TAMPINES MERIDIAN JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATION

CANDIDATE NAME	( )
CIVICS GROUP	

H2 PHYSICS 9749/03

Paper 3 Longer Structured Questions **24 September 2025**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name and Civics Group in the spaces at the top of the page.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.

Section B
Answer **one** question only.

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

For Examiner's Use		Percentage
Subtotal P1	/ 30	/ 15
Subtotal P2	/ 80	/ 30
Paper 3		
1	/ 8	
2	/ 6	
3	/ 9	
4	/ 7	
5	/ 9	
6	/ 10	
7	/ 11	
8	/ 20	
9	/ 20	
Deduction		
Subtotal P3	/ 80	/ 35
Subtotal P4	/ 55	/ 20
Grand total		/ 100

Data

speed of light in free space	c	=	3.00×10^{8} m s^{-1}
permeability of free space	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0	=	8.85×10^{-12} F m^{-1}
		=	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	e	=	1.60×10^{-19} C
the Planck constant	h	=	6.63×10^{-34} J s
unified atomic mass constant	u	=	1.66×10^{-27} kg
rest mass of electron	m_e	=	9.11×10^{-31} kg
rest mass of proton	m_p	=	1.67×10^{-27} kg
molar gas constant	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant	k	=	1.38×10^{-23} J K^{-1}
gravitational constant	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall	g	=	9.81 m s^{-2}

Formulae

uniformly accelerated motion	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on / by a gas	W	=	$p\Delta V$
hydrostatic pressure	p	=	ρgh
gravitational potential	ϕ	=	$-\frac{GM}{r}$
temperature	T /K	=	T /°C + 273.15
pressure of an ideal gas	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2\rangle$
mean translational kinetic energy of an ideal gas molecule	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.	x	=	$x_o \sin \omega t$
velocity of particle in s.h.m.	v	=	$v_o \cos \omega t$
		=	$\pm\, \omega\sqrt{x_o^{\,2} - x^2}$
electric current	I	=	$Anvq$
resistors in series	R	=	$R_1 + R_2 + \ldots$
resistors in parallel	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential	V	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current / voltage	X	=	$x_o \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_0 nI$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

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

1 Object A of mass *m* is projected with a velocity of 2.4 m s^{-1} on a frictionless surface, directly towards a stationary object B of mass 4*m*, as shown in Fig. 1.1.

A spring of negligible mass is fixed on object B such that the collision with object A is elastic and head-on.

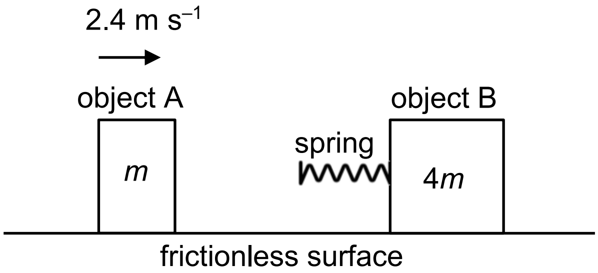

Fig. 1.1

(a) Explain what is meant by an *elastic collision*.

....

.... [1]

(b) Calculate the speed of object A after collision.

speed of object A = ... m s^{-1} [3]

(c) At one instant during the collision, the two particles have a common speed v_o.

Show that v_o is 0.48 m s^{-1}.

[1]

(d) On the axes in Fig. 1.2, sketch two graphs to show the variation with time t of the velocities v of object A and object B. Label the graphs A and B respectively.

Numerical labels are not required.

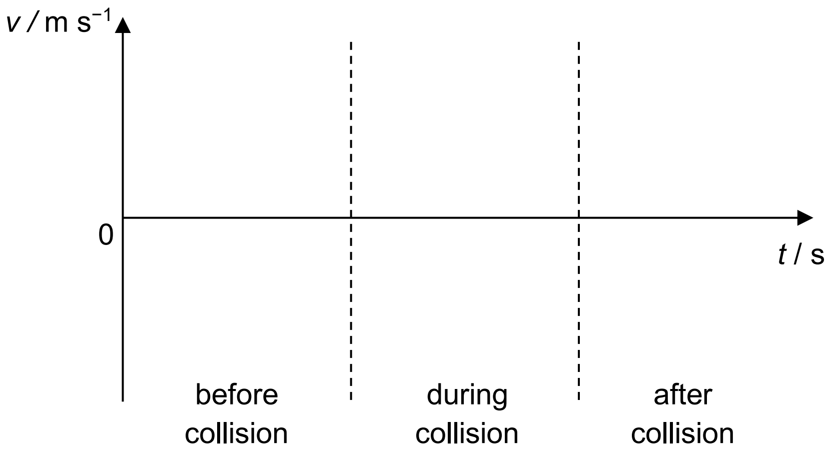

Fig. 1.2

[3]

2 A child slides down a slope PQ of height 7.0 m, as shown in Fig. 2.1.

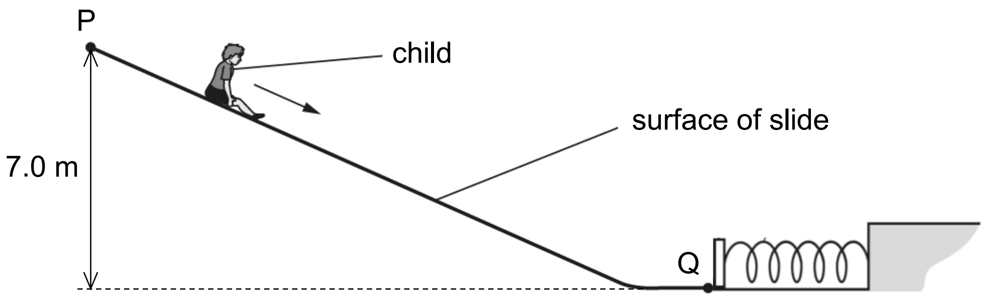

Fig. 2.1 (not drawn to scale)

She started from rest at P and reaches a speed of 4.8 m s^{-1} at Q. A resistive force opposes the motion of the child as she slides down.

(a) Determine the ratio $\dfrac{\text{kinetic energy of the child at Q with resistive force}}{\text{kinetic energy of the child at Q if there is no resistive force}}$.

ratio = ………………………… [2]

(b) At Q, the child, of mass 20 kg, makes contact with a soft board attached to a spring. The spring compresses and the child is eventually brought to rest, as shown in Fig. 2.2.

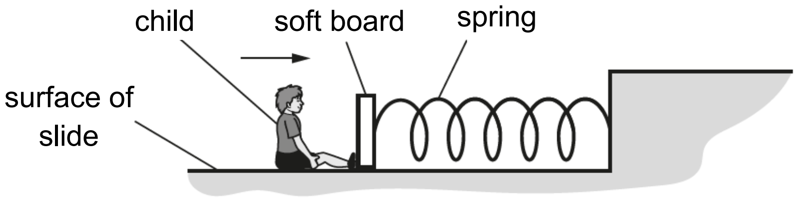

Fig. 2.2

The spring has a spring constant of 54 N m^{-1}. The maximum compression of the spring is 2.1 m.

Calculate the efficiency of the transfer of the kinetic energy of the child at Q to the elastic potential energy of the spring.

efficiency = ………………………… % [2]

(c) Suggest two reasons why the efficiency in **(b)** is not 100%.

1 ……………………………………………………………………………………………...

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

2 ……………………………………………………………………………………………...

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

3 **(a)** Define *gravitational field strength*.

……………………………………………………………………………………………………

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

(b) Explain why for a satellite in orbit around a planet, the gravitational field strength *g* at the position of the satellite must have the same magnitude and direction as the centripetal acceleration *a* of the satellite.

……………………………………………………………………………………………………

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

(c) At a distance r away from the centre of a planet X, the gravitational field strength due to the planet is given by g.

It is given that g obeys the inverse square law, where $g \propto \frac{1}{r^2}$.

Fig. 3.1 shows the variation with lg r of lg g.

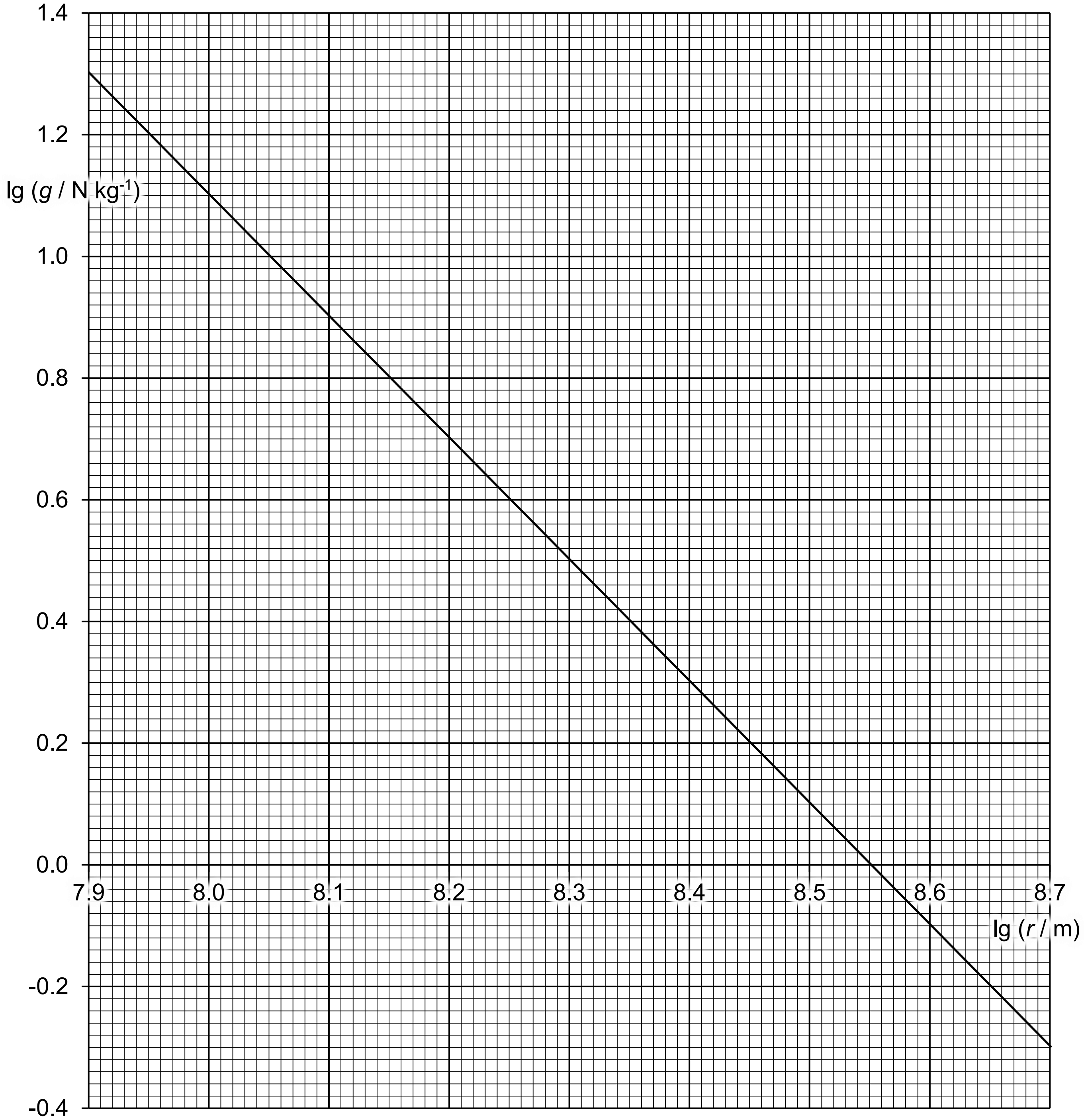

Fig. 3.1

(i) Use data from Fig. 3.1 to show that the gravitational field strength of the planet obeys the inverse square law.

[2]

(ii) A satellite is in an orbit of radius 4.18×10^8 m around the planet.

Using Fig. 3.1, determine the speed of the satellite.

speed = ……………..……… m s^{-1} [3]

(iii) Another planet Y has a smaller mass than planet X.

On Fig. 3.1, sketch the graph for planet Y.

[1]

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4 **(a)** **(i)** State what is meant by *plane polarisation* of waves.

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

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

(ii) State why a sound wave cannot be polarised

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

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

(b) A beam of unpolarised light is shone through two polarising filters X and Y, as shown in Fig. 4.1.

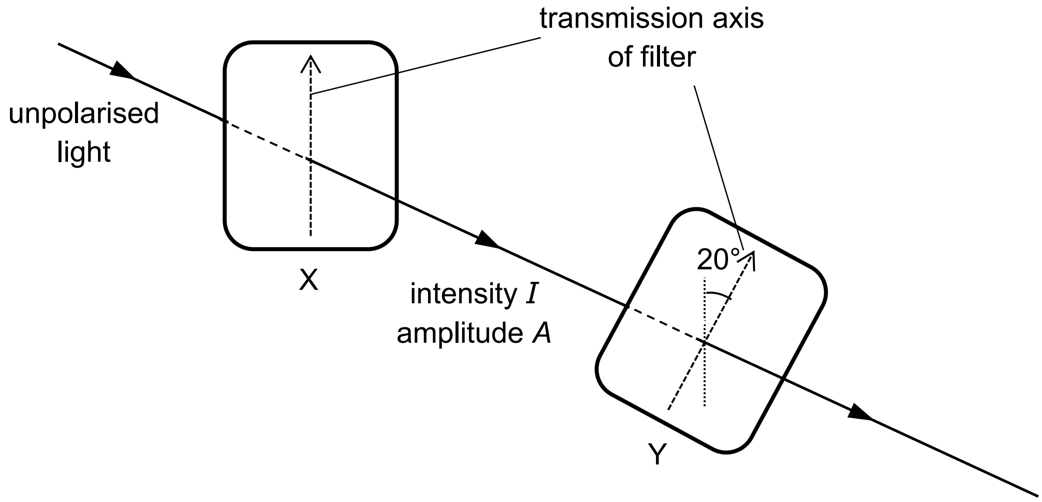


Fig. 4.1

The intensity and amplitude of the light after passing through polarising filter X is I and A respectively.

Polarising filter Y is positioned with its transmission axis at an angle of 20° to that of polarising filter X.

(i) For the unpolarised light before passing through polarising filter X, state

1. its amplitude, in terms of A.

amplitude = ………………………… [1]

2. its intensity, in terms of I,

intensity = ………………………… [1]

(ii) Calculate the intensity of light, in terms of I, after passing through polarising filter Y.

intensity = ………………………… [2]

(iii) Polarising filter Y is now rotated about the direction of the light beam, from its starting position shown in Fig. 4.1. The direction of rotation is such that the angle of the transmission axis to the vertical initially increases as shown in Fig. 4.2.

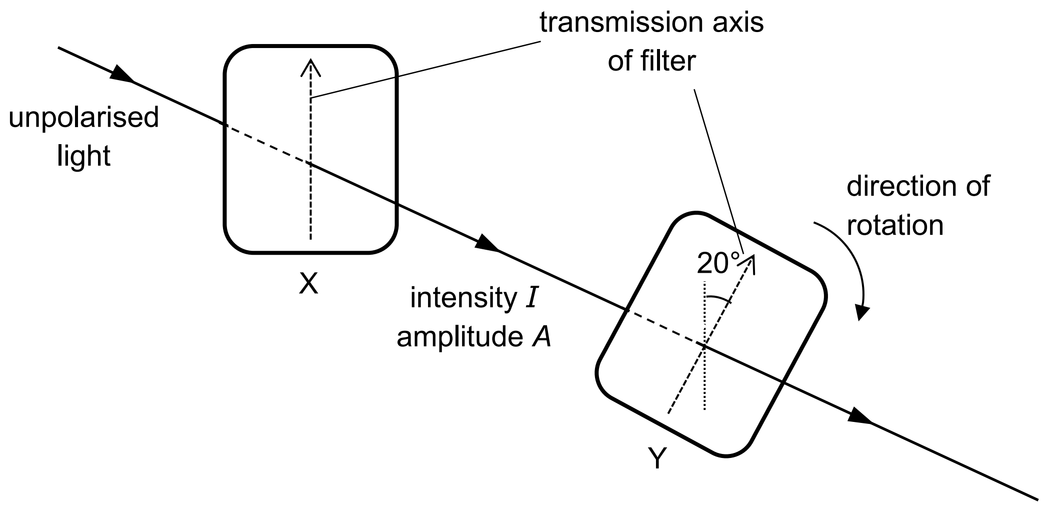


Fig. 4.2

Calculate the minimum angle through which filter Y must be rotated by so that the intensity of the light after passing through polarising filter Y returns to the value that it had when the filter was at its starting position.

angle = ………………………… ° [1]

5 **(a)** State the *principle of superposition*.

....

....

.... [1]

(b) A double slit consists of two parallel slits. The separation of the slits is 1.5 mm.

Coherent light of wavelength 590 nm is incident normally on the double slits as shown in Fig. 5.1. A screen is placed 3.2 m away from the double slit. Fringes are observed on the screen.

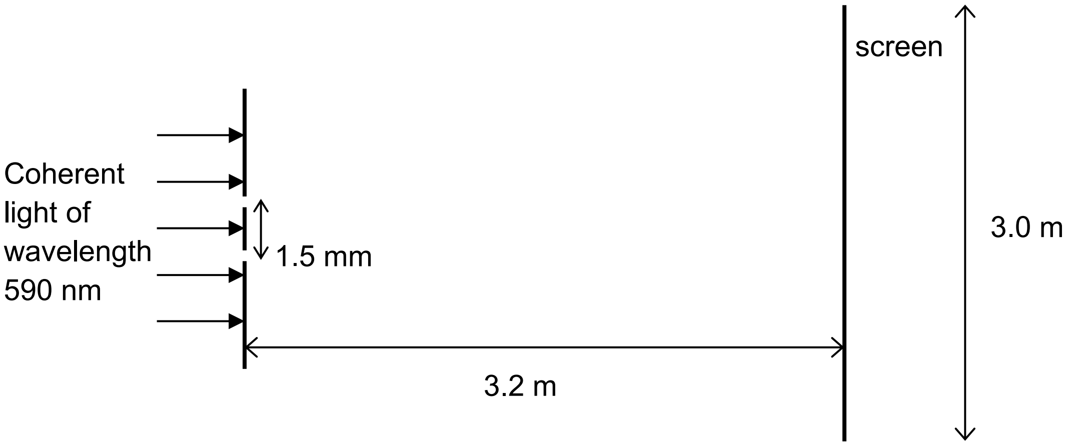


Fig. 5.1 (not to scale)

(i) Calculate the separation between the fringes.

separation = ... m [2]

(ii) The widths of the two slits are then increased while their separation is kept constant. Fringes are no longer observed.

Explain why the fringes are no longer observed.

....

....

.... [2]

(iii) The double slit is now replaced by a diffraction grating having 700 lines per millimetre. The same coherent light is now incident normally on the grating.

The screen is 3.0 m long as shown in Fig. 5.1.

Determine the maximum number of bright fringes that can be seen on the screen.

maximum number of bright fringes = ………………….…. [4]

6 A fixed mass of monatomic ideal gas has an initial volume of 0.075 m^3 at a pressure of 4.5×10^5 Pa and temperature of 60 °C.

(a) Calculate the number of moles of gas present.

number of moles = …………………… mol [2]

(b) The gas is subsequently heated to 150 °C. It expands at constant pressure.

(i) Determine the new volume of the gas.

new volume of gas = …………………….. m^3 [2]

(ii) Calculate the change in internal energy of the gas.

change in internal energy = …………………… J [2]

(iii) Determine the external work done by the gas.

work done by gas = …………………….. J [2]

(iv) Hence, determine the amount of heat supplied to the gas.

heat supplied to gas = …………………….. J [2]

7 Two charged metal spheres A and B of diameter 10 cm and 20 cm respectively, are situated in a vacuum. Their centres are separated by a distance of 50 cm, as shown in Fig. 7.1. x is the distance from the centre of sphere A to any arbitrary point along the line joining the centres of the two spheres.

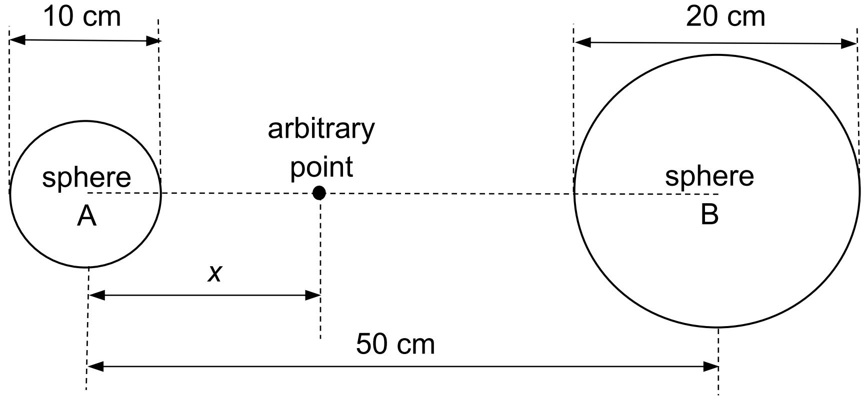


Fig. 7.1 (not to scale)

The variation with x of the electric potential V is shown in Fig. 7.2.

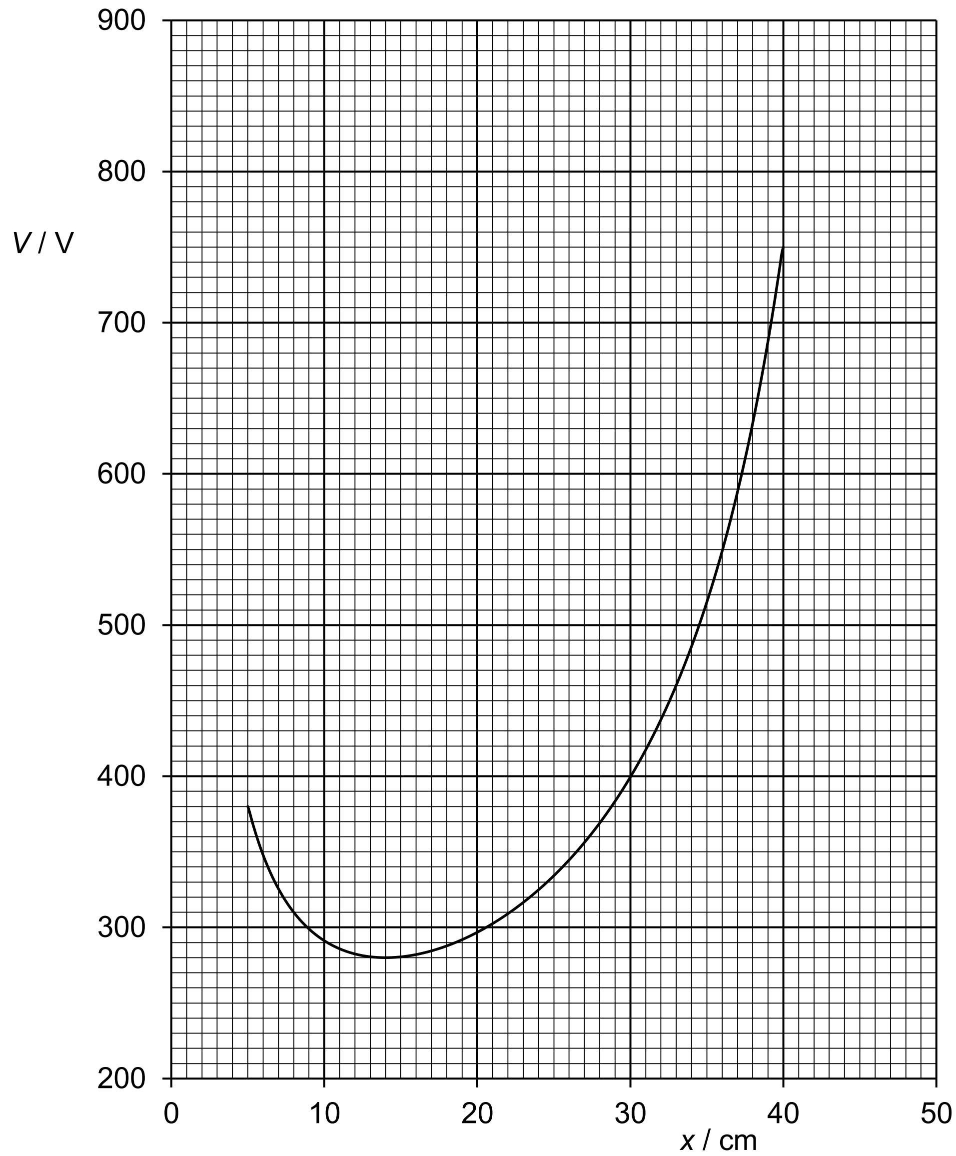


Fig. 7.2

(a) On Fig. 7.2, complete the graph for between x = 0 cm to x = 5.0 cm and between x = 40.0 cm and x = 50.0 cm. [1]

(b) Describe how the resultant electric force on an electron will vary as it is moved from the surface of sphere A to the surface of sphere B, along the line joining their centres.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [3]

(c) State and explain which sphere has a smaller magnitude of charge.

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(d) The charge on each sphere may be considered to be a point charge at its centre. The magnitude of charge of sphere A is 1.2 nC.

Estimate the magnitude of charge of sphere B, leaving your answer in nC.

magnitude of charge = ………………………… nC [2]

(e) An electron is ejected from the surface of sphere A at a speed of 9.7×10^6 m s $^{-1}$. It moves towards sphere B along the line joining the centre of the two spheres.

Determine, with suitable calculations, whether the electron is able to reach the surface of sphere B.

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

……………………………………………………………………………………….................. [3]

Section B

Answer **one** question from this Section in the spaces provided.

8 **(a)** A rigid rectangular metal loop has resistance *R*. It has dimensions *L* and *W*, and moves with a constant speed *v* to the right, as shown in Fig. 8.1.

It enters a region of uniform magnetic field with field strength *B* directed into the page. The region extends a distance of 3*W* in the horizontal direction.

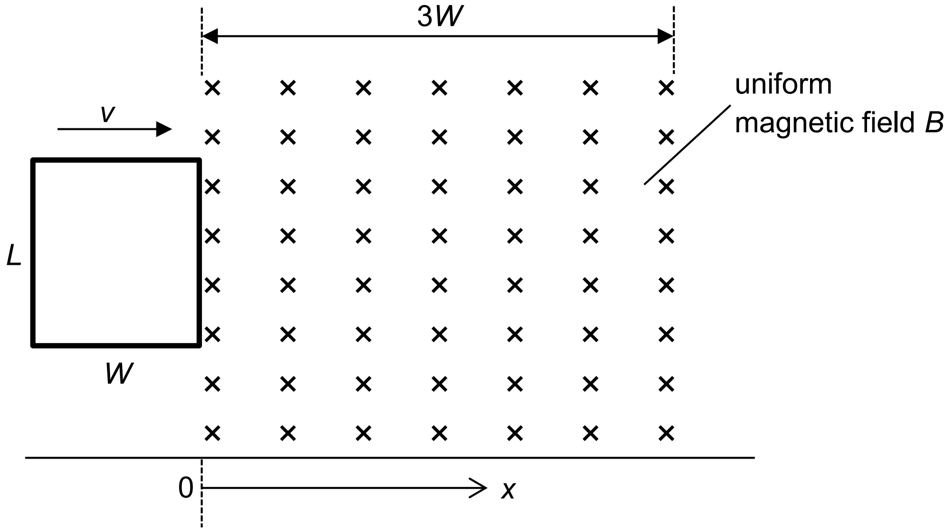
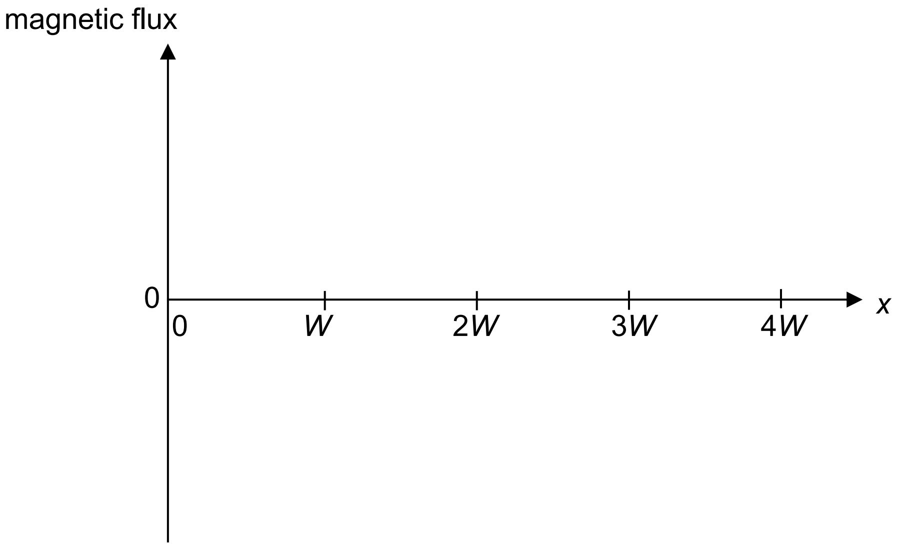


Fig. 8.1

Sketch for the entire duration from the point where the loop enters till it completely leaves the magnetic field,

(i) the variation of the magnetic flux through the loop with horizontal distance *x* from the left edge of the uniform magnetic field.

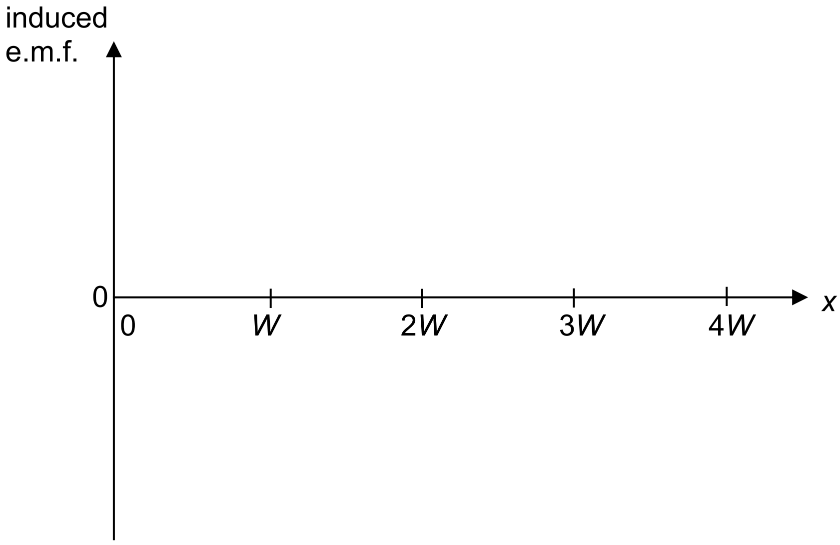
Include in your sketch, an appropriate expression for the maximum magnetic flux, in terms of *B*, *L*, *W*, *v* and *R* where appropriate.



[2]

(ii) the variation of the induced electromotive force (e.m.f.) in the loop with distance *x*.

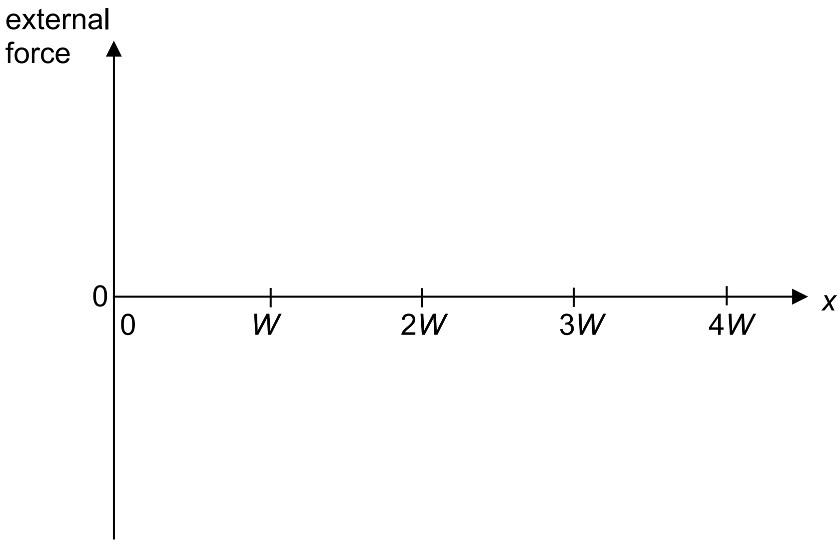
Include in your sketch, an appropriate expression for the maximum induced e.m.f., in terms of *B*, *L*, *W*, *v* and *R* where appropriate.



[2]

(iii) the variation of the external force applied to the loop to keep *v* constant with distance *x*.

Include in your sketch, an appropriate expression for the maximum external force applied, in terms of *B*, *L*, *W*, *v* and *R* where appropriate.



[2]

(b) Fig. 8.2 shows a simple generator where a metal coil rotates at a constant angular velocity about a vertical axis in a uniform magnetic field.

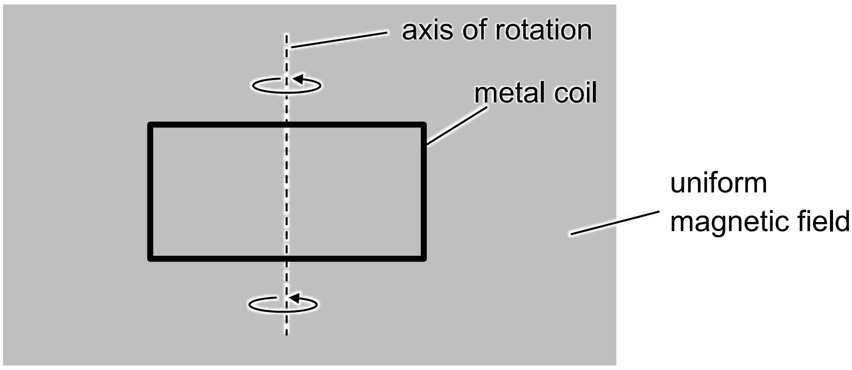


Fig. 8.2

(i) State Faraday's law of electromagnetic induction.

....

.... [2]

(ii) State two factors that affects the magnitude of the maximum induced e.m.f.

....

....

.... [2]

(iii) Explain why the e.m.f. induced is sinusoidal.

....

....

....

....

.... [3]

(c) A rigid metal coil with 50 turns measuring 11.0 cm by 9.0 cm is suspended from a sensitive newton-meter, as shown in Fig. 8.3. The metal coil is initially above a region of uniform magnetic field of flux density *B.*

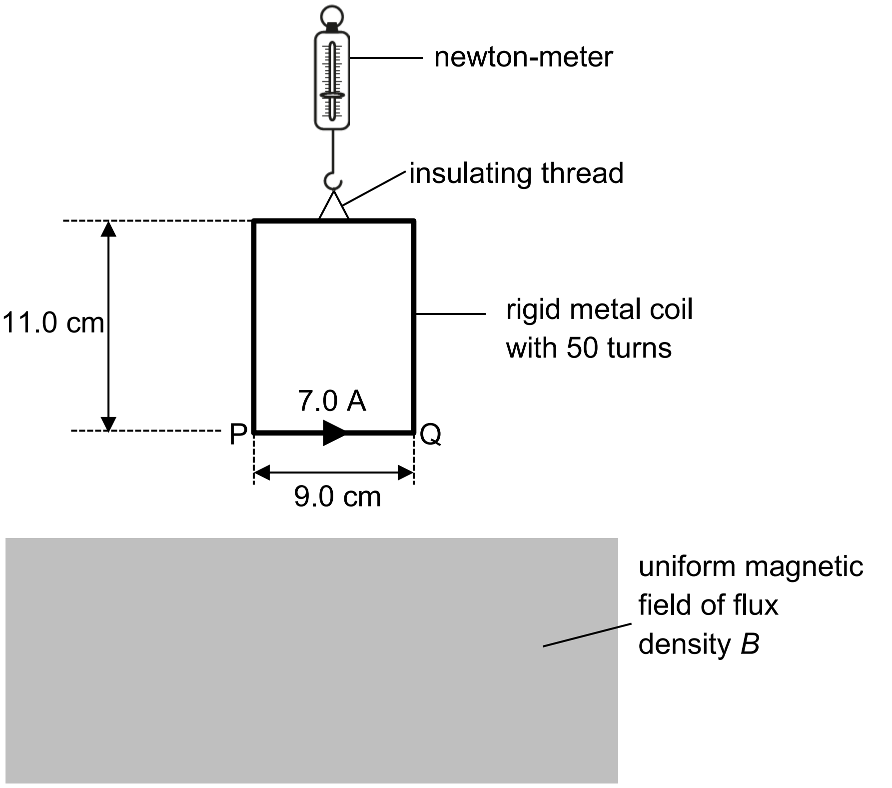


Fig. 8.3

The coil is connected to a power supply so that there is a current of 7.0 A in the direction indicated in Fig. 8.3.

The coil is then slowly lowered at a constant speed into the uniform magnetic field until all of side PQ enters the field. The magnetic field lines are in the horizontal plane and at an angle of 62° to PQ. The top view is shown in Fig. 8.4.

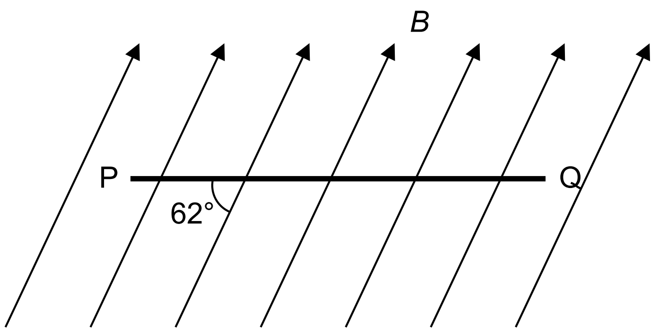


Fig. 8.4 (top view)

When side PQ of the coil first enters the magnetic field, the reading on the newton-meter changes by 0.35 N.

(i) Determine the magnetic flux density *B*.

B = ………………………… T [2]

(ii) State and explain if the change in the reading on the newton-meter is an increase or decrease from its initial value before the coil enters the magnetic field.

……………………………………………………………………………………...

…………………………………………………………………………………. [1]

(iii) The rigid coil is slowly lowered further so that the vertical sides start to enter the magnetic field.

State what additional motion will be observed.

……………………………………………………………………………………...

…………………………………………………………………………………. [1]

(d) An alternating current (a.c.) supply is connected to a laminated iron-cored transformer. The transformer consists of a primary coil of 30 turns and a secondary coil of 600 turns, as shown in Fig. 8.5.

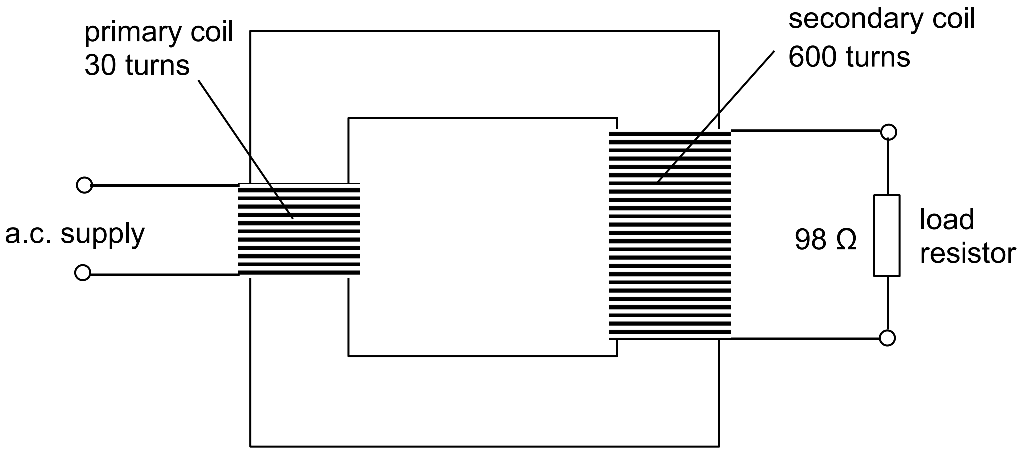


Fig. 8.5

The a.c. supply is a sinusoidal alternating voltage of peak value 102 V. The output from the transformer is connected to a load resistor of resistance 98 Ω.

(i) Suggest why the iron core is laminated.

…………………………………………………………………………………………..

……………………………………………………………………………………. [1]

(ii) Calculate the peak value of the output potential difference.

peak output potential difference = …………………………. V [1]

(iii) Calculate the root-mean-square (r.m.s.) current in the load resistor.

r.m.s. current = …………………………. A [1]

9 **(a)** **(i)** State a *phenomenon* each that demonstrates the particulate nature and wave nature of light.

particulate nature: …………………………………………………………….

wave nature: …………………………………………………………………… [2]

(ii) Explain how the existence of discrete electron energy levels in atoms gives rise to a line emission spectrum.

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

…………………………………………………………………………………………..

…………………………………………………………………………………………..

……………………………………………………………………………………… [2]

(b) To produce electromagnetic radiation in a gas lamp, cool gas atoms in the lamp are excited by bombarding them with energetic electrons.

Fig. 9.1 shows some electron energy levels of an isolated gas atom of such a lamp.

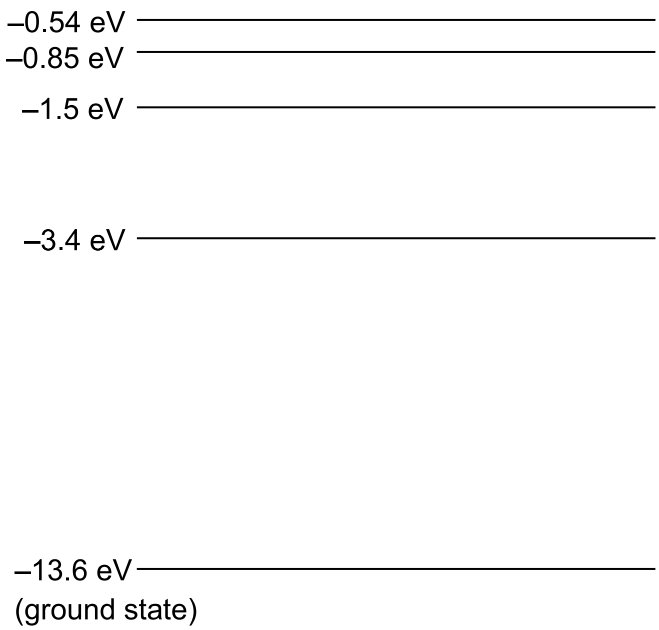


Fig. 9.1

The gas atoms are bombarded by electrons with energy of 12.8 eV, resulting in photons of different energies being emitted.

(i) On Fig. 9.1, draw clearly all the possible transitions which lead to the emission of photons.

[2]

(ii) Show that lowest wavelength of the photons emitted is 9.8×10^{-8} m.

[2]

(c) The electromagnetic radiation emitted from the gas lamp in **(b)** is now incident on metal Z used in a photoelectric experiment.

Fig. 9.2 shows the setup of the photoelectric experiment.

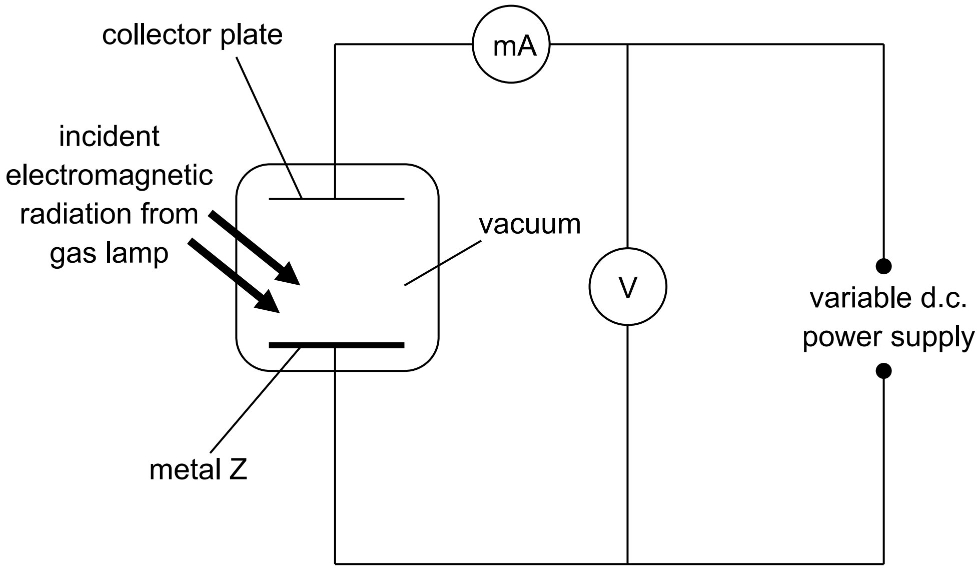


Fig. 9.2

The potential of the collector plate is varied gradually from positive to negative with respect to metal Z.

The variation of the current I with the potential difference V is shown in Fig. 9.3.

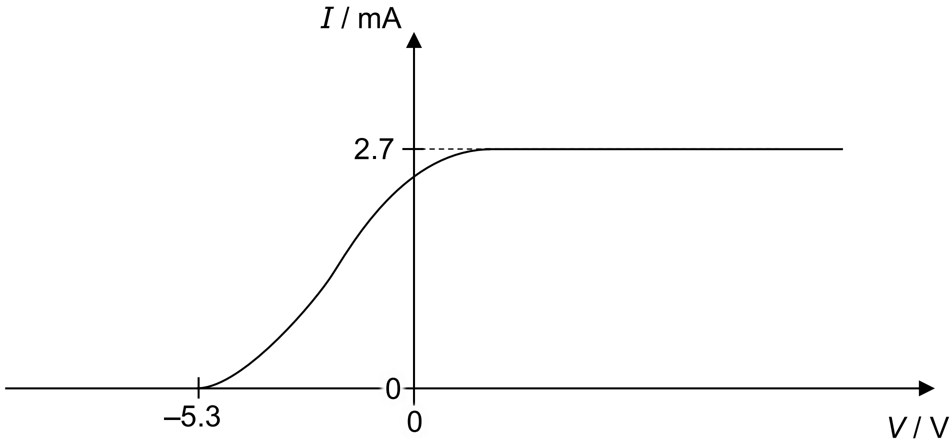


Fig. 9.3

(i) Explain why I decreases gradually as the potential of the collector plate is made more and more negative with respect to metal Z.

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………… [2]

(ii) Calculate the maximum rate of emission of photoelectrons.

rate of emission = ……………….…………… s^{-1} [2]

(iii) Show that the work function energy of metal Z is 1.2×10^{-18} J.

work function energy = ……………….…………… J [2]

(iv) Hence, calculate the threshold wavelength of metal Z, leaving your answer in nm.

threshold wavelength = ……………….…………… nm [1]

(v) The gas lamp is now replaced with a new electromagnetic radiation source, and the experiment is repeated.

Graph R in Fig. 9.4 shows the results of the new experiment.

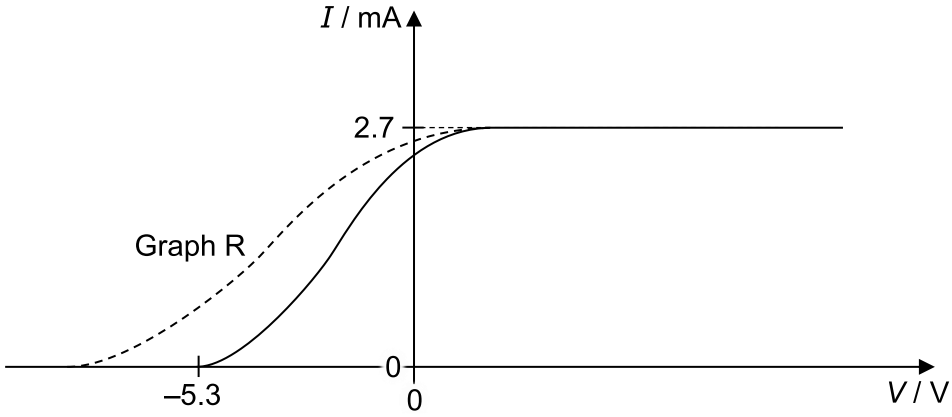


Fig. 9.4

State and explain one difference between this new electromagnetic radiation source and the gas lamp.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………… [2]

(vi) Photoelectric effect is applied in the manufacture of light meters.

Light meters are typically used by photographers to check the intensity of ambient visible light so that they can make adjustments before taking any photographs.

Explain briefly how photoelectric effect is used for such a purpose in a light meter.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………… [2]

(vii) Using your answer in **(iv)**, explain why metal Z is not suitable to be used in the manufacture of light meters.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………… [1]

End of paper

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