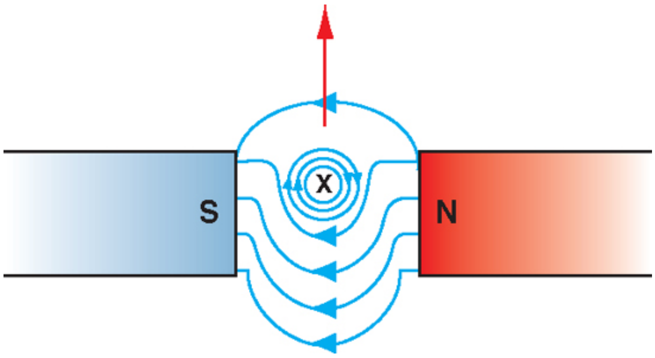
A



B



b)



c) i) ii) In both cases the wire moves downwards

d) Stronger magnets; larger current.

Q6 a) Beta particles have a small mass.

b) Alpha particles have a very large mass in comparison with beta particles.

c) Gamma rays are not charged.

Q7 The positive ions are deflected into the plane of the paper; the negative ions are deflected out of the plane of the paper. [The positive ions carry a conventional current to the right; the negative ions carry a conventional current to the left.]

Study questions 6.5 p200

Q1 i) Use stronger magnets.

ii) Use a larger current.

iii) Use more turns of wire.

Q2 a) The movement of the coil and paper cone is reversed.

b) The coil and paper can vibrate backwards and forwards, in and out of the cylindrical magnet.

c) i) A higher frequency sound is produced.

ii) A louder sound is produced.

Q3 a) i) downwards ii) upwards

b) Clockwise.

c) It is most likely to stop when it is vertical, because the wires going into the coil lose contact with the wires from the battery.

Q4 a) i) It is reversed
ii) It is reversed
iii) The forces remain the same.
b) Yes because the force is always in the same direction, regardless of current direction.
c) The coil and electromagnet have different resistances and so need different currents.

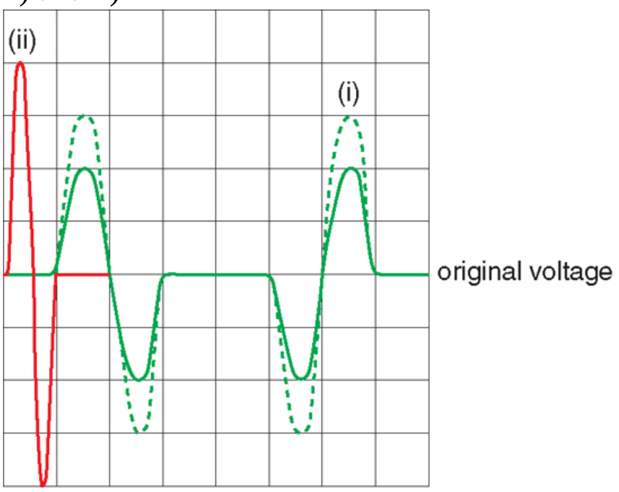
Study questions 6.6 p203

Q1 i) Move the wire faster.
ii) Use stronger magnets.

Q2 a) Zero.
b) i) To the left.
ii) To the right.
iii) To the left.

Q3 a) First a north pole approaches the coil then leaves: the voltage goes positive and then negative. Next a south pole approaches the coil then leaves: the voltage is reversed going negative and then positive.

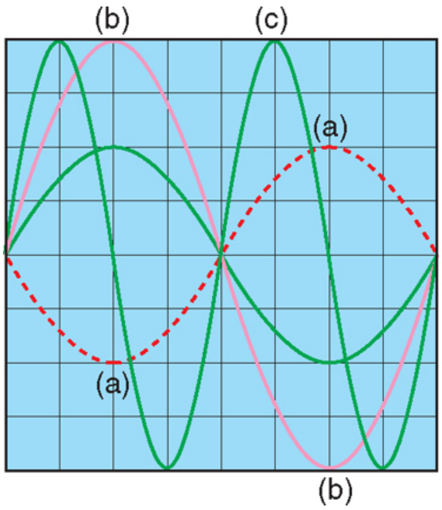
b) i) and ii)



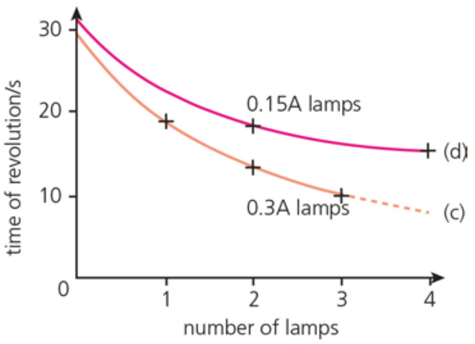
Study questions 6.7 p206

Q1 a) A diode which emits light when the current flows through it in one direction.
b) To ensure the charging current flows one way.
c) The movement of the magnet in the coil generates a voltage which drives the charging current.

Q2 a) b) c)



Q3 a) i) The flywheel's kinetic energy is transferred to thermal energy due to the frictional forces.
ii) Now the kinetic energy is also transferred to electrical energy then heat and light in the bulbs.
b) Energy is only transferred as in part a) i).
c) and d)



Study questions 6.8 p209

Q1 a) i) There is kick to the right, then the current reads zero.
ii) There is a reading to the right as long as the coils are moving.
iii) zero
iv) There is a reading to the left as long as the coils are moving.
b) The ammeter switches from left to right and back again with a frequency of 2 Hz.

Q2 A voltage is only induced in the secondary coil as long as there is a changing magnetic field. As an a.c. supply is changing so a voltage is induced. A d.c. supply is constant, so no voltage is induced.

Q3 a) 2.4 W
b) $P = V \times I$
$= 2 \times 1.2$
$= 2.4$ W

.

Q4 15 V step-down
250 V step-up
1000 turns step-down
15 000 turns step-down

Q5 High voltage allows currents to be low. A step-up transformer takes a low voltage, high current supply to a high voltage, low current supply. The power transferred to heat the transmission lines is calculated using the formula $P = I^2R$. Thus a low current reduces the power loss.

Q6 a) 2.4 V
b) i) 120 A
ii) 1.2 A
c) 288 W
d) 53 s. This assumes all the heat goes into the nail with no losses in the coils or to the air, and room temperature is 20°C.

Study questions 7.1 p220

Q1 a) i) 8
ii) 16
b) Because protons and electrons have equal but opposite charges: 8 positive protons balance the charge of 8 negative electrons.

Q2 a) 8 p 9 n
b) 92 p 146 n
c) 92 p 143 n
d) 19 p 21 n

Q3 See the text on pages 219–220.

Q4 a) See the text on page 220.
b) Isotopes are difficult to separate chemically because they are chemically identical. An atom's chemistry is determined by its electron structure. Isotopes have identical electron structures, but they have a different mass in the nucleus.

Q5 a) 209 and 210 are mass numbers; 82 is the atomic number of lead.
b) The number of protons.
c) Lead–209 has 127 neutrons; lead–210 has 128 neutrons.

Study questions 7.2 p223

Q1 The term 'radioactivity' is used to describe the emission of penetrating, ionising particles – alpha, beta or gamma radiation.

Q2 Becquerel discovered a radiation which could penetrate a light-sealed bag. No radiation was known which could do that.

Q3 a) The production of charged atoms or molecules by adding or removing electrons.
b) An electron is removed from one atom leaving a positive ion; then there is either a free electron or a negative ion if that electron attaches to another atom.

Q4 a) A helium nucleus
b) An electron
c) Electromagnetic waves.

Q5 a) ${}^{3}_{1}\mathrm{H} \rightarrow {}^{3}_{2}\mathrm{He} + {}^{0}_{-1}\mathrm{e}$

b) ${}^{229}_{90}\mathrm{Th} \rightarrow {}^{225}_{88}\mathrm{Ra} + {}^{4}_{2}\mathrm{He}$

c) ${}^{14}_{6}\mathrm{C} \rightarrow {}^{14}_{7}\mathrm{N} + {}^{0}_{-1}\mathrm{e}$ (In the text)

d) ${}^{209}_{82}\mathrm{Pb} \rightarrow {}^{209}_{83}\mathrm{Bi} + {}^{0}_{-1}\mathrm{e}$

e) ${}^{225}_{89}\mathrm{Ac} \rightarrow {}^{221}_{87}\mathrm{Fr} + {}^{4}_{2}\mathrm{He}$

f) ${}^{13}_{4}\mathrm{Be} \rightarrow {}^{12}_{4}\mathrm{Be} + {}^{1}_{0}\mathrm{n}$

Q6 $^{238}_{92}U \rightarrow ^{4}_{2}He + ^{0}_{-1}e + ^{0}_{-1}e + ^{234}_{92}U$

Q7 The nucleus loses energy but does not change its atomic or mass numbers.

Q8 The alpha particle produces negative and positive ions. The negative ions are repelled from the electroscope; the positive ions are attracted to the electroscope and then neutralise the negative ions.

Q9 $^{12}_{4}Be \rightarrow ^{11}_{5}B + ^{0}_{-1}e + ^{1}_{0}n$

Study questions 7.3 p226

Q1 b

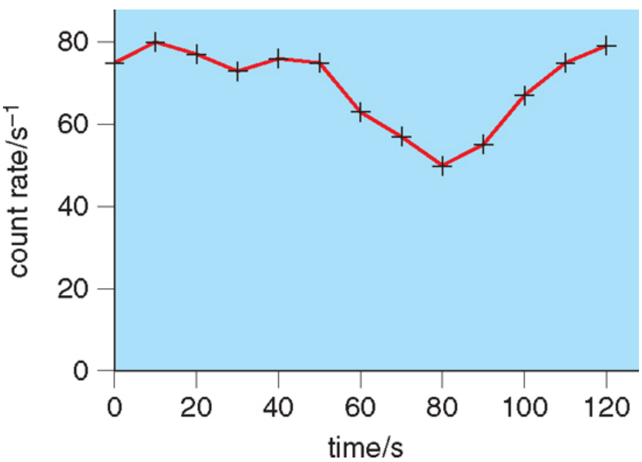
Q2 An airline pilot. They would be more exposed to cosmic rays high in the atmosphere.

Q3 a) In the text on p225.
b) Cosmic rays come from space. Most cosmic radiation comes from the sun: some charged particles come in the 'solar wind', and X-rays and γ-rays are emitted.
Background radiation also comes from: radon, rocks, buildings, the atmosphere and food.
c) The astronaut was not protected by the Earth's atmosphere so he was exposed to more cosmic rays.

Q4 45 Bq of activity is due to alpha radiation;
75 Bq of activity is due to beta radiation.

Q5 a) Radon can be breathed into the lungs. Once in the lung, alpha particles can damage body tissues. The particles are strongly ionising so cancer might result from such damage.
b) γ-rays travel long distances through air and other materials. So gamma rays can penetrate our bodies even though the source is far away,

Q6 a)



The count rate changes over the first 50 seconds because the emissions are random, so there is some variation.
b) Between 50 and 100 seconds the count rate drops because the foil is slightly thicker.

Study questions 7.4 p229

Q1 Count rate

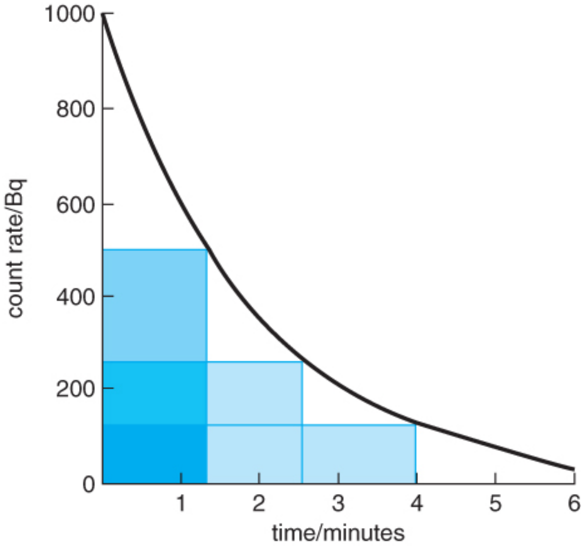
Q2 a) C b) A c) B

Q3 Random means unpredictable, or without a pattern.

Q4 The emission of radioactive particles from a source is random so there is some variation amongst the readings.

Q5 On average, half of a radioactive source will decay in one half-life.
8 minutes is four half-lives for this material; 1/16th of the source will be left.

Q6 a) A detector (a GM tube for example) will pick up radiation from the surroundings – decays from rocks and cosmic rays for example. We make a correction, by taking this away from the measured activity of a source.
b)



1 half-life – 1.3 min; 2 half-lives – 2.6 minutes; 3 half-lives 3.9 minutes. Average 1.3 minutes.

Q7 a) 600 Bq
b) 4.00 am on 4 March

Q8 a) $\frac{1}{16}$ of the carbon-14 means 4 half-lives have elapsed. So the settlement is 22 800 years old.
b) 50 000 years is about 9 half-lives.
By then the count rate is very low.

Q9 Rock A: 1.3×10^9 years
Rock B: 3.9×10^9 years

Study questions 7.5 p231

Q1 See text on page 231.

Q2 a) A radioactive tracer is radioactive isotope which is put into a body or plant. It can be 'traced' or observed as it moves through the system, by its radioactive transitions.
b) No. Tracers are isotopes of elements which occur in the body.

Q3 a) Lead is effective at reducing the count rate of the γ-rays.
b) It is surrounded by lead, without any direct path for γ-rays to escape.
c) p = 27; e = 27; n = 33.
d) 500 000 Bq
e) Use long tongs; work behind a metal screen; wear a radiation badge to monitor radiation level.

Q4 a) Xenon-133
A patient breathes in xenon-133 which is an inert gas. The radiation can be detected outside the body. You might find that part of the lung emits little radiation.
You make sure the dose is small for the patient. Radiographers work in a separate room to avoid regularly inhaling the gas. They check their radiation exposure levels.
b) See Figure 5.1, p230. Cobalt-60, which emits gamma rays, would be used.

Study questions 7.6 p234

Q1 Alpha, beta, gamma, neutrons.

Q2 50 mSv is the legal maximum; a dose of 100 mSv a year provides a small risk of cancer.

Q3 4.2 years

Q4 a) Radium luminisers (exposed to alpha) had a chance of 50 in 800 or 1 in 16 $\simeq$ 7% of death. This is high.

The Nagasaki bomb (gamma) produced a risk of 20 in 7000 or about 0.3%.

This might lead us to believe that alpha radiation is more dangerous, but there is no evidence about the size of dose. So we cannot draw firm conclusions.

b) There is not enough evidence. But if the two bombs were of the same strength and the populations the same, the Hiroshima death rate is slightly higher at 0.7%. Thus neutrons could be more deadly than gamma rays.

c) As mentioned above, this is not a fair test.

Q5 See text on page 234.

Study questions 7.7 p237

Q1 neutron

Q2 See the text on pages 235 and 236.

Q3 See the text on page 236 and Figure 7.3.

Q4 See the text; Figure 7.4 and pages 236 and 237.

Q5 $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3^{1}_{0}n$

Q6 $^{10}_{5}B + ^{1}_{0}n \rightarrow ^{11}_{5}B$

Study questions 7.8 p239

Q1 See the text on pages 238–239

Q2 See the text on page 239

Q3 The main advantages would be:

- there is an unlimited supply of hydrogen (in seawater)
- there would be fewer waste products.

The main disadvantage would be:

- it is difficult to control the fusion reaction at such high temperatures and pressures.

Study questions 8.1 p250

Q1 a) A moon orbits a planet.

b) A planet orbits a star.

c) A dwarf planet is a small (spherical) planet.

d) A star emits light due to nuclear fusion inside.

e) A galaxy is a large group containing billions (often hundreds of billions) of stars.

f) A group of galaxies contains lots of galaxies. These are pulled together by gravity.

Q2 a) The Milky Way.

b) Billions or hundreds of billions.

(Galaxies vary in size).

Q3 a) $d = v \times t$

$= 3 \times 10^8 \times 24 \times 3600 \times 365.25$

$= 9.47 \times 10^{15}$ m

b) $d = 4.25 \times 9.47 \times 10^{15}$

$= 4.0 \times 10^{16}$ m

c) $t = \dfrac{d}{v}$

$= \dfrac{4 \times 10^{16}}{30\ 000}$

$= 1.34 \times 10^{12}$ s or 42 500 years

d) Space travel to other stars is improbable.

Study questions 8.2 p254

Q1 a) Gravity

b) The force of gravity keeps deflecting the moon sideways. It does not speed up but it keeps changing direction.

Q2 A planet's orbit is nearly circular.

A comet's orbit is an elongated ellipse.

Q3 a) See Figure 2.8 (b)

b) i) B on Figure 2.8(b)

ii) D

c) B

d) D

Q4 a) $v = \dfrac{2\pi r}{T}$

$$3054 = \frac{2\pi \times 42\ 000\ 000}{T}$$

$$T = \frac{2\pi \times 42\ 000\ 000}{3054}$$

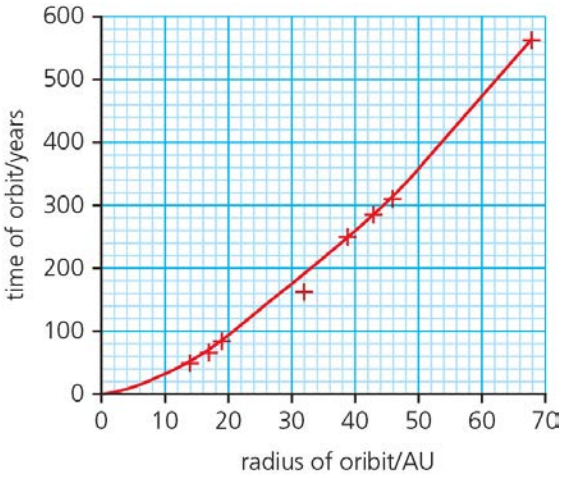
$= 86409$ s (86 365 s if using π 3.14) $\simeq$ 24 h

b) The satellite remains in the same position above the equator.

c) i) The time period is shorter.

ii) Weather; observation.

Q5 a)



b) Neptune – radius of orbit should be 30 AU.

c) 406 years

d) i) 42.9 million km/year

ii) 1360 m/s

Study questions 8.3 p258

Q1 a) D, A, C, B

b) i) Main sequence (ii) Black dwarf

Q2 Nuclear fusion.

Q3 a) A main sequence star converts hydrogen to helium by nuclear fusion.

b) The pull of gravity is balanced by the outward pressure due to the hot core of the star.

Q4 The white dwarf eventually cools down as it has no source of energy. Then it becomes a black dwarf.

Q5 a) A red supergiant collapses when there is no more nuclear fuel for the fusion process. The core cools down and gravity causes the star to collapse.

b) The star can collapse to a neutron star or a black hole.

Q6 The Earth has elements heavier than iron. These were made inside a supernova, which was once a very massive star.

Q7 A Barnard's Star

Surface temperature is 3100 K, so it is red. It is a dwarf because its radius and luminosity are small.

B Sirius B

Its diameter is very small.

It is also hot.

Its temperature suggests that it is of a blue colour – some hot white dwarfs are actually blue. (See the Hertzsprung–Russell diagram, Figure 4.3).

C Antares A

Its surface temperature of 3400 K means it is red.

It has an enormous diameter and it is very luminous.

Q8 See text.

Study questions 8.4 p261

Q1 a) i) The apparent magnitude is a relative measure of how bright a star appears to us as seen from Earth. (Low magnitudes are brighter than a higher magnitude.)

ii) The absolute magnitude is a measure of how bright a star would appear at a set distance (10 parsecs) from the Earth.

b) i) Apparent magnitude is affected by the luminosity (power emitted) of a star and its distance from us.

ii) Absolute magnitude is only affected by a star's luminosity.

Q2 a) See Figure 4.3

b) Giant stars have very large radii (and therefore surface areas). This makes giant stars very bright; they are brighter than a main sequence star of the same colour. They appear in the top right of the Hertzsprung–Russell diagram.

Dwarf stars have very small radii and surface areas. They are duller than a main sequence star of the same colour. So they appear at the bottom left of the Hertzsprung–Russell diagram.

Study questions 8.5 p263

Q1 Nuclei of helium were made by nuclear fusion after the birth of the Universe (which was very hot at that time).

Q2 After 700 000 years, the Universe had cooled to about 4000 K. Only at this temperature were the nuclei able to hold on to electrons, and thus make neutral atoms.

Q3 The matter in the early Universe was expanding rapidly. After billions of years, gravity had pulled matter together so that stars and galaxies formed.

Study questions 8.6 p267

Q1 Refer to the text.

Q2 Refer to the text.

Q3 $\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$

$\Delta\lambda$ = 370 nm – 280 nm

= 90 nm

$\frac{v}{c} = \frac{90}{280} = 0.32$

v = 0.32 C
= $0.32 \times 3 \times 10^8$
= 9.6×10^7 m/s