Section A

Answer **all** questions.

1 A ball is released from rest at point A and moves along a smooth track ABCDE as shown in **Fig. 1.1.** The ball is shown at point A and as it passes point B. The ball is always in contact with the track and air resistance is negligible.

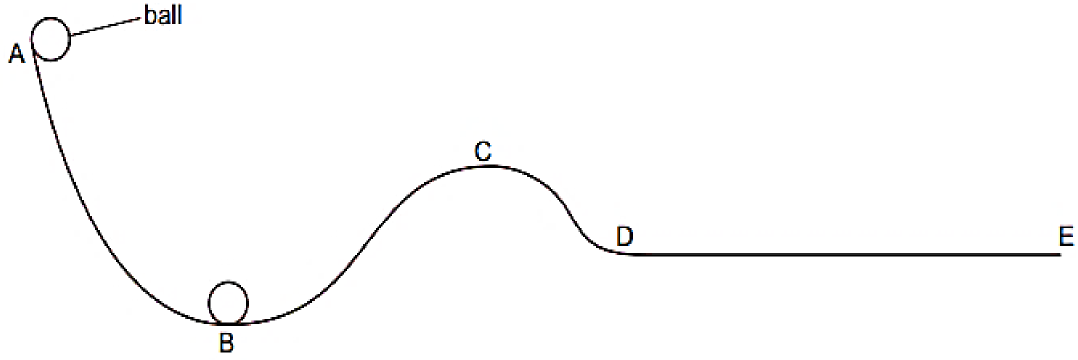

Fig. 1.1

Fig. 1.2 shows the distance−time graph for the ball as it moves from A to E.

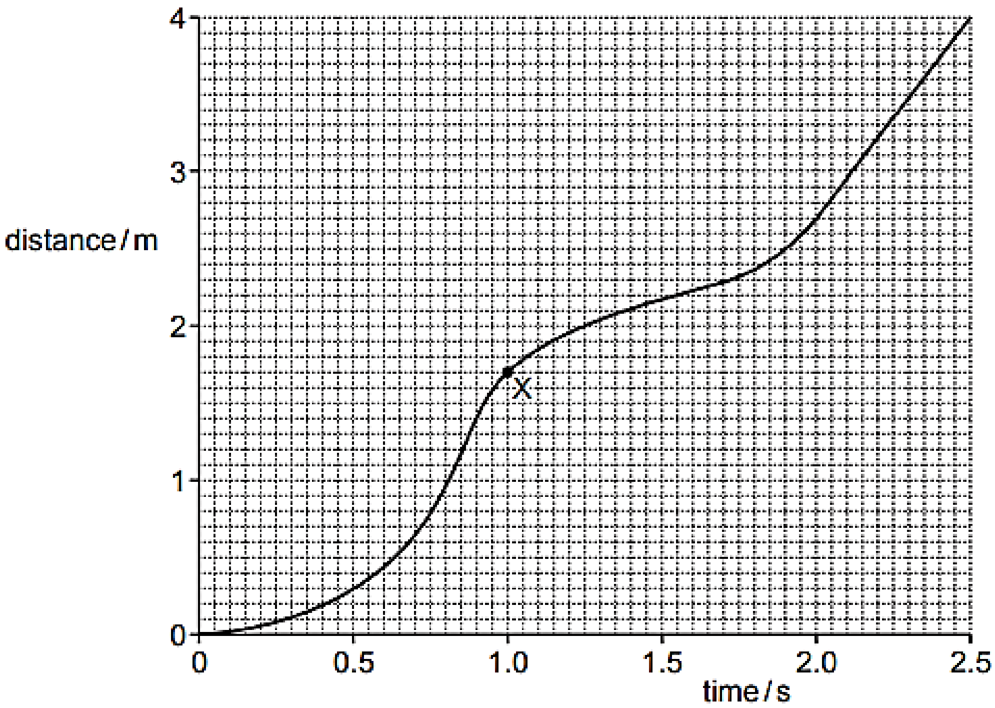

Fig. 1.2

(a) **(i)** On **Fig. 1.2**, mark:
- with the letter P one point where the ball accelerates
- with the letter Q one point where the ball has constant speed.

[2]

(ii) Determine the speed of the ball at point X on **Fig. 1.2**. Show your working.

speed = ...[2]

(b) The speeds of the ball at A, B, C and D are V_A, V_B, V_C and V_D respectively. Arrange these four speeds from slowest to fastest.

slowest ⟶ fastest

[1]

2 **Fig. 2.1** shows a uniform plank AB of length 2.0 m suspended from two ropes X and Y.

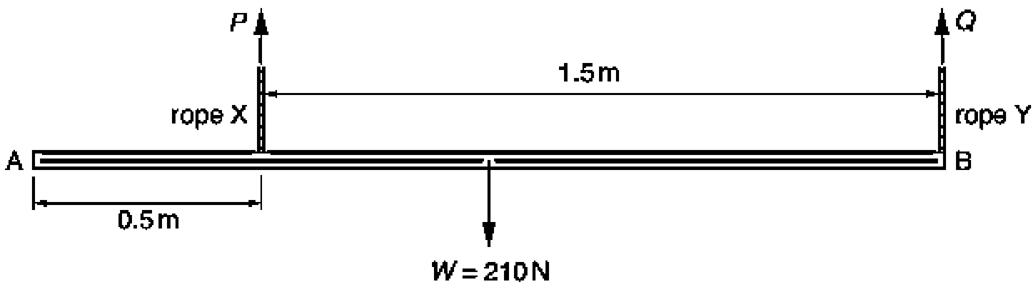

Fig. 2.1

The weight W of the plank is 210 N. The force in rope X is P. The force in rope Y is Q.

(a) State, in terms of P, the moment of force P about B.

....[1]

(b) Calculate:

(i) the moment of W about B

moment = ...[1]

(ii) the force P

force P = ...[2]

(iii) the force Q.

force Q = ...[2]

3 **(a)** State what is meant by the principle of conservation of energy.

....

....[1]

(b) **Fig. 3.1** shows a girl throwing a heavy ball.

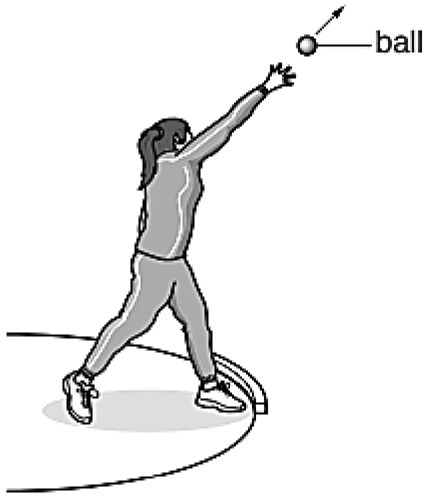

Fig. 3.1

(i) State the energy changes that take place from when the girl begins to exert a force on the ball until the ball hits the ground and stops moving.

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....

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....

....[2]

(ii) The mass of the ball is 4.0 kg. The girl exerts a force on the ball for 0.60 s. The speed of the ball increases from 0 m/s to 12 m/s before it leaves the girl's hand.
Calculate the average resultant force exerted on the ball.

average resultant force = ...[2]

4 A small aircraft takes off from the horizontal deck of a ship. Before taking off, the aircraft is held in place by a holdback bar. When the holdback bar is released, the aircraft is pulled along the deck by a steam-powered piston as shown in **Fig. 4.1**.

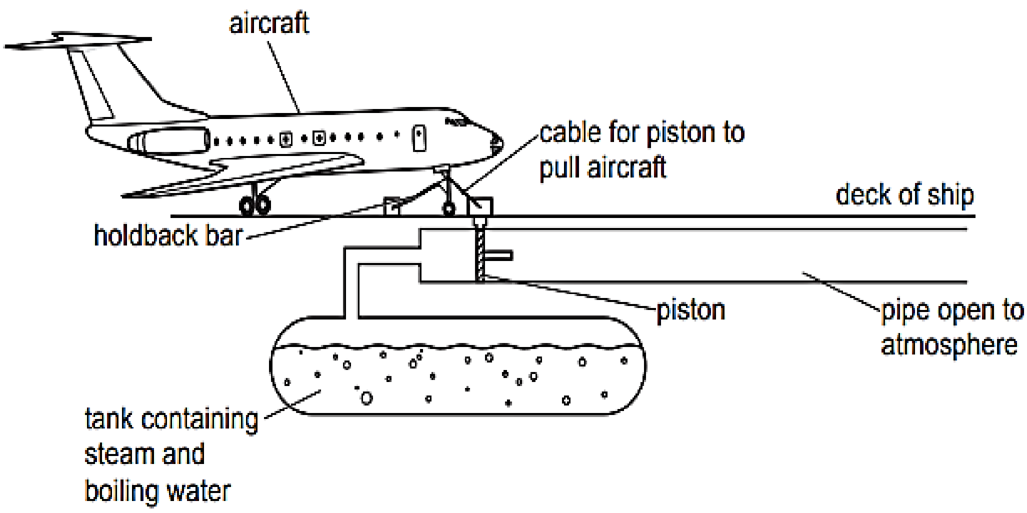

Fig 4.1 (not to scale)

The steam exerts a high pressure on the piston.

(a) **(i)** Explain, using ideas about particles, how the steam creates a pressure on the piston.

....

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....

....

....

....[2]

(ii) Explain why the pressure on the piston increases as the temperature of the steam increases.

....

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....

....[2]

(b) When the pressure is high enough, the holdback bar is released. The steam pushes the piston along the pipe shown in **Fig. 4.1**. The piston has a cross-sectional area of 0.30 cm^2. The pressure of the steam in the tank is 2.1×10^6 Pa. Atmospheric pressure is 1.0×10^5 Pa.

Determine the resultant force on the piston caused by the pressure difference.

Show your working.

force = ... [2]

5 The virtual reality headset in **Fig. 5.1** contains a display and a lens, as shown in **Fig. 5.2**.

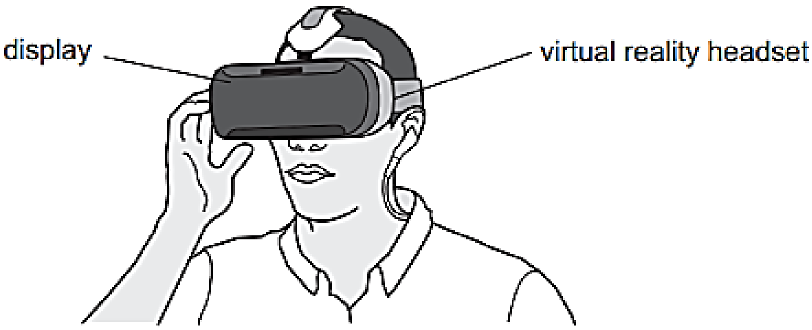

Fig. 5.1

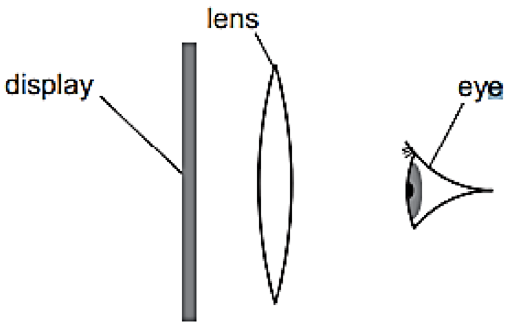

Fig. 5.2 (not to scale)

The display is the object for the lens. The lens acts as a magnifying glass and forms a virtual image of the display.

(a) **(i)** Describe where the display must be positioned relative to the focal length of the lens for the lens to act as a magnifying glass for the image on the display.

....

.... [1]

(ii) Explain how a virtual image is formed.

....

.... [1]

(b) An arrow on the display is 3.40 cm from the lens. The virtual image of the arrow is 22.0 cm from the lens. **Fig. 5.3** shows the arrow O, the lens L and the virtual image of the arrow I, drawn on a grid with a scale of 1:2.

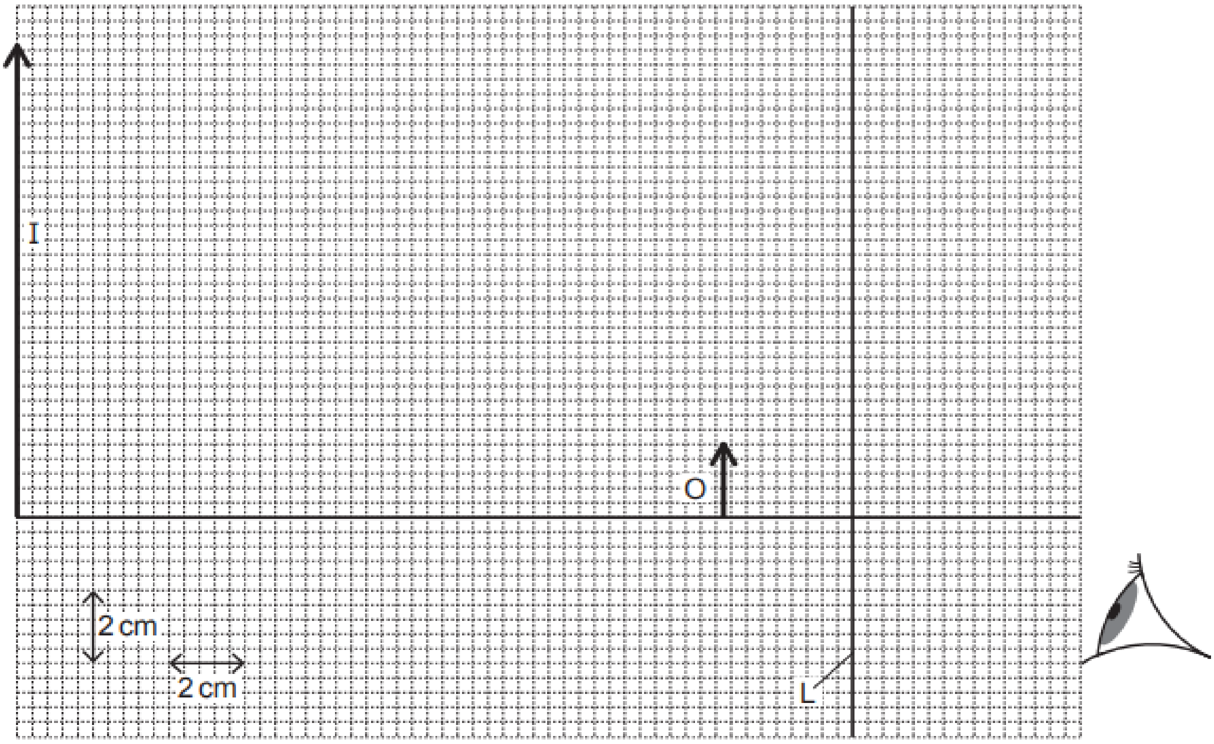

Fig. 5.3 (scale: 1 cm represents 2 cm)

(i) On **Fig. 5.3**, draw a ray diagram to show the formation of the virtual image I.

[2]

(ii) Determine the focal length of the lens.

focal length = ...[1]

6 **Fig. 6.1** shows a permanent magnet attached to one end of an unstretched spring and held at rest just above a solenoid.

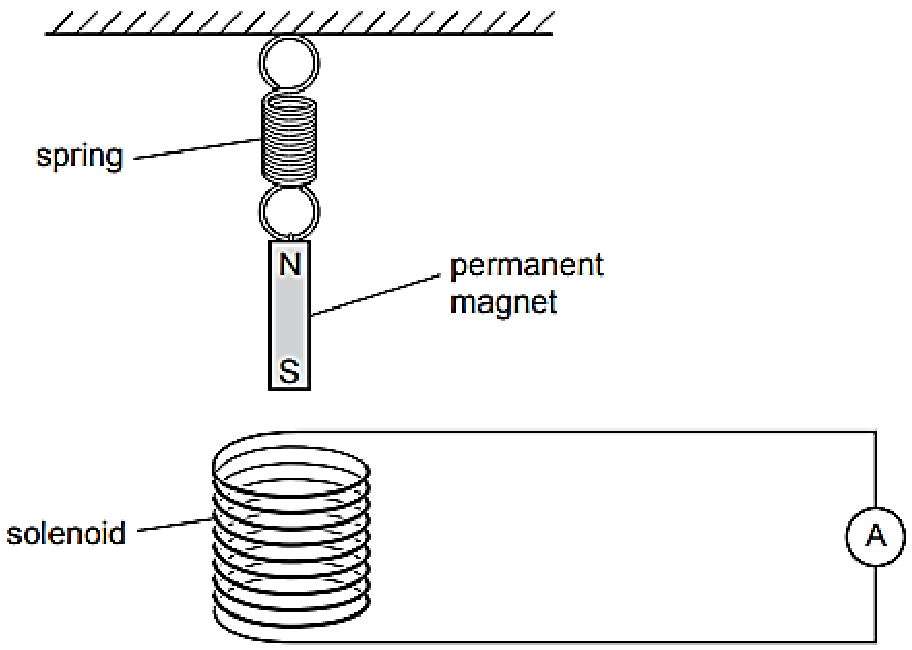

Fig. 6.1

The solenoid is connected to a sensitive ammeter.

(a) State the name of a substance from which permanent magnets are made.

.... [1]

(b) The magnet is released and moves downwards towards the solenoid. The ammeter shows that there is a current in the solenoid when the magnet moves.

(i) Explain why there is a current in the solenoid.

....

....

....

....

....

....

....[3]

(ii) The current causes the top end of the solenoid to become the S pole of an electromagnet. The bottom end of the permanent magnet is an S pole. Explain why the top end of the solenoid becomes an S pole as the magnet moves downwards towards the solenoid.

....

....

....

....

....

....[2]

(c) The magnet oscillates up and down. Describe what happens to the current in the solenoid.

....

....

....

....

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....[2]

7 **Fig. 7.1** shows part of a circuit containing a 240 V mains supply connected to a lamp and two heaters of resistance 40 Ω and 60 Ω.

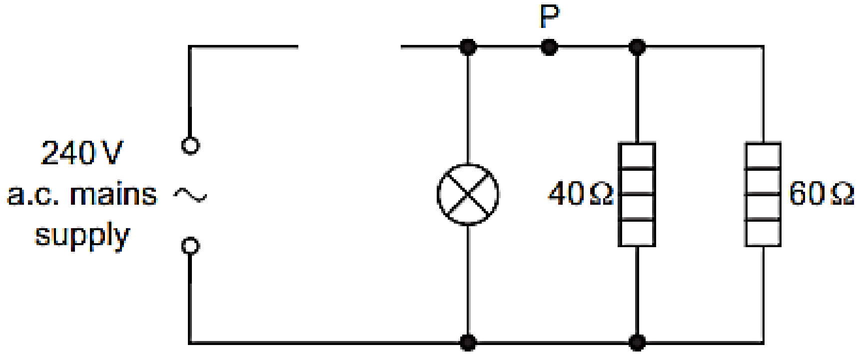

Fig. 7.1

(a) Complete **Fig. 7.1** by drawing the symbol for a fuse in the gap in the circuit. [1]

(b) **(i)** On **Fig. 7.2** sketch a current−voltage graph for a filament lamp.

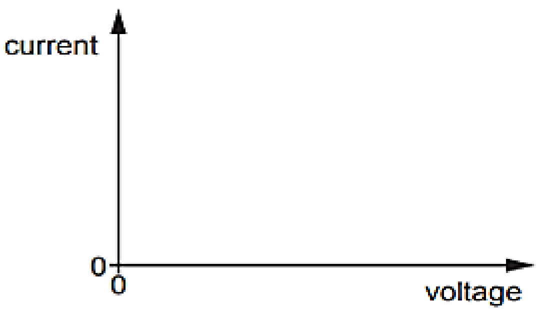

Fig. 7.2

[1]

(ii) Explain the shape of the current−voltage graph drawn in (i).

....

....

....

....

....[2]

[Turn over

(c) Calculate the current at point P in the circuit shown in **Fig. 7.1**.

current = ... [2]

8 A teacher places a radiation detector on a bench in a school laboratory and switches it on.

(i) The teacher measures and records the background radiation count rate.

Describe what is meant by 'background radiation' and state two significant sources of the count rate recorded by the teacher.

Background radiation ....

....[1]

Source 1 ....[1]

source 2 ....[1]

(ii) The teacher moves a sample of protactinium-234 so that it is next to the detector. Suggest one precaution that ensures that the sample is moved in a safe way.

....

....

....[1]

(iii) The count rate is measured every 20 s with the sample present and then corrected for background radiation.

Fig. 8.1 shows a graph of the corrected count rate against time for the protactinium-234 sample.

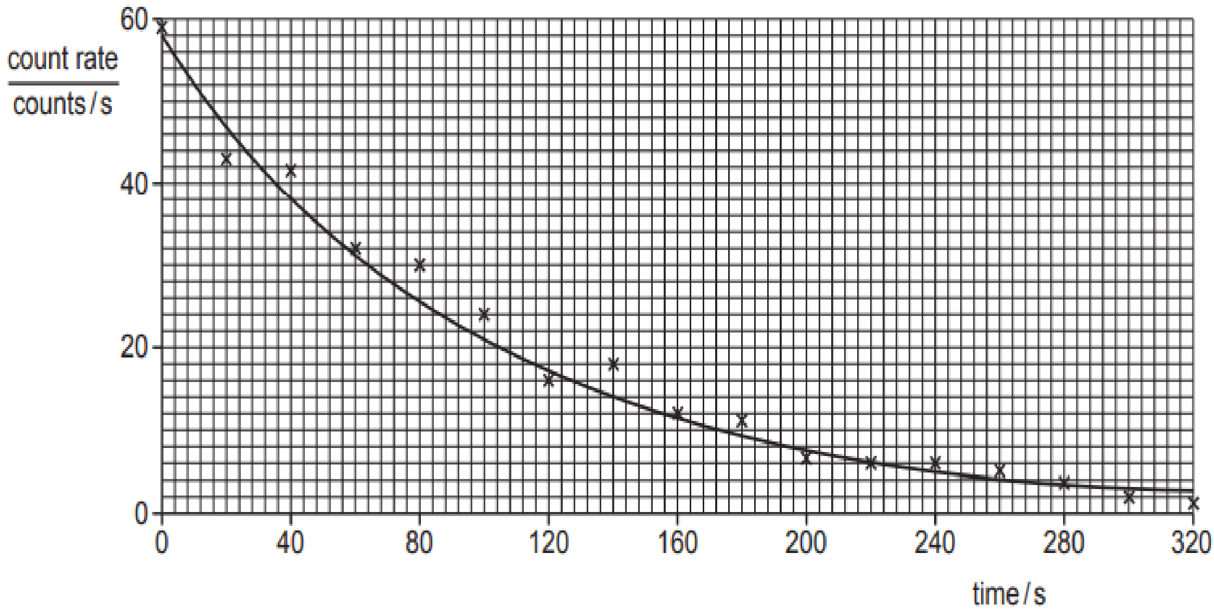

Fig. 8.1

The curve is the best-fit line. Explain why many of the crosses do not lie on the curve.

....

....

....[2]

(iv) Using **Fig. 8.1**, determine the half-life of protactinium-234.

Show your working.

half-life = ... [2]

(v) The uranium-234 formed from the protactinium-234 is also radioactive. Its half-life is many thousands of years. Explain why the radiation from uranium-234 does not affect the count rates measured in this experiment.

....

....

....[2]

9 Many electrical devices, such as televisions and computers, have a stand-by mode.

Fig. 9.1 shows the 230 V mains supply connected to a television.

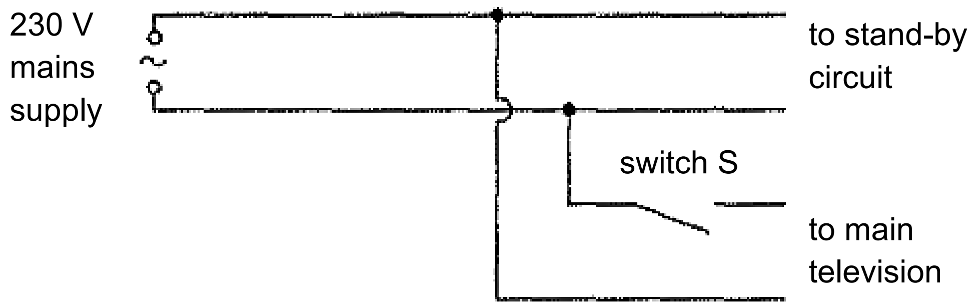

Fig. 9.1

When switch S is open, the television is in stand-by mode. No energy is supplied to the main television circuit. Some energy is supplied to the stand-by circuit.

When the television is in full use, switch S is closed, and energy is supplied to both circuits.

In the house of a student, the television is never unplugged.

In one week, the television is in full use for 30 hours and in stand-by mode for 138 hours.

Fig. 9.2 shows the current in the two circuits when in full use and in stand-by mode.

	in full use (switch S closed)	**in stand-by mode (switch S open)**
current in main television circuit / mA	450	0
current in stand-by circuit / mA	34	34

Fig. 9.2

(a) Calculate the total power supplied to the two circuits by the 230 V mains supply when the television is in full use.

power = ... [3]

(b) **(i)** Calculate the amount of energy supplied in one week by the mains supply to the television when in stand-by mode. Give your answer in joules.

energy = ...[2]

(ii) The cost of 1 kWh of electrical energy is 25 cents.

Calculate the cost of the energy in **(i).**

cost = ... [2]

(c) In the same house, there is a computer which is also never unplugged. This computer has a stand-by circuit and a switch similar to those in the television.

In one week, the computer is in full use for 50 hours and in stand-by mode for 118 hours.

Fig. 9.3 gives data for the computer similar to the data in **Fig. 9.2**.

	in full use	**in stand-by mode**
current in computer circuit / mA	270	0
current in stand-by circuit / mA	34	34

Fig. 9.3

(i) To save energy, the student decides to unplug **either** the television **or** the computer when not in use.

Explain, in words, why unplugging the television saves more energy.

.... [1]

(ii) Suggest one disadvantage in completely unplugging a computer when not in use.

....

.... [1]

10 A pan containing ice at –15°C is placed on a gas heater as shown in **Fig. 10.1**.

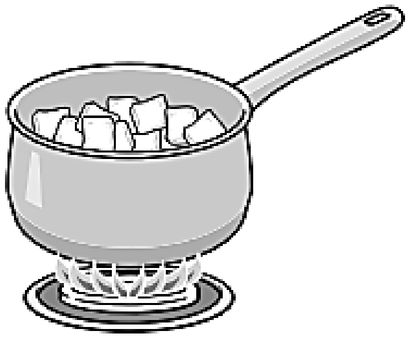

Fig. 10.1

(a) Thermal conduction occurs in the metal from which the pan is made. By referring to particles, describe the process of thermal conduction in a metal.

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....

....[2]

(b) **Fig. 10.2** shows how the temperature of the contents of the pan varies with time.

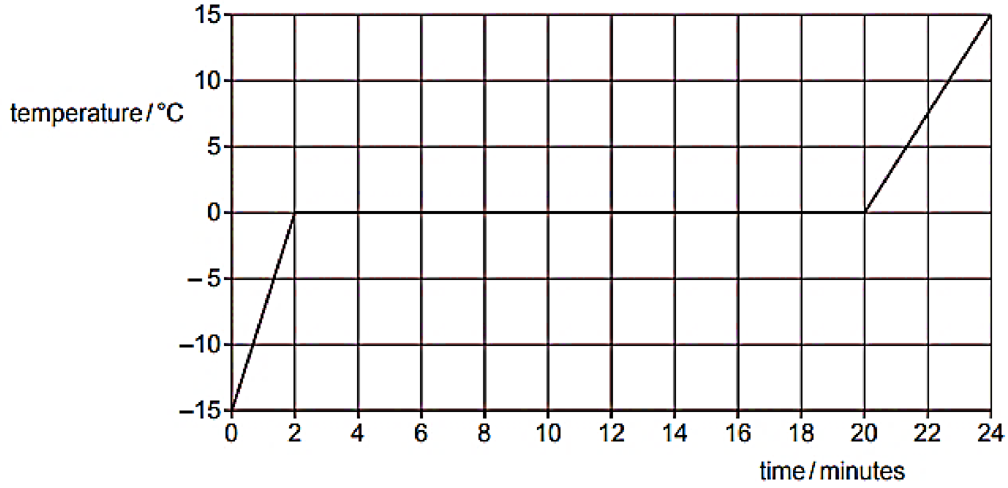

Fig. 10.2

(i) State the melting temperature of ice.

melting temperature = ... [1]

(ii) Explain why the temperature of the water is constant as the ice melts.

....

....

....

....

....

....[2]

(iii) The initial mass of ice in the pan is 1.5 kg and the initial temperature is –15°C. The specific heat capacity of ice is 2100 J/(kg°C).

Calculate the energy required to warm the ice to its melting temperature.

energy = ... [2]

(iv) All the energy transferred to the pan comes from the heater. Using your answer to (iii) and **Fig. 10.2**, determine the power of the heater used to warm the ice.

power = ... [2]

(v) The graph in **Fig. 10.2** has a smaller gradient when the water is liquid than when it is solid. Suggest **one** reason why.

....

.... [1]

Section B

Answer **one** question from this section.

11 An uncharged plastic rod is rubbed with an uncharged woollen cloth. As a result, the rod becomes negatively charged.

(a) Explain, in terms of particles, how the rod becomes charged and state what happens to the cloth.

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....

....

....

....

....[2]

(b) **Fig. 11.1** shows a metal sphere X on a plastic stand.

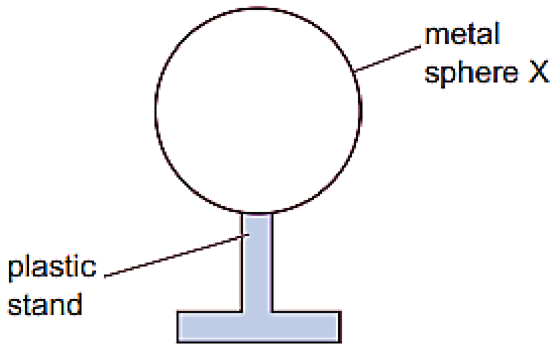

Fig. 11.1

Explain why metals are electrical conductors and why plastics are electrical insulators.

....

....

....

....[2]

(c) The negatively charged plastic rod is held above sphere X. **Fig. 11.2** shows that it does not touch the sphere.

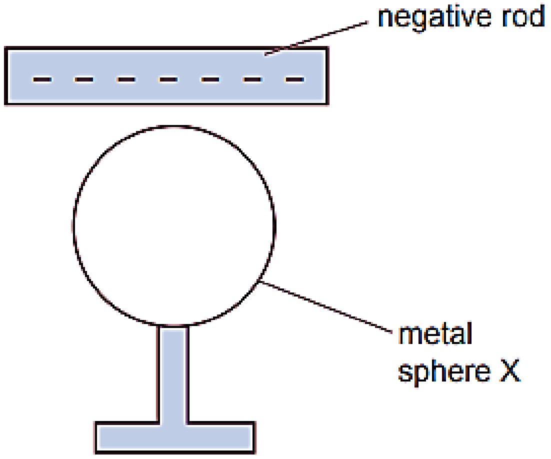

Fig. 11.2

(i) By drawing on **Fig. 11.2**, show the distribution of charge on X. [2]

(ii) An earth wire is now connected to the metal sphere as shown in **Fig. 11.3**.

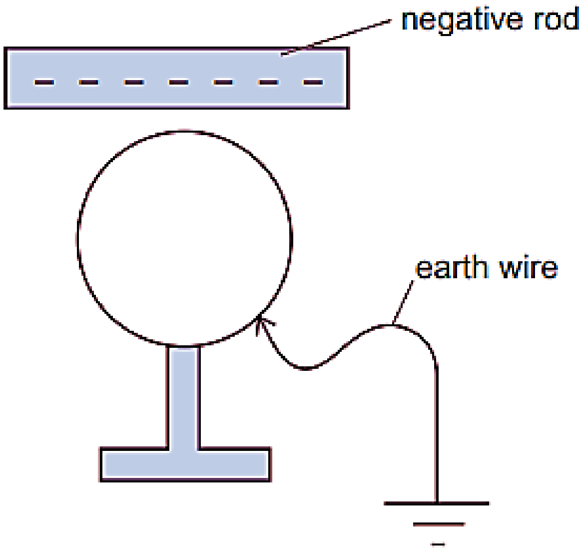

Fig. 11.3

State what happens to the charges on the sphere as the earth wire is connected.

....

....[1]

(iii) The earth wire in (ii) stays connected to the metal sphere. Describe the distribution of charge on the sphere.

....

....

....

....[1]

(iv) The earth wire is disconnected from the sphere and then the negatively charged rod is moved away from the sphere. Explain what happens to the charges on the sphere as the charged rod is moved away.

....

....

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....

....

....[2]

12 A loudspeaker is made from a coil of wire fixed to a cardboard tube. The tube is attached to a cardboard cone. **Fig. 12.1** shows part of the arrangement of the loudspeaker.

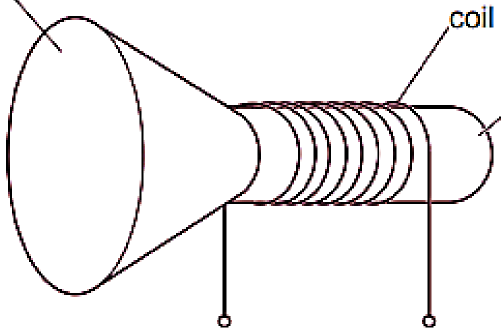

Fig. 12.1

When there is a current in the coil, the coil experiences a force.

(a) State what else is needed in a loudspeaker to make a current-carrying wire experience a force.

.... [1]

(b) A student connects the coil to the output of an alternating current (a.c.) generator. **Fig. 12.2** shows how the electromotive force (e.m.f.) produced by the generator varies with time.

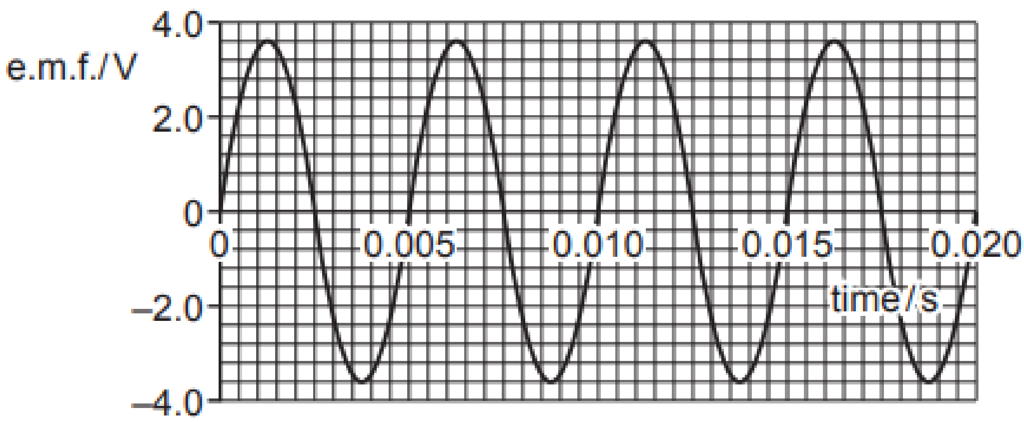

Fig. 12.2

The coil, tube and cone vibrate backwards and forwards.

(i) Explain why the e.m.f. shown in **Fig. 12.2** makes the coil vibrate.

....

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....

....

....

....[2]

(ii) The vibrating cone produces sound in the surrounding air. Explain, in terms of molecules, how the cone produces a sound wave that travels through the air.

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....[3]

(iii) Using **Fig. 12.2**, determine the number of times that the cone reverses its direction of motion in 1.0 s.

number = ... [1]

(v) The speed of sound in air is 340 m/s. Calculate the wavelength of the sound.

wavelength = ... [1]

(c) The student adjusts the generator so that the maximum voltage of the output is now 3.0 V. Everything else stays the same as the output shown on the graph in **Fig. 12.2**.

(i) Explain any effect on the loudness of the sound.

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....

....[1]

(ii) Explain any effect on the pitch of the sound.

....

....

....

....[1]