

Section A

Answer **all** the questions in this section.

- 1 Fig. 1.1 shows the velocity-time graph of an object released from a height as it falls to the ground.

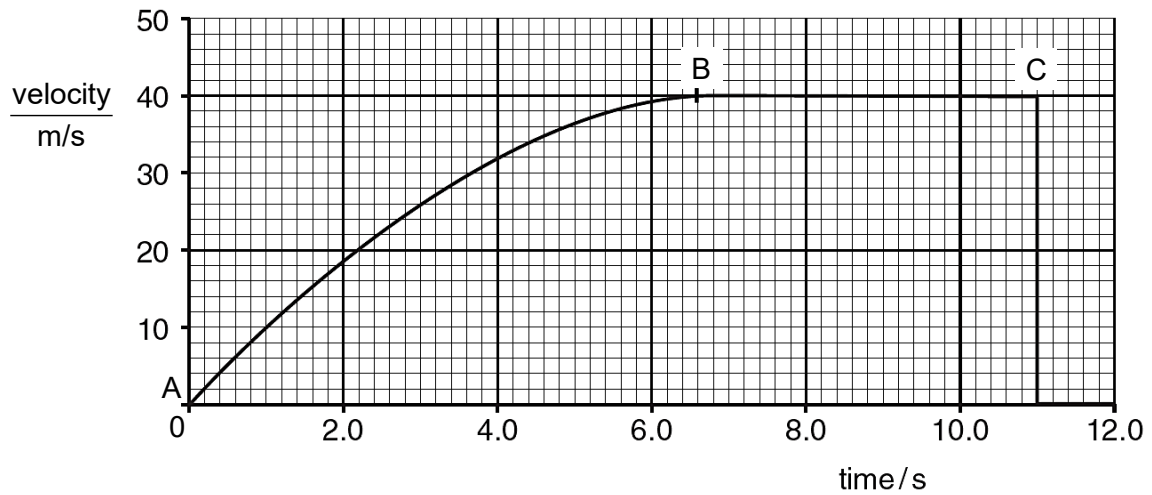


Fig. 1.1

- (a) Describe the motion of the object from

A to B:

B to C:[2]

- (b) Explain how Fig. 1.1 shows that the distance travelled by the object from A to B is greater than 130 m.

.....

 [2]

[Total: 4]

2 Fig. 2.1 shows a rocket about to be launched.

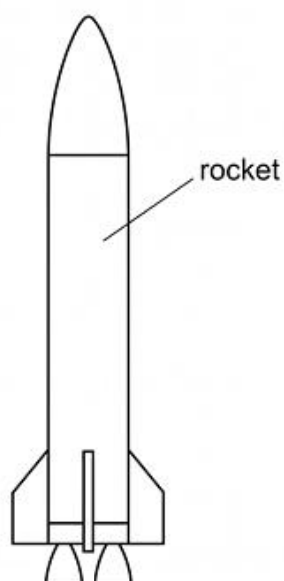


Fig. 2.1

The total mass of the rocket when it is fully loaded is $2.8 \times 10^6 \text{ kg}$.

The motor of the rocket provides a constant force.

The vertical acceleration of the rocket immediately after lift-off is 1.4 m/s^2 .

The gravitational field strength of Earth is 10 N/kg .

(a) On Fig. 2.1, draw arrows to represent all the forces acting on the rocket **just** as it lifts off.

Label the forces.

[2]

(b) Calculate the weight of the rocket when it is fully loaded.

weight = [1]

- (c) Calculate the constant force provided by the motor of the rocket just as it lifts off.

constant force = [2]

- (d) During lift-off, the downward force exerted by the rocket on the exhaust gases is one-half of an action-reaction pair of forces.

Describe the other half of this action-reaction pair.

.....
..... [1]

- (e) As the rocket rises, the motor continues to provide the constant force by burning its fuel.

Suggest and explain why the acceleration of the rocket increases as it rises further above the Earth's surface.

.....
.....
.....
..... [2]

[Total: 8]

- 3 In a factory, an electric motor is used to lift some boxes shown in Fig. 3.1.

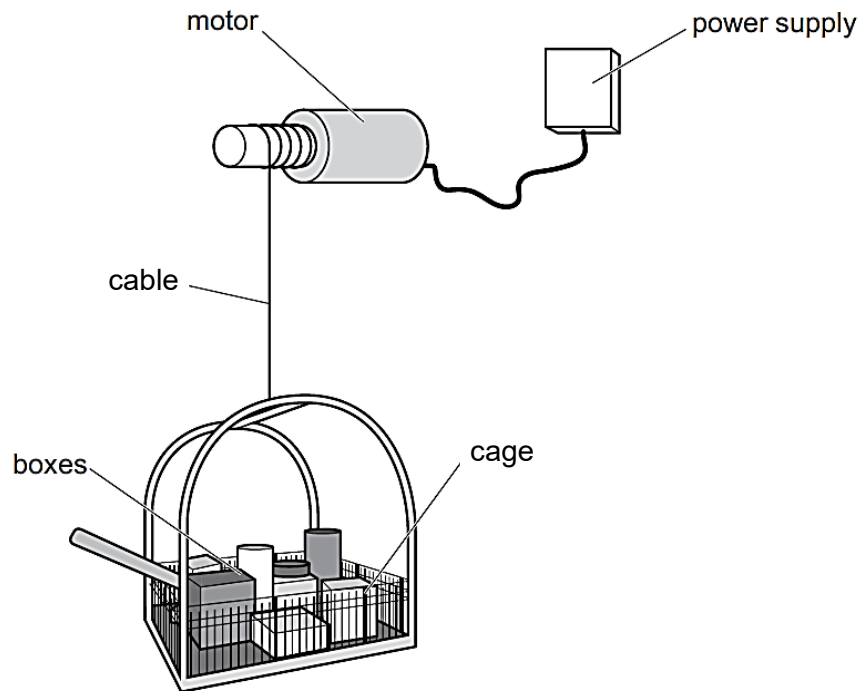


Fig. 3.1

The boxes are placed in a cage and the motor winds a cable around a cylinder to lift the cage and boxes. The total mass of the boxes and cage is 47 kg and they are lifted vertically through 13 m to a storage area.

Take the gravitational field strength to be 10 N/kg.

- (a) Calculate the useful work done in lifting the boxes and cage to the storage area.

useful work done = [2]

- (b) The electromotive force (e.m.f.) of the power supply for the motor is 230 V. The current in the motor is 5.6 A. It takes 11 s for the motor to lift the cage and boxes to the storage area.

- (i) Calculate the total energy transferred electrically to the motor in 11 s.

total energy = [2]

- (ii) The energy transferred to the motor during the lifting process is not fully converted to useful work.

State **one** reason why this is so.

.....

..... [1]

- (c) When the boxes are lifted to their storage area, the cable accidentally snapped and the boxes and cage fall to the ground. About 15% of their initial energy is lost before they hit the ground.

Calculate the speed of the falling boxes and cage just before they hit the ground.

speed = [3]

[Total: 8]

- 4 A uniform rod AB of length 3.0 m has a weight of 10 N. It is suspended by two identical strings at points X and Y as shown in Fig. 4.1. T_1 and T_2 are the tensions in the strings.

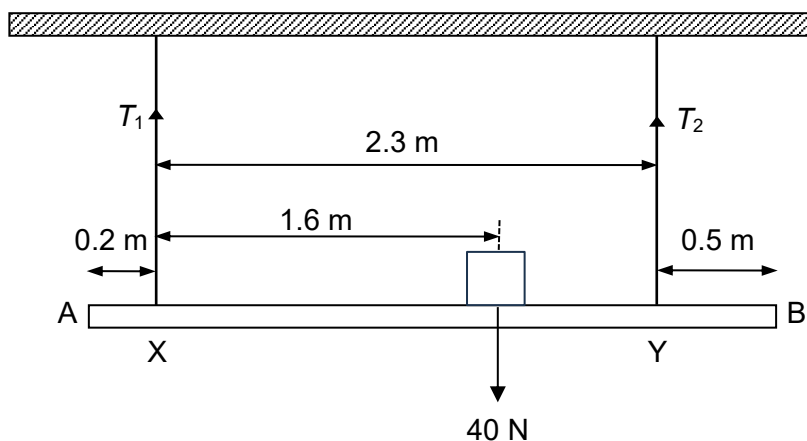


Fig. 4.1

A load of 40 N is placed on the rod at a distance of 1.6 m from X. The beam is in equilibrium.

- (a) State the principle of moments for an object in equilibrium.

.....

 [1]

- (b) On Fig. 4.1, draw an arrow to represent the weight of the rod and label it W . Indicate clearly its distance from point A. [1]

- (c) By taking moments about an appropriate point, calculate T_2 .

$$T_2 = \dots\dots\dots [2]$$

- (d) The load of 40 N is shifted to the left of the rod, nearer to A.

State and explain any change in T_2 .

.....

 [2]
 [Total: 6]

- 5 Fig. 5.1 shows a long vertical glass tube with one end immersed in mercury and the other connected to a vacuum pump at A. The tube fits tightly into a bell jar. With an opening at B and all air in the glass tube pumped out via A, the mercury rises to a maximum height of 76 cm above the dish.

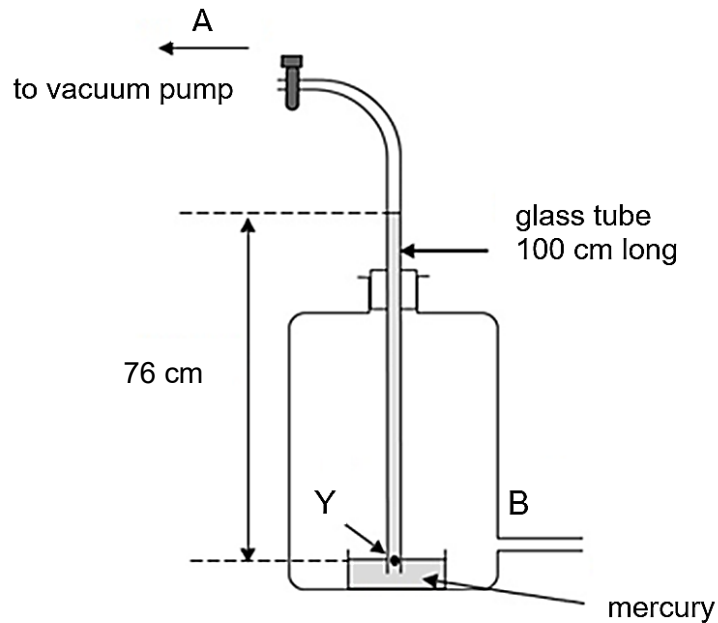


Fig. 5.1

- (a) Explain why the mercury can only reach a maximum height of 76 cm.

.....

 [1]

- (b) The density of mercury is 13600 kg/m^3 .

Calculate the pressure at Y.

pressure = [2]

- (c) A container of air initially at atmospheric pressure is connected to B and heated over a flame as shown in Fig. 5.2.

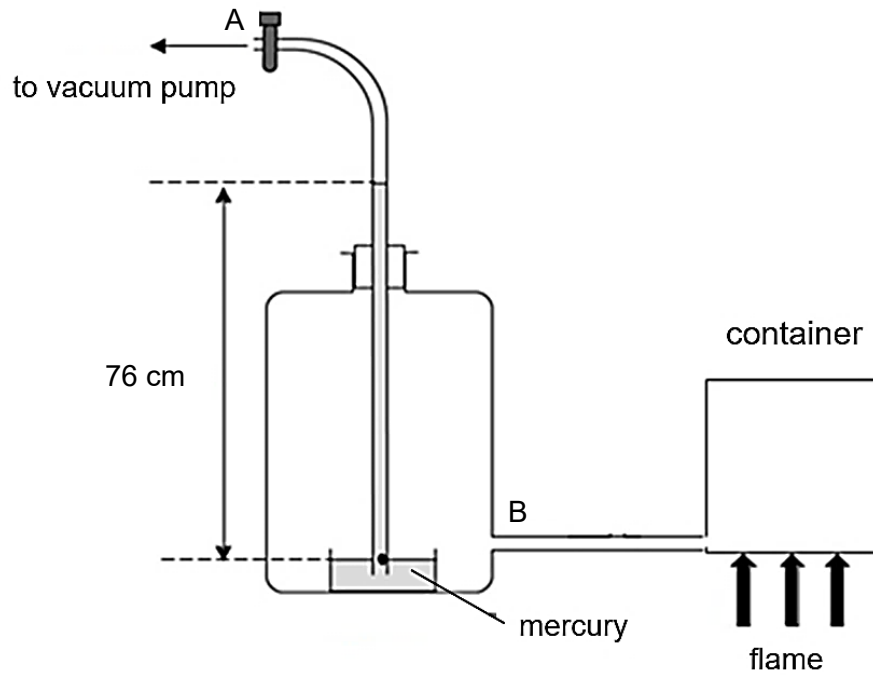


Fig. 5.2

- (i) State what happens to the height of the mercury column.

.....
 [1]

- (ii) Using the kinetic model of matter, explain your answer in (c)(i).

.....

 [2]

[Total: 6]

- 6 A cat's eye is a safety device installed on roads to help drivers see lane markings at night. It consists of a tough rubber housing embedded in the road surface, containing a glass prism, as shown in Fig. 6.1.



Fig. 6.1

Fig. 6.2 shows a light ray from the car's headlamps entering the prism. It strikes the surface at X at an angle of 60° . The refractive index of the glass prism is 2.2.

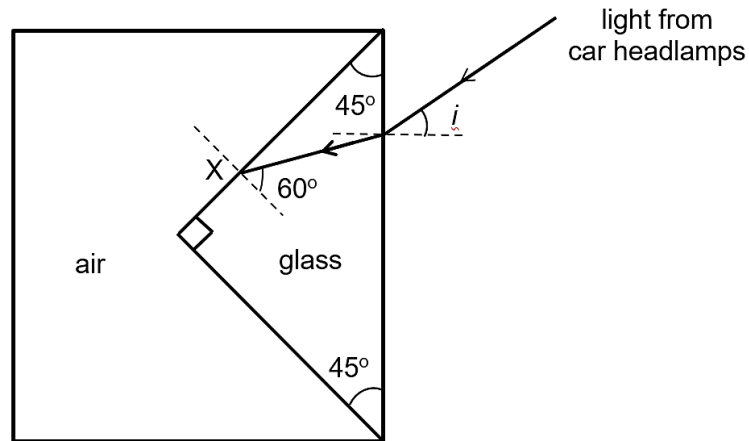


Fig. 6.2

- (a) Calculate the angle of incidence i for the light ray entering the glass prism.

angle of incidence = [2]

- (b) By performing further calculations, state and explain what happens to the light ray after it strikes the glass-air boundary at X.

.....
 [2]

- (c) Taking the speed of light in air to be 3.0×10^8 m/s, calculate the speed of light in the glass prism.

speed = [1]

[Total: 5]

- 7 Fig. 7.1 shows a beaker containing 100 g of water at a temperature of 40°C . An ice cube is dropped into the water. The ice cube is initially solid at 0°C and has a mass of 5.0 g.

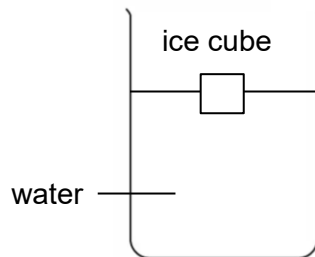


Fig. 7.1

- (a) Describe the process by which all the water in the beaker is cooled.

.....

 [2]

- (b) When the ice cube has melted, the water is stirred and has a temperature of 34°C . The specific heat capacity of water is $4.2 \text{ J/(g}^\circ\text{C)}$.

You can ignore the heat loss to the beaker and surroundings.

- (i) Calculate the energy lost by the water as it cools from 40°C to 34°C .

energy lost = [1]

- (ii) The ice cube melts into water and gains energy as it warms from 0°C to 34°C .

Calculate the thermal energy needed for this rise in temperature.

energy = [1]

- (iii) Use your answers to (i) and (ii) to determine the specific latent heat of fusion of water.

specific latent heat of fusion = [2]

[Total: 6]

- 8 Fig. 8.1 shows a thermistor connected to a battery of e.m.f. 6.0 V in a circuit. A voltmeter is connected across the 1.6 k Ω resistor.

Fig. 8.2 shows the graph of the voltmeter reading with temperature of the thermistor.

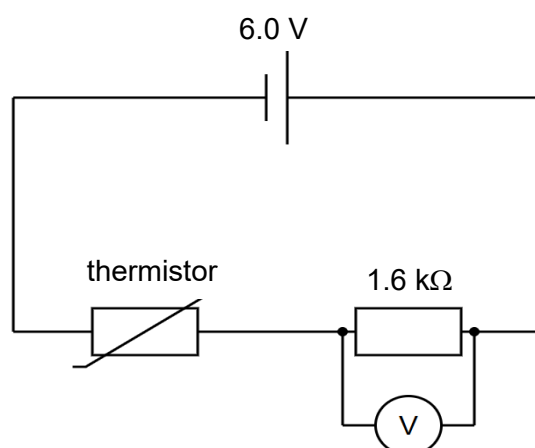


Fig. 8.1

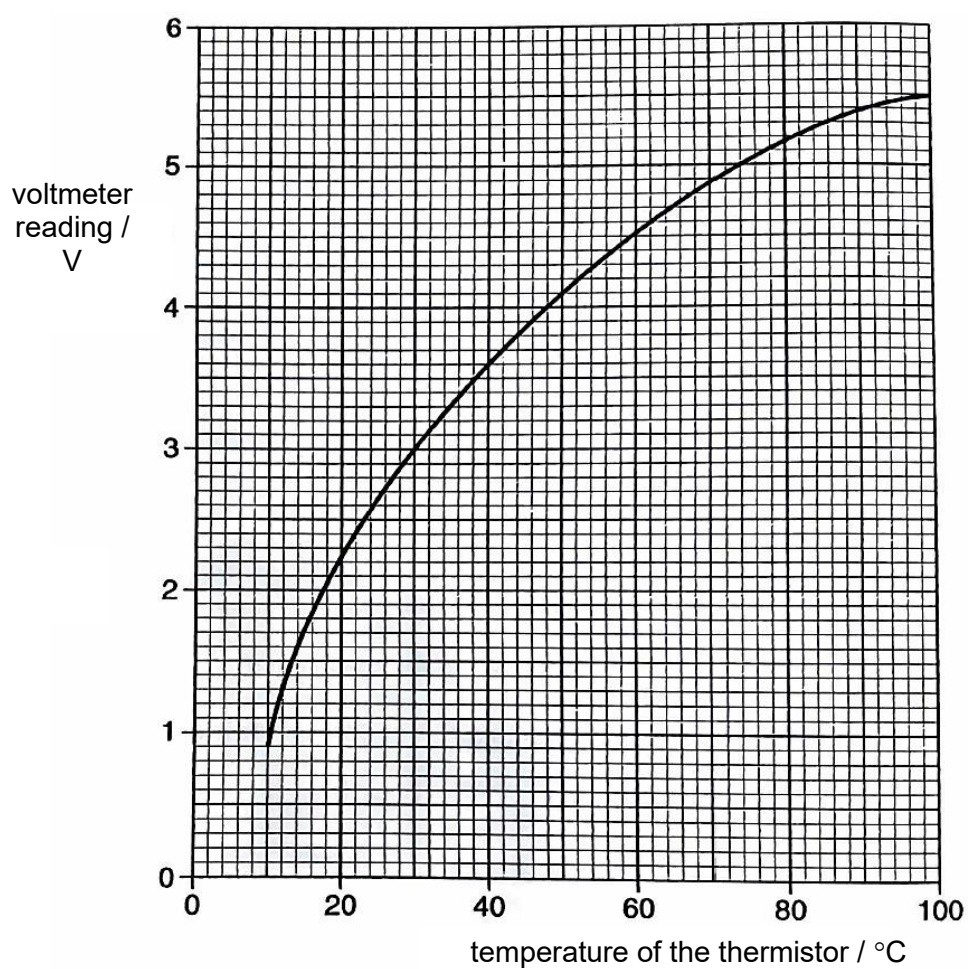


Fig. 8.2

(a) Explain why the voltmeter reading increases as the temperature rises.

.....

.....

.....

.....

..... [2]

(b) Using Fig. 8.2,

(i) calculate the current flowing in the $1.6 \text{ k}\Omega$ resistor when the temperature is 20°C .

current = [2]

(ii) determine the resistance of the thermistor when its temperature is 50°C .

resistance = [3]

[Total: 7]

- 9 A sound wave from a vibrating tuning fork is detected using a microphone and displayed on a screen, as shown in Fig. 9.1.

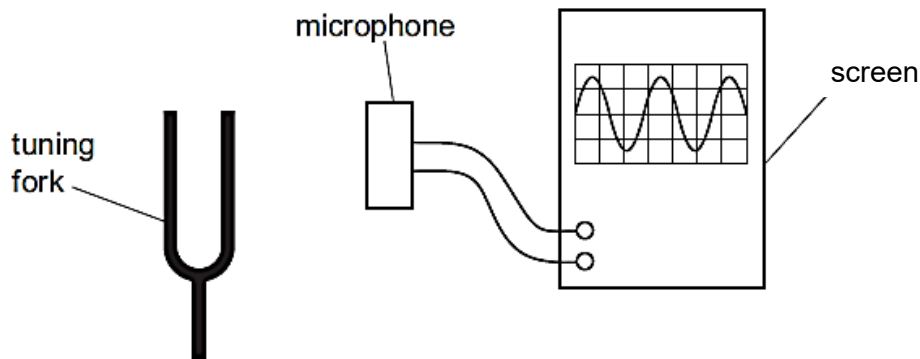


Fig. 9.1

- (a) Describe the motion of the air particles as the sound wave passes from the tuning fork to the microphone.

.....

 [2]

- (b) Fig. 9.2 shows the image shown on the screen when the tuning fork vibrates.

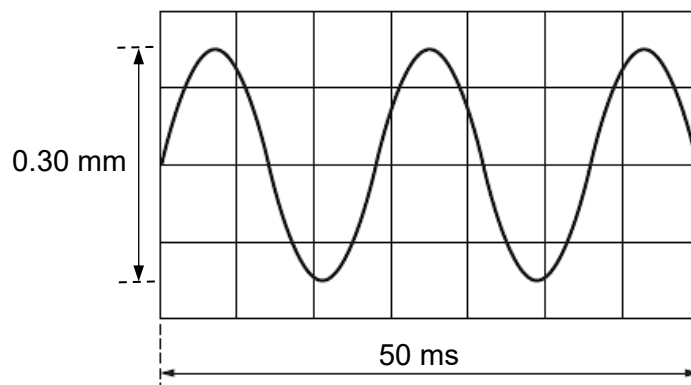


Fig. 9.2

- (i) Using Fig. 9.2, calculate the frequency of the sound wave.

frequency = [2]

- (ii) The sound wave travels through the air at a speed of 340 m/s.

Calculate the wavelength of this sound wave.

wavelength = [2]

- (c) The tuning fork is replaced by a new tuning fork that produces a sound wave with twice the amplitude and half the frequency of the original wave.

On Fig. 9.3, draw the trace obtained with the new tuning fork. The trace obtained with the original tuning fork is shown.

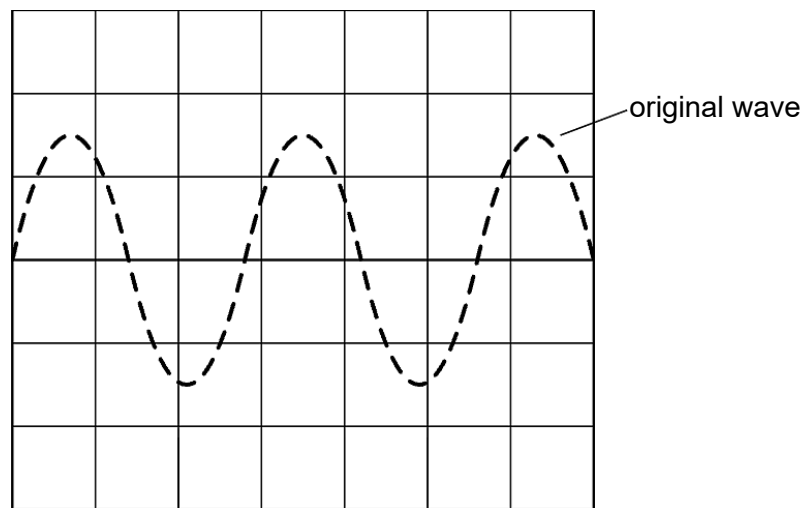


Fig. 9.3

[2]

- (d) Electromagnetic waves are another type of waves.

State **two** differences between electromagnetic waves and sound waves.

.....

 [2]

[Total: 10]

10 Table 10.1 gives information on different nuclides.

Table 10.1

isotope	radiation emitted	half-life
astatine-211	alpha particle	7.2 hours
hydrogen-2	none	none
hydrogen-3	beta particle	12 years
francium-223	beta particle	22 minutes
iridium-192	gamma ray	74 days
phosphorus-32	beta particle	14 days
radon-222	alpha particle	4 days
technetium-99m	gamma ray	6 hours

(a) Hydrogen-2 and hydrogen-3 are isotopes of the element hydrogen.

Explain, in terms of their nuclei, why they are isotopes of hydrogen.

.....
 [1]

(b) Phosphorus-32 undergoes beta-decay to form sulfur (S).

Using appropriate nuclide notation, complete the nuclear equation below for the decay of phosphorus-32 to form sulfur.



(c) One of the sources listed in Table 10.1 is used in medical procedures to identify abnormal bone structures. It is administered to a patient through injection, and the emitted radiation is detected externally.

(i) State which source in Table 10.1 is most suitable for this medical use.

..... [1]

(ii) Give **two** reasons for your choice.

.....

 [2]

(d) Radon-222 decays by emitting an alpha-particle.

(i) State how the nucleus of radon-222 changes when it emits an alpha-particle.

.....
.....
..... [2]

(ii) A sealed sample initially contains 7000 atoms of radon-222.

Using the information in Table 10.1, calculate the number of radon-222 atoms that have decayed after 12 days.

number of radon-222 atoms decayed = [2]

(iii) Explain why long-term exposure to radon gas is harmful to human health.

.....
..... [1]

[Total: 10]

Section B

Answer **one** question from this section.
Answer either **Question 11** or **Question 12**.

11 (a) Fig. 11.1 shows a wire passing through a hole in a horizontal, plastic board.

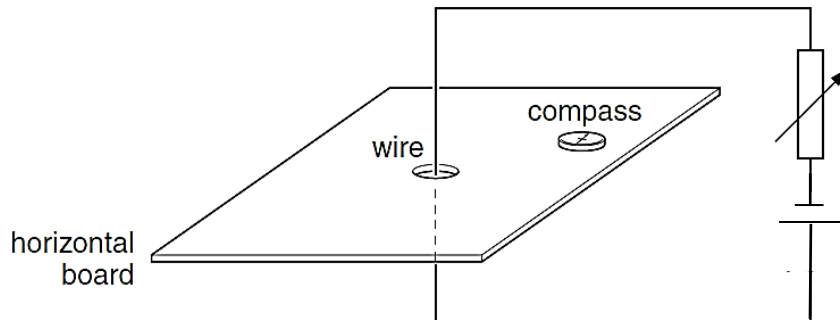


Fig. 11.1

The wire carries a current vertically upwards. A student moves a small compass around the board and plots the magnetic field lines due to the current.

(i) Fig. 11.2 shows the view from above the board. The circle represents the cross section of the wire.

On Fig. 11.2, draw the pattern of the magnetic field around the wire. Mark the direction of the magnetic field lines on your pattern.

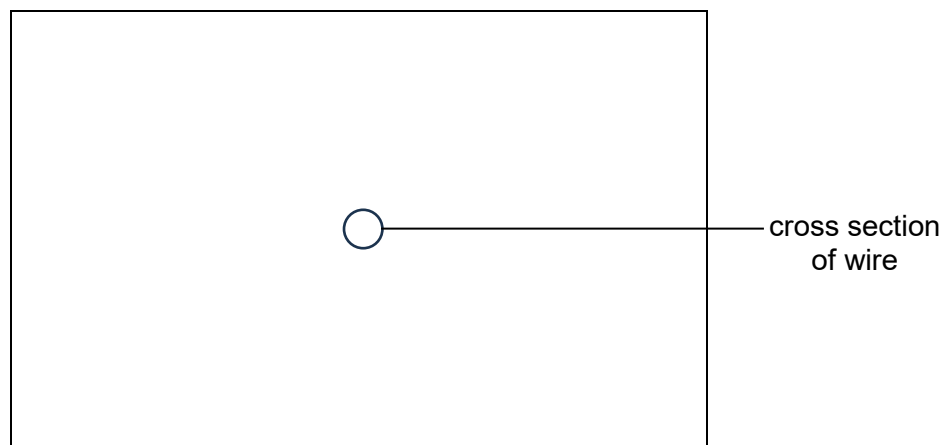


Fig. 11.2

[2]

- (ii) The north pole of a bar magnet is held on the left of the wire and the south pole of another bar magnet is held on the right, as shown in Fig. 11.3.

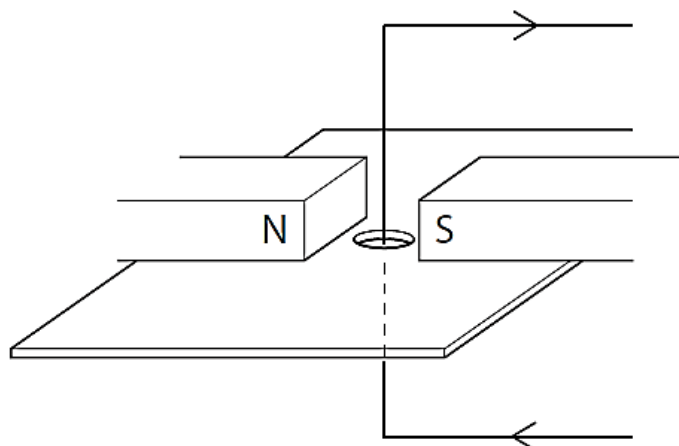


Fig. 11.3

On Fig. 11.3, draw the direction of the force acting on the wire.
Describe how you determine the direction of the force.

.....

.....

.....

..... [2]

- (iii) The 6.0 V battery is replaced with an alternating current source of frequency 50 Hz.

Describe the motion of the wire when the switch is closed.

.....

..... [1]

- (b) Fig. 11.4 shows a circuit containing a 230 V alternating current (a.c.) supply connected to a water heater and two lamps.

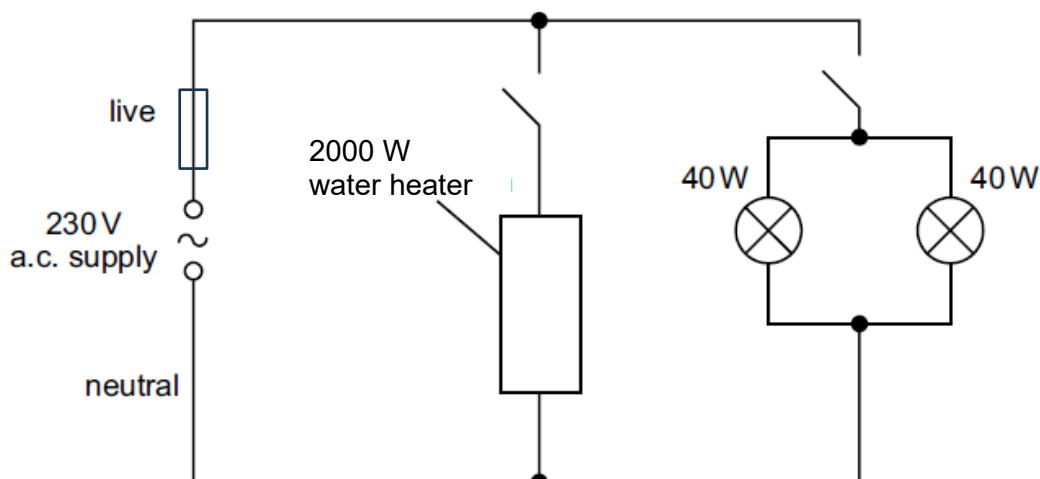


Fig. 11.4

In normal operation, both switches are closed. The power supplied to each lamp is 40 W and the power supplied to the water heater is 2000 W.

- (i) A fuse with a rating of 9 A is proposed to be installed as shown in Fig.11.4.

Explain, with clear calculation, whether the proposed fuse rating is suitable.

.....

 [3]

- (ii) The water heater is switched on for 45 minutes every day. The cost for 1.0 kWh of energy is 28 cents.

Calculate the cost of using the water heater for one week.

cost = [2]
 [Total: 10]

12 (a) Fig. 12.1 shows an a.c. generator constructed by a student to power a lamp.

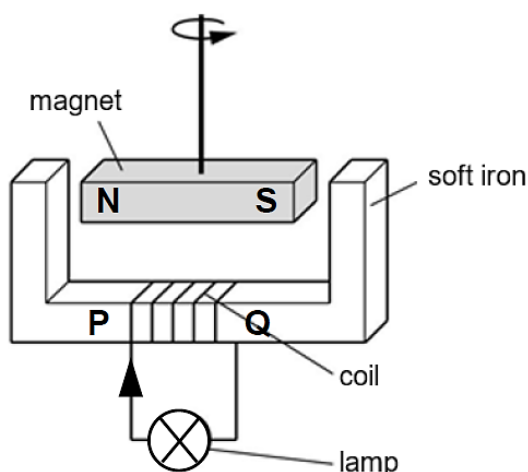


Fig. 12.1

- (i) Explain why the lamp lights up when the magnet is rotated about its axis in the direction shown in Fig. 12.1.

.....

 [2]

- (ii) As the north pole of the magnet approaches end P of the coil, the direction of induced current through the lamp is shown by the arrow in Fig. 12.1.

Explain why the current flows in the direction shown.

.....

 [2]

- (iii) Suggest one modification the student can make to the setup to increase the brightness of the lamp.

.....
 [1]

- (b) Fig. 12.2 shows how electrical energy is distributed from the power station to homes through a series of transformers and transmission cables.

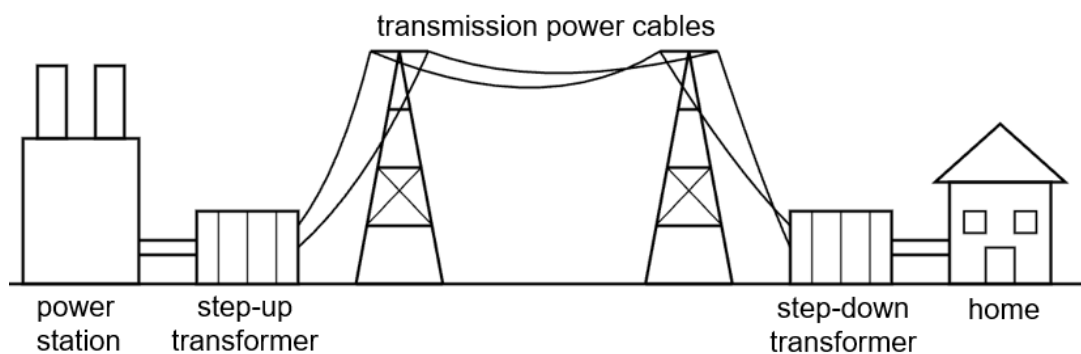


Fig. 12.2

The power station generates 0.12 MW of electrical power. This power is supplied to a step-up transformer at a voltage of 2400 V. The step-up transformer increases the voltage to 48 kV for long distance transmission.

- (i) The step-up transformer has 400 turns on its primary coil.

Calculate the number of turns on its secondary coil.

number of turns = [1]

- (ii) The efficiency of the transformer is 85%.

Calculate the current in the transmission cables.

current = [2]

- (iii) The transmission cables are made up of a pair of aluminum alloy cables that connect the power station to the step-down transformer. Each cable has a length of 20 km and a radius of 8.0×10^{-3} m. The resistivity of the cables is $3.2 \times 10^{-8} \Omega\text{m}$.

Calculate the resistance of one transmission cable.

resistance = [2]

[Total: 10]

END OF PAPER