# VICTORIA JUNIOR COLLEGE
# 2014 JC2 PRELIMINARY EXAMINATIONS

**PHYSICS** **9646/01**
**Higher 2**

**25 Sep 2014**
**THURSDAY**
**Paper 1 Multiple Choice** **2 pm – 3.15 pm**
**1 Hour 15 min**

Additional Materials: Multiple Choice Answer Sheet

**READ THESE INSTRUCTIONS FIRST**

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, CT group and NRIC number on the Answer Sheet in the spaces provided and shade the corresponding ovals.

There are **forty** 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 Answer Sheet.

**Read the instructions on the 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 booklet.

This document consists of **18** printed pages.

**Data**

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

gravitational potential, $\phi = -\frac{GM}{r}$

displacement of particle in s.h.m., $x = x_o \sin \omega t$

velocity of particle in s.h.m., $v = v_o \cos \omega t$

$= \pm\omega\sqrt{(x_o^2 - x^2)}$

mean kinetic energy of a molecule of an ideal gas, $E = \frac{3}{2}kT$

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, $x = x_o \sin \omega t$

transmission coefficient, $T \propto \exp(-2kd)$

where $k = \sqrt{\frac{8\pi^2 m(U-E)}{h^2}}$

radioactive decay, $x = x_o \exp(-\lambda t)$

decay constant, $\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

**1** What is the approximate volume of a typical inflated rubber party balloon?

**A** 0.001 $m^3$ **B** 0.01 $m^3$ **C** 0.1 $m^3$ **D** 1 $m^3$

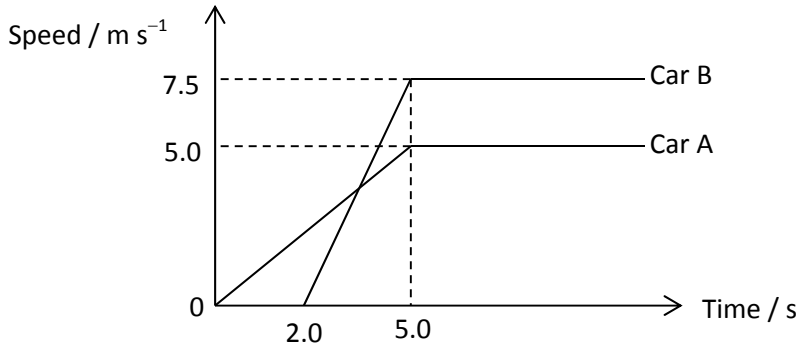
**2** A force of (2.0 ± 0.1) N is applied to a mass of (3.00 ± 0.05) kg. What is its acceleration?

**A** (0.67 ± 0.02) m $s^{-2}$
**B** (0.67 ± 0.03) m $s^{-2}$
**C** (0.67 ± 0.04) m $s^{-2}$
**D** (0.67 ± 0.07) m $s^{-2}$

**3** A rock is thrown with an initial kinetic energy of 15 J at an angle of 30° to the horizontal. What is its kinetic energy at the highest point of its trajectory?

**A** 0 J **B** 3.8 J **C** 7.5 J **D** 11 J

**4** Car A and car B both start from the same starting line. Car A moves off first, accelerating constantly for 5.0 s to a constant speed of 5.0 m $s^{-1}$. Car B starts moving 2.0 s after car A, and accelerates constantly for 3.0 s until it reaches a constant speed of 7.5 m $s^{-1}$. The speed-time graphs of both cars are shown in the graph below:



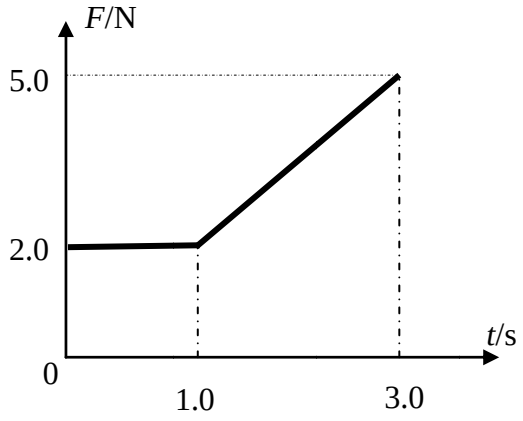

At what time does car B catch up with car A?

**A** 3.3 s **B** 5.0 s **C** 5.5 s **D** 7.5 s

**5** A man is standing inside a descending lift. Which of the following statements about the magnitude of the force exerted on the man's feet by the floor of the lift is always correct?

**A** It is less than the magnitude of his weight.
**B** It is equal to the magnitude of his weight.
**C** It would not be equal to what it would be in a stationary lift.
**D** It is equal to the magnitude of the force exerted on the floor of the lift by the man's feet.

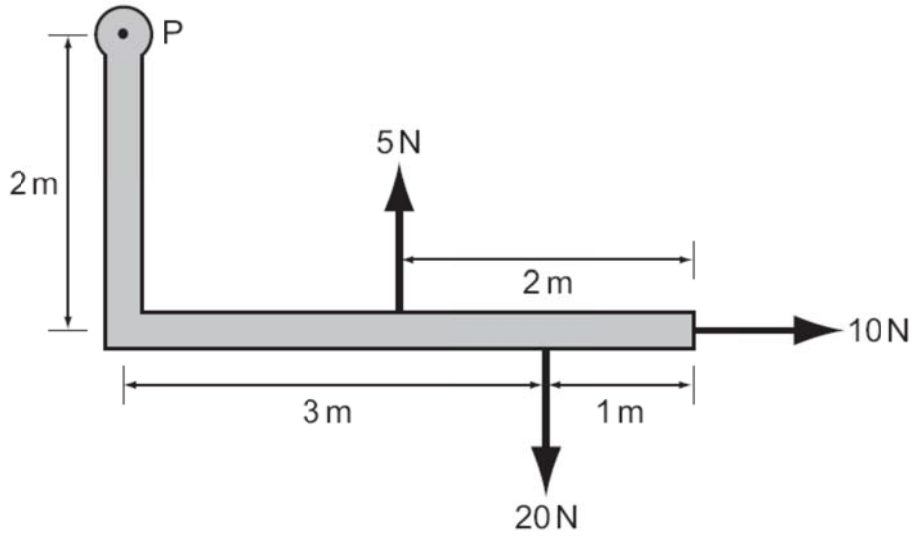
**6** The graph below shows how the force acting on a 2.0 kg body varies with time.




Assuming that the body is initially moving in a straight line at 2.0 m $s^{-1}$, what is its final velocity?

**A** 4.0 m $s^{-1}$ **B** 6.5 m $s^{-1}$
**C** 9.0 m $s^{-1}$ **D** 11.0 m $s^{-1}$

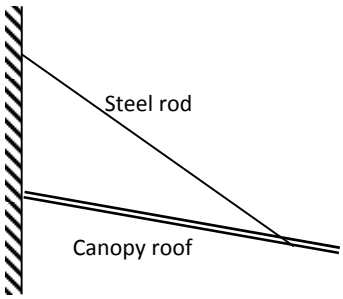
**7** An L-shaped rigid lever arm is pivoted at point P.




Three forces act on the lever arm, as shown in the diagram.
What is the magnitude of the resultant moment of these forces about point P?

**A** 30 N m **B** 35 N m
**C** 50 N m **D** 90 N m

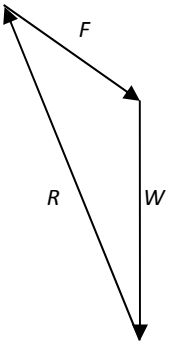
**8** A canopy roof, hinged to a vertical wall at one end and secured by a steel rod at the other end as shown below, is in equilibrium.



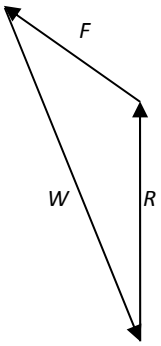

The weight of the canopy roof is *W*, the force exerted by the rod on the roof is *F* and the reaction by the wall on the roof is *R*.

Which vector triangle represents the forces acting on the canopy roof?

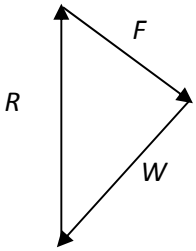
**A**



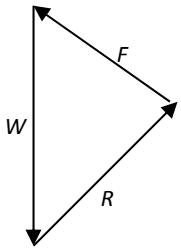

**B**




**C**




**D**



**9** A small metal sphere of mass $m$ is falling vertically from rest in liquid glycerine. When it reaches a constant velocity $v$, which of the following statements is false?

**A** The resistive force acting on the metal sphere is constant
**B** The gravitational potential energy decreases at a rate of $mgv$.
**C** The kinetic energy is constant and equal to $\frac{1}{2} mv^2$.
**D** The total mechanical energy of the sphere is constant.

**10** An object of mass $m$ is pushed against a spring, compressing it by a horizontal distance of $d$. The block is then released by launching it along a smooth horizontal surface, attaining a final speed of $v$. Another object of similar size and shape, but of mass $3m$, is pushed against the same spring and released in the same way. What is the distance that the spring is compressed by the second object if its final speed is $3v$?

**A** $1.7d$ **B** 5.2d **C** $9d$ **D** $15.6d$

**11** A car of mass 200 kg goes over a semicircular hill of radius 12 m at a speed of 8.0 m $s^{-1}$. What is the normal reaction that it experiences from the road surface when it is at the top of the hill?

**A** 0 N **B** 900 N **C** 2000 N **D** 3000 N

**12** Muthu is playing with a marble in a bowl. The bowl is hemispherical with a radius of 5.0 cm, and has a smooth interior. He shakes the bowl horizontally, so that the marble performs horizontal circular motion at a height of 2.0 cm above the bottom of the bowl.

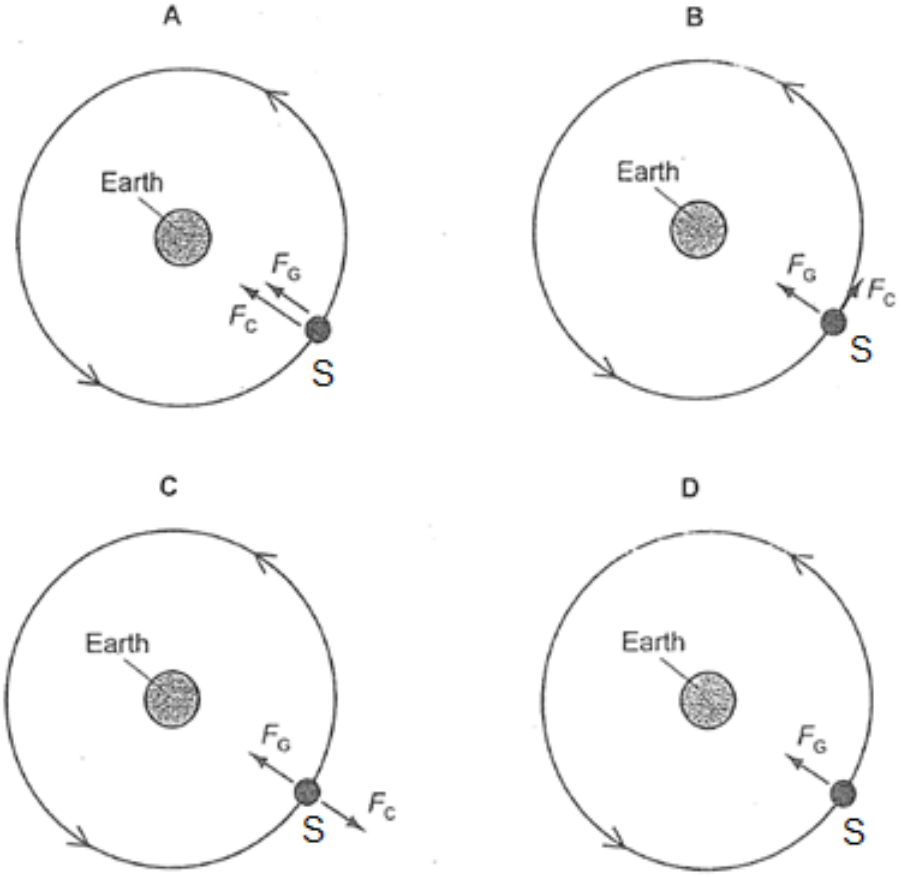
What is the period of the marble?

**A** 0.35 s **B** 0.39 s **C** 0.52 s **D** 3.9 s

**13** If a body of mass $m$ were released in a vacuum just above the surface of a planet of mass $M$ and radius $R$, what would be its gravitational acceleration?

**A** $\frac{Gm}{R}$ **B** $\frac{Gm}{R^2}$ **C** $\frac{GM}{R}$ **D** $\frac{GM}{R^2}$

**14** A satellite S orbits the Earth. The gravitational force on the satellite is $F_G$. The centripetal force required to maintain the satellite in orbit is $F_C$. Which of the following diagrams shows the force, or forces, acting on the orbiting satellite?




**15** Which of the following is true for a damped system of oscillations?

**A** The system does not oscillate at its natural frequency.
**B** When resonance takes place, the system will still lose energy.
**C** Damping causes the resonant frequency to become gradually bigger.
**D** The number of complete oscillations made by a system under critical damping is less than the number of complete oscillations made by a system under heavy damping.

**16** A body performs simple harmonic motion with a period of 0.63 s. The maximum speed of the body is 5.0 m $s^{-1}$. What are the values of the amplitude $x_0$ and the angular frequency $\omega$?

| | $x_0$ / m | $\omega$ / rad $s^{-1}$ |
|---|---|---|
| **A** | 2.0 | 9.97 |
| **B** | 0.50 | 0.100 |
| **C** | 0.50 | 9.97 |
| **D** | 0.020 | 0.200 |

**17** The specific latent heat of vaporisation of water at 25 ºC is appreciably greater than the value at 100 ºC because

**A** the mean speed of vapour molecules is less at 25 ºC than at 100 ºC.
**B** the molecules in the liquid are more tightly bound to one another at 25 ºC than at 100 ºC.
**C** more work must be done in expanding the water vapour against atmospheric pressure at 25 ºC than at 100 ºC.
**D** the specific latent heat at 25 ºC includes the heat required to raise the temperature of one kilogram of water from 25 ºC to 100 ºC.

**18** The first law of thermodynamics states that the increase in internal energy $\Delta U$ of a system is related to the heat $q$ supplied to it and the work done $w$ on it, and is given by the equation

$$\Delta U = q + w$$

What are $\Delta U$, $q$ and $w$ for a constant mass of ideal gas whose temperature is increased at constant pressure?

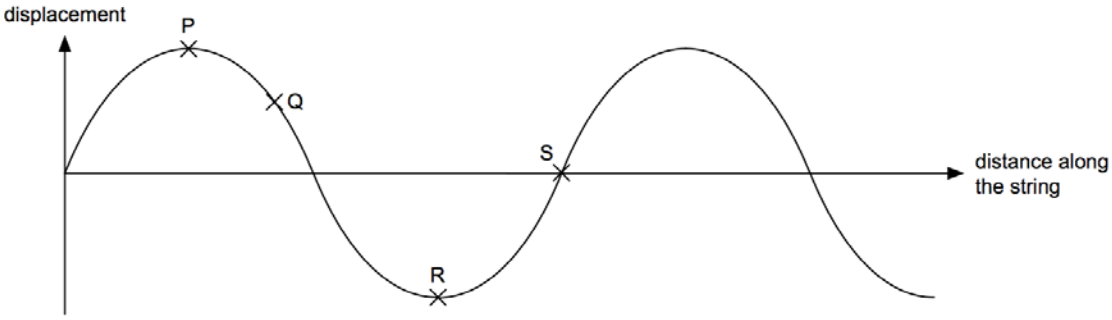
| | $\Delta U$ | $q$ | $w$ |
|---|---|---|---|
| **A** | negative | positive | negative |
| **B** | zero | negative | positive |
| **C** | positive | negative | positive |
| **D** | positive | positive | negative |

**19** A longitudinal wave of frequency 1.6 Hz travels along a stretched spring at a speed of 2.4 m $s^{-1}$.

What is the phase difference between points on the spring that are 0.50 m apart?

**A** $\frac{\pi}{3}$ rad **B** $\frac{2\pi}{3}$ rad **C** $\pi$ rad **D** $3\pi$ rad

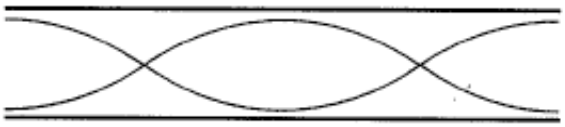
**20** The figure shows the shape at a particular instant of part of a transverse wave travelling from left to right along a string.




Which statement about the motion of elements of the string at this instant is correct?

**A** The speed of Q is higher than S.
**B** Both Q and R are moving upwards.
**C** The energy of P and S is entirely kinetic.
**D** The acceleration of P and R is a maximum.

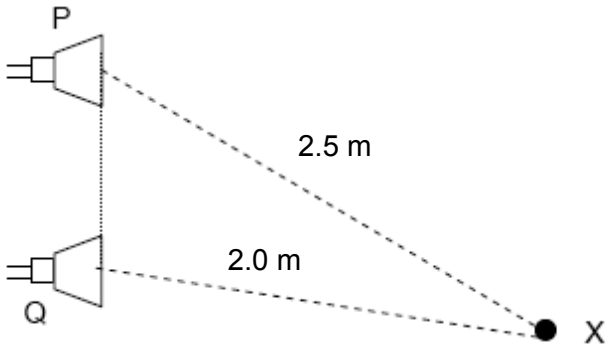
**21** A stationary wave is formed in the air in an open tube as represented in the diagram.



How many antinodes are formed by a stationary wave of twice the frequency?

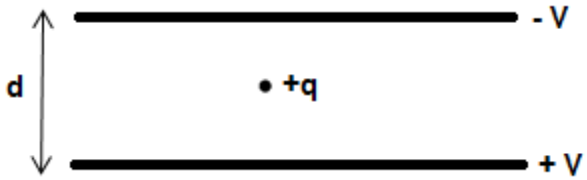
**A** 2 **B** 4 **C** 5 **D** 6

**22** Microwaves of wavelength 4.0 cm are produced by two microwave transmitters P and Q operating in phase. Point X is 2.5 m from transmitter P and 2.0 m from transmitter Q as shown in the figure. Microwaves from transmitter P arrives at point X with intensity $I$ and amplitude of oscillation $A$ while the microwaves from transmitter Q arrives at point X with intensity $4I$. Determine the resultant intensity at point X in terms of $I$.




**A** zero **B** $I$ **C** $3I$ **D** $9I$

**23** An oil droplet has a charge, $+q$ and is situated between two parallel horizontal metal plates as shown in the diagram.

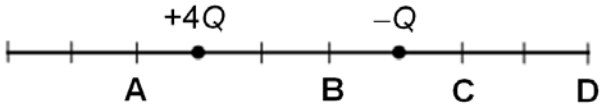



The separation of the plates is $d$. The droplet is observed to be stationary when the upper plate is at potential $-V$ and the lower at potential $+V$.

For this to occur, the weight of the droplet is equal in magnitude to

**A** $\frac{Vq}{d}$ **B** $\frac{2Vq}{d}$ **C** $\frac{Vd}{q}$ **D** $\frac{2Vd}{q}$

**24** Two point charges $+4Q$ and $-Q$ are situated as shown. At which point could the resultant electric field due to these charges be zero?



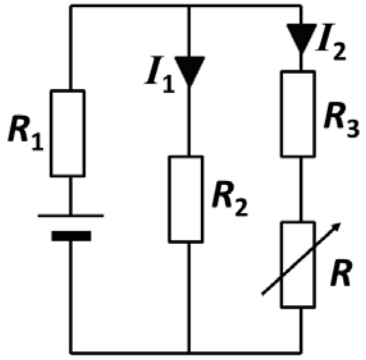
**25** A high electric potential is applied between two electrodes of a hydrogen discharge tube so that the gas is ionised. Electrons then move towards the positive electrode and protons towards the negative electrode. In each second, $5.0 \times 10^{18}$ electrons and $2.0 \times 10^{18}$ protons pass a cross-section of the tube. What is the current flowing in the discharge tube?

**A** 0.32 A **B** 0.48 A **C** 0.80 A **D** 1.1 A

**26** A generator produces 100 kW of power at a potential difference of 5.0 kV. The power is transmitted through cables of total resistance 5.0 Ω. How much power is dissipated in the cables?

**A** $1.0 \times 10^2$ W
**B** $2.0 \times 10^3$ W
**C** $5.0 \times 10^4$ W
**D** $5.0 \times 10^6$ W

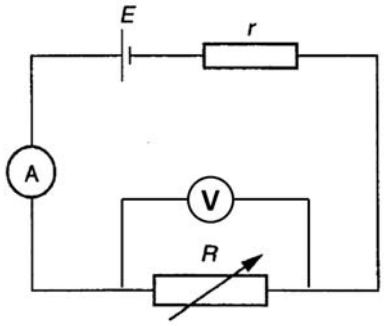
**27** In the circuit below, $R_1$, $R_2$ and $R_3$ are fixed resistors and $R$ is a variable resistor.




As $R$ decreases,

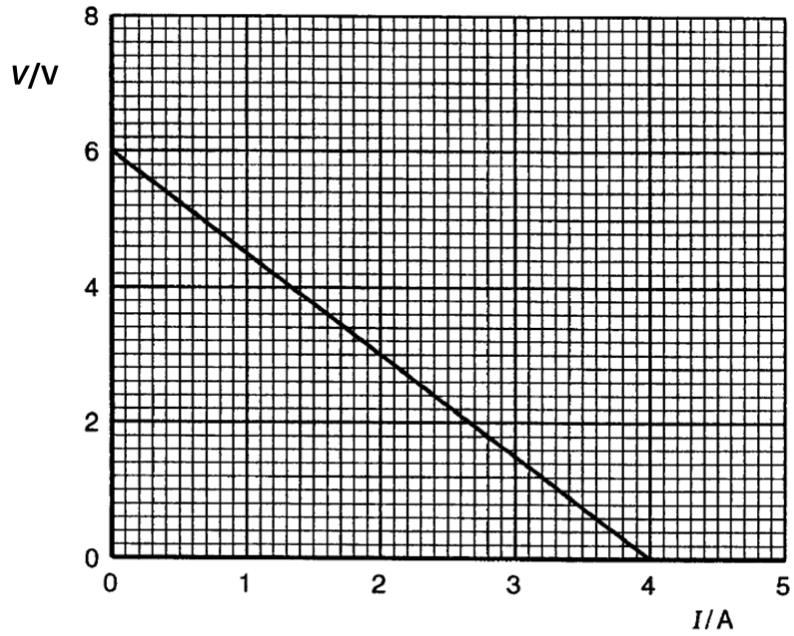
**A** $I_1$ remains unchanged, and $I_2$ increases.
**B** $I_1$ decreases, and $I_2$ remains unchanged.
**C** $I_1$ decreases, and $I_2$ increases.
**D** $I_1$ decreases, and $I_2$ decreases.

**28** A battery of e.m.f. *E* and internal resistance *r* is connected to a variable resistor of resistance *R*, as shown in the figure below.




The current $I$ in the circuit is measured with an ammeter of negligible resistance, and the potential difference *V* across *R* is measured with a voltmeter of very high resistance.

Having taken a series of voltage and current readings, the following voltage-current graph was obtained.

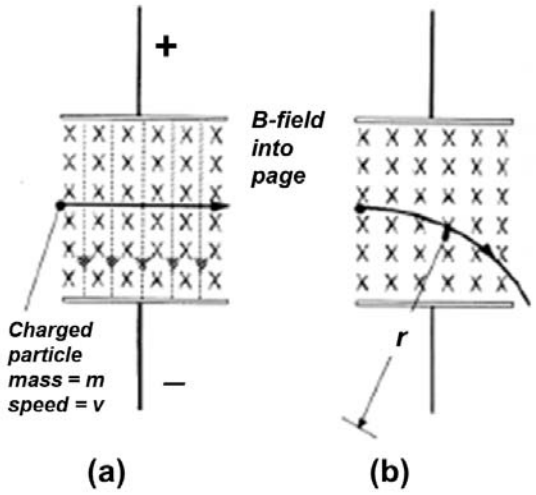



Which of the following set of data is correct when a current of 1.20 A flows in the circuit?

| | E.m.f. of the cell, *E* / V | Internal resistance of the cell, *r* / Ω |
|---|---|---|
| **A** | 4.2 | 1.5 |
| **B** | 4.2 | 3.5 |
| **C** | 6.0 | 1.5 |
| **D** | 6.0 | 3.5 |

**29** In Fig. (a) below, a beam of particles, each of charge $q$ and mass $m$, is travelling at speed $v$ through a region in which a magnetic field $B$ is perpendicular to an electric field $E$. The beam is undeflected by the crossed electric and magnetic fields.

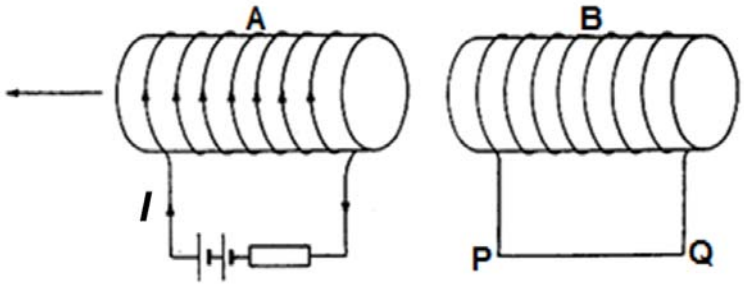
In Fig. (b) below, the electric field is switched off. The beam is found to form an arc of a circle of radius $r$.




Which one of the following expressions gives the mass $m$ of the charged particle?

**A** $\frac{qBr}{E}$ **B** $\frac{qBv}{E}$ **C** $\frac{qB^2r}{E}$ **D** $\frac{qB^2}{Er}$

**30** A and B are solenoids wound on cardboard tubes. A carries a constant current $I$ as shown below and moves with constant speed away from B along the common axis of the two tubes.

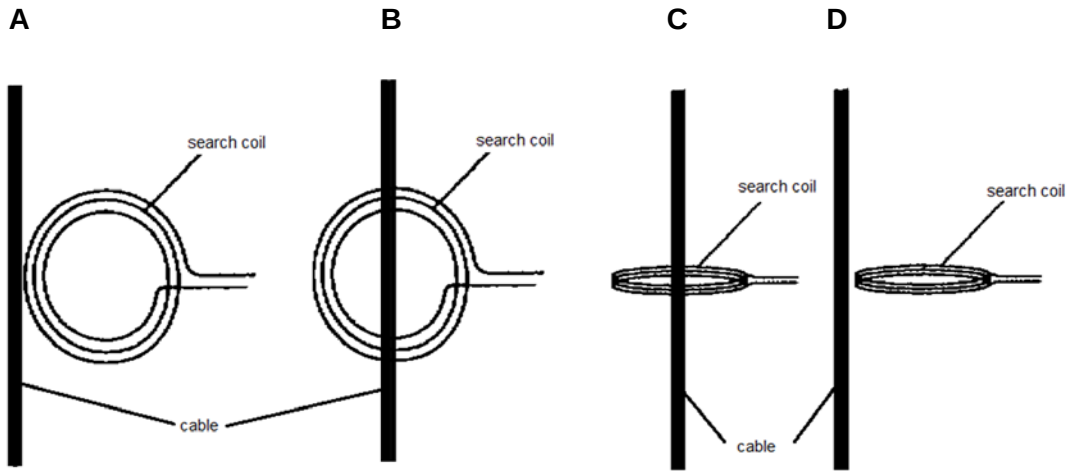



As a result of electromagnetic induction a current will flow in the straight wire PQ and there will be a force between A and B. Which one of the following correctly describes both the current and the force?

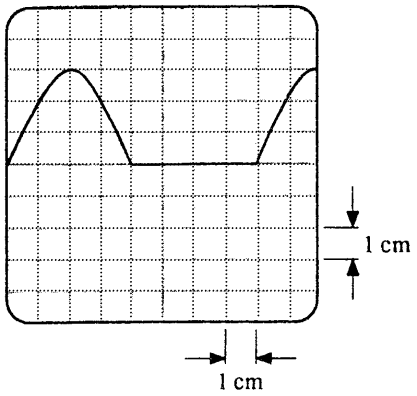
| | Nature and direction of current in straight wire PQ | Nature of force |
|---|---|---|
| **A** | diminishing, Q to P | attraction |
| **B** | diminishing, P to Q | repulsion |
| **C** | diminishing, Q to P | repulsion |
| **D** | constant, Q to P | attraction |

**31** Large alternating currents in a cable can be measured by monitoring the e.m.f. induced in a small coil situated near the cable. This e.m.f. is induced by the varying magnetic field set up around the cable.

In which arrangement of coil and cable will the e.m.f. induced be a maximum?




**32** A half-wave rectified voltage is displayed on the screen of an oscilloscope, as shown below.



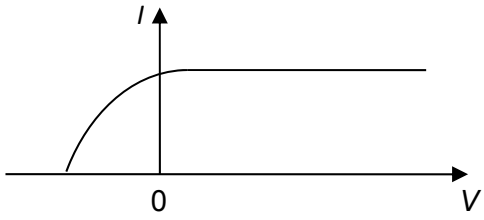

The Y-sensitivity is set to 2.0 V $cm^{-1}$ and the time base to 20 μs $cm^{-1}$. Which are the correct values for the peak voltage and frequency of the supply?

| | Peak Voltage / V | Frequency / Hz |
|---|---|---|
| **A** | 3.0 | $12.5 \times 10^3$ |
| **B** | 6.0 | $6.25 \times 10^3$ |
| **C** | 3.0 | $6.25 \times 10^3$ |
| **D** | 6.0 | $8.00 \times 10^3$ |

**33** The average power dissipated in a light bulb connected across an a.c. source of peak voltage 180 V is 50 W. If two such light bulbs are connected in series to the electrical mains of 230 V r.m.s., what would be the total power dissipated in both the lamps?

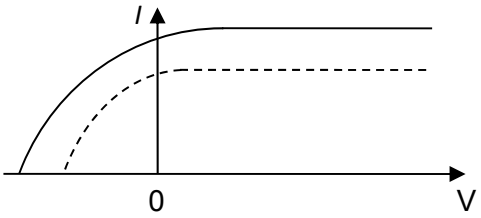
**A** 51 W
**B** 62 W
**C** 82 W
**D** 100 W

**34** A metal surface in an evacuated tube is illuminated with monochromatic light causing the emission of photo-electrons which are collected at an adjacent electrode. For a given intensity of light, the way in which the photocurrent *I* depends on the potential difference *V* between the electrodes is as shown in the diagram below.

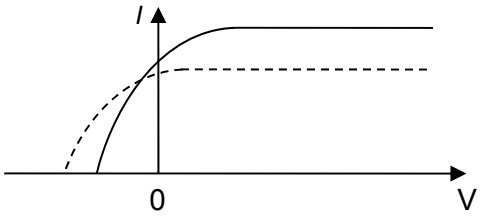



Which of the following graphs shows the result when the frequency of the light is increased while the intensity remains constant? (The solid curve represents the original graph and the dotted curve represent the new graph.)

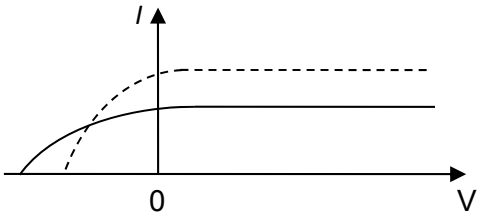
**A**



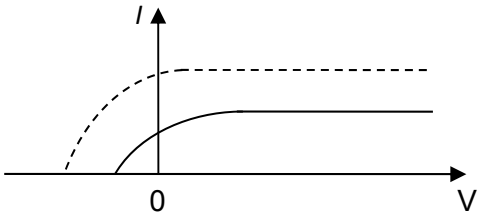

**B**




**C**



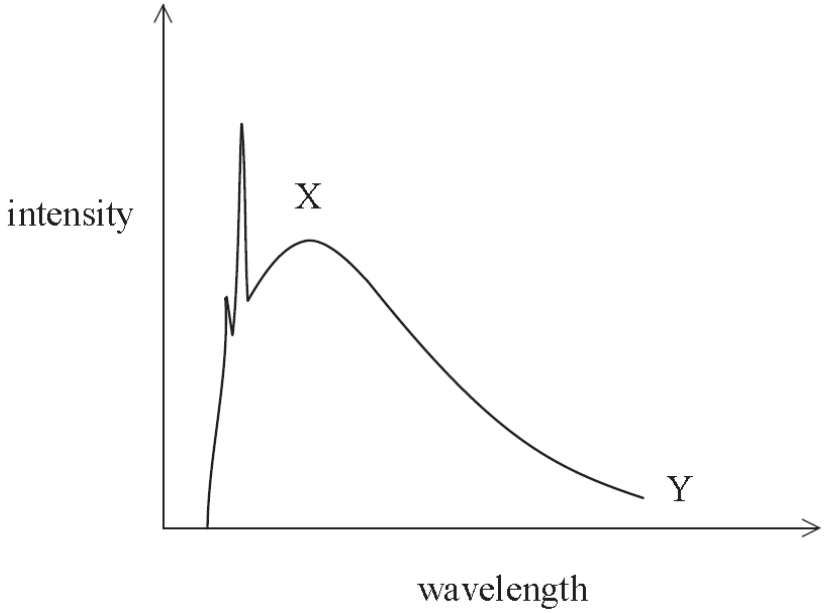

**D**




**35** Which one of the following provides direct evidence for the existence of discrete energy levels in an atom?

**A** The continuous spectrum of the light emitted by a white-hot metal.
**B** The emission of photoelectrons from a metal.
**C** The ionisation of gas atoms when bombarded by alpha particles.
**D** The line emission spectrum of a gas at low pressure.

**36** The diagram shows a typical X-ray spectrum produced by the bombardment of a heavy metal target by high energy electrons.




Which of the following best explains the part of the spectrum labelled XY?

**A** The acceleration of the electrons striking the metal target.
**B** The decrease in kinetic energy of photons
**C** Electron transitions between energy levels in the atoms of the metal target.
**D** The diffraction of the electrons striking the metal target.

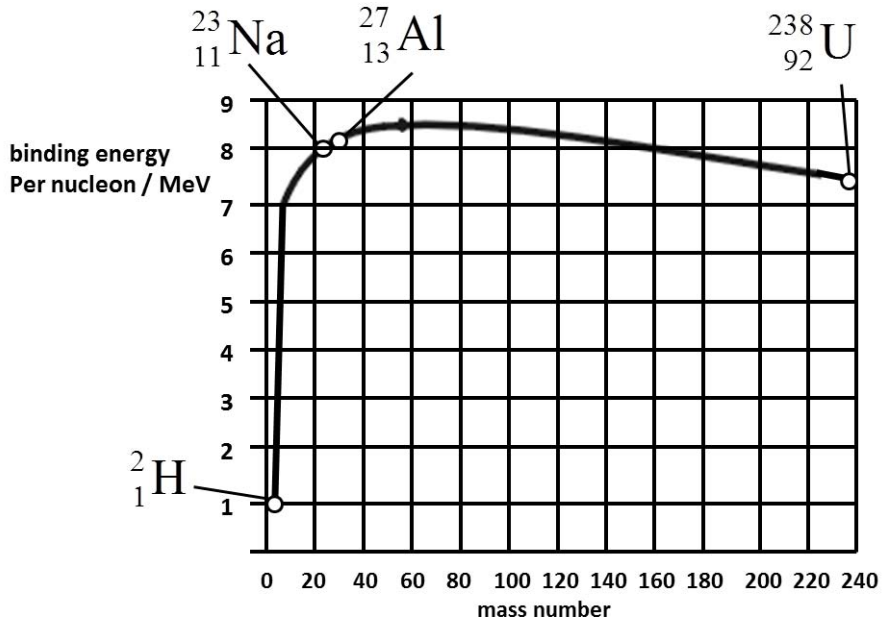
**37** Which of the following statements below on intrinsic semiconductors is true?

**A** The total current flow is the sum of both 'hole' and 'electron' currents.
**B** There are more electrons in the conduction band than there are holes in the valence band.
**C** The valence band is completely filled and the conduction band is partially filled.
**D** The valence band is completely filled and the conduction band is empty at room temperature.

**38** In the action of a laser, stimulated emission refers to

**A** an electron from a higher level falling to a lower level.
**B** a charged particle causing light to be emitted from an excited atom.
**C** a charged particle being emitted from an atom as a result of a high energy photon hitting the atom.
**D** a photon causing another photon of the same frequency to be emitted from an excited atom.

**39** The diagram shows a graph of the binding energy per nucleon for a number of naturally occurring nuclides plotted against their mass number.




Which of the following statements is a correct deduction from the graph?

**A** Energy will be released if a nucleus with a mass number less than about 80 undergoes fission as a result of particle bombardment.

**B** Energy will be released if a nucleus with a mass number greater than about 80 undergoes fusion with any other nucleus.

**C** $^{27}_{13}\text{Al}$ will not spontaneously emit an alpha particle to become $^{23}_{11}\text{Na}$.

**D** $^{238}_{92}\text{U}$ is the stable end-point of a number of radioactive series.

**40** A radioactive source contains two materials. One has a half-life of 4 days and decays by the emission of alpha particles whilst the other has a half-life of 3 days and emits beta particles. The initial activity is 160 Bq, but the activity drops to 96 Bq when a few sheets of paper are placed between the source and the detector. What will be the detected activity after 12 days, without the paper present?

**A** 10 Bq **B** 14 Bq **C** 20 Bq **D** 104 Bq