Name: _____ (  )  Class: 23 / _____

# ANDERSON SERANGOON JUNIOR COLLEGE

## 2023 JC2 Preliminary Examination

## PHYSICS Higher 2 9749/01

**Paper 1 Multiple Choice** **Wednesday 20 September 2023**

**1 hour**

Additional Materials: Multiple Choice Answer Sheet

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**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name and class on the Multiple Choice Answer Sheet.
Shade and write your NRIC/FIN.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Multiple Choice Answer Sheet.

**Read the instructions on the Multiple Choice Answer Sheet very carefully.**

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this question paper.
The use of an approved scientific calculator is expected, where appropriate.

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This document consists of **18** printed pages and **2** blank pages.

**Data**

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

**Formulae**

| | |
|---|---|
| uniformly accelerated motion | $s = ut + \frac{1}{2}at^2$<br>$v^2 = u^2 + 2as$ |
| work done on/by a gas | $W = p\Delta V$ |
| hydrostatic pressure | $p = \rho gh$ |
| gravitational potential | $\phi = -\frac{Gm}{r}$ |
| temperature | $T/\text{K} = T/°\text{C} + 273.15$ |
| 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. | $x = x_0 \sin \omega t$ |
| velocity of particle in s.h.m. | $v = v_0 \cos \omega t$<br>$= \pm\omega\sqrt{x_o^{\,2} - x^2}$ |
| 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 | $V = \frac{Q}{4\pi\varepsilon_o r}$ |
| alternating current/voltage | $x = x_0 \sin \omega t$ |
| magnetic flux density due to a long straight wire | $B = \frac{\mu_o I}{2\pi d}$ |
| magnetic flux density due to a flat circular coil | $B = \frac{\mu_o NI}{2r}$ |
| magnetic flux density due to a long solenoid | $B = \mu_o nI$ |
| radioactive decay | $x = x_0 \exp(-\lambda t)$ |
| decay constant | $\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$ |

**1** Which expression involving base units is equivalent to the volt?

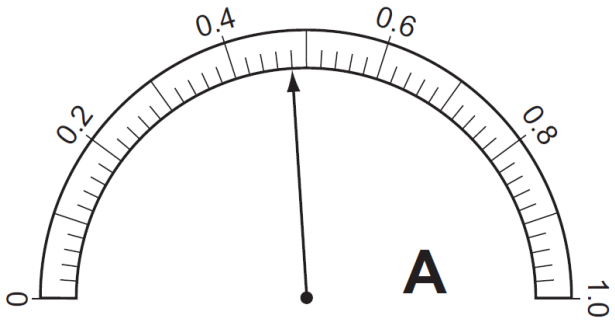
**A** kg $m^2$ $s^{-1}$ $A^{-1}$

**B** kg m $s^{-2}$ A

**C** kg $m^2$ $s^{-1}$ A

**D** kg $m^2$ $s^{-3}$ $A^{-1}$

**2** The resistance of an electrical component is measured. The following meter readings are obtained.


What is the resistance?

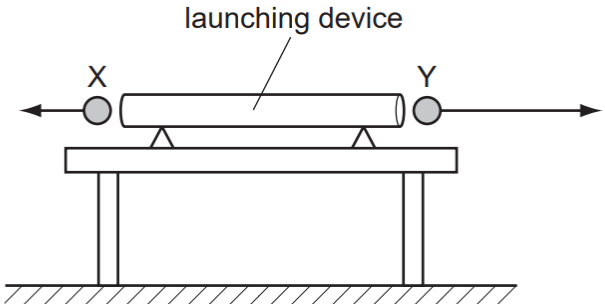
**A** 2.5 Ω **B** 2.7 Ω **C** 2500 Ω **D** 2700 Ω

**3** A car moves with uniform acceleration along a straight road. Oil leaks from the car at the rate of one drop every two seconds. The diagram shows the distances between three successive oil drops on the road.


What is the acceleration of the car?

**A** 0.38 m $s^{-2}$ **B** 0.75 m $s^{-2}$ **C** 2.6 m $s^{-2}$ **D** 5.3 m $s^{-2}$

**4** A double-ended launching device fires two identical steel balls X and Y at exactly the same time. The diagram shows the initial velocities of the balls. They are both launched horizontally, but Y has greater speed.




Which statement explains what an observer would see?

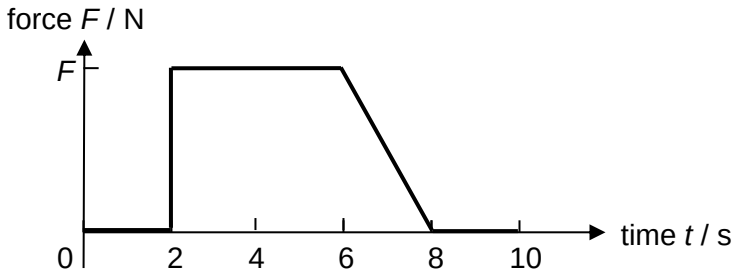
**A** Both X and Y reach the ground simultaneously, because air resistance will cause both to have the same final speed.

**B** Both X and Y reach the ground simultaneously, because gravitational acceleration is the same for both.

**C** X reaches the ground before Y, because X lands nearer to the launcher.

**D** Y reaches the ground before X, because Y has greater initial speed.

**5** The graph shows the variation with time $t$ of a braking force $F$ acting on a 2.0 kg mass. The mass decelerates from an initial speed of 30 m $s^{-1}$ to a final speed of 5.0 m $s^{-1}$.



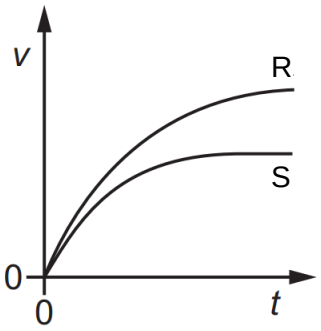

What is the maximum force $F$ exerted on the mass during this period of 10 s?

**A** 5.0 N **B** 10 N **C** 20 N **D** 50 N

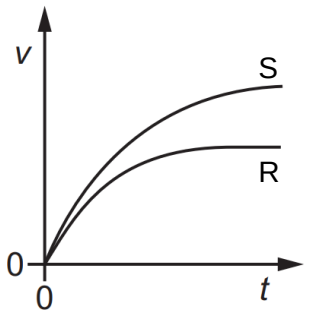
**6** A stone S and a foam rubber ball R are identical spheres of equal volume. They are released from rest at time $t = 0$ and fall vertically through the air. Both reach terminal velocity.

Which graph best shows the variation with time $t$ of the speed $v$ of the stone and of the rubber ball?

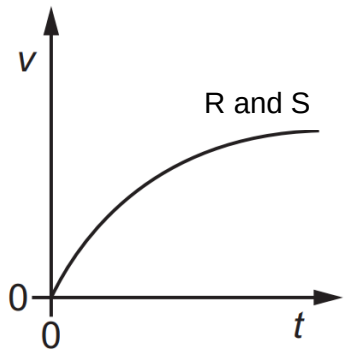
**A**



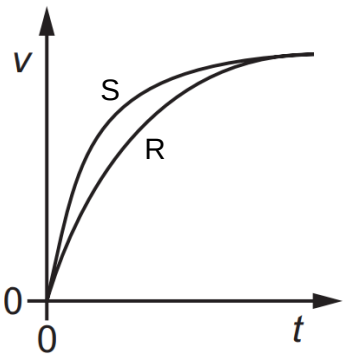

**B**



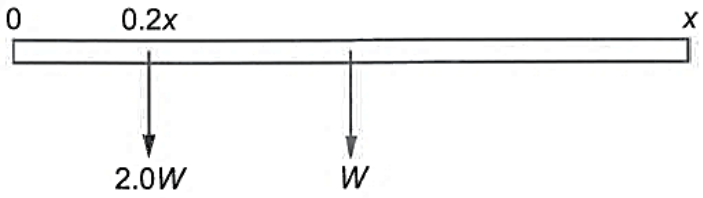

**C**




**D**




**7** A uniform rod of length $x$ and weight $W$ has a load $2.0W$ suspended at a distance $0.2x$ from one end.




A string is attached to the rod such that the rod is suspended in equilibrium.

The load is now moved so that it is a distance $0.2x$ from the other end of the rod.

How far along the rod does the string need to be moved so that the rod returns to equilibrium?

**A** $0.2\,x$ **B** $0.3x$ **C** $0.4x$ **D** $0.6x$

**8** Which statement about work done is correct?

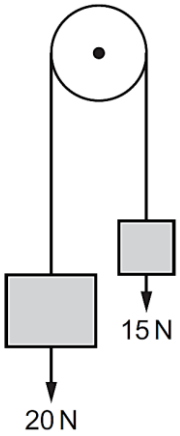
**A** More work is done to change the speed of an object from 2 m $s^{-1}$ to 3 m $s^{-1}$ than to change the speed of the same object from 1 m $s^{-1}$ to 2 m $s^{-1}$

**B** No work is done by a force that slows a moving object.

**C** The same amount of work is done when lifting an object 1 m at a constant velocity and pulling the same object 1 m across a smooth horizontal surface at a constant velocity.

**D** When an object is dropped, the force of gravity does no work.

**9** A pulley of radius 0.40 m supports weights of 20 N and 15 N by means of a thin string, as shown.

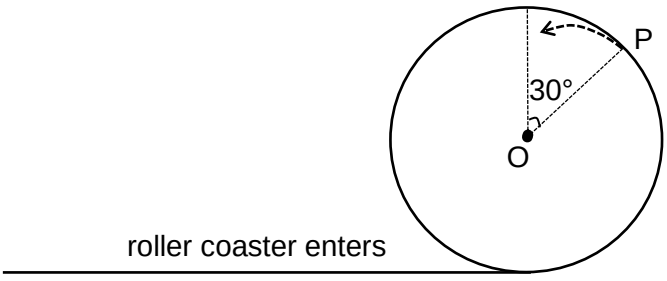



The weights are moved by slowly rotating the pulley clockwise through an angle of 60°.

What is the increase in the total gravitational potential energy of the weights?

**A** 0.33 J **B** 2.0 J **C** 2.1 J **D** 15 J

**10** A toy roller coaster attempts a loop-a-loop. It enters the bottom of loop of radius 1.0 m with insufficient speed. It loses contact at the point P as shown. The line joining P and the centre of the loop O makes an angle 30° with the vertical.




What is the speed at P which the roller coaster just loses contact with the loop?

**A** 0 m $s^{-1}$ **B** 2.2 m $s^{-1}$ **C** 2.9 m $s^{-1}$ **D** 3.1 m $s^{-1}$

**11** The acceleration of free fall at the surface of Neptune is approximately equal to the acceleration of free fall at the surface of the Earth. The mass of Neptune is 17 times the mass of the Earth.

What is the value of the ratio $\frac{\text{radius of Neptune}}{\text{radius of Earth}}$?

**A** 0.059 **B** 0.24 **C** 4.1 **D** 17

**12** A car tyre, initially at 25 ºC, has been inflated to a pressure of 200 kPa as indicated by the pressure gauge. This means that the pressure in the tyre is 200 kPa above atmospheric pressure of 100 kPa.

After driving on hot roads, the temperature of the air in the tyre is 50 ºC.

What is the percentage increase in the pressure gauge reading?

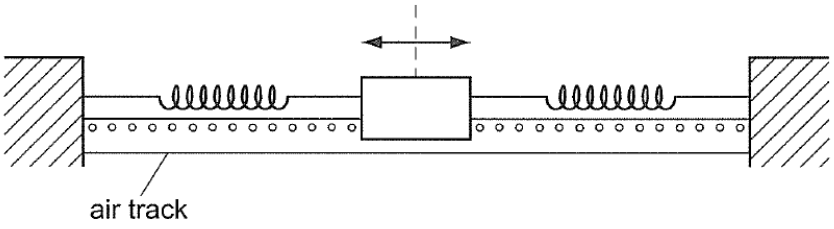
**A** 8.4 % **B** 12.5 % **C** 100 % **D** 150 %

**13** A copper block is placed in thermal contact with an iron block at a higher temperature. The blocks have the same mass, and energy exchange with the surroundings is negligible. There is negligible change in the volume of the blocks.

Which of the following will be true of the magnitudes of the change in internal energy and temperature of each block when thermal equilibrium is reached?

| | magnitude of change in internal energy | magnitude of change in temperature |
|---|---|---|
| **A** | Equal | Equal |
| **B** | Different | Equal |
| **C** | Equal | Different |
| **D** | Different | Different |

**14** A linear air track vehicle held centrally on an air track by two springs makes small simple harmonic oscillations.

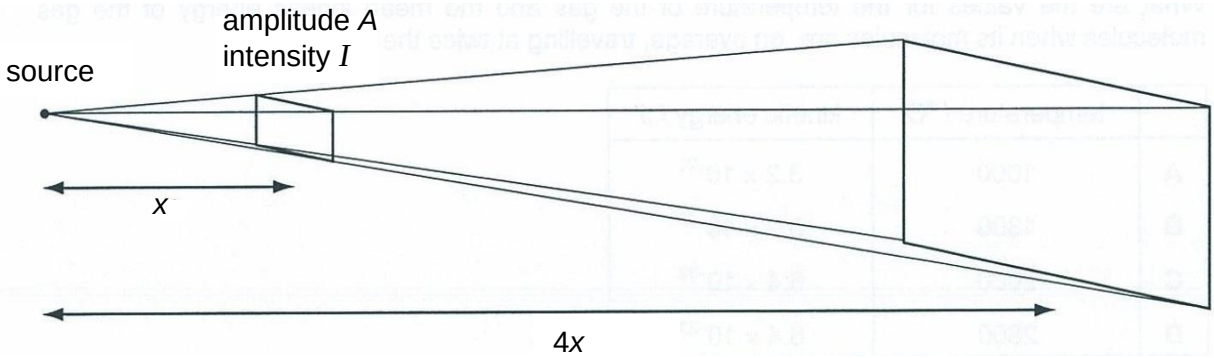



When its displacement from equilibrium is 20 mm, its speed is 30 mm $s^{-1}$.
When its displacement 30 mm, its speed is 20 mm $s^{-1}$.

What is its speed when its displacement is 25 mm?

**A** 24 mm $s^{-1}$ **B** 25 mm $s^{-1}$ **C** 26 mm $s^{-1}$ **D** 29 mm $s^{-1}$

**15** Energy from a point source of waves spreads out uniformly in all directions. The amplitude and intensity of the waves at a distance *x* from the source are *A* and $I$ respectively, as shown.




Assuming no absorption by the medium through which the waves are travelling, what are the amplitude and intensity at a distance of 4*x*?

| | intensity at distance 4*x* | amplitude at distance 4*x* |
|---|---|---|
| **A** | $\frac{I}{16}$ | $\frac{A}{4}$ |
| **B** | $\frac{I}{4}$ | $\frac{A}{16}$ |
| **C** | $\frac{I}{4}$ | $\frac{A}{2}$ |
| **D** | $\frac{I}{2}$ | $\frac{A}{4}$ |

**16** Two coherent progressive waves from different sources meet at a point.

Which condition **must** be satisfied for there to be zero resultant amplitude at the point where the waves meet?

**A** The two waves must be emitted from their sources with the same intensity.

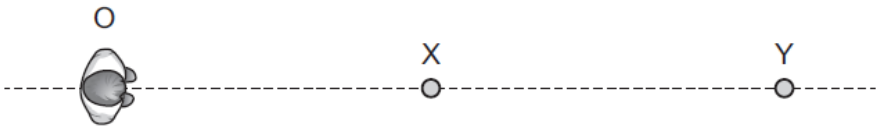
**B** The two waves must be in phase with each other at the point.

**C** The two waves must be travelling in opposite directions.

**D** The two waves must have the same amplitude at the point.

**17** Two loudspeakers X and Y emit sound waves that are in antiphase and of wavelength 0.60 m.

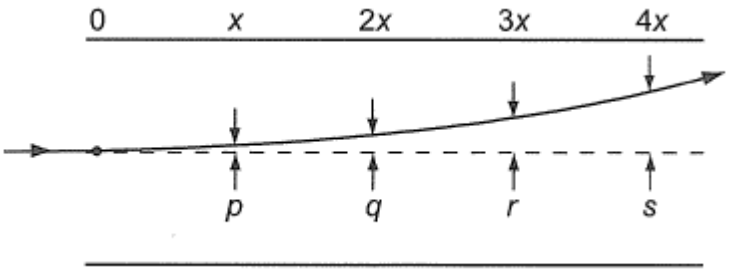
An observer O is able to stand anywhere on a straight line that passes through X and Y, as shown. The observer stands at a point where the sound waves from X and Y meet in phase.




What could be the distances OY and XY?

| | distance OY / m | distance XY / m |
|---|---|---|
| **A** | 1.25 | 3.70 |
| **B** | 1.50 | 1.20 |
| **C** | 2.00 | 2.50 |
| **D** | 2.20 | 1.60 |

**18** The diagram shows the path of a horizontal beam of electrons passing through the uniform vertical electric field between two horizontal electrodes. The diagram is not to scale.




The vertical displacements of the beam after travelling through horizontal distances of $x$, $2x$, $3x$ and $4x$ are represented by $p$, $q$, $r$ and $s$.

Which row represents the values of $p$, $q$, $r$ and $s$?

| | $p$ / mm | $q$ / mm | $r$ / mm | $s$ / mm |
|---|---|---|---|---|
| **A** | 1.0 | 1.4 | 1.7 | 2.0 |
| **B** | 1.0 | 2.0 | 3.0 | 4.0 |
| **C** | 1.0 | 2.0 | 4.0 | 8.0 |
| **D** | 1.0 | 4.0 | 9.0 | 16.0 |

**19** Two wires, X and Y, are made from the same metal. The diameter of wire Y is twice that of wire X. Wire X, wire Y and a battery are connected in series.

What is the ratio $\frac{\text{average drift speed of free electron in wire X}}{\text{average drift speed of free electron in wire Y}}$?

**A** $\frac{1}{4}$ **B** $\frac{1}{2}$ **C** $\frac{2}{1}$ **D** $\frac{4}{1}$

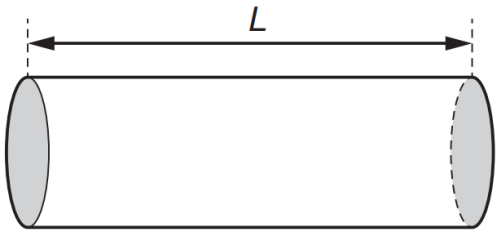
**20** For an electron beam, the following quantities are known or are easily measured.

- area $A$ when beam hits a target
- beam current $I$
- accelerating potential difference $V$
- elementary charge $e$

Which expression gives the rate of arrival of electrons per unit area on the target?

**A** $\frac{I}{eA}$ **B** $\frac{IA}{e}$ **C** $\frac{V}{eA}$ **D** $\frac{Ve}{A}$

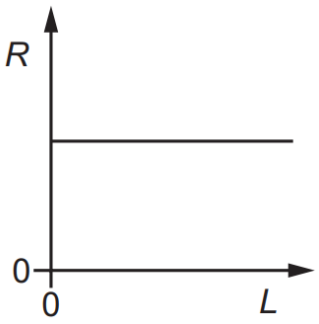
**21** A piece of conducting putty (modelling clay) of constant resistivity is formed into a cylindrical shape. The resistance $R$ between its flat ends (shaded) is measured.



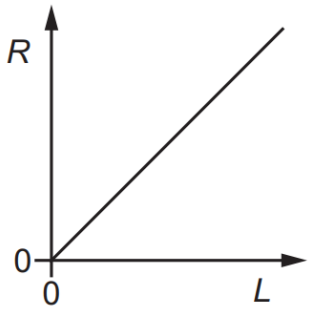

The same volume of putty is re-formed into cylinders of different lengths $L$, and the resistance $R$ between the flat ends is measured for each value of $L$.

Which graph best shows the variation of $R$ with $L$?

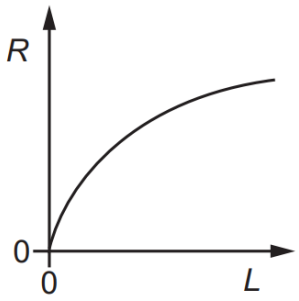
**A**



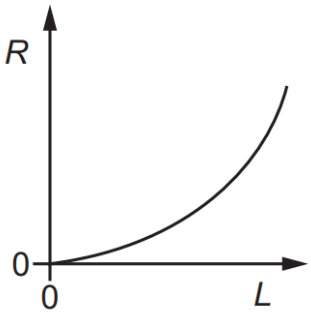

**B**




**C**

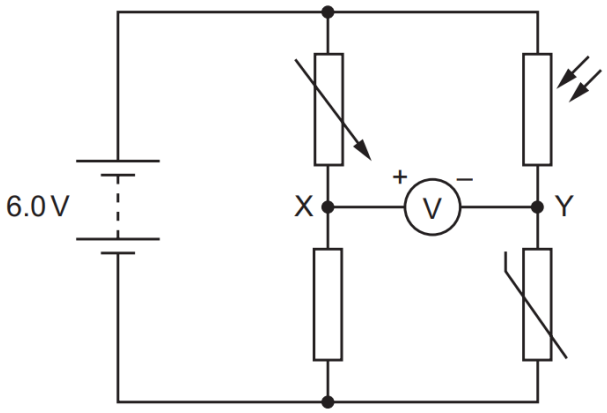



**D**



**22** A battery of electromotive force (e.m.f.) 6.0 V and negligible internal resistance is connected to a voltmeter and four other components, as shown.

The voltmeter is connected between points X and Y. The positive terminal of the voltmeter is connected to X and the negative terminal of the voltmeter is connected to Y.




Initially, the resistance of each of the four components is 1.0 kΩ.

Which change, on its own, will cause the voltmeter to show a positive reading?

**A** Decrease the temperature of the thermistor.

**B** Increase the resistance of the variable resistor.

**C** Reduce the intensity of light incident on the light-dependent resistor (LDR).

**D** Replace the fixed resistor with a 500 Ω resistor.

**23** Fig. (a) shows the top view of two long parallel wires, wire X and wire Y, carrying currents $I_X$ and $I_Y$ respectively in a direction perpendicular to the plane of the paper. The distance between wire X and wire Y is *L*.

Fig. (b) shows the variation of the net magnetic field at distances to the right of wire Y along the line joining wire X and wire Y. At a distance *d* from wire Y, the net magnetic field is zero.

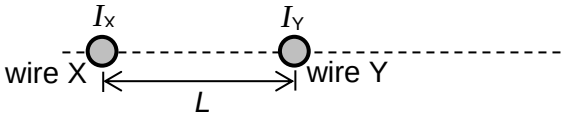



**Fig. (a) top view (not to scale)**

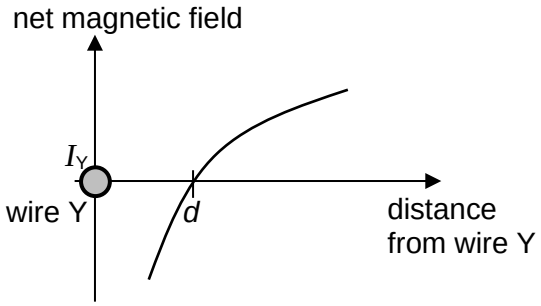


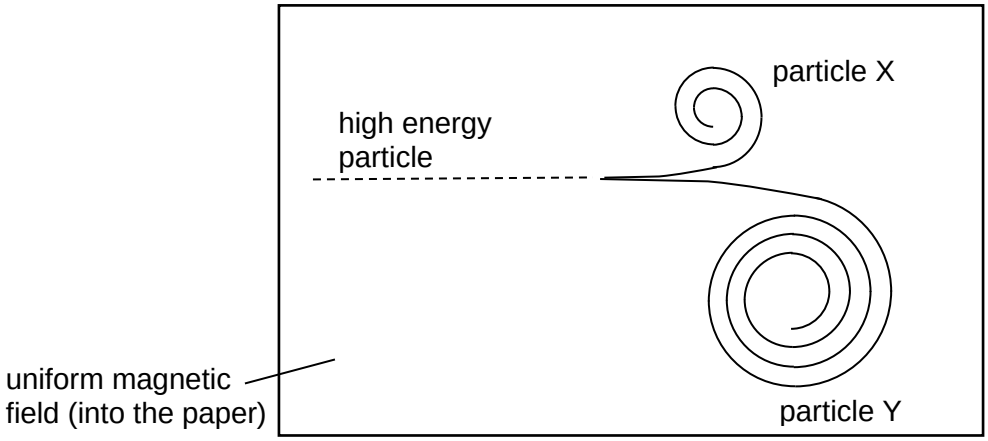

**Fig. (b)**

Given that the ratio $\frac{I_X}{I_Y}$ is 4.00 and taking the upwards direction to be positive, which of the following gives the relative direction of $I_X$ and $I_Y$ and the value of *L* in terms of *d*?

| | relative direction of $I_X$ and $I_Y$ | *L* in terms of *d* |
|---|---|---|
| **A** | $I_X$ and $I_Y$ flow in opposite directions. | *d* |
| **B** | $I_X$ and $I_Y$ flow in the same direction. | *d* |
| **C** | $I_X$ and $I_Y$ flow in opposite directions. | *3d* |
| **D** | $I_X$ and $I_Y$ flow in the same direction. | *3d* |

**24** A high energy particle which carries no charge enters a region of uniform magnetic field directed into the paper.

The particle subsequently disintegrates to form two particles X and Y which have the same mass and same magnitude of charge. The paths of X and Y are shown in the diagram below and the initial radius of Y is twice the initial radius of X.




Which of the following statements is correct?

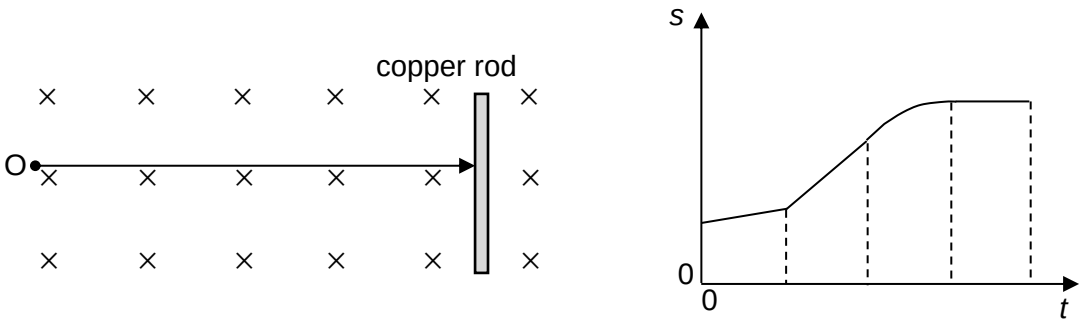
**A** Particle X is negatively charged, and particle Y is positively charged.

**B** Particle X has a larger momentum than particle Y.

**C** The speeds of both particles are increasing steadily.

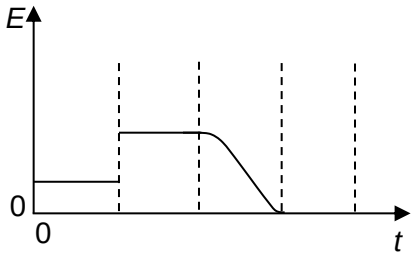
**D** The ratio of the initial kinetic energy of particle X to particle Y is 0.25.

**25** A copper rod is moved at right angles to a uniform magnetic field as shown in the diagram. The graph on the right shows the variation with time *t* of the displacement *s* of the copper rod from point O.

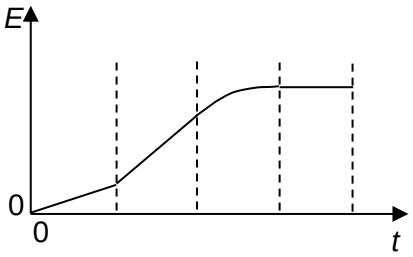



Which graph best shows the variation with time *t* of the e.m.f. *E* induced across the rod?

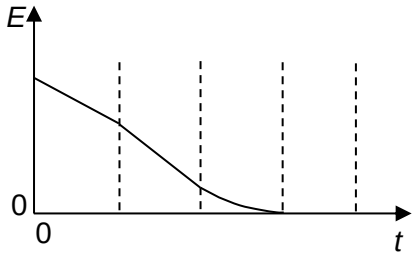
**A**



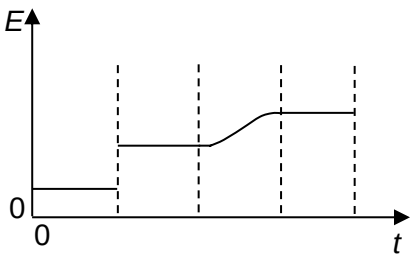

**B**



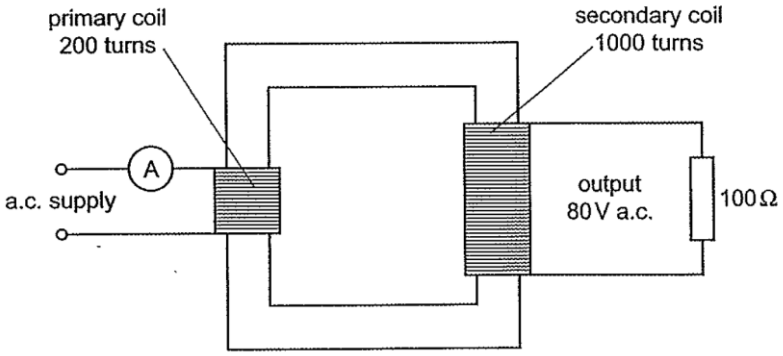

**C**




**D**



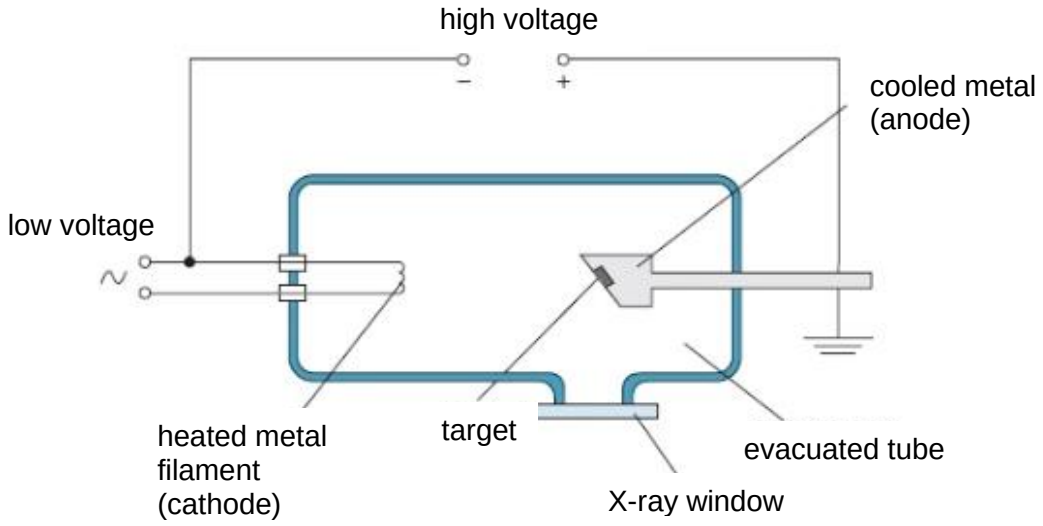

**26** A 100% efficient transformer is connected to a sinusoidal a.c. supply.




What is the reading on the ammeter?

**A** 0.16 A **B** 0.80 A **C** 2.8 A **D** 4.0 A

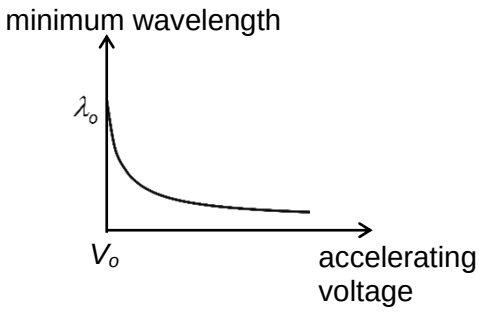
**27** In an X-ray tube shown, the high voltage supply accelerates the electrons towards the target. X-rays with a range of wavelengths are emitted from the target.



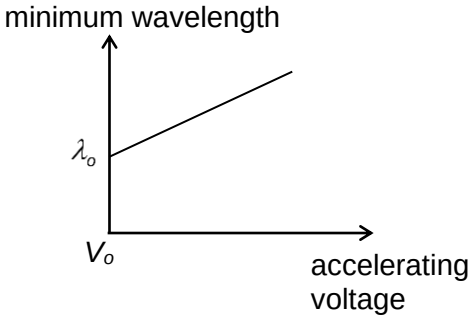

When the high voltage supply is $V_o$, the minimum wavelength of the x-ray emitted is $\lambda_o$.

Which of the following graph shows the variation with accelerating voltage of the minimum wavelength emitted?

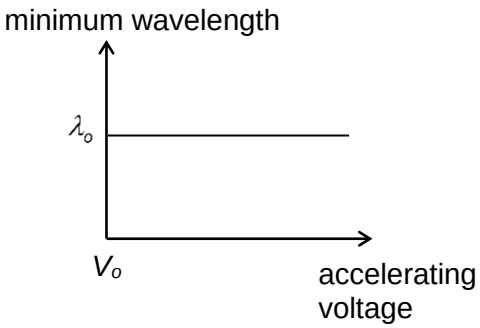
**A**



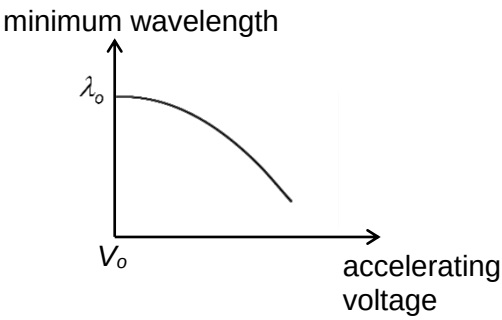

**B**




**C**




**D**



**28** A monochromatic light source emits a narrow, parallel beam of light of wavelength 546 nm on the cathode of a photocell. The power in the beam is 0.080 W.

If only 1.5% of the photons incident on the cathode liberate electrons, what is the photocell current?

**A** 0.30 mA **B** 0.53 mA **C** 10.0 mA **D** 35.0 mA

**29** In the $\alpha$-particle scattering experiment, a beam of $\alpha$-particles is aimed at a thin gold foil. Most of the $\alpha$-particles go straight through or are deflected by a small angle. A very small proportion are deflected by more than 90°, effectively rebounding towards the source of the $\alpha$-particles.

Which conclusion about the structure of atoms **cannot** be drawn from this experiment alone?

**A** Most of the atom is empty space.

**B** Most of the mass of an atom is concentrated in the nucleus.

**C** The nucleus contains both protons and neutrons.

**D** The nucleus is charged.

**30** Which of the following radioactive samples has the greatest activity?

| | nuclide | amount / mole | half-life / day |
|---|---|---|---|
| **A** | $^{225}_{89}Ac$ | 0.003 | 10 |
| **B** | $^{228}_{90}Th$ | 0.1 | 400 |
| **C** | $^{228}_{88}Ra$ | 0.6 | 2100 |
| **D** | $^{241}_{94}Pu$ | 1.0 | 4800 |

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