# Answers to exam-style questions

## Topic 1

All numerical answers are quoted to 2 s.f.

**1** Thickness of sheet = 7 mm/160 = 0.044 mm = $4.4 \times 10^{-5}$ m [1]

**2** **a** systematic or zero error [1]

**b** 9 swings [1]

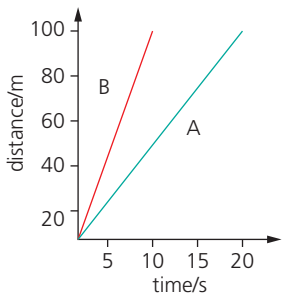
**c** time = 5.9 – 0.5 = 5.4 s [1]

**d** time for 1 swing = 5.4/9 = 0.60 s [1]

**3** Scalars: mass, kinetic energy, time [3]
Vectors: velocity, weight, acceleration [3]

**4** Resultant velocity = $\sqrt{12^2 + 4^2} = 4.1$ m/s [1]
$\tan\theta = 4$, $\theta = 76°$ north of due east [1]

**5** **a**



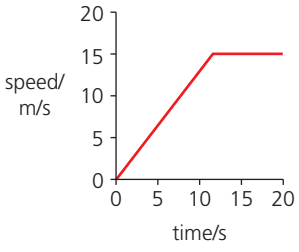

[3]

**b** average speed

$$= \frac{\text{total distance travelled}}{\text{total time taken}} = \frac{100}{20} = 5\,\text{m/s}$$ [2]

**c** Line B as shown in image [2]

**6** **a** Speed in m/s on *y*-axis [1] time in s on *x*-axis [1] line plotted as shown below [1]




**b** Distance travelled = area under the graph [1] = 210 m. [1]

**c** Average speed = $\frac{\text{total distance}}{\text{total time}} = \frac{210}{20}$

= 11 m/s to 2 s.f. (10.5 m/s exactly). [2]

**d** $a = \frac{\Delta v}{\Delta t} = \frac{15}{12} = 1.3$ m/s² to 2 s.f. (1.25 m/s² exactly) [2]

**7** **a** $9.8 = \frac{8820}{m}$ [1]

$m = 900$ kg [1]

**b** $g = \frac{3330}{900} = 3.7$ N/kg [1]

**8** **a** Answers in *italics*

| Substance | Mass/g | Volume/cm³ | Density/g/cm³ |
|---|---|---|---|
| A | 540 | 200 | *= 540/200 = 2.7* [1] |
| B | 67.5 | *= 67.5/1.5 = 45* [1] | 1.5 |
| C | *= 250 × 0.5 = 125* [1] | 250 | 0.5 |

**b** C only [1]

**9** **a** $V = 140 - 20 = 120$ cm³ [1], mass = 246 – 150 = 96 g [1], $\rho = m/V = 0.80$ g/cm³ [1]

**b** $V = 200 - 140 = 60$ cm³ [1], mass = 411– 246 = 165 g [1], $\rho = m/V = 2.8$ g/cm³ to 2 s.f. [1] (2.75 g/cm³ exactly)

**10** Liquid B floats on liquid A [1]
Either calculate both densities $\rho = m/V$: liquid A $\rho = 1.1$ g/cm³ [1], liquid B $\rho = 0.92$ g/cm³ [1]
Or state as both liquids have same mass, since B has greater volume [1], it has lower density [1]

**11** **a** Graph A shows a directly proportional relationship. [1] This could be a spring. [1]
Graph B shows a non-linear relationship. [1] The load/force required stretching the material changes with extension / Below 5 cm, a large force is needed per unit extension; beyond 5 cm, the force required decreases then begins to increase again. [1]
Graph C is linear until 20 cm [1] then non-linear [1] (Supplemental students – this could be a spring stretched beyond its limit of proportionality.)

**b** extension = 0.1 m [1] $k = \frac{F}{x} = \frac{5}{0.2} = 25$ N/m [1]

**c** Limit of proportionality occurs at 40 cm. [1]

**12** **a** There is no resultant force/resultant force is zero. [1]

**b** The resultant force is in the opposite direction to the movement of the car. [1]

**13** **a** resultant force = 1800 – (980 + 500) = 320 N [1] upwards [1]

**b** The rocket will accelerate [1] upwards. [1]

**c** $m = \frac{W}{g} = \frac{980}{9.8} = 100\,\text{kg}$ [1]

acceleration $= \frac{F}{m} = \frac{320}{100} = 3.2\,\text{m/s}^2$ [1]

The rocket accelerates upwards at $3.2\,\text{m/s}^2$. [1]

**14 a** $450 \times 1.2 = 540\,\text{N m}$ [1]

**b** To balance there must be no resultant moment. [1]

$540 = 1.5 \times W$

$W = 360\,\text{N}$ [1]

**15** Clockwise moment $= 1.8 \times 300 = 540\,\text{N m}$ [1]

Anticlockwise moment $= 1.4 \times 400 = 560\,\text{N m}$ [1]

To balance clockwise moment, must increase by 20 N m. [1]

$20\,\text{N m} = 2 \times F$

$F = 10\,\text{N}$ down [1]

**16** A Bunsen burner has a base with a large area; [1] it is also heavier at the bottom so the centre of gravity is low. [1]

**17 a** momentum before collision

$= 6000 \times 6 + 10\,000 \times 2$

$= 36\,000 + 20\,000$

$= 56\,000\,\text{kg m/s}$ [1]

momentum after collision $= 16\,000 \times 3.5$

$= 56\,000\,\text{kg m/s}$ [1] so momentum is conserved.

**b** $E_k = \frac{1}{2}mv^2$

Before $= (\frac{1}{2} \times 600 \times 6^2) + (\frac{1}{2} \times 10\,000 \times 2^2)$

$= 128\,000\,\text{J}$ [1]

After $= \frac{1}{2} \times 16\,000 \times 3.5^2 = 98\,000\,\text{J}$ [1] Reduced by 30 000 J. Not conserved. [1]

**c** Energy is transferred to the thermal store of the surroundings. [1]

**18** $F = \frac{\Delta p}{\Delta t} = \frac{0.45 \times 25}{0.02} = 560\,\text{N}$ [2]

**19** Answers in italics: 1 mark for each correct answer

| Device | Energy store at the start that decreases | Energy transfer process | Energy store at the end that increases |
|---|---|---|---|
| battery-powered fan | chemical energy | *electrical working* | kinetic energy |
| roller coaster | *gravitational potential energy* | *mechanical working* | kinetic energy |
| catapult | elastic energy | *mechanical working* | *kinetic energy* |

**20 a** gravitational potential energy [1]

**b** kinetic energy [1] elastic (strain) energy [1]

**c** $\Delta E_p = mg\Delta h = 60 \times 9.8 \times 20 = 11\,760\,\text{J}$ [2]

**d** $E_k = \frac{1}{2}mv^2 = \frac{1}{2} \times 60 \times 15^2 = 6750\,\text{J}$ [2]

elastic energy $= 11\,760\,\text{J} - 6750\,\text{J} = 5000\,\text{J}$ (exact answer $= 5010\,\text{J}$) [1]

**21** $E_k = \frac{1}{2}\,mv^2 = \frac{1}{2} \times 0.060 \times 12^2 = 4.32\,\text{J}$ [1]

$E_k = \Delta E_p$ [1]

$4.32 = 0.06 \times 9.8 \times h$

$h = 7.3\,\text{m}$ [1]

**22 a** $W = Fd = 25 \times 2 = 50\,\text{J}$ [1]

**b** weight $= mg = 15 \times 9.8 = 147\,\text{N}$ [1]

$W = Fd = 147 \times 1.5 = 220\,\text{J}$ (exact answer 220.5 J) [1]

**23 a** There is no air pollution [1], but the other types of pollution are a matter of opinion. Some people consider that the landscape can be spoiled (visual pollution), but others like to look at wind turbines. Wind turbines create noise pollution that upsets some people. The scientific evidence about whether or not noise is a real problem is unclear. [1] Over a whole year, a well-chosen location will give a reliably predictable amount of energy. [1] But, day-to-day, the amount of wind is very uncertain [1], so wind farms need to be part of a complete energy strategy for a country, together with other types of electricity generation.

**b** Wind energy is renewable. [1] Wind energy will not be used up / kinetic energy of the wind is transferred to the turbine. [1]

**c** e.g. Energy from hydroelectric dams is from a renewable source. [1]

e.g. Energy from fossil/nuclear fuel is from a non-renewable source. [1]

**24** $\text{efficiency} = \frac{\text{useful power output}}{\text{total power input}} \times 100\,\%$

$= \frac{432}{1080} \times 100\,\% = 40\,\%$ [2]

**25** work done on load $= 40 \times 1.4 = 56\,\text{J}$ [1]

$\text{efficiency} = \frac{\text{useful energy output}}{\text{total energy input}} \times 100\,\%$

$= \frac{56}{70} \times 100\,\% = 80\,\%$ [2]

**26 a** $P = \frac{\Delta E}{t} = \frac{96\,000}{2 \times 60} = 800\,\text{W}$ [2]

**b** $P = \frac{750 \times 15}{30} = 375\,\text{W}$ [2]

**27** power input = work done each second $= Fd = mgd$

$= 24 \times 9.8 \times 60 = 14\,112\,\text{J/s}$ [1]

power output $= 11\,000\,\text{W}$ [1]

$\text{efficiency} = \frac{\text{useful power output}}{\text{total power input}} \times 100\,\%$

$= \frac{11\,000}{14\,112} \times 100\,\% = 78\,\%$ [1]

**28** The head of the drawing pin has a much larger surface area than the pointed end. [1] This means for the same force applied the pressure on the head is less than the pressure at the point. [1]

**29** area = $0.8 \times 1.3 = 1.04\,m^2$ [1]

$$P = \frac{F}{A} = \frac{4900}{1.04} = 4700\,Pa$$ [1]

**30 a** The pressure increases with depth. [1] The bottom of the dam is thicker so that it is strong enough to withstand the pressure. [1]

**b** $\Delta p = \Delta h \rho g = 78 \times 1000 \times 9.8 = 760\,000\,Pa$ [1]

## Topic 2

**1 a** The momentum of the gas particle changes [1] which requires a force on the particle exerted by the wall. [1]

**b** The total force [1] due to collisions of all the particles divided by the total area of the walls is the pressure on the walls of the container. [1]

**2 a** pressure decreases [1]

**b** kinetic energy of particles stays the same [1]

**c** rate of collisions per unit area decreases [1]

**d** total force per unit area decreases [1]

**3** B [1]

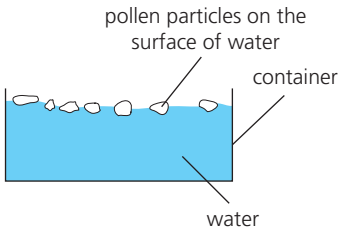
**4 a** increases [1] because the speed and kinetic energy of the particles is higher at higher temperature [1]

**b** increases [1] because the particles are moving faster and so move between the walls in a shorter time [1]

**c** increases [1] because more collisions cause greater change of momentum and greater force [1]

**5** B [1]

**a**




[1]

Microscope drawn in viable position. [1]

**b** The pollen particles are seen to move [1] randomly. [1]

**c** Moving water molecules [1] collide randomly with pollen particles and cause them to move. [1]

**7** $p_1V_1 = p_2V_2$ [1]

$p_1 = p_2V_2/V_1 = (700 \times 300)/800$ [1]

$p_1 = 260\,Pa$ [1]

initial pressure = 160 Pa above atmospheric pressure [1]

**8 a** stays the same [1] because the ice receives thermal energy but its temperature cannot rise above 0°C [1]

**b** decreases [1] because the water transfers thermal energy to the ice so its temperature decreases [1]

**c** increases [1]

**d** stays the same [1]

**9** Difference: evaporation takes place at all liquid temperatures; boiling takes place at a definite temperature. [1]

Difference: evaporation takes place on the surface; boiling takes place throughout the liquid; [1]

Difference: evaporation takes place without energy input; continuous boiling requires continuous energy input. [1]

Similarity: substance changes state from liquid to gas. [1]

Similarity: energy is required to break bonds between molecules. [1]

**10** 373 K [1], 100°C [1]

**11** The strips will curl with the bronze on the outside [1] because bronze expands more than invar [1]

**12 a** energy = $200 \times 5 \times 60$ [1] = 60 000 J [1]

**b** specific heat capacity = energy/(mass × temperature rise) [1]

= $60\,000/(2 \times 31)$ [1] = 970 J/(kg°C) [1]

**c** mass = energy/(specific heat capacity × temperature rise) = $35\,000/(970 \times 260)$ [1]

= 0.14 kg [1]

**13** Metals have free electrons. [1] These electrons move through the metal transferring thermal energy. [1] Gases and liquids rely on the secondary mechanism of conduction by collisions between molecules. [1]

**14 a** conduction [1], there is solid contact between their hand and the metal gate [1]

**b** convection [1], the water molecules move past their hand removing thermal energy [1]

**c** infrared radiation [1], no medium is required for the transfer of thermal energy [1]

**15 a** infrared [1] radiation [1]

**b** probe X [1]

**c** temperature decreases [1], the rate of thermal energy radiation received from the Sun becomes less [1], temperature of the probe falls until it emits thermal energy at the same rate as it is received [1]

**16** mainly convection [1], the radiator heats the air next to it causing its density to fall so it rises [1]

small amount of radiation [1], the radiator is at a higher temperature than the room so thermal energy is radiated to the room [1]

## Topic 3

**1 a** 0.75 m [1]

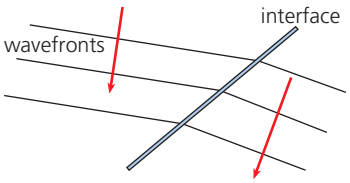
**b** $f = 12/60$ [1]

$f = 0.20$ Hz [1]

**2 a** towards and away from him [1]

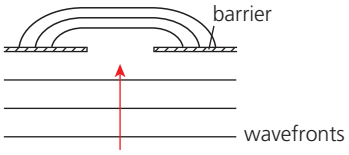
**b** vertically up and down [1]

**3**




[4]

**4 a**




[3]

**b** diffraction [1]

**c** The straight portion in front of the gap would be longer. [1] The part-circles at the ends of the straight portion would be unchanged. [1]

**5 a** B [1]

**b** E [1]

**c** B = 30°, C = 90°, D = 65° [1], E = 35°, F = 90° [1]

**6 a** An endoscope is used and inserted into the patient to reach the region to be examined. Light passes along the optical fibres (endoscope) to illuminate this region. [1] Despite any twists and turns, total internal reflection within the optical fibre ensures that all the light reaches the end. [1] Light from the illuminated region returns in a similar way back through other fibres and the doctor can see the region. [1]

**b** The signal is transmitted in digital form as a series of pulses of light. [1] Light passes along the optical fibres to sensors at the receiving device. Despite any twists and turns, total internal reflection within the optical fibre ensures that all the light reaches the end. [1] Any reply signal is returned in a similar way through other fibres. [1]

**7 a** two correct converging rays [2] size 3.0 cm (reasonable tolerance 2.7–3.3 cm), [1]

position 9.0 cm from the lens (reasonable tolerance 8.3–9.7 cm) [1]

**b** real [1], inverted [1] and enlarged [1]

**8 a** The two rays diverge and will not meet at an image. [1]

**b** Dashed lines drawn back [1] to converge behind the object. [1]

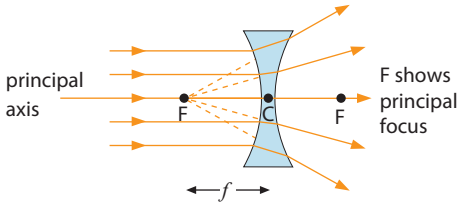
**c i** size 4.5 cm (reasonable tolerance 4.1–4.9 cm), position 6.0 cm from the lens (reasonable tolerance 5.4–6.6 cm) [1]

**ii** virtual, upright and enlarged [1]

**9 a** Upside down, so they appear the correct way up to the observer. [1]

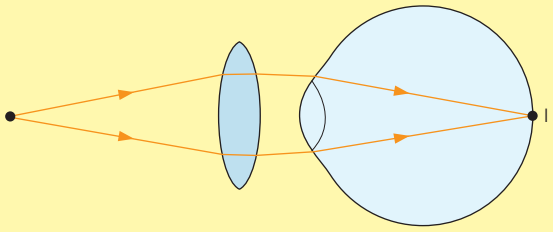
**b** enlarged [1], inverted [1], virtual [1]

**10 a, b**




[2], [2]

**11** A converging lens is used, as the lens in the person's eye cannot be made thick enough. [4]




**12 a** $v = f\lambda$ [1]

$f = 3 \times 10^8 / 5.5 \times 10^{-7}$ [1]

$f = 5.5 \times 10^{14}$ Hz ($5.4545 \times 10^{14}$ Hz) [1]

Notes: Extended candidates are expected to know the speed of electromagnetic waves. All students are expected to be able to use standard notation, including positive and negative indices.

**b** $7.1 \times 10^{-7}$ m [1]

Notes: Students are not expected to know this value. However, they should be aware that the visible spectrum is a narrow range of wavelengths. Students should know that infrared has a longer wavelength than ultraviolet. It is a reasonable deduction that red has the longest wavelength of the colours.

**13 a** X-rays [1]

**b** gamma rays [1]

**c** same time [1]

**d** distance = speed × time [1]

$= 3 \times 10^8 \times 4 \times 365 \times 24 \times 3600$ [1]

$= 3.8 \times 10^{16}$ m [1]

**14 a** D [1]

**b** Violet light refracted more than blue. [1] Microwaves and ultrasound would not pass through the prism and orange light would be refracted less. [1]

**15** A [1]

**16 a** radio waves [1]

**b** When radio waves pass through walls [1] the signal is weakened. [1]

**17 a i** electromagnetic radiation [1]

**ii** Two from: electric grills, remote controllers, intruder alarms, thermal imaging/night vision, optical fibres [2]

**b i** Similarity: both in the electromagnetic spectrum [1]

Difference: microwaves have shorter wavelength or higher frequency [1]

**ii** internal overheating of body cells [1]

**18 a** $v = f\lambda$ [1]

$\lambda = v/f = 1500/750 = 2.0\,\text{m}$ [1]

**b** distance travelled by wave $= vt$ [1]

$= 1500 \times 0.037$ [1]

$= 56\,\text{m}$ [1]

depth of shoal = 56/2 = 28 m

**c i** Yes. [1] The audible range of frequencies is 50 Hz to 20 kHz. [1]

**ii** $\lambda = v/f = 330/750$ [1] $= 0.45\,\text{m}$ [1]

## Topic 4

**1 a** north [1]

**b** north [1]

**2** Bring both poles of the magnet close to the three blocks. The magnet will have no effect on the non-magnetic material. [1] The magnet will only attract the iron block. [1] The magnet will both attract and repel the magnet. [1]

**3** The crane has to be able to let go of the cars and only a temporary magnet such as an electromagnet can be switched on and off. [1] They can alter the strength of the electromagnet. [1]

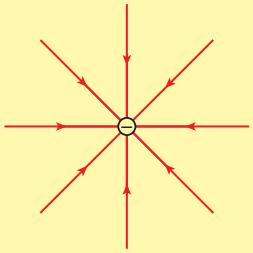
**4 a** Suspend one of the rods. [1] Bring the other rod close. [1] If the suspended rod is attracted, the two rods have opposite charges. [1]

**b** Friction causes electrons on the Perspex rod to be transferred to the dry cloth. [1] Electrons are negatively charged. [1] This leaves the rod with more positive charge than negative charge. [1]

**c** The polythene becomes negatively charged/has gained electrons [1] so the rod must have lost electrons and become positively charged. [1]

**5** Lines radiating out from a central point [1]

Arrows pointing towards the centre [1]



**6** 0 to 1 A [1]

**7** $t = 5 \times 60 = 300\,\text{s}$ [1]

$I = \frac{Q}{t} = \frac{75}{300} = 0.25\,\text{A}$ [1]

**8 a** 0 to 5 V [1] and 0 to 10 V [1]

**b** 0.2 V [1]

**c** Reverse the connections so that the positive terminal is on the side where the current flows in. [1]

**9** 1 mark for each correct row

| Measurement to be taken | AB | CD | EF |
|---|---|---|---|
| current through *R* when connected to battery | nothing | nothing | ammeter |
| p.d. across *r* when connected to battery | nothing | voltmeter | wire |

**10 a** $E = \frac{W}{Q} = \frac{45}{15} = 3.0\,\text{V}$ [1]

**b** $V = \frac{W}{Q}$, $W = VQ = 12 \times 180 = 2200\,\text{J}$

(exact answer = 2160 J) [2]

**11** $R = \frac{V}{I} = \frac{6.0}{1.5} = 4\,\Omega$ [1]

**12** $R = \frac{V}{I}, I = \frac{V}{R} = \frac{2.5}{20} = 0.13\,\Omega$ (exact answer 0.125 Ω) [2]

**13** Resistance is a ¼ of the original. [1]

So either reduce the length to a ¼ [1], since the length of the block is directly proportional to the resistance [1] keeping the cross-sectional area the same. [1]

OR increase the cross-sectional area of the block by 4 (or increase diameter by 2) [1] as area is inversely proportional to the resistance [1] keeping the length the same. [1]

**14** $P = 0.8\,\text{kW}$ [1], $t = 0.5$ hours [1],
$E = 0.8 \times 0.5 = 0.4\,\text{kWh}$ [1]

**15 a** $t = 4 \times 60 = 240\,\text{s}$ [1] $E = ItV = 4.0 \times 12 \times 240$
$= 12000\,\text{J}$ (exact answer 11 520 J) [1]

**b** $P = IV = 12 \times 4 = 48\,\text{W}$ [1]

**16** $\Delta E = mc\Delta\theta = Pt$ [1]

$\Delta\theta = Pt/mc = (3000 \times 2 \times 60)/(2.5 \times 4200)$ [1]

$\Delta\theta = 34.285$ [1]

final temp = 50°C to 2 s.f. (50.29°C) [1]

**17** In series [1] with positive (+) terminal connected to the negative (–) terminal of the next [1]

**18 a** $R_T = 20 + 40 = 60\,\Omega$ [1]

**b** $\frac{1}{R_T} = \frac{1}{20} + \frac{1}{40}$ [1] $R_T = 13\,\Omega$ to 2 s.f. [1]

**19 a** $V = I \times R = 0.3 \times 40 = 12\,V$ [2]

**b** $I_3 = 0.5 - 0.3 = 0.2\,A$ [1] p.d across $R_2 = 12\,V$ [1]

$R = V/I = 12/0.2 = 60\,\Omega$ [1]

**20** ratio 1:3 [1]

$V_1 = 1 \times \frac{12}{4} = 3\,V$ [1]

$V_2 = 3 \times \frac{12}{4} = 9\,V$ [1]

**21** As the temperature increases, the resistance of the thermistor decreases. [1]

The p.d. across the thermistor decreases. [1]

The p.d. across the fixed resistor R increases. [1]

When the p.d. is high enough, the relay switches on the bell circuit/bell rings. [1]

**22 a** $I = P/V = 500/220 = 2.3\,A$ [1] Use 3 A fuse [1]

**b** $I = P/V = 2500/220 = 11\,A$ [1] Use 13 A fuse [1]

**c** $I = P/V = 1100/220 = 5.0\,A$ [1] Use 13 A fuse [1]

**23 a** Increase the speed it is moved. [1]

Increase the strength of the magnetic field. [1]

Have a coil of wire move upwards. [1]

**b** clockwise [1]

**24 a** Needle moves to the right. [1]

**b** Needle moves to the left. [1]

**c** Needle moves to the right. [1]

**25 a** The magnetic field direction alternates. [1]

**b** The force direction alternates. [1]

**c** The cone vibrates at the frequency of the a.c. signal. [1]

**26** Wire perpendicular to a (uniform) magnetic field. [1] When current flows, the wire feels a force.[1] When the current is reversed, the wire feels a force in the opposite direction. [1] A labelled diagram with explanation of reversing current could be used instead for the marks.

**27 a** The coil will turn (or experience a moment). [1]

**b i** same [1]

**ii** increased [1]

**iii** decreased to zero [1]

**iv** increased [1]

**28 a i** down [1]

**ii** up [1]

**b i** Decreased to zero, no current flows in the coil. [2]

**ii** Decreased to zero, no current flows in the coil. [2]

**c i** up [1]

**ii** down [1]

**29** $\frac{V_p}{V_s} = \frac{N_p}{N_s}$ [1]

$\frac{240}{6} = \frac{N_p}{100}$ [1]

$N_p = \frac{100 \times 240}{6} = 4000$ turns [1]

**30** $\frac{V_p}{V_s} = \frac{N_p}{N_s}$

$\frac{120}{V_s} = \frac{1200}{20}$ [1]

$V_s = \frac{20 \times 120}{1200} = 2\,V$ a.c. [1]

$I_pV_p = I_sV_s$

$0.01 \times 120 = I_s \times 2$ [1]

$I_s = 0.6\,A$ [1]

**31 a** $P = I^2R = 2.5^2 \times 500$ [1], $P = 3100\,W$ (3125 W exact answer) [1]

**b** $P = I^2R = 250^2 \times 500$ [1], $P = 31\,MW$ [1]

## Topic 5

**1** 1 mark for each correct answer

| Isotope | Number of protons | Number of neutrons | Number of electrons |
|---|---|---|---|
| $^{88}_{38}Sr$ | 38 | 50 | 38 |
| $^{90}_{38}Sr$ | 38 | 52 | 38 |

**2 a** nucleon number 23 [1] proton number 11 [1]

correct form $^{23}_{11}Na$ [1]

**b** positive ion (charge + 1) [1]

**c** relative mass is 23 [1] and relative charge is +11 [1]

**3 a** Max 4 marks with 2 correct for fission and 2 for fusion.

Nuclear fission means splitting. The nucleus of an element with a high proton number is bombarded by a neutron moving with a suitable velocity. The nucleus splits into two nuclei with lower proton numbers.

Nuclear fusion means joining together. Two nuclei, usually of elements with a low proton number, join together under conditions of extremely high temperature and pressure. A nucleus with a higher proton number is formed.

**b** A large amount of energy is released/mass of products is less than the mass of the reactants [1]

**c** in the reactor of a nuclear power station [1]

**d** inside the Sun [1]

**4** $^{236}_{92}U + {}^{1}_{0}n \rightarrow {}^{144}_{56}Ba + {}^{89}_{36}Kr + 3{}^{1}_{0}n$ [2]

**5** Background radiation is low-level radiation around you all the time. [1]

1 mark each, max 2 marks. Possible sources: radon gas/food and drink/rocks and buildings/cosmic rays

**6** **a** count rate = 24/ (2 × 60) = 0.2 count/s [2]
(1 mark for 12 count/min)

**b** corrected count rate = 40 – 0.2 = 39.8 count/s [1]

**7** 1 mark for each tick in the correct place

| Sample | CR (none) | CR (card) | CR (Al) | Cr (Pb) | α | β | γ |
|---|---|---|---|---|---|---|---|
| 1 | 6000 | 1000 | 1000 | 20 | ✓ | | ✓ |
| 2 | 3000 | 3000 | 20 | 20 | | ✓ | |

**8** **a** deflected downwards [1]

**b** undeflected [1]

**9** 1 mark for each correct term in the equation (max 4): $^{238}_{92}\mathrm{U} \rightarrow {}^{234}_{90}\mathrm{Th} + {}^{4}_{2}\mathrm{He} + \gamma$

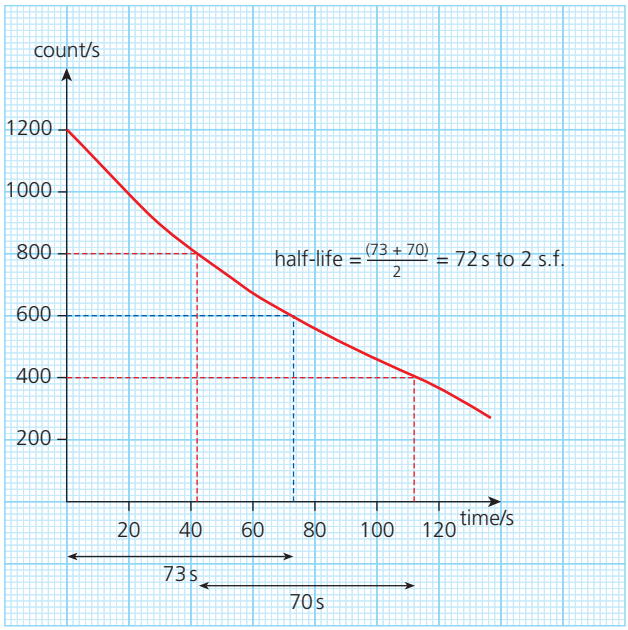
**10** 1 mark for each correct term in the equation (max 3): $^{137}_{55}\mathrm{Cs} \rightarrow {}^{137}_{56}\mathrm{Ba} + {}^{0}_{-1}\mathrm{e}$

**11** Some nuclei are unstable because they have too many neutrons in the nucleus. [1] During a beta-decay, a neutron becomes a proton and fast-moving electron. [1] This reduces the number of neutrons in the nucleus making it more stable. [1]

**12** **a** Half-life is 4 minutes. [1]

**b** After 12 minutes the fraction left is 1/8. [1]

**13** **a** suitable scale chosen for both axes, [1], both axes labelled with units [1], points plotted correctly [1] and smooth curve drawn. [1]




**b** Value for half-life taken from graph in at least 2 places and mean found. [1] Value approximately 72 seconds ± 4 seconds. [1]

**14** **a** C. [1] This is a gamma-source and is the most penetrating so it can be detected outside the body. [1] It has a suitably short half-life. It will be active during the measurements but within a day the activity level will be very low. [1]

**b** Source A. [1] The source needs to be a beta-emitter because it needs to be absorbed a little by the aluminium. The gamma-source is too penetrating and the reading would not change with the thickness of the aluminium. [1] The half-life is long enough for the activity to remain constant. [1]

**15** **a** Max 2 marks from:

Only have the source in the classroom when needed.

Handle with long tongs only.

Keep students at least 2 metres away.

Don't point the source at themselves or the students.

Place a lead screen between them and the source.

**b** Max of two marks from: idea of reducing exposure time/increasing distance between source and teacher and students/using shielding ideas linked to students suggestion.

## Topic 6

**1** **a** **i** As in Figure 6.1 [2]

**ii** As in Figure 6.1 [1]

**b** at an angle to 90° to plane of Solar System [1]

**2** D [1]

**3** B [1]

**4** **a** $T = 2\pi r/v$ [1]

$T = 2\pi \times 5.8 \times 10^{10} / 48\,000\ \mathrm{s}$ [1]

$T = (2\pi \times 5.8 \times 10^{10} / 48\,000)/(3600 \times 24)$
$= 88$ days [1]

**b** **i** less [1]

**ii** less [1]

**5** **a** Neptune is further from the Sun. [1] It has a longer orbit time because it has a greater distance [1] for one orbit and travels slower [1]. The surface temperature is lower because it receives less thermal radiation because of its greater distance from the Sun. [1]

**b** Because of its large diameter, Jupiter has a much higher mass despite lower density. [1] The increased gravitational attraction of this greater mass causes the increase of gravitational field strength. [1]

**6 a** The four inner planets are rocky and small. [1] The four outer planets are gaseous and large. [1]

**b** The Solar System was formed from clouds of hydrogen gas and particles of dust and heavier elements. [1] The particles of dust and heavier elements joined together to form a disc in an accretion process. [1] Heavier elements gradually accreted by gravitational attraction to grow into the inner planets. [1] The lighter elements drifted further from the Sun and eventually grew by gravitational attraction to be large enough to attract even the lightest elements to form the gaseous outer planets. [1]

**7** $t = d/v$ [1]

$= 390\,000\,000/3 \times 10^8$ [1]

$= 1.3$ s [1]

**8 a** elongated ellipse [1], comet marked and labelled on line of ellipse [1], Sun marked and labelled within ellipse near one end [1]

**b** X and Y labelled on line of ellipse [1], velocity greater at point closer to Sun [1], gravitational potential energy less at point closer to Sun [1], total energy same [1]

**9** B [1]

**10 a** about the same [1]

**b** hydrogen [1] and helium [1]

**c** nuclear fusion reaction [1] of hydrogen [1]

**d** stars [1]

**e** Milky Way [1]

**11** $d = vt$ [1]

1 light-year $= 3 \times 10^8 \times 3600 \times 24 \times 365$ [1]

diameter of Milky Way = $100\,000 \times 3 \times 10^8 \times 3600 \times 24 \times 365$ [1]

$= 9.5 \times 10^{20}$ m [1]

**12 a** change of frequency of radiation [1] from receding objects [1]

**b** Since the Big Bang, the Universe has been expanding. [1] So all other galaxies are receding from us. [1]

**13** A [1]

**14 a** cosmic background [1] microwave radiation [1]

**b** CMBR is part of electromagnetic spectrum. [1] Microwaves are electromagnetic radiation. [1]

**c** Radiation was emitted at the Big Bang. [1] Redshift has taken the radiation into the microwave region. [1]

**d** $9.5 \times 10^{15}$ m [1]

**15 a** change of wavelength of light from the galaxy [1] due to redshift [1]

**b** brightness [1] of a supernova in that galaxy [1]

**16 a** $H_0 = v/d$ [2], $H_0$ is Hubble constant [1]
$v$ is recession speed of far galaxy [1]
$d$ is distance of far galaxy [1]

**b** $2.2 \times 10^{-18}$ [1] $s^{-1}$ [1]

**17 a** $d/v = 1/H_0$ [2], $H_0$ is Hubble constant [1]
$v$ is recession speed of far galaxy [1]
$d$ is distance of far galaxy [1]

**b** $1/(2.2 \times 10^{-18})$ [1], $1/(2.2 \times 10^{-18} \times 3600 \times 24 \times 365)$ [1], $1.4 \times 10^{10}$ or 14 billion years [1]

**c** At the Big Bang [1] all matter was at a single point. [1]