TAMPINES MERIDIAN JUNIOR COLLEGE

JC2 PRELIMINARY EXAMINATION

CANDIDATE
NAME

( )

CIVICS GROUP

H2 PHYSICS

Paper 3 Longer Structured Questions

9749/03

18 September 2024

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, 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.

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	/ 8	
3	/ 10	
4	/ 9	
5	/ 8	
6	/ 9	
7	/ 8	
8	/ 20	
9	/ 20	
Deduction		
Subtotal P3	/ 80	/ 35
Subtotal P4	/ 55	/ 20
Grand total		/ 100

This document consists of **25** printed pages and **1** blank page.

Data

speed of light in free space	c =	3.00×10^8 m s^{-1}
permeability of free space	μ_0 =	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	ε_0 =	8.85×10^{-12} F m^{-1}
	=	$\left(1/(36\pi)\right) \times 10^{-9}$ 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 =	$-\dfrac{GM}{r}$
temperature	T/K =	$T/°C + 273.15$
pressure of an ideal gas	p =	$\dfrac{1}{3}\dfrac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule	E =	$\dfrac{3}{2}kT$
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 =	$R_1 + R_2 + ...$
resistors in parallel	$1/R$ =	$1/R_1 + 1/R_2 + ...$
electric potential	V =	$\dfrac{Q}{4\pi\varepsilon_0 r}$
alternating current / voltage	X =	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B =	$\dfrac{\mu_0 I}{2\pi d}$
magnetic flux density due to a flat circular coil	B =	$\dfrac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid	B =	$\mu_0 nI$
radioactive decay	x =	$x_0 \exp(-\lambda t)$
decay constant	λ =	$\dfrac{\ln 2}{t_{\frac{1}{2}}}$

4

Section A

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

1 **(a)** State two conditions for an object to be in equilibrium.

....

....

.... [2]

(b) A trailer is attached to the towbar of a stationary car as shown in Fig. 1.1.
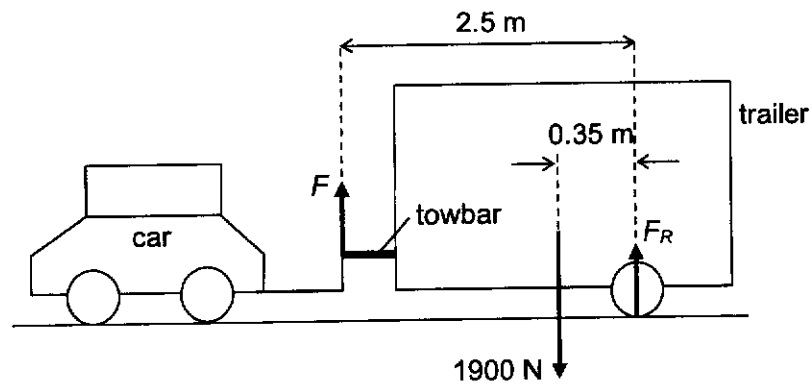The weight of the trailer is 1900 N.

Fig. 1.1 (not to scale)

(i) Calculate the vertical force F exerted by the towbar on the trailer.

$F =$ .... N   [2]

(ii) F_R is the total normal reaction force of the road on the trailer.

Calculate the force F_R.

F_R = ... N   [2]

(c)   The car and the trailer move to the left at a constant acceleration of 3.0 m s^{-2}.

The resistive force on the trailer is 200 N.

Calculate the horizontal force exerted by the towbar on the trailer.

horizontal force = ... N   [2]

2   Fig. 2.1 shows an airplane of mass m moving in a horizontal circular motion of radius 12 km and speed v. L is the lift force on the airplane and L makes an angle θ with the vertical.

The airplane completes one revolution in 250 s.
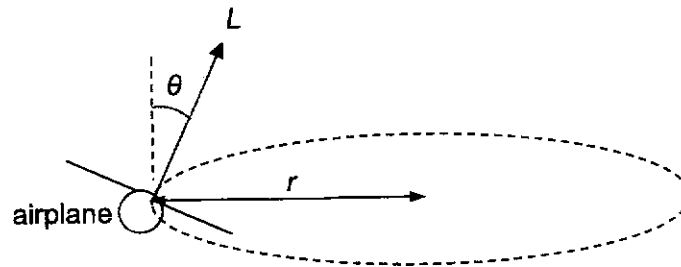
Fig. 2.1

(a)   Explain why the wings of the airplane need to be tilted for it to move in a horizontal circle.

....

.... [1]

(b)   Calculate the speed v of the airplane.

v = ... m s^{-1} [2]

(c)   Calculate the angle θ.

θ = ...°   [3]

(d) The wings are suddenly tilted for a larger angle θ.

State and explain one subsequent effect on the motion of the airplane.

....

....

....

.... [2]

8

3 **(a)** With reference to the kinetic theory of gases, state and explain the pressure and temperature conditions for a real gas to behave like an ideal gas.

....

....

....

....

.... [3]

(b) 0.428 mole of an ideal gas undergoes the following thermodynamic processes:

Process A: adiabatic compression (no net heat flow).

Process B: expansion at constant temperature T.

Process C: decrease in pressure at constant volume.

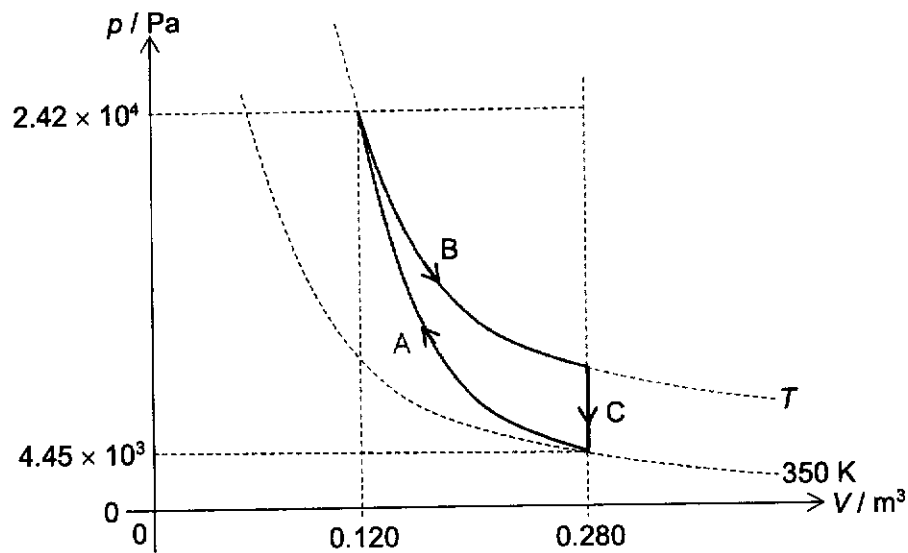Fig. 3.1 shows the variation of pressure p with volume V of the gas.

Fig. 3.1

(i) Calculate the temperature T.

$T = $ .... K   [2]

(ii) Show that the amount of thermal energy removed from the system during Process C is 2490 J.

[3]

(iii) Calculate the work done on the system during Process A.

work done = ... J   [2]

BP~568

10

4 Two small spherical charged conductors **A** and **B** are isolated in space. The variation with distance x of the electric potential V between the conductors along the line joining their centres is shown in Fig. 3.1.
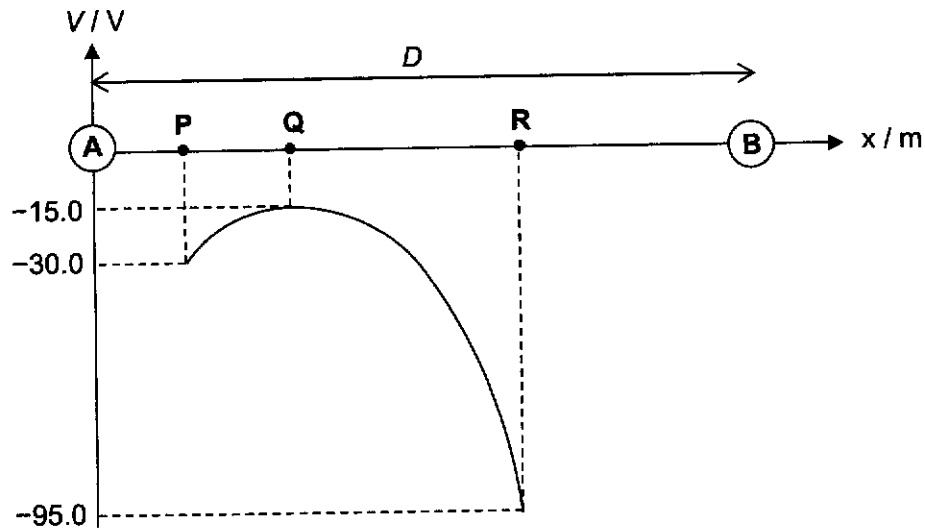

Fig. 3.1

The distance D between the two conductors is very much larger than the radii of the conductors. At point **Q**, the electric potential is a maximum.

(a) State and explain the signs of the charge of conductors **A** and **B**.

....

....

....

....

.... [2]

Tampines Meridian Junior College   *2024 JC2 Preliminary Examination H2 Physics*

(b) By considering the relation between electric field strength E and electric potential V, use Fig. 3.1 to explain which conductor has a larger magnitude of charge.

....

....

....

....

....

.... [3]

(c) Determine the work done by an external force in moving a negative charge of −2.0 C from point **P** to point **R** at constant velocity.

work done = ... J   [2]

(d) On Fig. 3.2, sketch the variation with distance x of the electric field strength E between point **P** and point **R**. Numerical values are not expected.
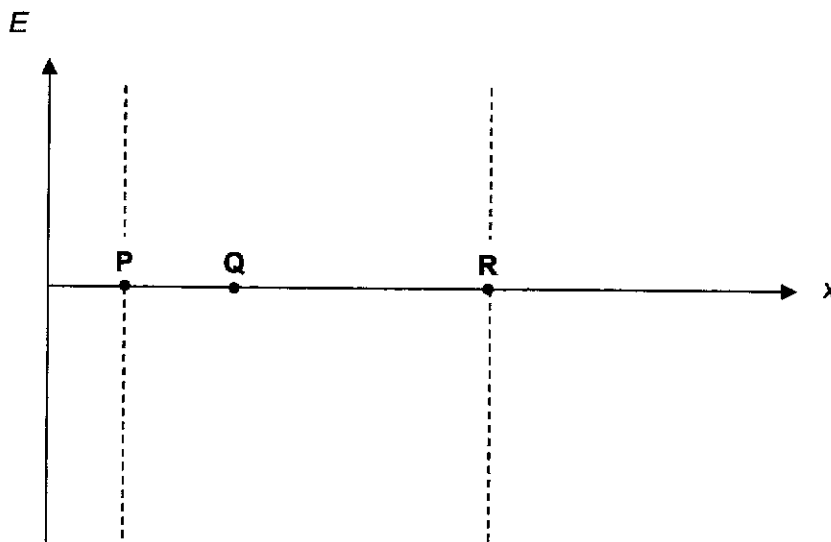

Fig. 3.2

[2]

5 **(a)** **(i)** Define magnetic flux.

....

....

.... [1]

(ii) Hence define magnetic flux linkage for a coil of N turns.

....

....

.... [1]

(b) A square copper coil of five turns moves at a constant speed of 2.5 cm s^{-1} from initial position X to final position Y as shown in Fig. 5.1. The length of each side of the square coil is 5.0 cm. There is a square region of uniform magnetic field, B = 2.0 T placed in between X and Y. The length of each side of the magnetic field is 10 cm.
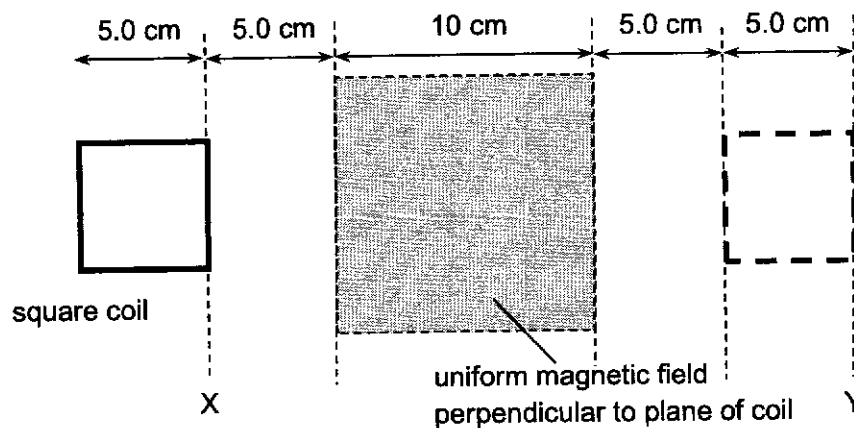

Fig. 5.1 (top view)

(i) Calculate the maximum e.m.f. E_{max} induced in the coil.

E_{max} = ... V [2]

(ii) On Fig. 5.2, sketch a graph of how induced e.m.f. E in the coil varies with time t as the coil moves from initial position X to final position Y.
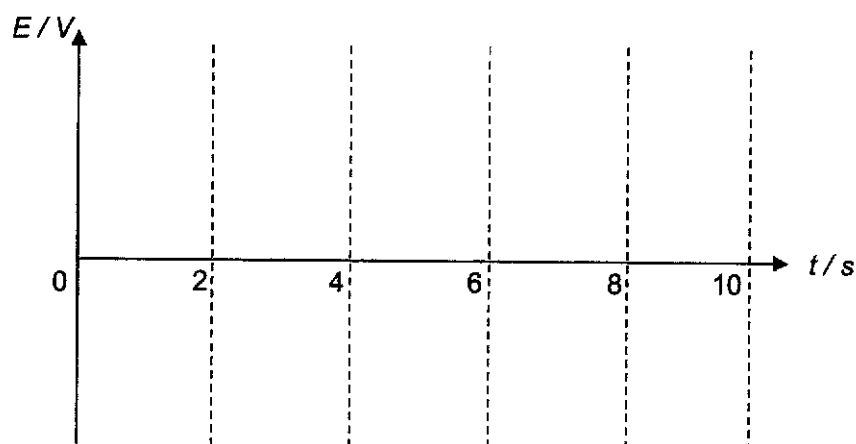
E / V

0   2   4   6   8   10   t / s

Fig. 5.2

[2]

(iii) The copper coil is now replaced by a solid copper disc of the same size.

It is found that more work is needed to push the copper disc to enter the magnetic field at the same speed.

Explain the observation.

....

....

....

.... [2]

6 **(a)** An alternating power supply is connected to a resistor R, a diode and an ideal battery of e.m.f. 6.0 V as shown below in Fig. 6.1.
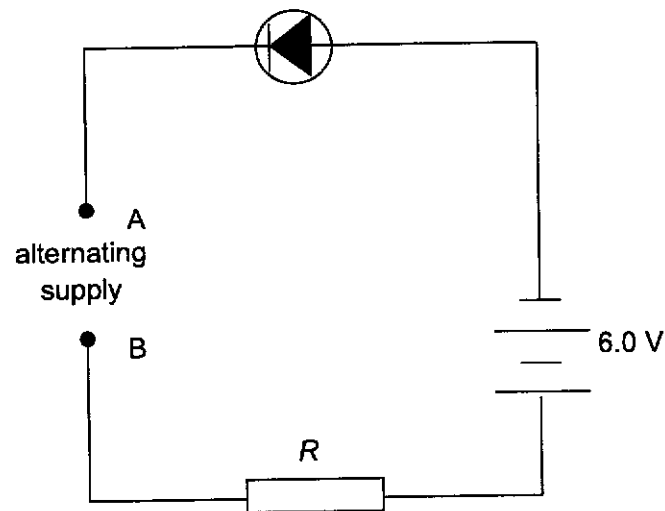

Fig. 6.1

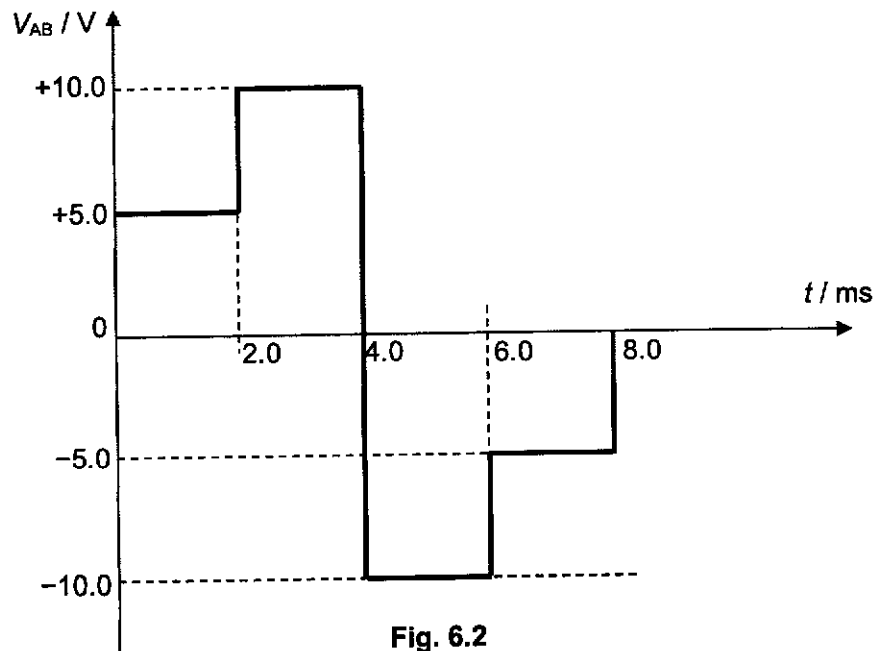The variation of the potential of A with respect to B, V_{AB}, is as shown in Fig. 6.2.

Fig. 6.2

(i) Calculate the root-mean-square potential difference V_{rms} across points A and B.

V_{rms} = ... V [2]

(ii)   Determine the potential difference across resistor R when

   1. V_{AB} = +5.0 V

   potential difference = ... V   [1]

   2. V_{AB} = −10.0 V

   potential difference = ... V   [2]
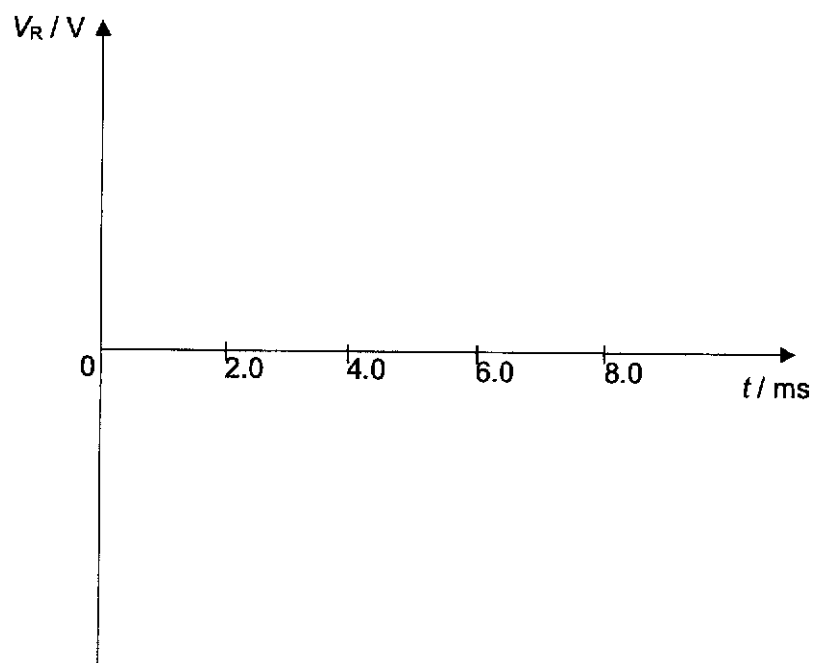
(iii)   Hence, sketch on Fig. 6.3 the variation with time t of the potential difference V_R across R.

Fig. 6.3   [2]

(b)   Explain an advantage of using alternating current to transmit electrical energy.

....

....

....   [2]
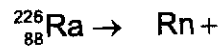
7 (a) Radium-226 ($^{226}_{88}$Ra) decays by alpha emission to form radon (Rn).

Complete the nuclear equation for the decay.

$$^{226}_{88}\text{Ra} \rightarrow \quad \text{Rn} +$$

[1]

(b) Radium-226 has a half life of 1600 years.

Show that the activity of a sample of pure radium-226 can be considered to be constant over a period of 6.0 days.

....

....

.... [2]

(c) An experiment was carried out to measure the amount of alpha particles produced by radium-226. A sample of pure radium-226 was placed in a small cylinder A, which was fixed in the centre of a larger cylinder B as shown in Fig. 7.1.
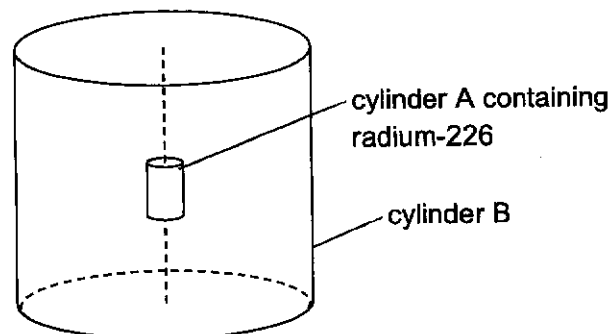
cylinder A containing radium-226

cylinder B

Fig. 7.1

As the alpha particles pass through the wall of cylinder A, they combine with electrons and are trapped inside cylinder B as helium gas atoms.

(i) Explain why the wall of cylinder A must be made of very thin glass.

....

.... [1]

(ii) After a period of 6.0 days, the pressure inside cylinder B was found to increase by 0.82 Pa. The volume of cylinder B was 1.5×10^{-5} m^3 and the volume of cylinder A was negligible. The experiment was conducted at a temperature of 25 °C.

Calculate the number of helium gas atoms which accumulated in cylinder B during the 6.0 day period. Assume that helium gas behaves as an ideal gas.

number of atoms = ... [2]

(iii) Calculate the activity of the sample of radium-226 during the experiment.

activity = ... Bq [2]

18
BLANK PAGE

Section B

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

8 **(a)** **(i)** Explain what is meant by polarisation.

....

....

.... [1]

(ii) A beam of initially unpolarised light of intensity I_0 is passed through three polaroids. The intensities of the beam emerging from each polaroid are I_1, I_2 and I_3 respectively. The polarising axis of each polaroid is shown by an arrow and held at different angles to the vertical axis, as illustrated in Fig. 8.1.
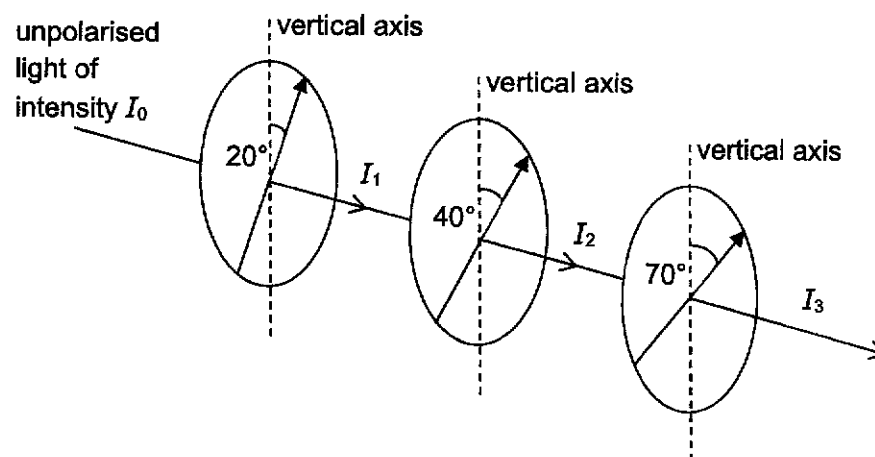

Fig. 8.1

1. State in terms of I_1, the intensity I_0 of the unpolarised light.

intensity I_0 = ... [1]

2. Determine, in terms of I_1, the intensity I_3 of the beam emerging from the third polaroid.

intensity I_3 = ... [2]

(b) The polarised light has a wavelength λ of 650 nm. It is incident normally on a double slit such that the waves emerge from the slits are in phase, and reach a screen 1.5 m away, as shown in Fig. 8.2.
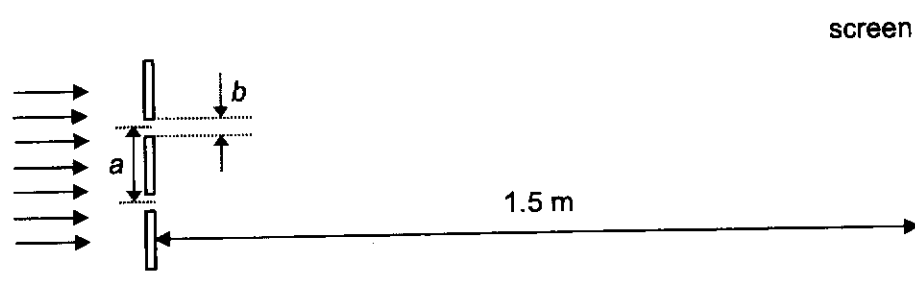

Fig. 8.2

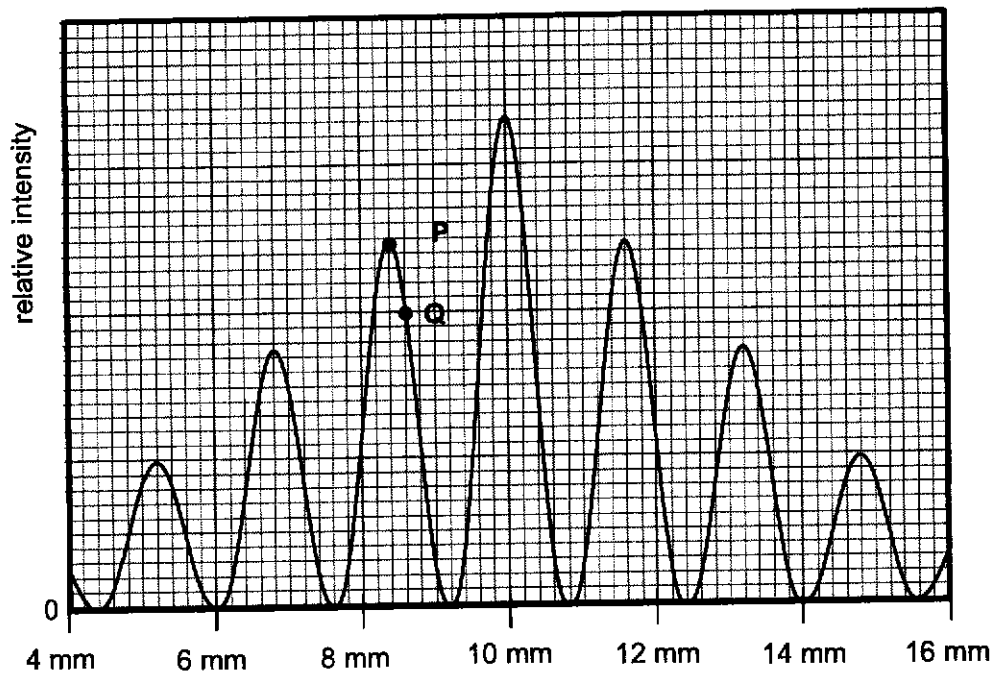The variation of intensity with distance along the screen is shown in Fig. 8.3.

Fig. 8.3

(i) Explain how it can be deduced from Fig. 8.3 that the waves from the two slits are coherent and have the same amplitudes.

....

....

....

....

.... [2]

(ii) Calculate the separation a, between the slits.

separation a = ... mm   [3]

(iii) State the path difference between the waves from the slits when the waves meet to produce the intensity at point **P** in Fig. 8.3.

path difference = ... [1]

(iv) Determine the phase difference between the waves from the slits when the waves meet to produce the intensity at point **Q** in Fig. 8.3.

phase difference = ... rad   [2]

(v) At a distance of 9.6 mm from the central bright fringe, there is a missing bright fringe due to the single slit diffraction effect.

Calculate the width b, of each slit in the double slit.

width b = ... mm   [3]

(c) The double slit is replaced with a diffraction grating as shown in Fig. 8.4. The same light of wavelength 650 nm is incident normally on the grating and a series of bright fringes are observed on the screen.
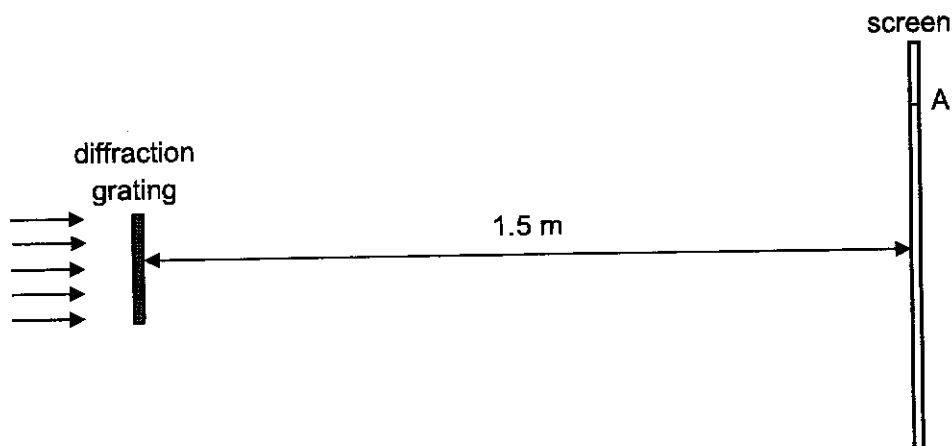

Fig. 8.4

(i) Another light M of a different colour is incident on the grating concurrently with the original light. It is observed that the second order of the original light and the third order of light M overlap at point A.

Calculate the wavelength of light M and hence state its colour.

wavelength = ... nm

colour: .... [3]

(ii) The coloured lights are now replaced by a single white light source. Suggest the effects on the appearance of bright fringes observed on the screen.

....

....

....

....

.... [2]

9 (a) A circuit used to investigate the photoelectric effect is shown in Fig. 9.1.

Fig. 9.1

Explain how the photoelectric effect provides evidence for the particulate nature of electromagnetic radiation.

....

....

....

....

....

....

....

.... [3]

24

(b) Electrons travel towards the anode with a maximum speed of 1.42×10^6 m s^{-1}.

Calculate the stopping potential V_s.

$V_s = $ V   [2]

(c) State how the circuit should be modified in Fig. 9.1 to stop all the electrons from reaching the anode.

.... [1]

(d) **(i)** The electrons in **(b)** have been emitted from the cathode whose work function is 2.80 eV.

Calculate the wavelength of the EM radiation that caused the emission of the electrons.

wavelength = ... m   [2]

(ii) Suggest the type of EM radiation which has this wavelength.

type of EM radiation: .... [1]

(e) X-rays are produced in an X-ray tube as shown in Fig. 9.2.

Fig. 9.2

Describe how this setup is used to produce a continuous X-ray spectrum.

....

....

....

....

....

....

....

....

....

.... [5]

(f) State **one** similarity and **one** difference between the setups for the experiment to demonstrate photoelectric effects and the experiment to produce X-ray spectrum.

similarity: ....

....

difference: ....

.... [2]

26

(g) Fig. 9.3 shows the X-ray spectrum of two target anodes.

An X-ray spectrum is first produced by an X-ray tube with tungsten (atomic number, Z = 74) anode. Another X-ray spectrum is then produced with the same X-ray tube by using barium (atomic number, Z = 56) anode.

Fig. 9.3

(i) Determine the accelerating potential of the X-ray tube.

accelerating potential = ... V   [2]

(ii) Use Fig. 9.3 to explain why the relative intensity of the K_α line of the tungsten is larger than that of barium spectrum.

....

....

....

....

....

[2]

Tampines Meridian Junior College
2024 JC2 H2 Physics Preliminary Examination Paper 3 Suggested Solution

| 1 | (a) | Resultant force in any direction must be zero. [B1] |
| | | Resultant torque about any axis must be zero. [B1] |

| | (b) | (i) | Taking moments about the wheel of trailer |
| | | | the sum of clockwise moments = the sum of anti-clockwise moments |

$$F(2.5) = 1900 \times 0.35 \quad [C1]$$
$$F = 266 \text{ N} \quad [A1]$$

| | | (ii) | Summing all vertical forces |

$$F + F_R = 1900$$
$$F_R = 1900 - 266 \quad [C1]$$
$$F_R = 1630 \text{ N} \quad [A1]$$

| | (c) | Let the horizontal force be F_h. |

$$F_{net} = ma$$
$$F_h - 200 = \frac{1900}{9.81}(3.0) \quad [C1]$$
$$F_h = 781 \text{ N} \quad [A1]$$

2	(a)	(lift is perpendicular to the wings) the wings are tilted so that the lift has a horizontal component to provide the centripetal force	A1
	(b)	$v = \dfrac{2\pi r}{T} = \dfrac{2\pi \times 12000}{250}$	C1
		301.6 m s^{-1}	A1
	(c)	$L\sin\theta = \dfrac{mv^2}{r}$	C1
		$L\cos\theta = mg$	C1
		first eq / second eq $\Rightarrow \tan\theta = \dfrac{v^2}{rg} = \dfrac{(301.6)^2}{12000 \times 9.81} \Rightarrow \theta = 37.7°$	A1
	(d)	larger θ so $L\cos\theta < mg$ [B1] $\Rightarrow$ airplane falls [B1] OR $L\sin\theta$ increases so r decreases [B1] $\Rightarrow$ airplane moves in smaller circle [B1] (airplane moves in a downward helical path of smaller radius)	

3	(a)	A real gas approaches ideal gas behaviour at <u>high temperature</u> and <u>low pressure</u>. [B1]	
		At high temperature, the <u>intermolecular forces are negligible</u> as the gas molecules moving very rapidly. [B1]	
		At low pressure, <u>total volume of the gas molecules is negligible (or particles are far apart)</u> compared to the <u>volume of the container</u>. [B1]	
	(b)(i)	$\dfrac{p_1 V_1}{T_1} = \dfrac{p_2 V_2}{T_2}$ $\dfrac{\left(4.45 \times 10^3\right)(0.28)}{350} = \dfrac{\left(2.42 \times 10^4\right)(0.12)}{T}$ [C1] $T = 816 \text{ K}$ [A1] Or use $pV = nRT$	
	(b)(ii)	$\Delta U = \dfrac{3}{2} nR\Delta T$ $= \dfrac{3}{2}(0.428)(8.31)(350 - 816)$ [M1] $= -2490 \text{ J}$ $\Delta U = Q + W$ $\because W = 0$ [M1] $\Delta U = Q$ [M1] $= -2490 \text{ J}$ [A0] Hence, heat removed = 2490 J [A0]	
	(b)(iii)	For adiabatic process, Q is zero. For a cyclic process, $\Delta U_{A \to B \to C} = 0$ $\Delta U_A + 0 + (-2490) = 0$ [M1] $\Delta U_A = Q + W_A$ $W_A = 2490 \text{ J}$ [A1]	

4	(a)	The total <u>electric potential</u> is <u>negative for all points</u> between them.	M1
		<u>Both</u> conductors **A** and **B** are <u>negatively charged</u>.	A1
	(b)	<u>Field strength</u> of the electric field at a point is numerically equal to the (negative) <u>potential gradient</u> at that point	B1
		At <u>Q (or turning point)</u>, the <u>resultant electric field strength is zero.</u>	B1
		Since <u>Q (or turning point) is closer to A</u> (or further from B), <u>conductor B</u> has a larger magnitude of charge.	B1
	(c)	work done by external force = change in electric potential energy = q $(V_R - V_P)$ = = $(-2.0)(-95.0 + 30.0)$ = + 130 J *Allow BOD if substitution is (2.0)(95.0 – 30.0)*	M1 A1
	(d)	 **Fig. 3.2** Correct shape [M1] E_P is zero at point Q, magnitude of E_P smaller than E_R and both touching the dotted boundary lines [A1]	

5	(a)	(i)	The magnetic flux through a plane surface is the <u>product of the magnetic flux density normal to the surface and the area of the surface</u>.	B1
		(ii)	The magnetic flux linkage through a coil of N turns is the <u>product of the number of turns of the coil and the magnetic flux</u> linking each turn.	B1
	(b)	(i)	$$\|\varepsilon\| = \frac{d\varphi}{dt} = \frac{d(NAB)}{dt} = \frac{d(N\ell^2 B)}{dt} = NB\ell v$$ $$= 5 \times 2.0 \times 0.05 \times 0.025$$ $$= 0.0125 \text{ V}$$	C1 A1

		(ii)	

M1 for correct shape
A1 for correct label of E_{max} value
Allow -0.0125 V for $2 \text{ s} \le t \le 4 \text{ s}$ and +0.0125 V for $6 \text{ s} \le t \le 8 \text{ s}$

		(iii)	The (larger) <u>eddy currents induced</u> or <u>larger/more induced current</u> in the copper disc. [B1]	B1
			Will result in a <u>larger force that opposes the direction of motion</u> Or will result in <u>more energy dissipated as heat.</u> [B1]	B1
			thereby requiring more energy to maintain the copper disc at constant speed.	

6	(a)	(i)	$V_{ms} = \sqrt{\dfrac{2(5.0)^2(2.0)+2(10.0)^2(2.0)}{8.0}}$ [M1]	
			$= 7.9$ V [A1]	

		(ii) 1.	0 V	[A1]

		(ii) 2.	p.d. across resistor $R = -10.0 + 6.0$	[M1]
			$= -4.0$ V	
			OR $+4.0$ V	[A1]

(iii)
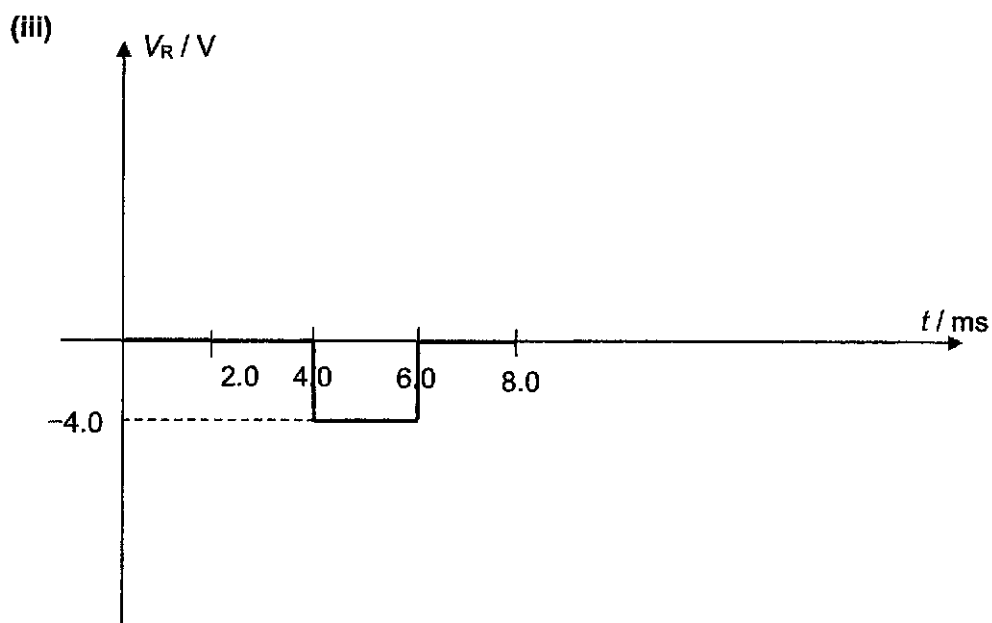
1 mark for shape of graph.
1 mark for labelled axes (values of V_R if graph is correct)
Allow + 4.0 V

	(b)	Transmission voltage can be stepped up [B1], thereby minimising power loss [B1].

7	(a)	$^{226}_{88}\text{Ra} \rightarrow {}^{222}_{86}\text{Rn} + {}^{4}_{2}\text{He}$		A1
	(b)	$$\frac{A}{A_0} = \left(\frac{1}{2}\right)^{\frac{6.0}{1600 \times 365}} = 0.99999 \approx 1.0$$		B1
		Since the ratio of activity after 6 days to the initial activity is very close to 1, the activity can be considered constant over 6 days. (calculation should be followed with explanation). [Also award 2 marks to reasoned calculation and explanation that the experimental duration of 6 days is insignificant compared to the half-life of 1600 years and so the activity will not decrease significantly.]		B1
	(c)	(i)	<u>Alpha particles have very low penetrating power</u> (So the glass wall of cylinder A has to be very thin for the alpha particles to pass through into cylinder B.) No marks are awarded for simple rephrasing of the stem of the question, e.g. "The glass must be thin so that alpha particles can pass through."	B1
		(ii)	$pV = NkT$ $\Delta N = \dfrac{\Delta p \times V}{kT}$ $\Delta N = \dfrac{0.82 \times 1.5 \times 10^{-5}}{1.38 \times 10^{-23} \times (273 + 25)}$ $= 2.99 \times 10^{15}$ Benefit of the doubt was given if the equation used was $N = \dfrac{pV}{kT}$ rather than $\Delta N = \dfrac{\Delta pV}{kT}$	C1 A1
		(iii)	$A \approx \dfrac{N}{t} = \dfrac{2.99 \times 10^{15}}{6.0 \times 24 \times 60 \times 60}$ $= 5.8 \times 10^{9}$ Bq	C1 A1

8	(a)	(i)	Polarisation is said to occur when particles in the wave <u>oscillate only in a single direction perpendicular to the direction of energy transfer</u> of the wave.	A1
		(ii)	**1.** $I_0 = 2I_1$	A1
			2. $I_2 = I_1 \cos^2 20° = 0.883 I_1$ $I_3 = I_2 \cos^2 30° = 0.662 I_1 \approx 0.66 I_1 (2 \text{ or } 3 \text{ s.f.})$	C1 A1
	(b)	(i)	Coherent: Observable interference pattern or maximas and minimas Same amplitudes: Minima is at zero intensity (Accept: complete cancellation)	B1 B1
		(ii)	$x = \dfrac{14.8 - 5.2}{6} = 1.6$ mm (Accept: x = 1.6 mm directly stated or substituted in equation below.) $a = \dfrac{\lambda D}{x} = \dfrac{650 \times 10^{-9} \times 1.5}{1.6 \times 10^{-3}}$ $a = 0.61$ mm	C1 M1 A1
		(iii)	One wavelength (λ) or 650 nm	A1
		(iv)	$\Delta\phi = \dfrac{1.4}{1.6} \times 2\pi$ $= 5.5$ rad	C1 A1
		(v)	$\theta = \tan^{-1}\left(\dfrac{0.0096}{1.5}\right) = 0.0064$ rad $b = \dfrac{\lambda}{\sin\theta} = \dfrac{650 \times 10^{-9}}{\sin(0.0064 \text{ rad})}$ $b = 0.102$ mm	C1 M1 A1
	(c)	(i)	$d \sin\theta_n = n\lambda$ Since d and $\sin\theta_n$ are the same when the fringes overlap, $n\lambda$ = constant. $\dfrac{\lambda_{original}}{\lambda_M} = \dfrac{3}{2} \Rightarrow \lambda_M = \dfrac{2(650 \times 10^{-9})}{3}$ $\lambda_M = 433 \times 10^{-9}$ m = 433 nm Therefore, light M is indigo. (Accept violet or blue)	 C1 M1 A1
		(ii)	<u>Central</u> bright fringe is <u>white</u>. The rest of the bright fringes/<u>others</u> contain a <u>spectrum</u> of colours.	B1 B1

9	(a)	1) The <u>existence of a threshold frequency</u> below which no photoelectrons are emitted proves that <u>electromagnetic radiation</u> (EM) <u>consists of discrete quanta of energy given by</u> *hf*. [B1]
		2) The <u>instantaneous emission</u> of photoelectrons when <u>all the photon energy is transferred immediately to the electron in a single collision</u> gives evidence to particulate nature of EM. [B1]
		3) The <u>maximum kinetic energy of the photoelectrons</u> being <u>dependent only on frequency of radiation *f*, which relates to the discrete energy of photon, and independent on the intensity</u> of radiation also give evidence for the particulate nature of EM. [B1]
	(b)	$eV_s = \dfrac{1}{2}mv^2$ $(1.6 \times 10^{-19})V_s = \dfrac{1}{2}(9.11 \times 10^{-31})(1.42 \times 10^6)^2$ [C1] $V_s = 5.74$ V [A1]
	(c)	reverse the polarity of the voltage source (and p.d. to be at least 5.74 V) [B1]
	(d)	(i) $h\dfrac{c}{\lambda} = \phi + \dfrac{1}{2}mv^2$ $h\dfrac{c}{\lambda} = (2.80 + 5.74)eV$ $6.63 \times 10^{-34} \dfrac{3.00 \times 10^8}{\lambda} = 8.54 \times 1.6 \times 10^{-19}$ [C1] $\lambda = 1.46 \times 10^{-7}$ m [A1]
		(ii) Ultra-violet [B1] [since visible light is between 4.0×10^{-7} m to 7.0×10^{-7} m]
	(e)	[B1]: The cathode is heated to <u>release electrons.</u> [B1]: These electrons are then <u>accelerated (speed up) via</u> the accelerating potential (p.d.) in the circuit to have high speeds. [B1]: when these high speed electrons strike the anode, electrons <u>experienced large deceleration,</u> thus producing X-ray photons. [B1]: the electrons decelerate to <u>different extents,</u> hence results in a range of X-ray photon energies produced [B1]: high speed electron stops abruptly in a single collision and <u>all the kinetic energy of the electron is completely converted to a single X-ray photon (with the smallest wavelength).</u> that resulted in the continuous spectrum of X-ray spectrum.

	(f)	Similarity [B1]: any of the following
		1) presence of cathode and anode
		2) vacuum is needed
		3) potential difference (p.d.) is set up across 2 plates
		4) electrons moving across cathode towards anode
		5) a complete circuit
		Difference [B1]: any of the following
		1) p.d. across photoelectric is only a few volts while p.d. across X-ray tube is hundred thousand volts.
		2) speed of electrons emitted (from cathode) due to photoelectric effect is significantly lower than that of X-ray tube.
		3) p.d. across photoelectric can be reverse (to find stopping potential) while p.d. across X-ray tube is one directional (for accelerate the electrons).
		4) electrons emitted from cathode of photoelectric is due to one-to-one interaction of photon with electron, while electrons emitted from X-ray tube is through heating of cathode.
		5) Source of reference: EM radiation is needed to demonstrate photoelectric effects while high speed electrons are needed to produce X-ray spectrum.
		6) One absorbs photon, another produces photon.
	(g) (i)	$$eV = h\frac{c}{\lambda_{min}}$$ $$(1.6 \times 10^{-19})V = (6.63 \times 10^{-34})\frac{3.00 \times 10^8}{16 \times 10^{-12}} \quad [C1]$$ $$V = 77.7 \times 10^3 \text{ V} \qquad [A1]$$

		(ii)	Relative intensity of K_α line comprise of contribution from both the continuous spectrum and characteristic peaks.
			a) Difference in intensities between the two K_α lines is primarily due to a <u>difference in the continuous spectrum of tungsten and barium</u>. [B1] AND b) The continuous radiation contribution for tungsten is more because tungsten has a <u>larger and more positive nuclei</u> as compared to Barium. Hence <u>more electrons passing in the vicinity of the tungsten nuclei are likely to deflect and give out an x ray photon</u>. [B1] Alternatively, tungsten has a <u>larger and more positive nuclei</u>. Thus for an <u>electron at a fixed distance</u> from the nuclei, the electron is likely to <u>deflect more and give out a higher energy x ray photon</u>. The intensity <u>of the high energy x ray photons for tungsten is thus larger</u>. [B1] Thus the continuous radiation contribution for tungsten is more. OR: Higher Z, stronger attractive force. Hence, larger braking effect Higher Z, target area is increased. Hence, larger probability of electrons striking.—leading to higher intensity of X ray produced. Thus the continuous spectrum of tungsten has a higher intensity as compared to Barium.