BP~797

Class	Adm No

Candidate Name: ______________________________

2024 Preliminary Examination
Pre-University 3

H2 PHYSICS

9749/03

Paper 3 Longer Structured Questions

Section A Booklet

16 September

Candidates answer on the Question Paper.

2 hours

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Do not turn over this page until you are told to do so.

Write your full name, class and Adm number in the spaces at the top of this page.

Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams, graphs or rough working.
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.

You are advised to spend one and half hours on Section A and half an hour on Section B.

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

For Examiner's Use		
Section A		
1		**/ 10**
2		**/ 10**
3		**/ 10**
4		**/ 11**
5		**/ 9**
6		**/ 10**
Section B		
7		**/ 20**
8		**/ 20**
Presentation (overall)		
P3 Total		**/80**

Data

speed of light in free space	$c = 3.00 \times 10^{8}\,\mathrm{m\,s^{-1}}$
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}\,\mathrm{H\,m^{-1}}$
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}\,\mathrm{F\,m^{-1}}$
	$(1/(36\pi)) \times 10^{-9}\,\mathrm{F\,m^{-1}}$
elementary charge	$e = 1.60 \times 10^{-19}\,\mathrm{C}$
the Planck constant	$h = 6.63 \times 10^{-34}\,\mathrm{J\,s}$
unified atomic mass constant	$u = 1.66 \times 10^{-27}\,\mathrm{kg}$
rest mass of electron	$m_e = 9.11 \times 10^{-31}\,\mathrm{kg}$
rest mass of proton	$m_p = 1.67 \times 10^{-27}\,\mathrm{kg}$
molar gas constant	$R = 8.31\,\mathrm{J\,K^{-1}\,mol^{-1}}$
the Avogadro constant	$N_A = 6.02 \times 10^{23}\,\mathrm{mol^{-1}}$
the Boltzmann constant	$k = 1.38 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
gravitational constant	$G = 6.67 \times 10^{-11}\,\mathrm{N\,m^{2}\,kg^{-2}}$
acceleration of free fall	$g = 9.81\,\mathrm{m\,s^{-2}}$

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	$p = \rho gh$
gravitational potential	$\phi = -Gm/r$
temperature	$T/\text{K} = T/°\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.	$x = x_0 \sin\omega t$
velocity of particle in s.h.m.	$v = v_0 \cos\omega t$ $= \pm\,\omega\sqrt{x_0^2 - x^2}$
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	$x = x_0 \sin\omega t$
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	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Section A
Answer **all** the questions in the spaces provided.

1 (a) A bar magnet is suspended from a helical spring and one end of the magnet is situated in a coil of wire, as shown in Fig. 1.1. The coil is connected in series with a switch and a resistor. The switch is opened.

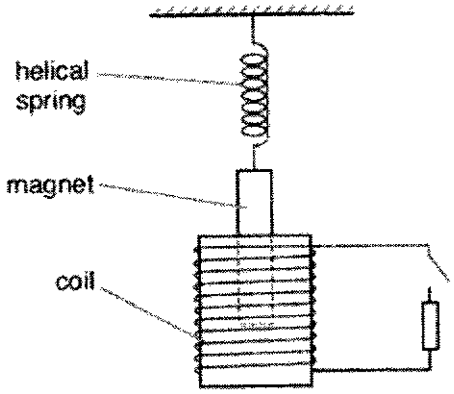


Fig. 1.1

The bar magnet is displaced vertically and then released. As the magnet passes through its rest position, a timer is started. The variation with time t of the vertical displacement of the magnet from its rest position is shown in Fig. 1.2. At t = 4.0 s, the switch is closed.

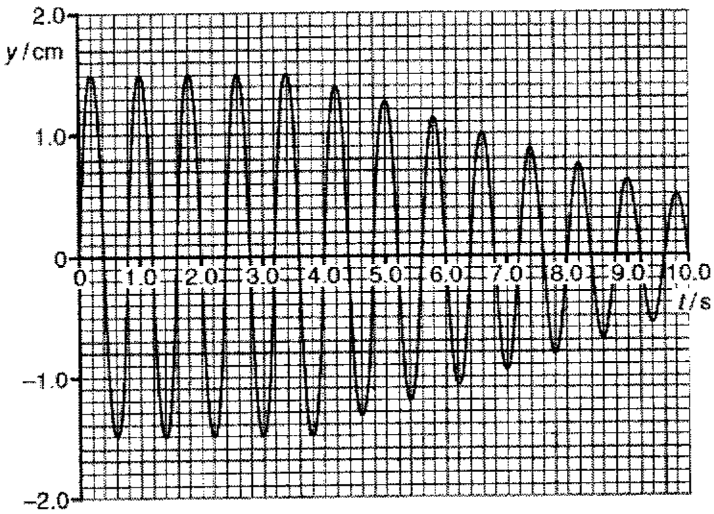


Fig. 1.2

(i) Use Fig. 1.2 to determine the frequency of oscillation of the magnet.

frequency = ... Hz [2]

(ii) State Faraday's Law of electromagnetic induction.

....

.... [1]

(iii) Use the laws of electromagnetic induction to explain why the amplitude of oscillation decreases after the switch is closed.

....

....

....

....

....

....

....

....

.... [4]

(b) The set-up in **(a)** is modified by suspending the magnet above the coil and adding an alternating voltage supply source in series with the coil and resistor, as shown in Fig.1.3. The frequency of the voltage source is set at 0.50 Hz. The magnet was at rest initially and starts oscillating when the switch is closed.

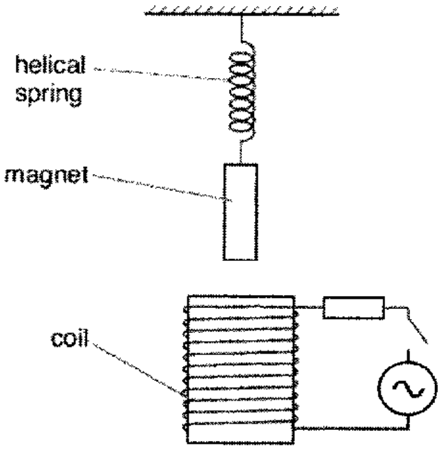


Fig. 1.3

(i) State the frequency of oscillation of the magnet.

frequency of oscillation = ... Hz [1]

(ii) The frequency of the voltage source is gradually increased to 5.0 Hz. State and explain what will be observed about the amplitude of oscillations of the magnet.

....

....

....

.... [2]

[Total: 10]

2 **(a)** Point source P, consisting of light with wavelength 630 nm, passes through a narrow slit and is incident on a screen at a distance of 2.4 m from the slit. Fig. 2.1 below shows the variation of intensity I of the light on the screen with distance x along the screen.

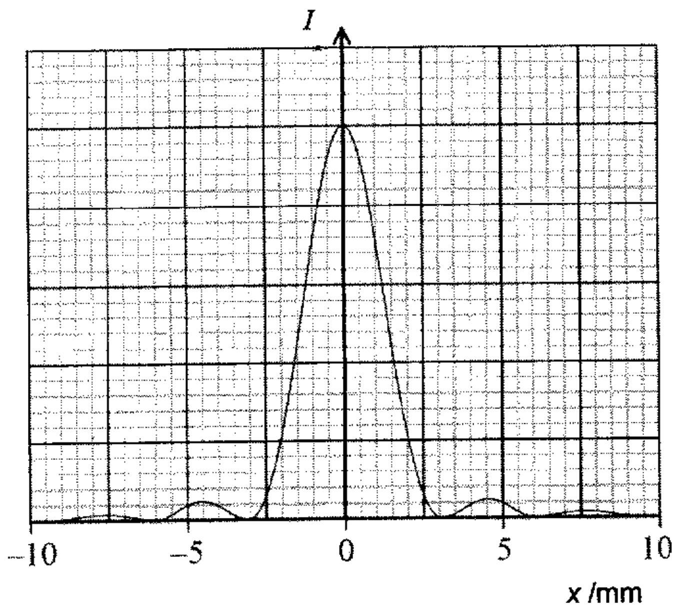


Fig. 2.1

(i) Use Fig. 2.1 to determine the width of the slit.

width = ... mm [2]

(ii) State the effect on the pattern on the screen in terms of width and intensity of central maximum if each of the following changes is made separately:

1. the width of the single slit is reduced,

....

....[2]

2. the red source is replaced with another source of violet light of the same intensity.

....

....[2]

(b) Light of wavelength 633 nm from a laser is directed normally at a diffraction grating, as illustrated in Fig. 2.2.

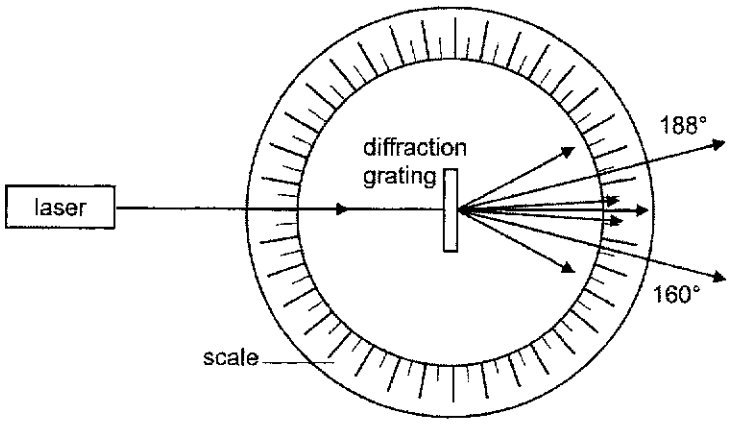


Fig. 2.2

The diffraction grating is situated at the centre of a circular scale, marked in degrees. The readings on the scale for the second order diffracted beams are 160° and 188°.

Calculate the number of lines per unit length of the slits in the diffraction grating.

number of lines per unit length = ... m^{-1} [4]

[Total: 10]

[Turn over

3 (a) Define *electric potential.*

....

....[1]

(b) Fig. 3.1 shows a square ABCD of sides 2.0 cm. Three negative point charges of −1.2 μC are fixed at B, C and D.

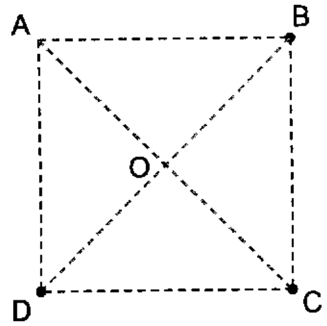


Fig. 3.1

(i) On Fig. 3.1, draw and label each of the forces acting on the charge at C due to the charges at B and D.

[1]

(ii) Determine the magnitude and direction of the resultant force acting on the charge at C due to the charges at B and D.

magnitude = ...N

direction = ... [3]

(iii) Determine the electric potential at the centre of the square, O, due to the three charges at B, C and D.

electric potential = ...V [3]

(iv) Determine the work done in bringing a positive charge of 1.2 μC from 100 m away to the centre of the square.

work done = ... J [2]

[Total: 10]

4 **(a)** State two ways to increase the magnetic field strength of a solenoid.

....

....

....[2]

(b) The magnetic flux density in a solenoid is measured using a current balance. The current balance is a U-shaped piece of stiff wire ABCDEF pivoted at BE, as shown in Fig. 4.1.

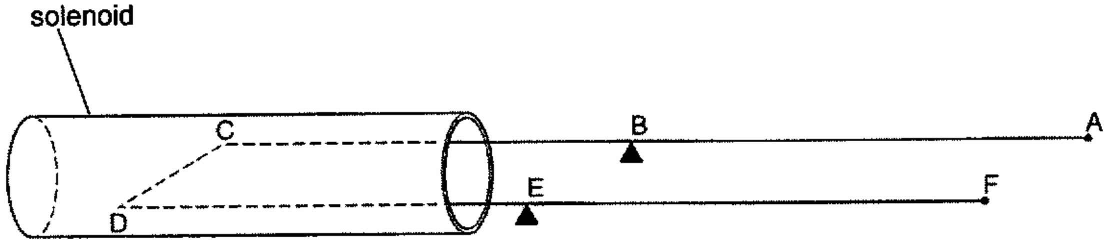


Fig. 4.1

When in use, there is a turning force on the stiff wire caused by a current in CD. CD has length 25 mm, CB and DE each have length 106 mm.

The stiff wire is first balanced when there is no current in it. A current of 4.9 A is then passed through CD and, in order to rebalance the stiff wire, a force of 5.7×10^{-4} N is applied at a distance of 77 mm from the pivot, as shown in Fig. 4.2. which is the side view of the balance.

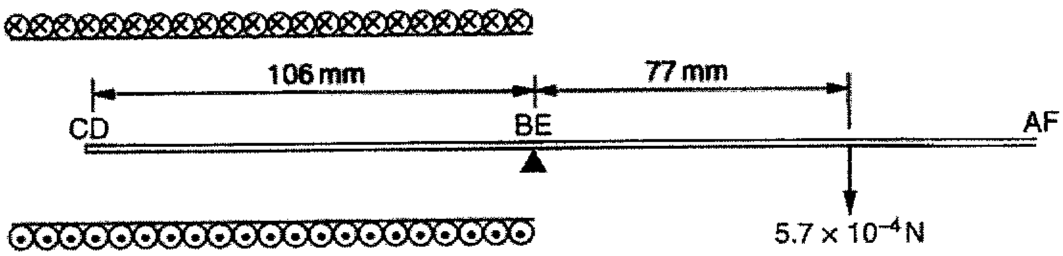


Fig. 4.2 (side view)

(i) On Fig. 4.1, indicate the direction of the current in CD. [1]

(ii) Calculate the magnetic flux density in the solenoid.

magnetic flux density = ...

full name of unit = ... [4]

(c) Fig. 4.3 shows a rectangular coil placed at the centre of a solenoid with its plane perpendicular to the axis of the solenoid.

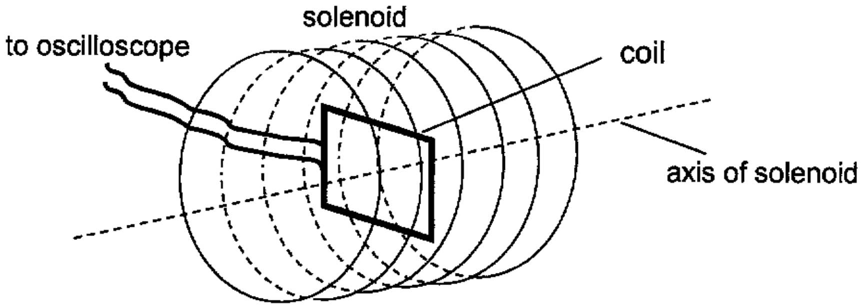


Fig. 4.3

The solenoid has 400 turns, a cross-sectional area of 0.0050 m^2 and a length of 50 cm. An alternating current of 50 Hz is passed through the solenoid. The rectangular coil has nine turns with dimensions of 0.010 m by 0.018 m. The ends of the coil are connected to a cathode ray oscilloscope.

Fig. 4.4 shows the variation with time of the current through the solenoid.

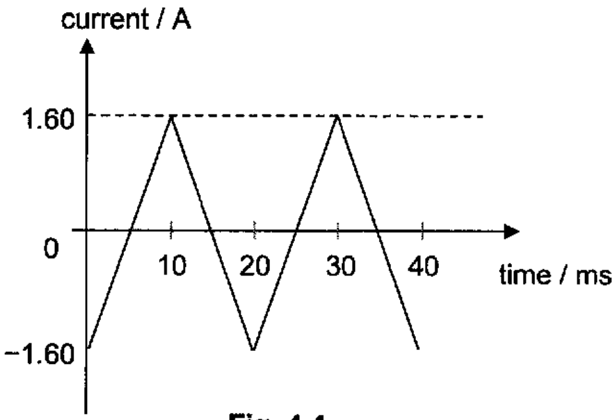


Fig. 4.4

(i) The flux density of the solenoid is given by $B = \mu_o nI$, where μ_o is the permeability of free space, n is the number of turns per unit length of the solenoid and I is the current through the solenoid.

Determine the magnitude of the e.m.f. induced in the coil.

e.m.f. = ... V [2]

[Turn over

(ii) On Fig. 4.5, sketch a labelled graph to show the variation with time of the induced e.m.f. in the coil over two cycles of current change.

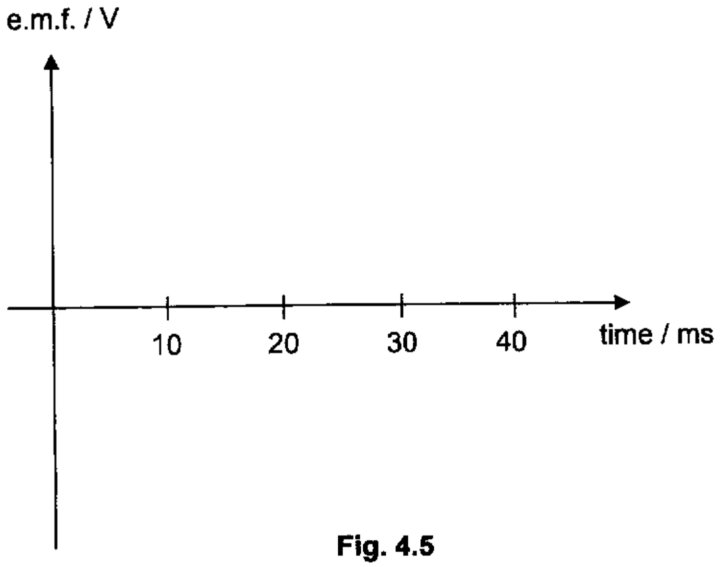


Fig. 4.5

[2]

[Total: 11]

5 (a) Two resistors and two ideal diodes are connected to an AC supply as shown in Fig. 5.1. Ideal diodes have zero resistance when forward-biased and infinite resistance when reverse-biased.

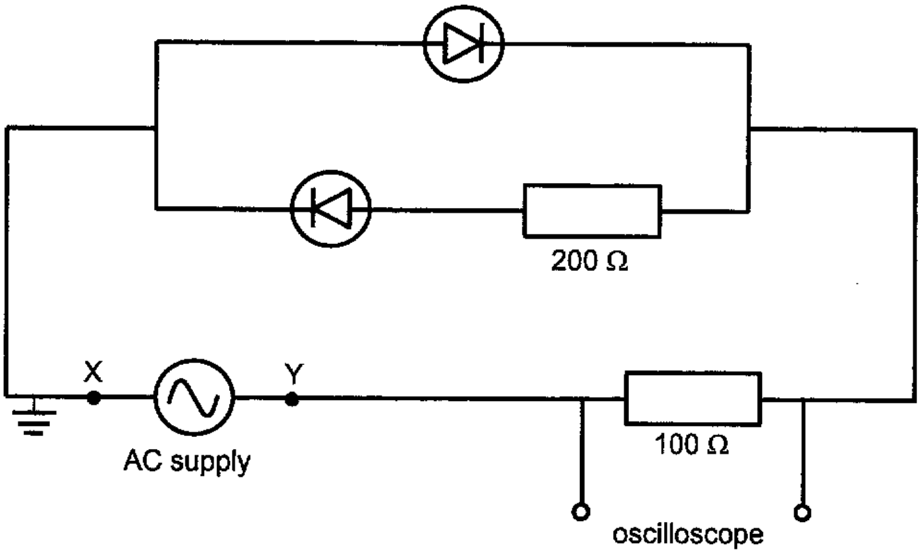


Fig. 5.1

Fig. 5.2 shows the variation with time of the potential of the AC supply at point Y.

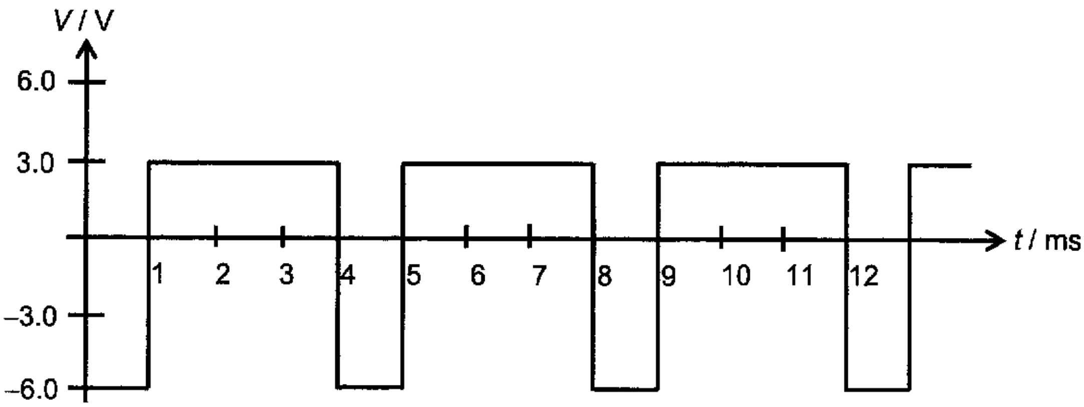
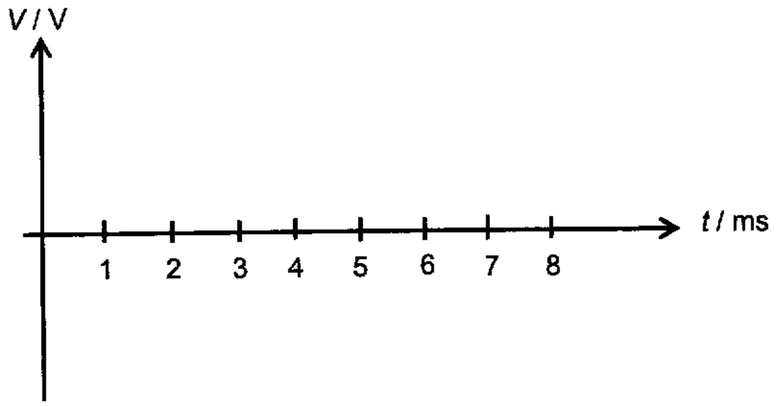


Fig. 5.2

(i) Determine the root-mean-square voltage of the AC supply.

root-mean-square voltage = ... V [2]

(ii) Sketch the variation with time of the voltage across the 100 Ω resistor for the first 8 seconds using the axes below.



[2]

(b) A transmission line that has a resistance per unit length of $4.50 \times 10^{-4}\ \Omega m^{-1}$ is to be used to transmit 5.00MW over 6.44×10^{5} m. The output voltage of the generator is 4.50 kV.

(i) A transformer is used to step up the voltage to 500 kV before transmission of power. Determine the turns ratio of the transformer.

turns ratio = ... [1]

(ii) Determine the power loss during transmission.

power loss = ... W [3]

(iii) Explain the advantage to step up the voltage before transmission of power.

....

.... [1]

[Total: 9]

6 (a) The wave properties of electrons can be demonstrated using electron diffraction. The arrangement used includes a parallel beam of electrons accelerated by a potential difference in a glass envelope as shown in Fig. 6.1. A graphite film is placed perpendicularly to the path of the electron beam.

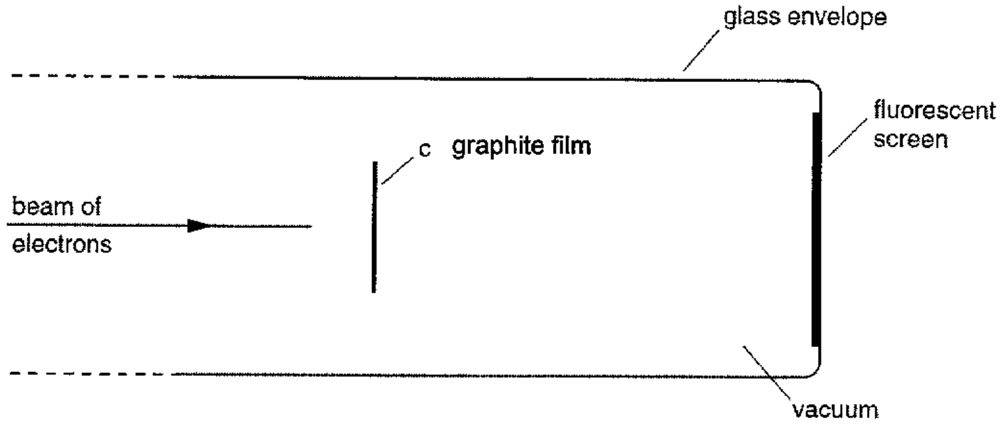


Fig. 6.1

The electrons incident on a fluorescent screen created a pattern consisting of bright and dark rings, as shown in Fig. 6.2.

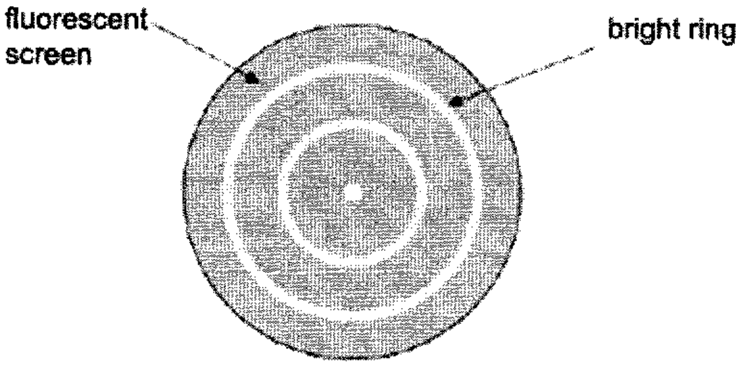


Fig. 6.2

(i) Identify two key features in Fig. 6.2 and explain how they provide evidence for the wave nature of electrons.

....

....

....

....

.... [2]

(ii) Electrons of mass m are accelerated in a vacuum through a potential difference V.

1. Show that the associated wavelength λ of the electrons can be expressed as

$$\lambda = \frac{h}{\sqrt{2meV}}.$$

[2]

2. Hence, calculate the wavelength λ of the electrons, if $V = 250$ V.

λ = ... m [2]

(iii) Describe and explain how the observed pattern in Fig. 6.2 changes as the potential difference V is increased.

....

....

....

....

....[2]

(b) The wave properties of matter do not seem to affect us noticeably in everyday life.

When a 80 kg man walks in a straight line at 2.0 m s^{-1} and passes through a doorway of width 1.2 m, he is not obviously deflected from his path.

Show, using Heisenberg's Uncertainty Principle and some appropriate workings, that the deflection of the man is negligible. You may take the width of the doorway as the uncertainty in position of the man.

....

....

.... [2]

[Total: 10]

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Candidate Name: ______________________

Class	Adm No

H

millennia institute

2024 Preliminary Examination
Pre-University 3

H2 PHYSICS **9749/03**

Paper 3 Longer Structured Question

Section B Booklet **16 September**

Candidates answer on the Question Paper. **2 hours**

No Additional Materials are required.

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The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.

Section B
Answer **one** question only. **Circle** the question number on the cover page

You are advised to spend one and half hours on Section A and half an hour on Section B.

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

For Examiner's Use		
Section B (Circle 1 question)		
7		**/ 20**
8		**/ 20**
Presentation		

Section B
Answer **ONE** question from this Section in the spaces provided.

7 **(a)** Explain what are meant by the *moment of a force* and the *torque of a couple*. Distinguish between the two terms.

....

....

....

....

....

.... [3]

(b) One type of weighing machine, known as a steelyard, is illustrated in Fig. 7.1

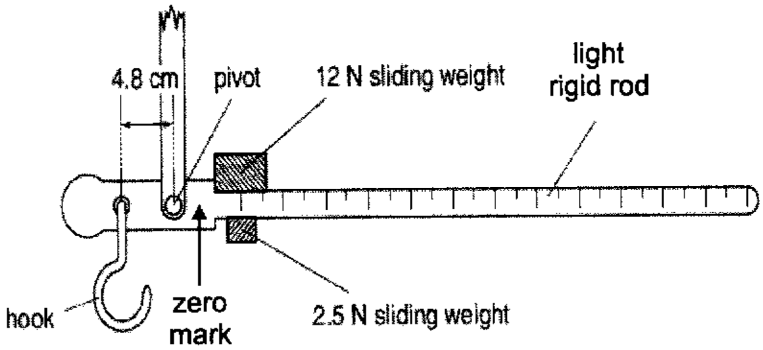

Fig. 7.1

The 12 N and 2.5 N sliding weights can be moved independently along the light rigid rod.

With no load on the hook and the sliding weights at the zero mark on the rigid rod, the rod is horizontal. The hook is 4.8 cm from the pivot.

(i) Explain why the light rigid rod can remain horizontal with no load on the hook.

....

....

....[1]

(ii) Explain why the perpendicular distance from the hook to the pivot is deliberately kept shorter compared to the length of the rigid rod.

....

....

....

.... [2]

(iii) A sack of flour is suspended from the hook. In order to return the light rigid rod to the horizontal position, the 12 N sliding weight is moved 84 cm along the rod and the 2.5 N sliding weight is moved 72 cm.

Calculate the mass of the sack of flour.

mass= ....kg [2]

(iv) Explain why this steelyard would be less accurate when weighing objects with a weight of about 25 N.

....

....

....[2]

(c) (i) By referring to work done being the product of force and the displacement in the direction of the force, derive the formula $E_p = mgh$ for potential energy changes near the Earth's surface.

[3]

(ii) A typical escalator rises at an angle of 30° to the horizontal. It lifts people through a vertical height of 15 m in 0.50 minute. Assuming all the users stand still while on the escalator, 60 users can get on at the bottom and get off at the top in 0.50 minute. The average mass of a user is 55 kg.

1. Determine the average power needed to lift the users when the escalator is fully laden.

   Assume that any kinetic energy transferred to the users by the escalator is negligible.

average power = ...W [2]

2. The frictional force in the escalator system is 1.0×10^4 N when the escalator is fully laden.

   Calculate the power to overcome friction.

power = ...W [3]

3. When there are 60 users walking up the moving escalator, instead of standing still, at any point in time, explain whether more or less power is required by the motor to maintain the escalator at the same speed.

....

....

....

....[2]

[Total: 20]

8 **(a)** Radioactive decay is a random and spontaneous process. The stationary radioactive isotope Plutonium-238 $\left({}^{238}_{94}Pu\right)$ decays by emitting an alpha particle.

The daughter nucleus is an isotope of Uranium. The mass of ${}^{238}_{94}Pu$ is 238.0496 u and the mass of an α-particle is 4.0026 u.

(i) Explain what is meant by a spontaneous process.

....

....

....[2]

(ii) Write down an equation representing the decay, indicating clearly the atomic number and mass number of each nucleus.

....[2]

(iii) Given that the total kinetic energy of the products is 5.649 MeV, calculate,

1. in terms of atomic mass units, the mass of the uranium nucleus formed in the reaction,

mass of uranium nucleus = ...u [3]

2. the ratio of the kinetic energy of the α-particle to that of the uranium nucleus formed,

ratio = ... [3]

[Turn over

3. the kinetic energy of the α-particle, in MeV.

kinetic energy of α-particle = ...MeV [2]

(b) Fig. 8.1 shows a simple experiment set up by a student to estimate the activity of a radioactive source. The source emits α, β and γ-radiation particles and is placed 10 cm from a detector that is connected to a counter.

The detector is capable of detecting all types of radioactive emissions.

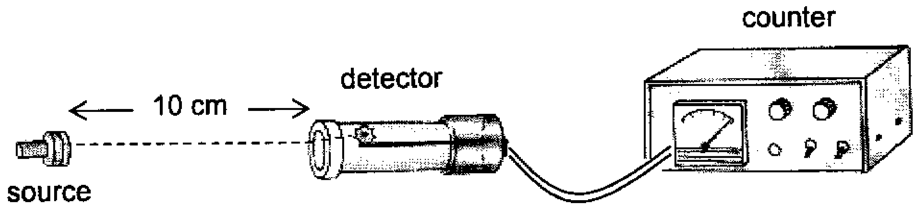

Fig. 8.1

(i) Distinguish between α and γ-radiation in terms of their relative ionizing strength and penetrating abilities.

....

....

....

....[2]

(ii) Explain whether emission of α-particles will be detected in the above set-up.

....

....[1]

(iii) Without the source, the counter gives a count-rate of 600 min^{-1}. When the source is placed 10 cm in front of the detector, the following count rates are observed at two different times, *t*.

t / hour	Count-rate / min^{-1}
0	7009
6.0	1401

Calculate the half life of the source.

half-life = ... hours [3]

(iv) State two effects of ionizing radiation on living tissues and cells.

....

....

....

....

....[2]

[Total: 20]

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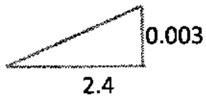
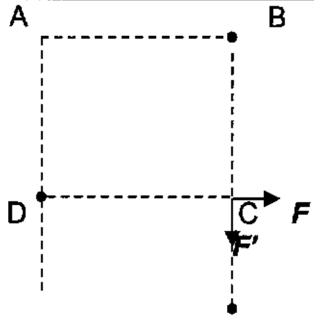
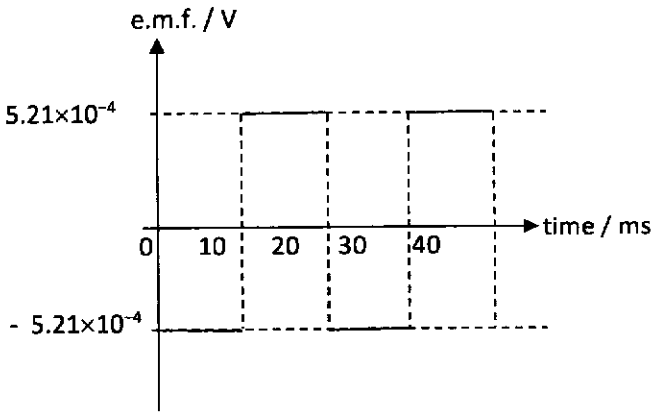
2024 PU3 Preliminary Examinations H2 Physics Paper 3 Suggested Answers

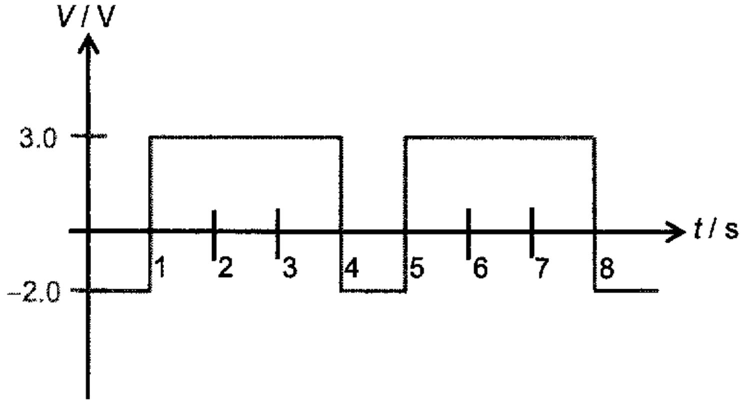
<u>Section A</u>

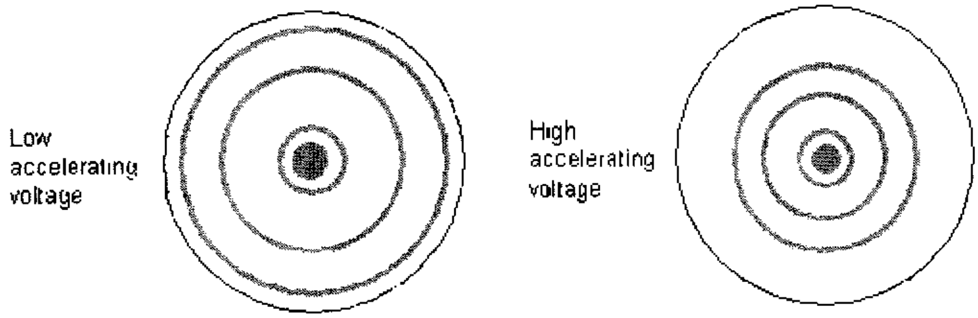
1	**(a)(i)**	Period = 0.80 s Frequency = 1/T = 1/0.80 = 1.25 Hz	**C1** **A1**
	(a)(ii)	Magnitude of induced emf is proportional to the rate of change of flux linkage	**A1**
	(a)(iii)	1. As magnet oscillates in the coil, the flux linkage with the coil changes and emf is induced in the coil, from Faraday's Law. 2. This causes an induced current to flow when the switch is closed. 3. The oscillating system loses energy as there is heat loss in the resistor. 4. Since energy of the system is proportional to the square of amplitude, amplitude decreases. OR 3. From Lenz Law, the flow of induced current produces a magnetic field which results in a force opposing the motion of the magnet. [B1] 4. The maximum resultant force on the magnet decreases and since amplitude is proportional to the maximum resultant force, amplitude decreases. [B1]	**B1** **B1** **B1** **B1** **OR** **B1** **B1**
	(b)(i)	0.50 Hz	**A1**
	(b)(ii)	Amplitude increases then decreases Amplitude is maximum at 1.25 Hz when resonance occurs. (Amplitude of oscillation increases as freq increases from 0.5 Hz to 1.25 Hz. At 1.25 Hz, resonance occurs. As frequency increases beyond 1.25 Hz to 5.0 Hz, the maximum amplitude decreases)	**B1** **B1**

2	**(a)(i)**	Single slit: $\sin\theta = \lambda/b$ using small angle approximation $\sin\theta \approx \tan\theta$  $sin\theta = \frac{0.003}{2.4} = \frac{\lambda}{b}$ (Accept 0.0325) $b = 5.04 \times 10^{-4}\ m$ (accept 4.65×10^{-4}m)	**C1** **A1**
	(a)(ii)1.	(When B decreases↓ , then sinθ increases ↑, and hence θ increases↑, therefore) this results in <u>increase in width of central maximum</u> and the maxima are further apart. The central maximum is also <u>lower in intensity</u>.	**B1** **B1**
	(a)(ii)2.	(When wavelength λ decreases↓, sinθ decreases↓, and hence θ decreases↓) Therefore there is <u>reduced width of central maximum</u> and the maxima are closer. <u>Intensity of the central maximum is unchanged</u> (bright and dark regions)	**B1** **B1**
	(b)(i)	$\theta = \frac{1}{2}(188 - 160) = 14°$ $d\sin\theta = n\lambda \rightarrow d\sin(14°) = 2(633 \times 10^{-9})$ $d = 5.23 \times 10^{-6}$ m $d = \frac{1}{N} \rightarrow N = \frac{1}{d} = 1.91 \times 10^{5}$	**C1** **M1** **C1** **A1**

3	(a)	Electric potential at a point is the work done per unit positive charge in bringing a charge from infinity to that point.	B1
	(b)(i)	 Two arrows of equal length, correct direction with labels (i.e. Force on C by B, Force on C by D) – 1 Mark	B1
	(b)(ii)	$F = \frac{Q^2}{4\pi\varepsilon_o r^2} = (9 \times 10^9)\frac{(1.2\times10^{-6})^2}{(2.0\times10^{-2})^2} = 32.4$ N	C1
		Resultant force = $\sqrt{(F^2 + F^2)} = F\sqrt{2} = 32.4\sqrt{2} =$ **45.8 N**	A1
		Direction: Along A to C (ecf (i))	A1
	(b)(iii)	Distance from corner to centre, $r = \sqrt{2}$ cm	C1
		$V = \frac{Q}{4\pi\varepsilon_o r} = (9 \times 10^9)\frac{-1.2\times10^{-6}}{\sqrt{2}\times10^{-2}} = -7.64 \times 10^5$ V	C1
		Electric potential due to the three charges = $3V = 3\,(-7.64 \times 10^5)$ $= \mathbf{-2.29 \times 10^6}$ **V**	A1
	(b)(iv)	*At 100m away, potential due to the 3 charges is negligible*	
		$W = q\Delta V = (1.2 \times 10^{-6})(-2.29 \times 10^6 - 0)$	C1
		$=$ **−2.75 J**	A1

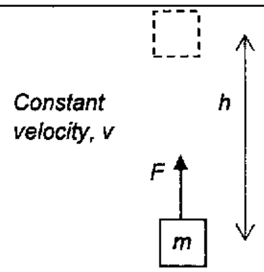
4	(a)	Any of 2 of the following: Increase current flowing through the solenoid Increase the number of turns per unit length in the solenoid Insert a ferrous core into the solenoid	 **B1** **B1** **B1** **(Max 2)**
	(b)(i)	C to D	**B1**
	(b)(ii)	By POM, F x 0.106 = 5.7x10^{-4} x 0.077 And F = BIL = B(4.9)(0.025) B = 3.38 x 10^{-3} T Tesla	 **C1** **C1** **A1** **B1**
	(c)(i)	$E = \left\| -\frac{d\Phi}{dt} \right\|$ $= \frac{d(NBA)}{dt}$ $= NA\frac{dB}{dt}$ $= NA\frac{d(\mu_o nI)}{dt}$ $= NA\mu_o n\frac{dI}{dt}$ $= (9)(0.010 \times 0.018)(4\pi \times 10^{-7})(\frac{400}{0.50})(\frac{3.2}{10 \times 10^{-3}})$ $= 5.21 \times 10^{-4}$ V	**C1** **A1**
	(c)(ii)	 Horizontal lie of constant e.m.f. with correct values (allow for e.c.f.) Correct sign of V	 **B1** **B1**

5	**(a)(i)**	$\langle V^2 \rangle = [(3^2 \times 3) + (6^2 \times 1)] / 4$ $= 15.75\ V^2$ $V_{rms} = (15.75)^{0.5}$ $= 4.0\ V$	 **C1** **A1**
	(a)(ii)	 Shape (not rectified) with correct period – 1m Correct values either (3.0 V, -2.0 V) Or (-6.0 V, 1.0 V) – 1m	**B1** **B1**
	(b)(i)	Turns ratio = 4.50 :500 = 9:1000 = 0.009 (allow for 500:4.50 = 111)	**A1**
	(b)(ii)	transmission line resistance = $6.44 \times 10^5 \times 4.50 \times 10^{-4} = 289.8\ \Omega$ Given the voltage is stepped up to 500 kV at the output of the transformer, The current flowing in the tx line = $5 \times 10^6 / 500 \times 10^3 = 10$ A Power loss = $10^2(289.8)$ = $\underline{2.9 \times 10^4\ W}$	**C1** **C1** **A1**
	(b)(iii)	By stepping up the voltage, the current in the transmission line will be lowered and hence the amount of power loss in the transmission line will be lowered.	**A1**

6	(a)(i)	The spread of the electron beam to form bright rings due to diffraction, The presence of dark regions between bright rings indicate that destructive interference is taking place	B1 B1
	(a)(ii)1.	$KE = eV = p^2/2m$ $\lambda = \frac{h}{p}$ $= \frac{h}{\sqrt{2meV}}$	M1 M1 A0
	(a)(ii)2.	$\lambda = \frac{h}{\sqrt{2meV}}$ $= \frac{6.63\times10^{-34}}{\sqrt{2(9.11\times10^{-31})(1.60\times10^{-19})(250)}}$ $= 7.77 \times 10^{-12}$ m	 C1 A1
	(a)(iii)	As potential difference V increases, the de Broglie wavelength decreases since $\lambda \, \alpha \frac{1}{\sqrt{V}}$. Since $d\sin\theta = n\lambda$, the angles at which the maxima are produced decrease. The rings become smaller/closer together.  	B1 B1
	(b)	$\Delta p \, \Delta x \gtrsim h$ $\Delta p \, (1.2) \gtrsim 6.63 \times 10^{-34}$ $\Delta p \gtrsim 5.53 \times 10^{-34}$ kg m s^{-1} p = 80 x 2.0 = 160 kg m s^{-1} Hence, the uncertainty in his momentum is negligible as compared to his linear momentum. OR $\tan\theta = \frac{\Delta p}{p} = \frac{5.53\times10^{-34}}{160} = 3.46\times10^{-36} \approx 0$ Hence, the angle of deflection is negligible.	 M1 B1

2024 PU3 Preliminary Examinations H2 Physics Paper 3 Suggested Answers

Section B

7	**(a)**	The moment of a force about a pivot is the product of that force and the perpendicular distance between the line of action of the force and the pivot. The torque of a couple between two forces is the product of one of the forces and the perpendicular distance between their lines of action. One force for moment & two forces for torque OR about a pivot for moment & no need for pivot for torque	**B1** **B1** **B1**
	(b)(i)	The anti-clockwise moment due to the weight of the hook is balanced by the total clockwise moments due to the weight of the sliding weights. OR c.g of the weighing machine is at the pivot	**B1**
	(b)(ii)	For the same load on the hook, a smaller perpendicular distance from the hook to the pivot will result in smaller anti-clockwise moment to be balanced by the sliding weights. A longer rigid rod will allow for smaller sliding weights to be used. OR A longer rigid rod will give a better precision to the reading. OR With the same sliding weights, a bigger range of loads can be measured.	**B1** **B1**
	(b)(iii)	Weight of sack of flour = mg $mg \times 4.8 = (12 \times 84) + (2.5 \times 72)$ $m = 25.2$ kg	**C1** **A1**
	(b)(iv)	The movement of the sliding weights will be much smaller for such a small load hence the corresponding fractional uncertainty of the weight of the object will be higher.	**B1** **B1**
	(c)(i)	A force F acts on a mass m to move it vertically upwards at constant speed (so that no change in E_k) by a displacement h in the direction of the force.  Since the object moves at constant speed, the upward force, F, must be equal to the weight of the object, mg. (no resultant force). Using Work done on object = $Fh = (mg)h$ Since Fh is the work done on the object and is equal to the increase in potential energy, $E_p = mgh$	**B1** **B1** **B1**
	(c)(ii)1.	Power = $\frac{n \times mgh}{t} = \frac{60 \times (55)(9.81)(15)}{1 \times 30}$ $= 1.62 \times 10^4$ W	**C1** **A1**

	(c)(ii)2.	v (in direction parallel to escalator) = $\frac{15}{\sin 30°} \div 30$ = 1.0 m s^{-1} Power = Fv = 1.0 x 10^4 x 1.0 = 1.0 x 10^4 W	C1 C1 A1
	(c)(ii)3.	To maintain constant speed, the escalator has to supply more power to overcome the (downward) force exerted on escalator steps by users moving up. OR higher rate of increase of GPE of the users	B1 B1

8	(a)(i)	A spontaneous radioactive decay is one whereby it is not triggered by external stimuli such as chemical composition and physical environment (temperature, pressure, electric fields, magnetic fields, luminosity, etc.)	B1 B1
	(a)(ii)	${}^{238}_{94}Pu \rightarrow {}^{234}_{92}U + {}^{4}_{2}He$ correct symbols correct mass and atomic number	 B1 B1
	(a)(iii)1.	Conservation of mass-energy K.E of products = $(m_{Pu} - m_u - m_\alpha)\,c^2$ $(5.649\times10^6)(1.6\times10^{-19}) = (238.0496 - m_u - 4.0026)(1.66\times10^{-27})(3\times10^8)^2$ m_u = 234.0409 u	 C1 C1 A1
	(a)(iii)2.	By the principle of conservation of momentum, $0 = m_u v_u + m_\alpha v_\alpha$ $\frac{v_\alpha}{v_u} = -\frac{m_u}{m_\alpha}$ $\frac{T_\alpha}{T_u} = \frac{\frac{1}{2}m_\alpha v_\alpha^2}{\frac{1}{2}m_u v_u^2} = \frac{m_\alpha}{m_u}\left(-\frac{m_u}{m_\alpha}\right)^2 = \frac{m_u}{m_\alpha} = \frac{234.0409}{4.0026} = 58.47$ = 58.5	 C1 C1 A1
	(a)(iii)3.	$T_\alpha + T_u = 5.649$ MeV $T_\alpha\left(1 + \frac{1}{58.47}\right) = 5.649$ MeV T_α = 5.55 MeV	 C1 A1
	(b)(i)	α-particles are highly ionising due to their charge and relatively large mass. Due to its ionising ability, an α-particle has very short range as it loses its energy rather rapidly. γ-rays are very weakly ionising because they are electromagnetic waves and carry no charge and no rest mass. Hence, they are most penetrating.	B1 B1
	(b)(ii)	Alpha particles are highly ionizing and will not penetrate further than 10 cm of air. Thus emission of α-particles will not be detected.	A1

	(b)(iii)	True count = observed count – background count | t / hour | True count-rate / min^{-1} | | 0 | 6,409 | | 6.0 | 801 |	C1
		$\frac{C'}{C_0} = \frac{801}{6409} = \left(\frac{1}{2}\right)^n$	C1
		$\lg\left(\frac{801}{6409}\right) = n \lg\frac{1}{2}$ $\Rightarrow n = 3.0$ $\Rightarrow 6.0\text{hrs} = 3.0\, t_{1/2}$ $\therefore t_{1/2} = 2.0\text{hrs}$	A1
	(b)(iv)	Short-term effect: Ionizing radiation can cause immediate damage to human tissue and could be accompanied by radiation burns, radiation sickness, etc.	B1
		Long-term effect: Delayed effects such as cataracts, hair loss, leukaemia, cancer, etc. could appear years after the exposure. Hereditary defects may also occur in succeeding generations as a result of gene damage.	B1