Class / Index Number /	Centre Number / 'O' Level Index Number /	Name

新加坡海星中学

MARIS STELLA HIGH SCHOOL

PRELIMINARY EXAMINATION

SECONDARY FOUR

PHYSICS **6091/02**

Paper 2 Structured and Free Response **28 August 2025**

1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name 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, 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. **Circle your choice** of question on the **cover page**.

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.
The total marks for this paper (Sections A and B) is 80.

For Examiner's Use	
Section A	70
Section B (11 / 12)	10
Total	80

This document consists of **22** printed pages.

Section A

Answer **all** questions in this section.

1 **(a)** A ball is thrown vertically down towards the ground and rebounds as illustrated in Fig. 1.1.

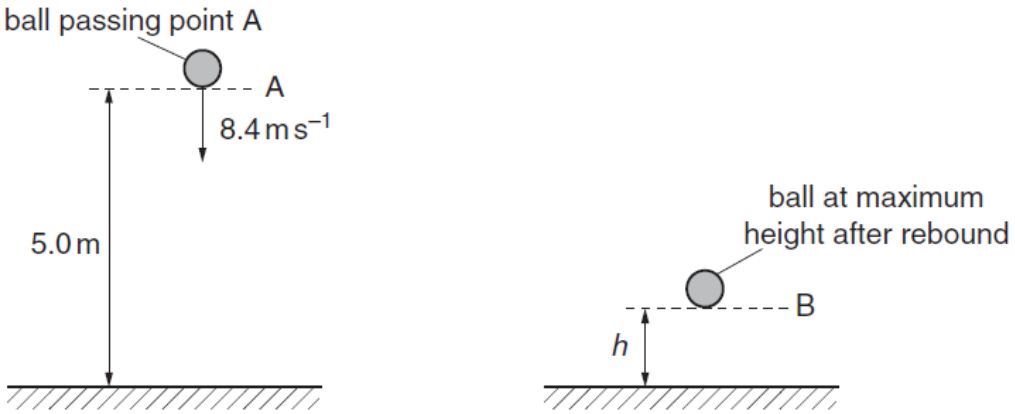

Fig. 1.1

As the ball passes A, it has a speed of 8.4 m s^{-1}. The height of A is 5.0 m above the ground. The ball hits the ground and rebounds to B. Assume that air resistance is negligible.

(i) Calculate the speed of the ball just before hitting the ground.

speed = ... [2]

(ii) Show that the time taken for the ball to reach the ground is 0.46 s.

[1]

(b) The ball rebounds vertically with a speed of 4.2 m s^{-1} as it leaves the ground. The time the ball is in contact with the ground is 20 ms. The ball rebounds to a maximum height *h*.

The ball passes A at time t = 0. On Fig. 1.2, plot a graph to show how the velocity *v* of the ball varies with time *t*. Continue the graph until the ball has rebounded from the ground and reaches B.

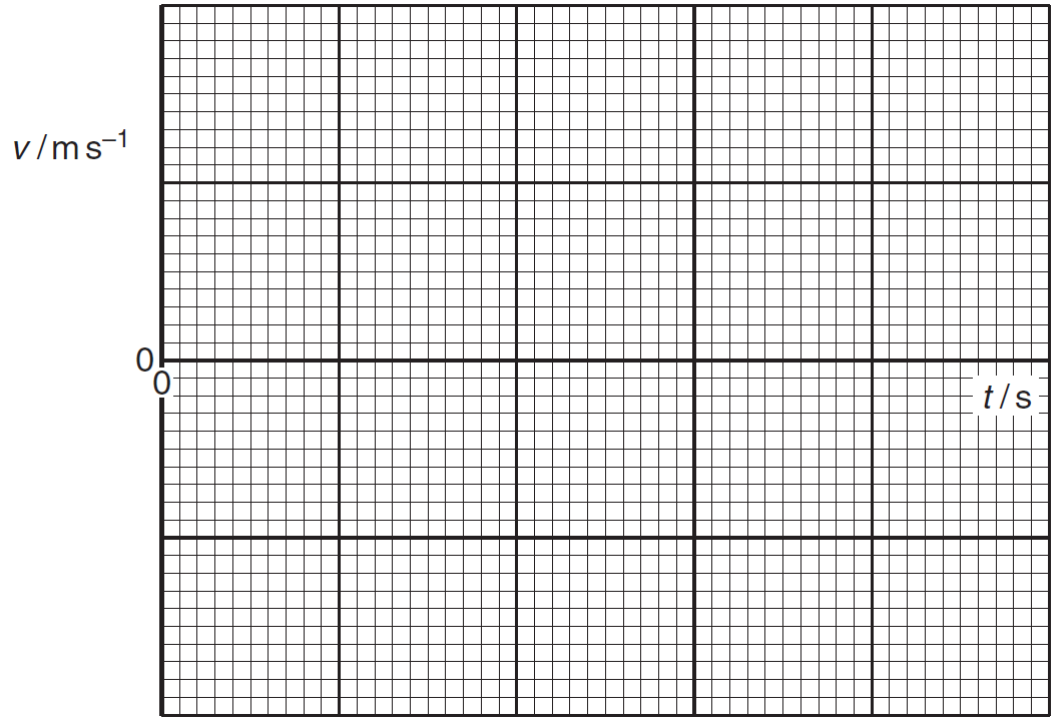

Fig. 1.2

[3]

[Total: 6]

2 Fig. 2.1 shows a 60.0 kg painter on a uniform scaffold of mass 25.0 kg and length 6.0 m, supported from above by ropes at points A and B. A 4.0 kg pail of paint is placed 1.0 m away from one of the supports.

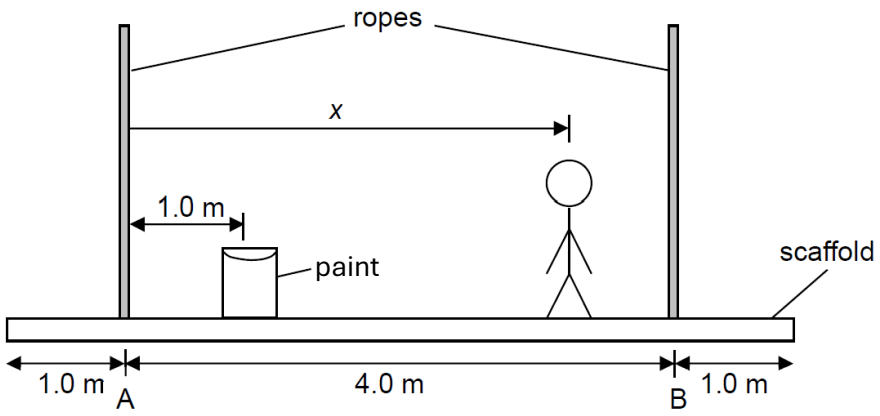

Fig. 2.1

(a) On Fig. 2.2, draw and label the forces acting on the scaffold. [2]

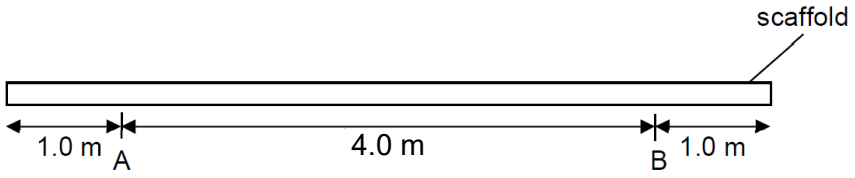

Fig. 2.2

(b) Given that the painter is standing at x = 3.6 m, determine

(i) the tension in the rope attached to point B,

tension = ... [2]

(ii) the tension in the rope attached to point A.

tension = ... [2]

(c) Describe and explain what would happen to the tension in both ropes as the painter walks slowly towards point A on the scaffold.

.....

.....

.....

.....

.....

..... [3]

[Total: 9]

3 Fig. 3.1 shows a gas sealed in container using a rubber bung. The container is connected to a mercury manometer.

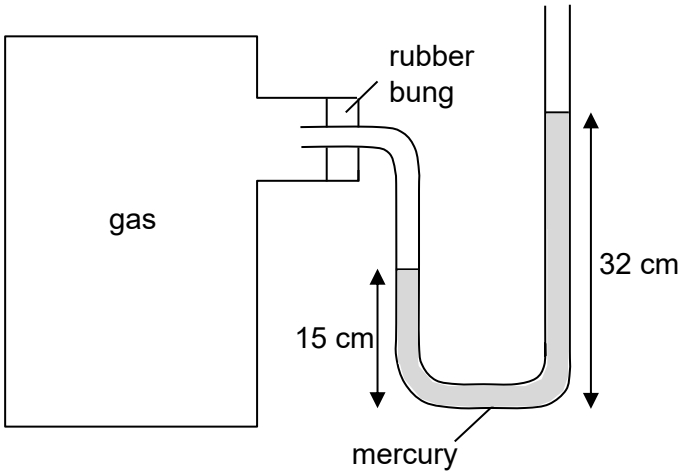

Fig. 3.1

(a) The atmospheric pressure is 76 cm Hg and density of mercury is 13 600 kg/m^3.

Calculate the pressure of the gas in pascal. Take *g* as 10 N/kg.

pressure = ……[2]

(b) The gas pressure exerted at the rubber bung is equal to the gas pressure exerted at the walls of the container. Explain why this is true, in terms of the particles of the gas.

……...

……...

……...

……...

……...

……..… [3]

(c) A Physics student notices that small increases in gas pressure are not noticeable enough because the mercury level in the right column of the manometer rises very little.

Suggest and explain a change that the student can implement to the manometer so that the rise in level is more noticeable.

……...

……...

……...

……...

…….. [2]

[Total: 7]

4 *Yunnan Guoqiao-mixian* (云南过桥米线) is a famous Chinese noodles dish.

The first step in preparing this dish is to cook a pot of chicken broth. A pot of water containing chicken is heated over a high flame until it boils. A low flame is then used to keep the soup boiling for 3.0 hours.

(a) Explain, in terms of molecules, why the temperature of the boiling soup remains unchanged, even though it is being heated.

..……

……..… [1]

(b) **(i)** The power output of the low flame is 300 W. If 70% of the energy supplied is transferred to the surroundings, calculate the mass of soup that would be vaporized after being heated for 3.0 hours. Assume the specific latent heat of vaporization of the soup is 2.26×10^6 J kg^{-1}.

mass of soup vaporized = ... [2]

(ii) Explain, in terms of the amount of water molecules remaining in the soup, why it is preferable to use a low flame than a high flame to keep the soup boiling.

.....

..... [1]

(c) As shown in Fig. 4.1, customers ordering the *mixian* are served with the following:

a bowl of hot soup with a layer of oil on the surface,
a dish of thin slices of raw meat, and
a bowl of pre-cooked *mixian* (noodles)

Fig. 4.1

The meat is first put into the soup. After a while, the *mixian* is also added.

(i) Explain, in terms of thermal processes, why the meat must be sliced into thin pieces.

.....

..... [1]

(ii) Explain, in terms of thermal processes, the purpose of adding a layer of oil to the bowl.

.....

..... [1]

(iii) The following data are given:

Mass of the soup	= 1.0 kg
Initial temperature of the soup	= 97°C
Specific heat capacity of the soup	= 4200 J kg^{-1} K^{-1}
Mass of each slice of meat	= 0.020 kg
Initial temperature of the meat	= 27°C
Specific heat capacity of the meat	= 3500 J kg^{-1} K^{-1}

For health reasons, the meat has to be heated to a minimum temperature of 82°C.

Determine the maximum number of slices of meat that can be added to the soup. You may assume that there is no transfer of energy to the surroundings.

maximum number of meat slices = …….. [2]

(iv) A customer first places the *mixian* into the soup before adding the meat.

Explain why this is undesirable.

……..

…… [1]

[Total: 9]

5 Fig. 5.1 shows an object placed 20 mm from a converging lens of focal length 40 mm.

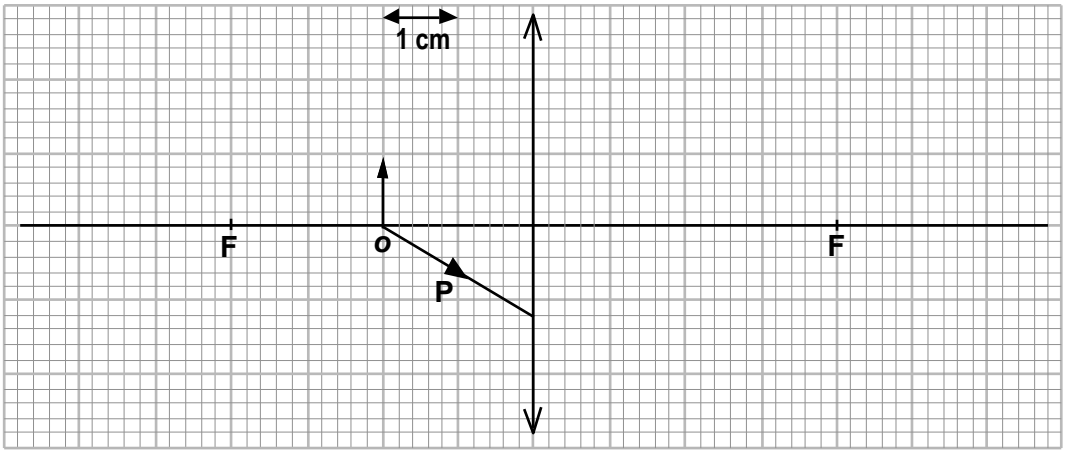

Fig. 5.1

(a) On Fig. 5.1, complete the diagram to locate the position of the image. [2]

(b) Ratio of image to object size is known as the magnification.

Using Fig. 5.1, determine the magnification.

magnification = ... [1]

(c) On Fig. 5.1, complete the path of the given ray P to show its passage through the lens and to the image. [1]

[Total: 4]

6 Fig. 6.1 shows a conducting sphere that has been given excess positive charges. The sphere is mounted on an insulating stand.

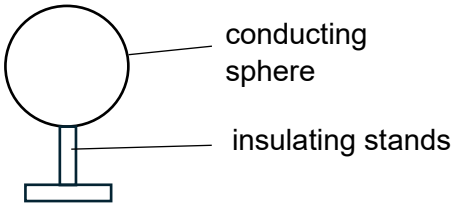

Fig. 6.1

(a) Draw in Fig. 6.1 the distribution of excess charges on the conducting sphere. [1]

(b) Draw in Fig. 6.1 the electric lines of force produced by these excess charges. [1]

(c) An electrically neutral aluminum ball suspended from a nylon string is brought near to the conducting sphere. It is attracted towards the conducting sphere but not touching the sphere as shown in Fig. 6.2.

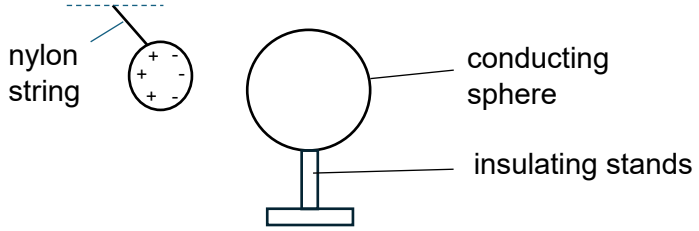

Fig. 6.2

Charges are induced on the aluminum ball as shown in Fig. 6.2.

Explain, in terms of electric forces, why the aluminum ball is attracted towards the positively charged conducting sphere.

……

……

……

…….. [2]

(d) The aluminum ball is moved to the right such that it is allowed to touch the conducting sphere as shown in Fig. 6.3.

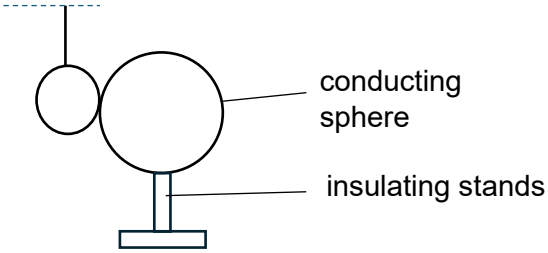

Fig. 6.3

On Fig. 6.3, draw the final position of the aluminum ball and label it as **(d)**.

Explain, in terms of charges, your answer for the final position of the aluminum ball.

……

…….. [2]

[Total: 6]

7 A battery of electromotive force 12 V and negligible internal resistance is connected to two resistors and a light-dependent resistor (LDR), as shown in Fig. 7.1.

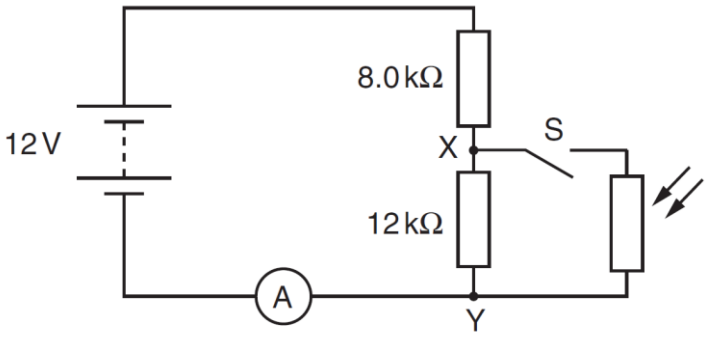

Fig. 7.1

An ammeter is connected in series with the battery. The LDR and switch S are connected across the points XY.

(a) The switch S is open. Calculate the potential difference (p.d.) across XY.

p. d. = ... [2]

(b) The switch S is closed. The resistance of the LDR is 4.0 kΩ. Calculate the current in the ammeter.

current = ... [2]

(c) The switch S remains closed. The intensity of the light on the LDR is increased. State and explain the change to

(i) the ammeter reading,

.....

.....

..... [2]

(ii) the p.d. across XY.

.....

.....

..... [2]

[Total: 8]

8 **(a)** Current is passing through an air-cored solenoid that is connected to a direct current (d.c.) emf voltage source as shown in Fig. 8.1.

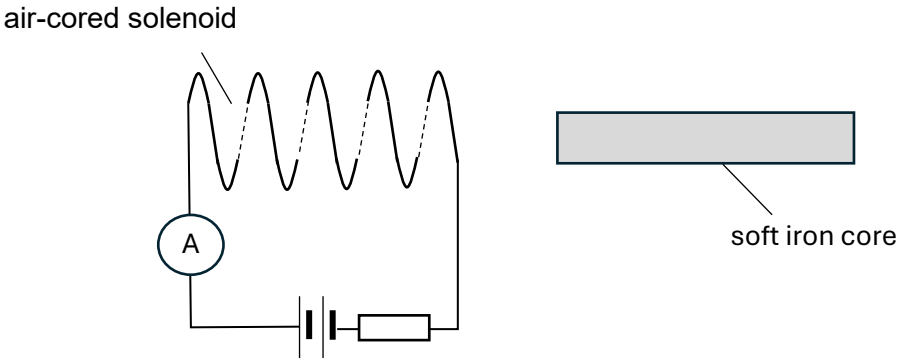

Fig. 8.1

Explain why reading on the ammeter decreases when an soft iron core is inserted into the solenoid.

……

……

……

…….. [2]

(b) The primary coil of a transformer is connected to the mains supply. The voltage of the a.c. mains supply is 240 V.

Fig. 8.2 is a diagram of the arrangement.

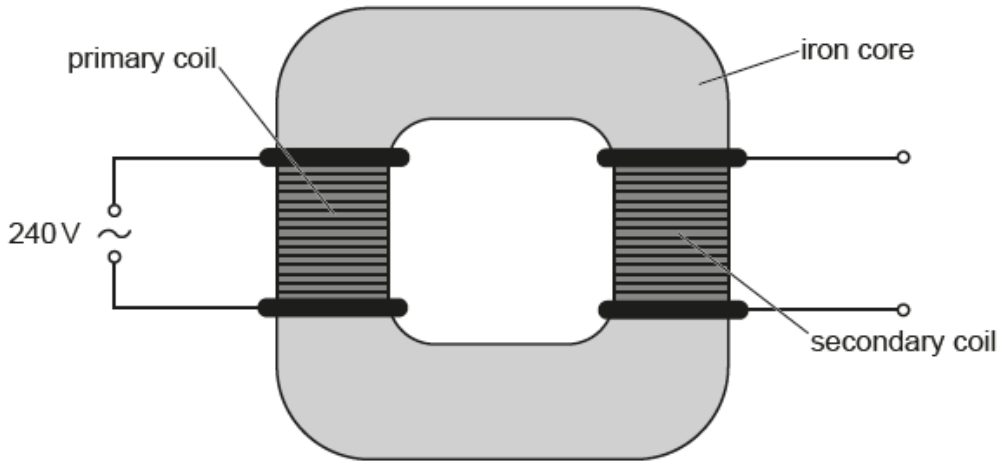

Fig. 8.2

There are 5600 turns on the primary coil of the transformer and 350 turns on the secondary coil.

The output of the transformer is connected to a 90 W filament lamp which operates at normal brightness.

Calculate the current in the lamp.

current = ... [3]

[Total: 5]

9 Sodium-24 is used in the treatment of various conditions. It is used to trace blood flow and locate obstructions in blood vessels.

The half-life of $^{24}_{11}\mathrm{Na}$ is 15 hours. A sample of $^{24}_{11}\mathrm{Na}$ having an activity of 32 x 10^3 disintegrations per second is injected into the blood stream of a patient.

After 45 hours, 6.0 cm^3 of blood is taken out from the patient's body and its activity is found to be 5.0 disintegrations per second.

(a) Deduce the number of half-lives elapsed after 45 hours.

…….. [1]

(b) Estimate the volume of blood in the patient's body.

volume = …… [2]

(c) Suggest a reason for using $^{24}_{11}\mathrm{Na}$ as a medical tracer.

……

…….. [1]

[Total: 4]

10 A light bulb manufacturer makes 240 V, 60 W bulbs, like the one shown in Fig. 10.1.

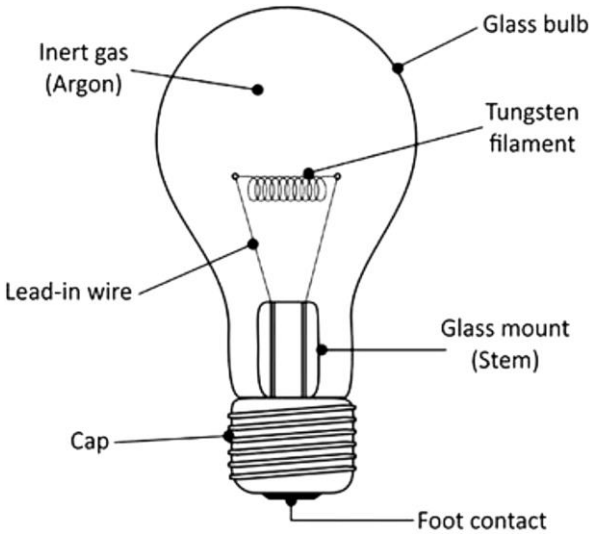

Fig. 10.1

The filament of the bulb is at a temperature of 2600 °C and the bulb lasts for 1000 hours before the filament breaks.

There are two schools of thought concerning these bulbs. One group of people wants the manufacturer to raise the temperature at which the filament operates, so that for the same power, more light is emitted. The other group of people thinks that the manufacturer makes too much profit on the bulbs by making them so that they break after 1000 hours. They want the manufacturer to make bulbs that last 2000 hours. The manufacturer can happily satisfy both of these requirements – but only by manufacturing the two other bulbs alongside the original bulb.

The material used for making the filament of the bulb is made of tungsten which has a resistivity of $7.9 \times 10^{-7}\ \Omega$ m at 2600 °C.

The manufacturer is going to make the 3 bulbs using different length and diameters of tungsten filament as shown in Fig. 10.2. The filament B is used to manufacture the standard bulb operating at 2600 °C.

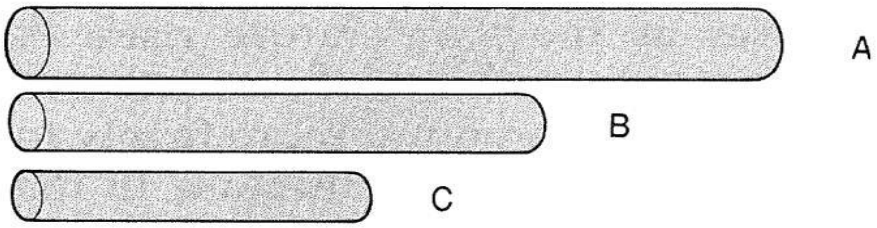

Fig. 10.2

The manufactured bulbs will have the same resistance.

(a) (i) State what is meant by the resistance of the bulb.

……

……[1]

(ii) Calculate the resistance of the 240 V, 60 W bulb.

resistance = …… [2]

(b) Calculate the diameter of tungsten wire needed to manufacture this bulb if the length of the filament wire in bulb B is 0.14 m. Leave your answer in mm.

diameter = ……mm [2]

(c) Explain how it is possible for the filaments in Fig. 10.2, to have the same resistance.

……..…….....……

……..……..……..……[1]

(d) State and explain which filament should be used to manufacture the bulb that can last 2000 hours.

……..…….....……

……..…….....……

……..……..……..……[2]

(e) Fig 10.3 compares the characteristics of the different filaments.

	A	B	C
resistance/ Ω			
diameter/ mm	0.0129		0.0113
length/ m		0.14	

Fig. 10.3

Complete the missing values in Fig. 10.3. [2]

(f) The bulb at the highest temperature lasts 500 hours. The cost of manufacturing each bulb is \$0.50 and each kilowatt-hour electricity costs \$0.172.

Determine the running cost when used for a duration of 2000 hours.

running cost = …… [2]

[Total: 12]

Section B

Answer **one** question in this section.

11 Fig. 11.1 shows a bar magnet dropped from rest through the centre of a coil of wire which is connected to a resistor and datalogger.

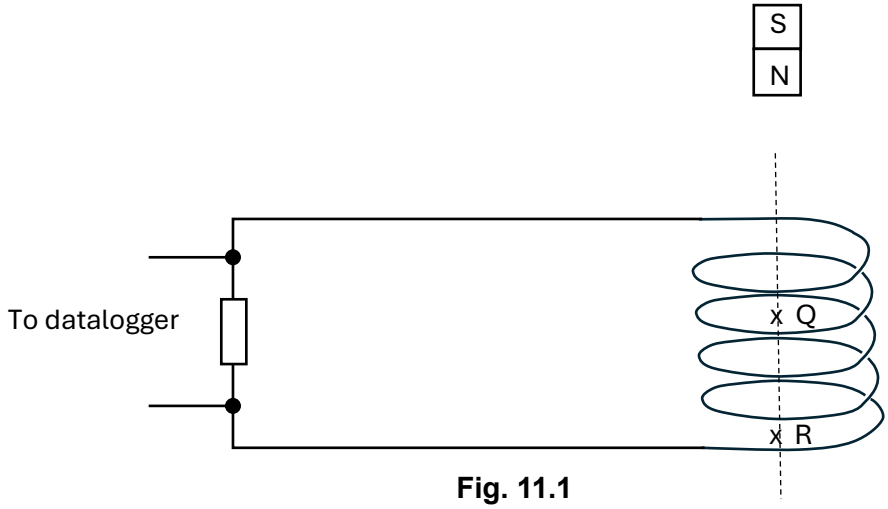

Fig. 11.1

(a) In Fig. 11.1, points Q and R represent positions lying along the central axis of the coil.

Identify and explain the position (Q or R) where the acceleration of the falling magnet is greater.

……

……

……

…… [2]

(b) Fig. 11.2 shows the variation of the induced current in the resistor with time as the magnet falls.

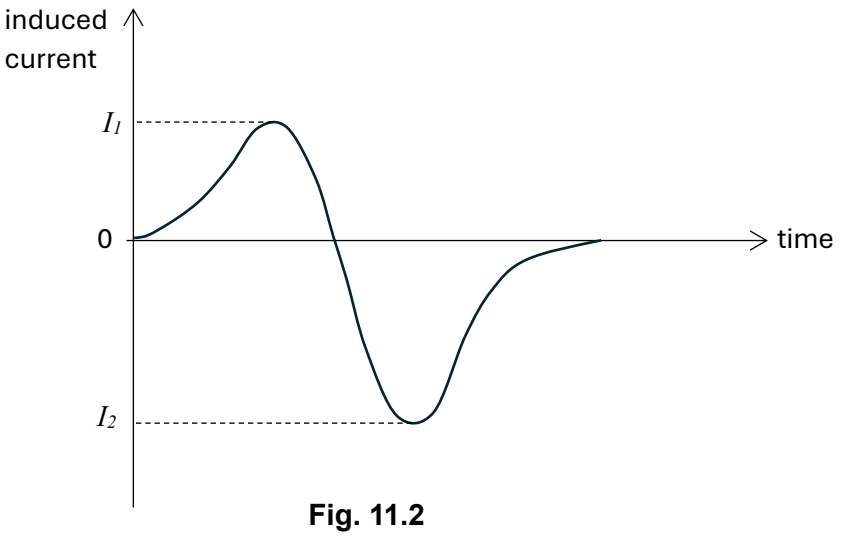

Fig. 11.2

(i) Explain why the magnitude of I_2 is greater than I_1.

……

……

……

…….. [2]

(ii) With reference to Fig. 11.2, explain why direction of the current changes in the coil as the magnet falls.

……

……

……

…….. [2]

(iii) The experiment is repeated with a length of coil of wire that is much longer than before, for instance 10 times or more than the magnet's length.

On the same axes in Fig. 11.2, sketch the expected current – time graph. [2]

(c) The original setup in **(a)** is now modified with a diode connected in series to the coil as shown in Fig. 11.3 below.

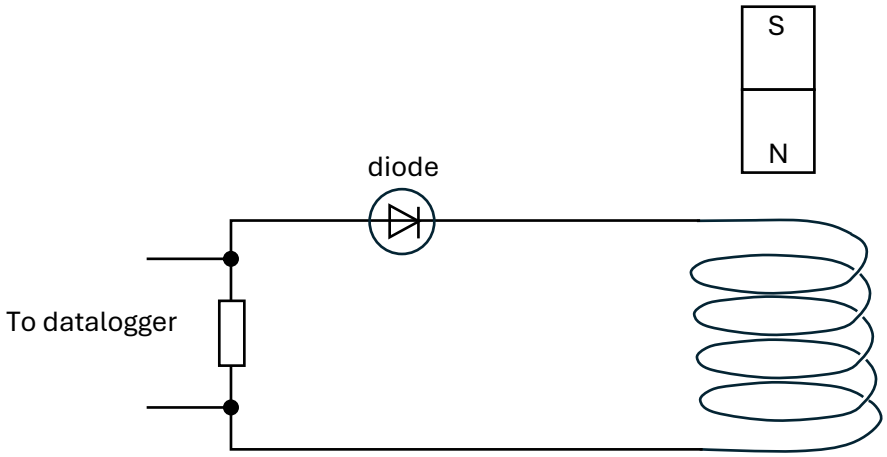

Fig. 11.3

Describe how the motion of the magnet and the current in the coil are being affected by the diode.

……

……

……

…….. [2]

[Total: 10]

12 Fig. 12.1a shows a smoke detector. The circuit within the detector is shown in Fig. 12.1b.

Fig. 12.1a

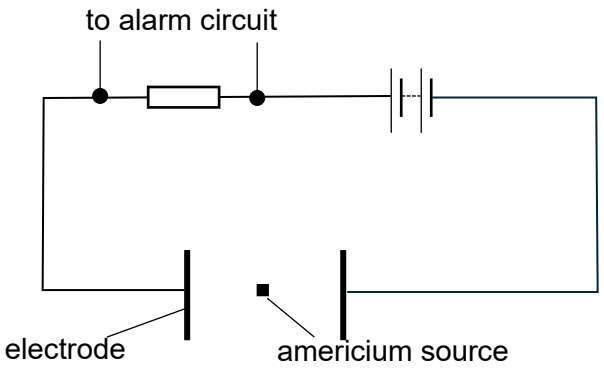

Fig. 12.1b

A small amount of the radioisotope americium-241 ($^{241}_{95}\mathrm{Am}$) is placed between two electrodes. The two electrodes are connected to a battery and an alarm circuit. The detector has slots in it to allow air flow.

(a) An americium-241 nucleus decays by emitting an α-particle to form a daughter nucleus neptunium (Np), with a half-life of 432 years.

(i) Write down an equation for the decay of an americium-241 nucleus.

…… [1]

(ii) Deduce the number of neutrons in the daughter nucleus.

number of neutrons = …… [1]

(b) Under normal conditions, a small current flows in the circuit inside the detector. However, when smoke particles enter the detector, the current drops significantly. This triggers the alarm to sound.

(i) Explain why a current flows between the electrodes under normal conditions.

……...

…… [1]

(ii) Suggest one possible reason why the current drops when smoke particles enter the detector.

……...

…… [1]

(c) Explain why it is preferable for the radioactive source used in smoke detectors to have a long half-life.

……..

……..

……..

…… [2]

(d) Carbon-14 ($^{14}_{6}\mathrm{C}$) is a radioisotope which decays by emitting β-particles and has a half-life of 5700 years.

Explain whether this source is suitable for use in smoke detectors.

……..

……..

……..

…… [2]

(e) Members of public are concerned about the biological hazards of radiation.

If you were the manufacturer of the smoke detector, describe how you would convince the public that using the detector will not pose a health hazard.

……..

……..

……..

…… [2]

[Total: 10]

- End of paper –