Geylang Methodist School (Secondary)
Preliminary Examination 2024

Candidate Name			
Class		Index Number	

PHYSICS

6091/02

Paper 2

Sec 4 Express

Candidates answer on the Question Paper.

1 hour 45 minutes

No Additional Materials are required.

13 August 2024

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.
Write your answers in the spaces provided.

Section B
Answer **one** question.
Write your answers in the spaces provided.

Candidates are reminded that **all** quantitative answers should include appropriate units.
The use of an approved scientific calculator is expected, where appropriate.
Candidates are advised to show all their working in a clear and orderly manner, as more marks are awarded for sound use of Physics than for correct answers.

The number of marks is given in brackets [ ] at the end of each question or part question.

Acceleration due to gravity, ***g***, is assumed to be 10 m/s^2 unless otherwise specified.

For Examiner's Use	
Section A	/70
Section B	/10
Total	/80

This document consists of **19** printed pages and **1** blank page.

Section A

Answer **all** questions.

1 Fig. 1.1 shows the velocity-time graph for the first 80 s after an object is dropped from rest at a height of 2000 m above the ground.

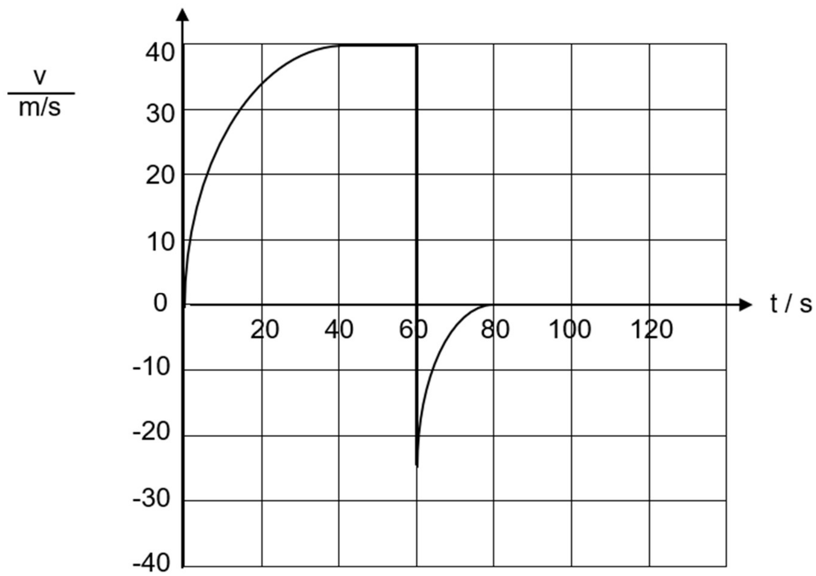

Fig. 1.1

The object has a mass of 9.0 kg.

(a) State the acceleration of the object at 0 s.

acceleration = ……………………… [1]

(b) Describe the motion from 0 to 80 s.

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……………………………………………………………………………………………[4]

(c) Describe the energy transfer when the object is travelling at terminal velocity.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

(d) Calculate the maximum possible air resistance acting on the object when the object is falling at terminal velocity.

maximum air resistance = ……………………………[1]

2 A 7.0 kg picture frame is being suspended from a nail by a string. The string forms two segments L_1 and L_2, as shown in the Fig. 2.1. L_1 and L_2 make an angle of 35° and 60° with the vertical respectively.

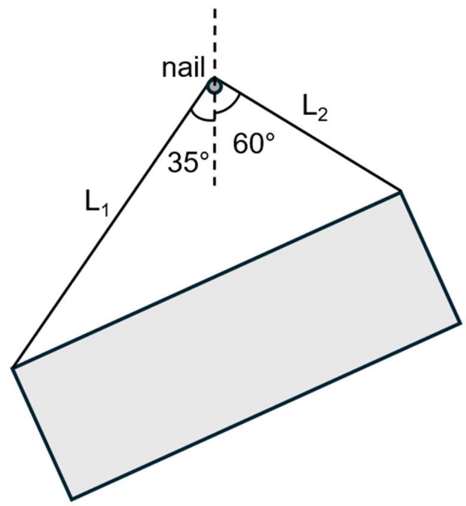


Fig. 2.1

(a) In the space below, draw a vector diagram to determine the tensions in segments L_1 and L_2. Specify the scale used.

scale = …………………… , tension in L_1 = ……… , tension in L_2 = ……… [4]

(b) State the magnitude and direction of the force by the nail, on the string.

…………………………………………………………………………………………………...

…………………………………………………………………………………………………...

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

(c) The picture frame was adjusted such that both segments of the string make an **equal** angle with the vertical.

State the changes to the tensions in segment L_1 and L_2 and how their magnitudes compare.

…………………………………………………………………………………………………...

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

3 Fig. 3.1 shows a man holding a 0.20 N object in his hand with his forearm in a horizontal position. He can support the object in this position because the flexor muscle exerts a force, F_M vertically upward on the forearm. The man's forearm weighs 22 N and its centre of gravity (C.G.) is indicated in the diagram. The forearm can rotate about the elbow joint.

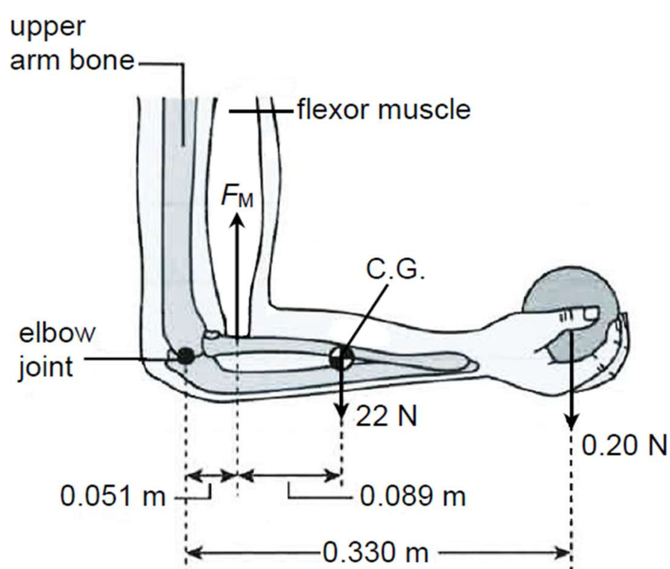


Fig. 3.1

(a) Calculate the value of F_M.

F_M = …………. [2]

(b) To keep the forearm in the horizontal equilibrium position, the upper arm bone exerts a force at the elbow joint.

Determine the magnitude and direction of this force.

magnitude = ……………………….

direction is ………………..……[3]

(c) Explain why the force in **(b)** is not considered in the calculation in **(a)**.

…………………………………………………………………………………………………...

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

4 Fig. 4.1 shows two vertical tubes P and Q, each closed at the upper end. The pressure in the space above the mercury meniscus in tube P is 16800 Pa. The pressure in the space above the mercury meniscus in tube Q is unknown.

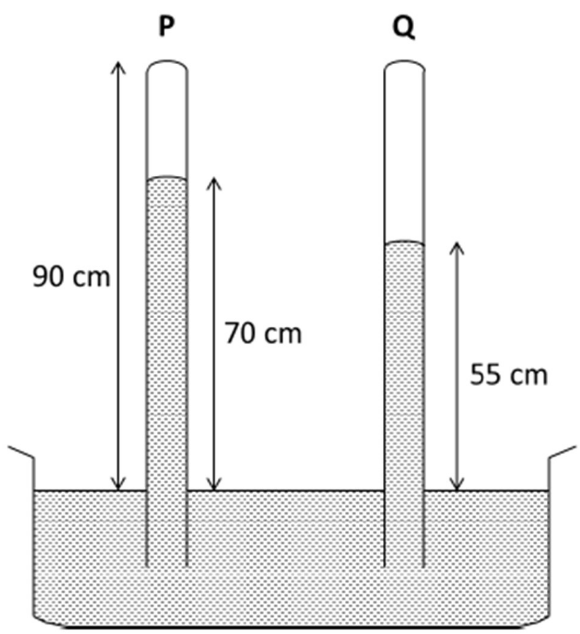


Fig. 4.1

Take the density of mercury to be 13600 kg/m^3

(a) Using the information provided, calculate

(i) the atmospheric pressure;

atmospheric pressure = …………………………… [2]

(ii) the pressure in the space above the mercury meniscus in tube Q.

pressure = …………………………… [2]

(b) Due to a small knock, tube Q is slightly shifted and ends up at an angle 15° to the vertical, as shown in Fig. 4.2.

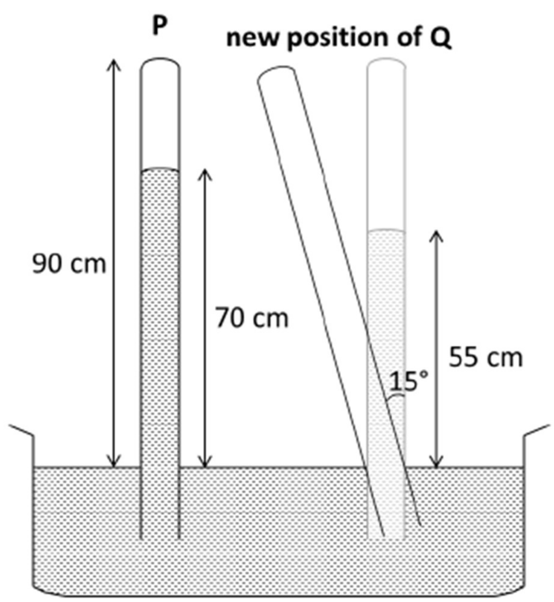


Fig. 4.2

On Fig. 4.2, draw the new level of the mercury meniscus in tube Q, and explain your answer.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

5 Fig. 5.1 shows the structure of a water cooler that supplies cold water.

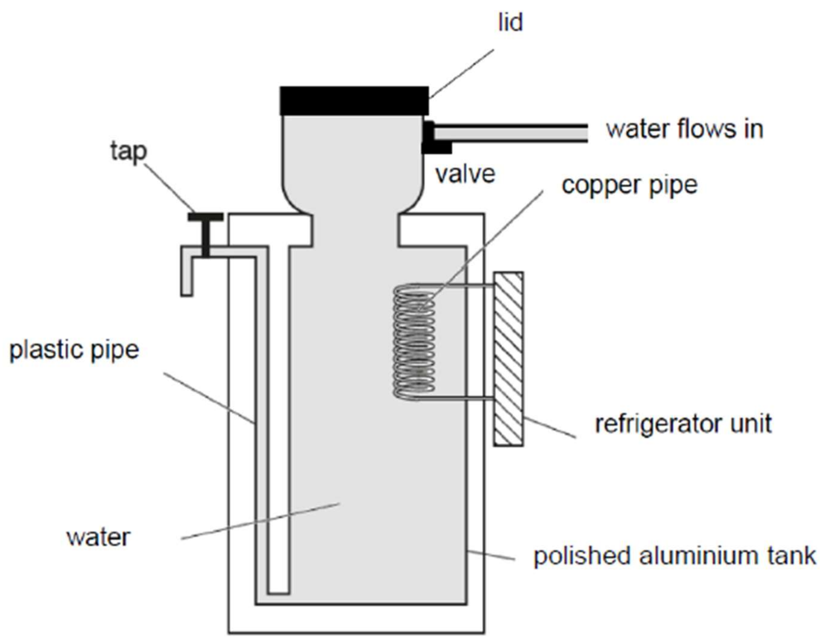


Fig. 5.1

(a) In the refrigerator unit, a coolant is pumped through the copper pipe.

Explain how energy is transferred from the water to the coolant in the pipe.

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

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

(b) Describe how the entire tank of water is cooled.

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

…………………………………………………………………………………………………..

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

(c) Explain how the polished aluminium tank helps to keep the water cold.

…………………………………………………………………………………………………..

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

6 Fig. 6.1 shows the equilibrium positions of some particles in a medium at time t = 0 s. When a longitudinal wave travels through this medium, the displacements of these particles at time t = 1 s are shown in the displacement - position graph (Fig. 6.2).

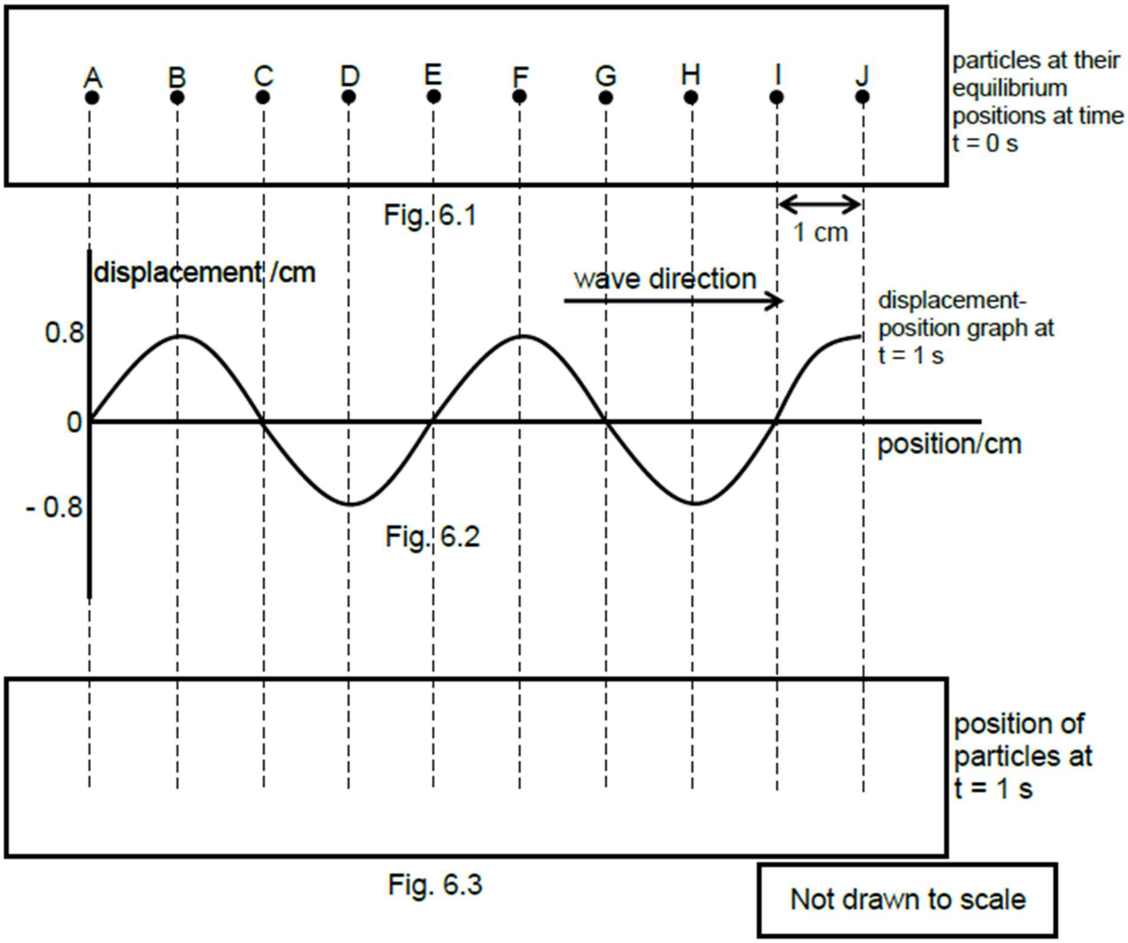


Fig. 6.1

Fig. 6.2

Fig. 6.3

(a) Mark the positions of the particles A – J at the time t = 1 s in the space provided in Fig. 6.3 with reference to the displacement - position graph shown in Fig. 6.2. [1]

(b) With reference to your answer to (a) which particle(s) is/are at the

(i) centre of compression,

particle(s) ……………………………. [1]

(ii) centre of rarefaction.

particle(s) ……………………………. [1]

(c) If the speed of the wave is 340 m s^{-1}, find the period of the wave.

period = ……………………………. [2]

7 Fig. 7.1 shows a converging lens. Parallel rays of light from point A which is from the top of a distant building is brought to a focus at *I*. Parallel rays of light from another point B which is from the bottom of the same building is incident on the lens as shown. One of the ray from A is refracted as shown.

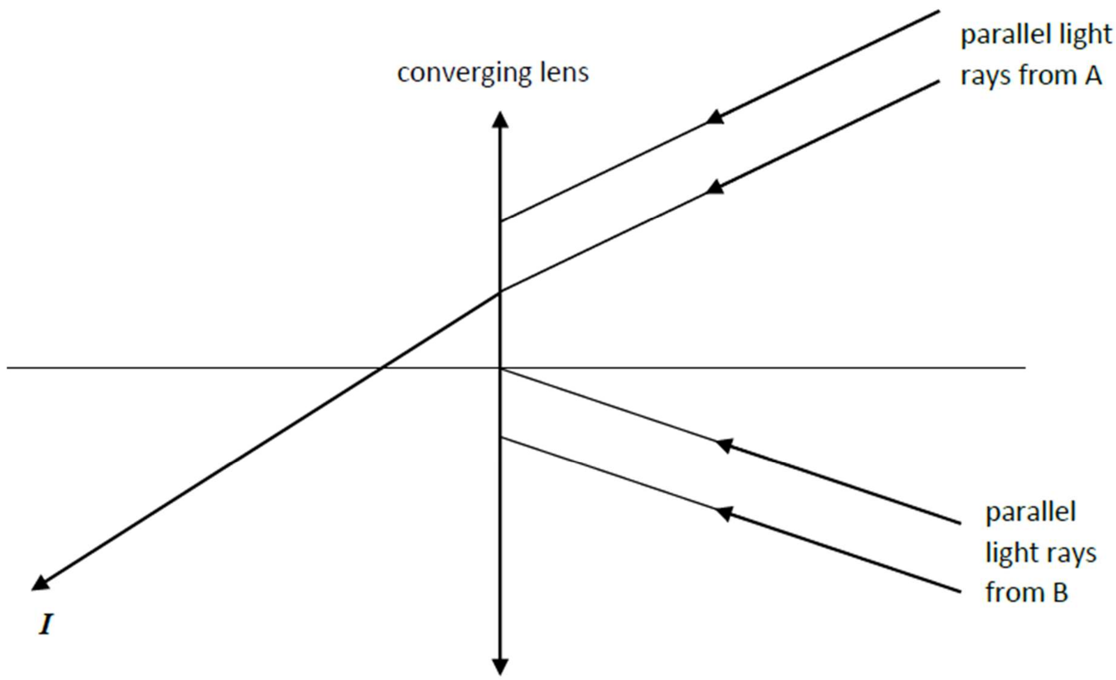


Fig. 7.1

(a) Complete the rays from A and B on Fig. 7.1 to show how the image is formed. [2]

(b) Indicate on Fig 7.1 the height of the image with letter *h* and principal focal point with the letter *F*. [2]

8 LASER is the acronym for Light Amplification by Simulated Emission of Radiation.

Table 8.1 shows different brands of laser guns for industrial use and their specific wavelengths. All laser guns emit electromagnetic waves.

An enthusiastic laser user sorts out the different brands of laser guns into Types I, II and III. He also discovers that the Red Beam laser gun emits a bright, red light.

Table . 8.1

Type	brand of laser gun	wavelength / x 10^{-7} m
I	Trace	3.2
II	Eagle Eye	4.9
	Fire Fly	5.5
	Red Beam	6.3
III	Sparrow Beak	9.8

(a) State the type of electromagnetic waves emitted by Type I, Type II and Type III laser guns in the electromagnetic spectrum respectively.

Type I : ……………………………………………

Type II : ……………………………………………

Type III : …………………………………………… [2]

(b) State and explain which brand(s) of the laser guns listed in Table 8.1 can be used in a vacuum environment?

………………………………………………………………………………………………...

………………………………………………………………………………………………...

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

9 Fig. 9.1 shows a coil of wire wound on a soft iron core. A current is passed through the coil in the direction indicated by the arrows.

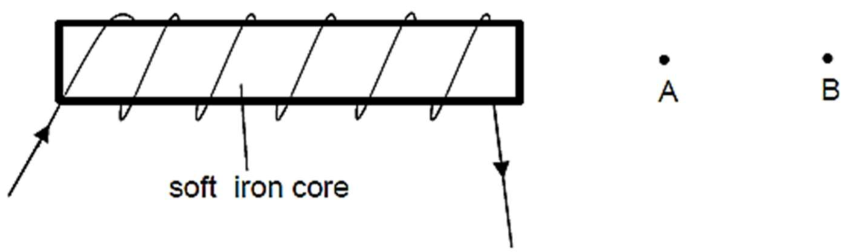


Fig. 9.1

(a) Show by drawing an arrow, the direction in which the north end of a compass needle would point when placed at position A in Fig. 9.1. Label the arrow C. [1]

(b) A beam of electrons flows through the point B in a direction that is perpendicularly downwards into the paper.

Show clearly by an arrow labelled F, the direction of the force exerted by the magnetic field on the electron beam. [1]

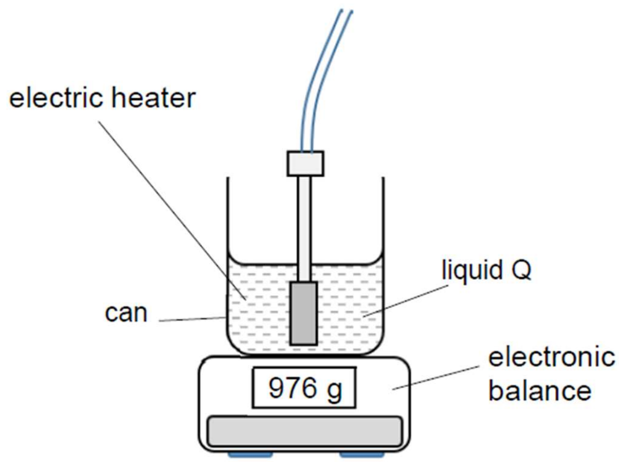
(c) Explain how you determine the direction indicated in **(b)**.

………………………………………………………………………………………………...

………………………………………………………………………………………………...

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

10 Fig. 10.1 shows an experimental set up that can be used to calculate the specific heat capacity and specific latent heat of vaporisation of a liquid Q. Energy is continuously provided by a 100 W electric heater to liquid Q. The temperature and electronic balance readings are recorded at regular intervals of time.



power of electric heater = 100 W

mass of empty can = 100 g

mass of liquid Q and can = 976 g

specific latent heat of vaporisation of liquid Q = 330 kJ/kg

Fig. 10.1

Fig. 10.2 shows how the total mass (mass of can + mass of liquid Q) changes with time.
Fig. 10.3 shows how temperature of liquid Q changes with time.

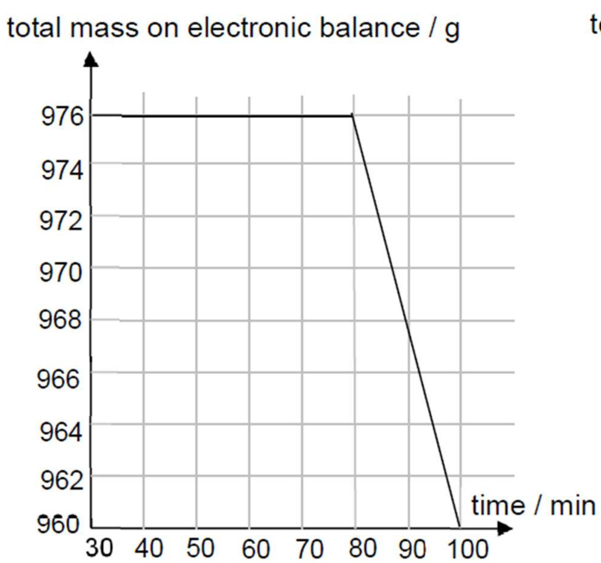


Fig. 10.2

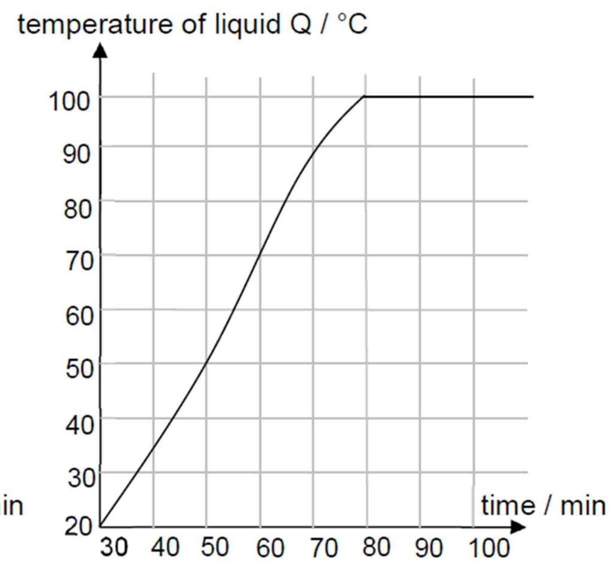


Fig. 10.3

(a) Define *specific latent heat of vaporisation*.

……………………………………………………………………………………………..

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

(b) **(i)** Calculate the amount of energy supplied by the heater from 30 minutes to 80 minutes.

energy supplied = ………………………… [2]

(ii) Given that 60 000 J of energy is transferred from the experimental set up to the surroundings from 30 minutes to 80 minutes, calculate the specific heat capacity of the liquid Q. Assume the can has negligible specific heat capacity.

specific heat capacity of liquid Q = ……………………………… [3]

(iii) With reference to your calculation in (b)(ii), explain whether the value of the specific heat capacity of liquid Q calculated is higher or lower than the actual specific heat capacity of the liquid if specific heat capacity of the can is not negligible.

……………………………………………………………………………………….

……………………………………………………………………………………….

……………………………………………………………………………………….

……………………………………………………………………………………….[2]

(c) **(i)** Calculate the amount of energy needed to boil off liquid Q from 80 minutes to 100 minutes.

energy = ………………………… [1]

(ii) The mass of the liquid remains relatively constant from 0 minutes to 80 minutes. The rate of evaporation is hence insignificant.

Suggest why the rate of evaporation is insignificant.

……………………………………………………………………………………….

……………………………………………………………………………………….[1]

11 Fig. 11.1 shows a radioactive source used to measure and control the thickness of cardboard during manufacture.

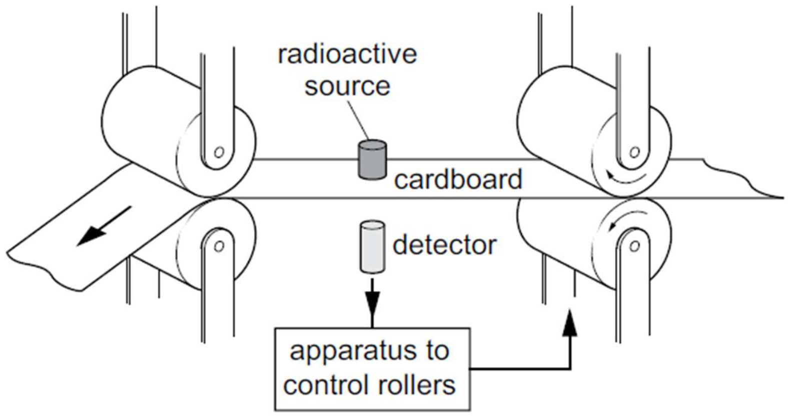


Fig. 11.1

(a) Some radioactive sources emit alpha-particles, some beta-particles and some gamma radiation.

Explain why emission count of alpha-particles and gamma radiation are not suitable for the application shown in Fig. 11.1.

……………………………………………………………………………………………...

……………………………………………………………………………………………...

……………………………………………………………………………………………...

…………………………………………………………………………………..…[2]

(b) Strontium-90 is an isotope used in the radioactive source in Fig. 11.1.

A nucleus of strontium-90 emits a beta-particle as it decays.

(i) The radioactive decay of a nucleus is a random and spontaneous process.

Explain what is meant by a random decay.

……………………………………………………………………………………….

…………………………………………………………………………………….[1]

(ii) In nuclide notation, strontium-90 is written as ${}^{90}_{38}Sr$.
When a nucleus of strontium-90 emits a beta-particle (β), it decays to an isotope of yttrium (Y).

Complete the decay equation below for this decay.

$$ {}^{90}_{38}Sr \longrightarrow {}^{\cdots\cdots}_{\cdots\cdots}Y + {}^{\cdots\cdots}_{\cdots\cdots}\beta $$

[2]

(iii) Beta decay can be considered as the decay of a neutron to a proton and an electron.

Explain how the composition of the nuclei of the strontium and yttrium isotopes illustrates this statement.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

(c) The half-life of strontium-90 is 29 years.

(i) Suggest why a radioactive source with a half-life of millions of years is unsuitable for use in the apparatus shown in Fig. 11.1.

……………………………………………………………………………………………

……………………………………………………………………………………………[1]

(ii) A pure source of strontium-90 emits 1.6×10^5 beta-particles per second.

Calculate the number of beta-particles emitted per second by the source after 87 years.

number of particles per second = ………………………………[2]

End of Section A

Section B

Answer **one** question from this section.

12 Two light bulbs (A and B) are at their normal brightness when each is connected to a 3 V battery. The graph in Fig. 12.1 shows how the current varies with the applied voltage (potential difference) for each bulb.

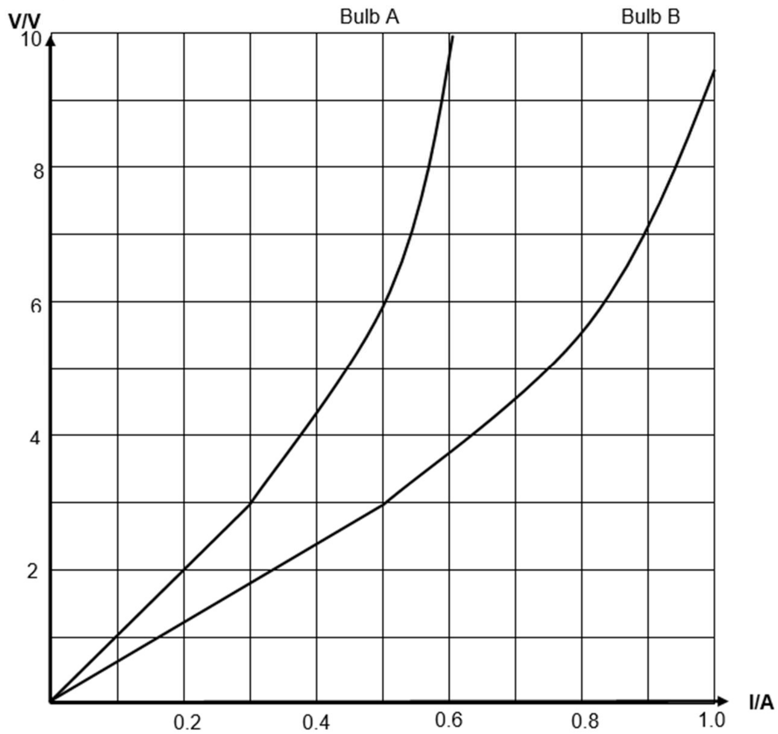


Fig. 12.1

(a) **(i)** Explain the shape of the V-I graph of bulb A.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[2]

(ii) Determine the resistance of each bulb when they are operating at normal brightness.

resistance of bulb A = …………. , resistance of bulb B = …………[2]

(b) A pupil studying potential dividers sets up the circuit as shown in Fig. 12.2 using bulb A.

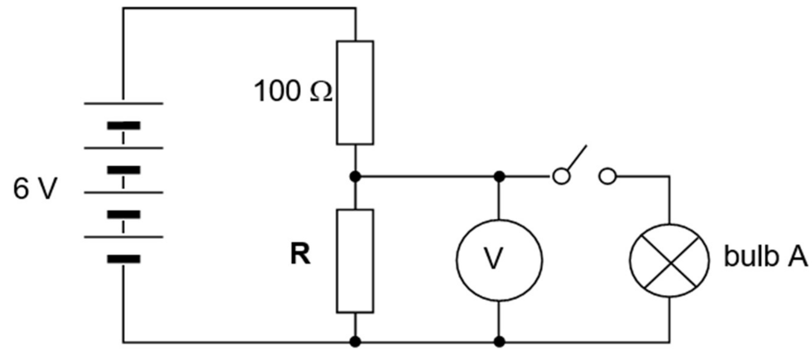


Fig. 12.2

When the switch is open the voltmeter shows a reading of 3.5 V.

(i) Calculate the value of R.

R = …………… [2]

(ii) Explain why the reading shown on the voltmeter decreases.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………[2]

(iii) Suggest and explain how the circuit can be modified so that it can be used in a temperature sensor which lights up when placed in a very hot environment.

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………

………………………………………………………………………………………………[2]

13 Fig 13.1 represents a typical transformer. When a primary voltage V_P is applied across the primary coil, a secondary voltage V_S occurs in the secondary coil.

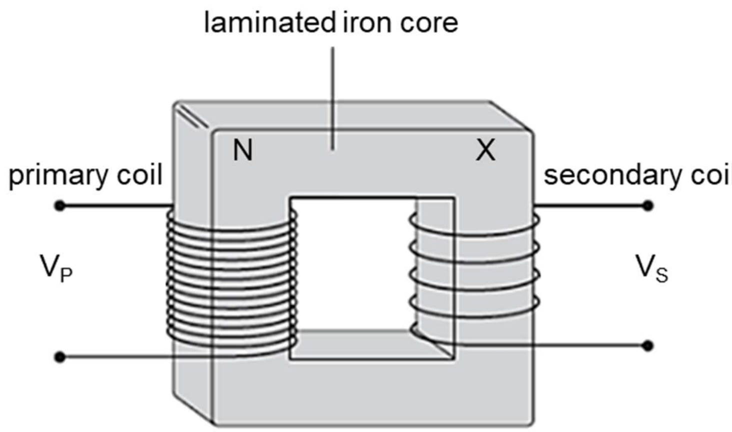


Fig. 13.1

(a) **(i)** Explain how current can flow in the secondary coil when V_P is applied even though there is no electrical contact between the primary and secondary coil.

....

....

....[1]

(ii) Explain why the secondary voltage V_S is reduced when the number of turns in its secondary coil is reduced.

....

....

....[1]

(iii) Fig 13.1 shows an instant when the current in the primary coil produces a north pole above the coil.

State the pole that is formed at X above the secondary coil at this instant. Explain how you obtained your answer.

....

....

....

....

....[2]

(b) A remote village is supplied with electrical energy from a power station some distance away by power cables as shown in Fig. 13.2 below. At the village, a transformer steps down the potential difference from 10,000 V to 250 V.
R represents the net resistance of the electrical circuits in the village. The mean rate of supply of electrical energy to the village is 400 kW.

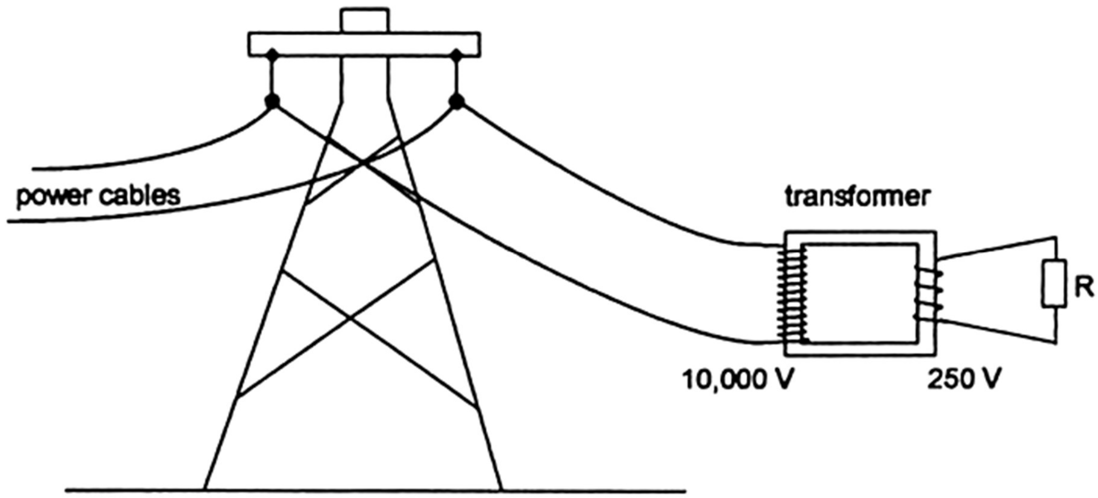


Fig. 13.2

(i) Explain why a high voltage of 10,000 V is used to transmit the electrical power.

....

....

....

....

....[2]

(ii) Calculate the current flowing in the secondary coil of the transformer.

Hence, calculate the current in the primary coil assuming that the transformer is 100% efficient.

current in secondary coil = ... , current in primary coil = ...[2]

(iii) If the power cables have a resistance of 25 Ω, calculate the rate at which energy is lost in the power cables.

Hence, deduce the power the cables must draw from the power station, in order to deliver 400 kW of electrical power to the village.

rate = …..………………. , power = ……………………[2]

End of Paper 2

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