Name: _____ ( ) Class: 24 / _____

ANDERSON SERANGOON JUNIOR COLLEGE

2024 JC2 Preliminary Examination

PHYSICS Higher 2 — 9749/01

Paper 1 Multiple Choice — **Monday 16 September 2024**

1 hour

Additional Materials: Multiple Choice Answer Sheet

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.

Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
	$(1/(36\pi)) \times 10^{-9}$ 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 K^{-1} mol^{-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

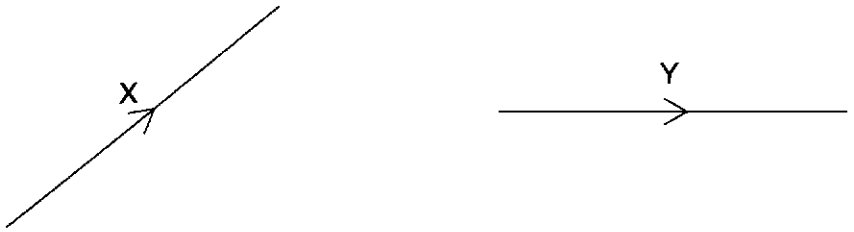
uniformly accelerated motion	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$
work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -\frac{Gm}{r}$
temperature	$T/\text{K} = T/^\circ\text{C} + 273.15$
pressure of an ideal gas	$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
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.	$v = v_0 \cos \omega t$ $= \pm\omega\sqrt{x_o^{\,2} - x^2}$
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 When a beam of light is incident on a surface, it delivers energy to the surface. The intensity of the beam is defined as the energy delivered per unit area per unit time.

What is the unit of intensity, expressed in SI base units?

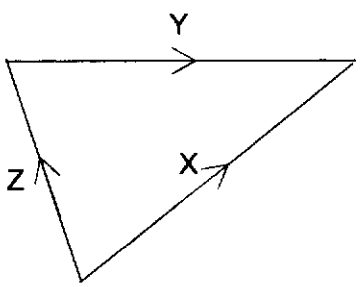
A $kg\ m^{-2}\ s^{-1}$ **B** $kg\ m^{2}\ s^{-3}$ **C** $kg\ s^{-2}$ **D** $kg\ s^{-3}$

2 The diagram shows two vectors X and Y.



In which vector triangle does the vector Z show the magnitude and direction of vector X – Y?

A



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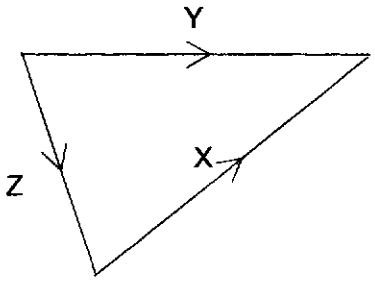

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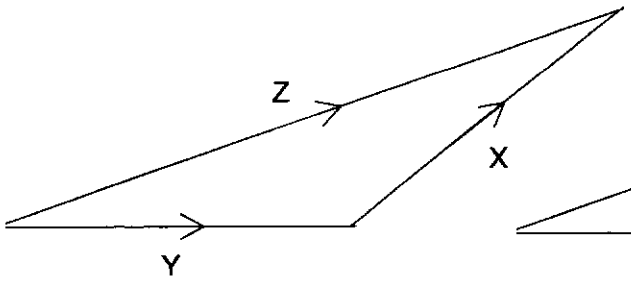

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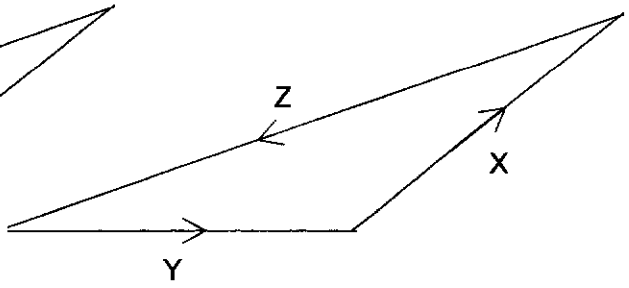
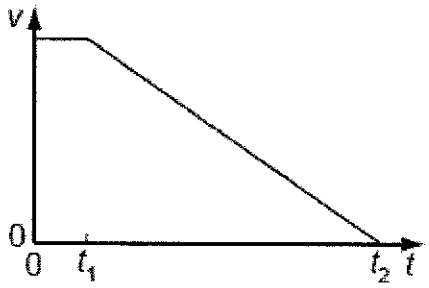
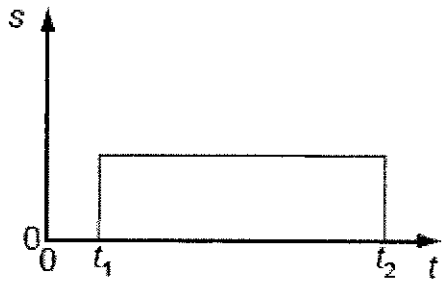


3 When a car driver sees a hazard ahead, she applies the brakes as soon as she can and brings the car to rest. The graph shows how the speed v of the car varies with time t after hazard is seen.

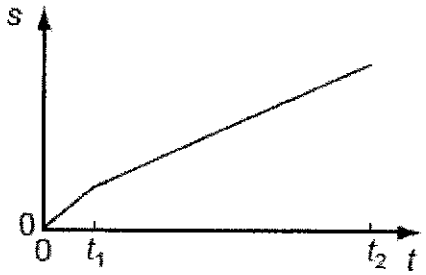


Which graph represents the variation with time t of the distance s travelled by the car after the hazard has been seen?

A



B



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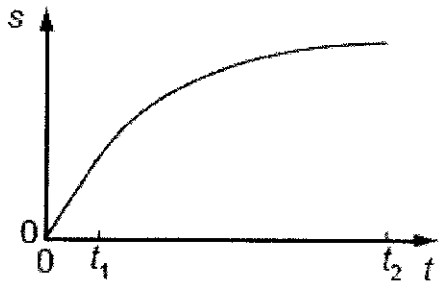

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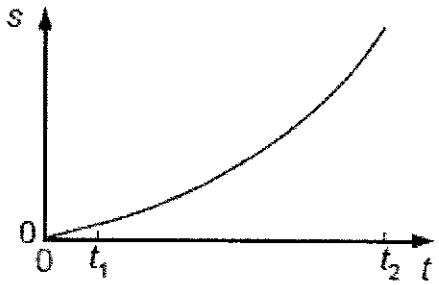
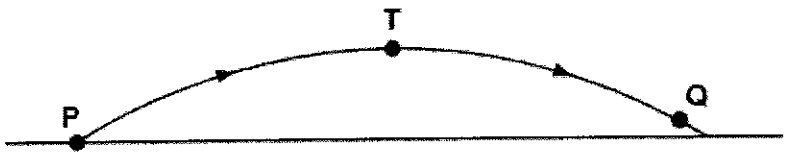


4 In the absence of air resistance, a stone is thrown from **P** and follows a parabolic path in which the highest point reached is **T**. The stone reaches point **Q** just before landing.



The vertical component of acceleration of the stone is

A zero at **T**.

B greatest at **T**.

C greatest at **Q**.

D the same at **Q** as at **T**.

5 A man is skiing down a slope with constant speed.

According to Newton's third law, which force makes an action–reaction pair with the weight of the man?

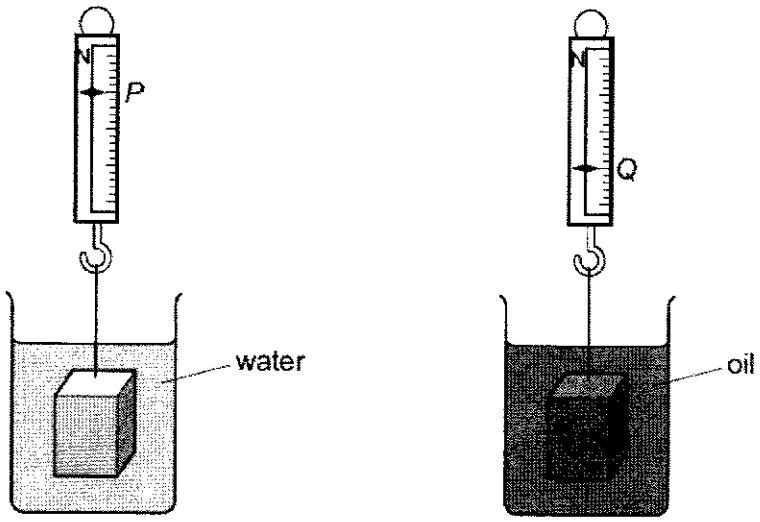
A the friction from the slope

B the normal contact force from the slope

C the gravitational force on the Earth due to the man

D the sum of normal contact force and friction from the slope

6 An object of weight W is suspended from a newton meter. When the object is completely immersed in water, the newton meter reads P. When the object is completely immersed in oil, the newton meter reads Q.



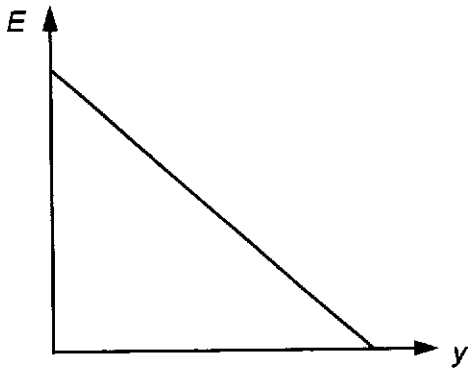
What is the ratio $\frac{\text{density of oil}}{\text{density of water}}$?

A $\frac{W-P}{Q-P}$ **B** $\frac{Q-P}{W-P}$ **C** $\frac{W-P}{W-Q}$ **D** $\frac{W-Q}{W-P}$

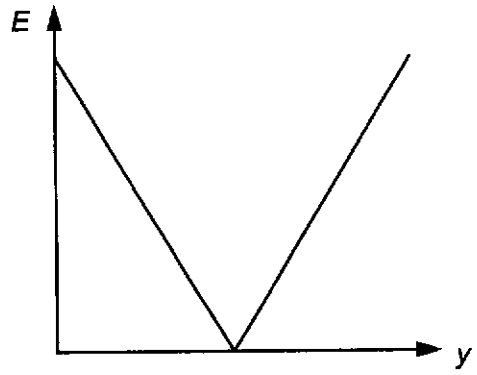
7 A man throws a ball vertically upwards. The ball reaches a maximum height, and then falls back into the man's hand. Air resistance may be assumed to be negligible.

Which graph shows how the kinetic energy E of the ball varies with the vertical displacement y?

A



B



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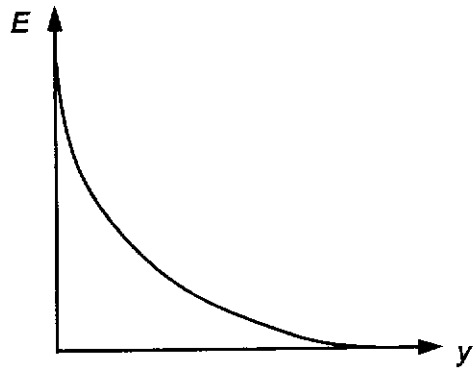

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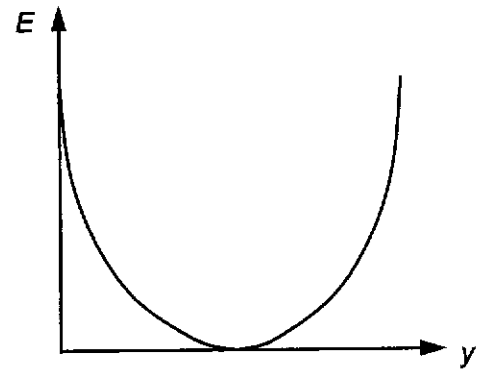


8 A man drags an object of mass 5.0 kg up a plane inclined at 30° to the horizontal. It travelled through a vertical height of 12 m at a constant speed. The total work done by the man is 1500 J.

What is the average friction force between the object and the plane?

A 8.3 N **B** 38 N **C** 63 N **D** 88 N

9 A marble moves in a circular path of radius 0.80 m at an angular speed of $\frac{\pi}{2}$ rad s^{-1}. At $t = 0$, it passes by point P.

What is its displacement from P at $t = 6.0$ s?

A 1.1 m **B** 1.6 m **C** 7.5 m **D** 9.4 m

10 A satellite is in an orbit around the Earth. It is moved to a new orbit that is closer to the surface of the Earth. Which of the following correctly describes the changes in the gravitational potential energy and orbital speed of the satellite?

	potential energy	**speed**
A	increases	increases
B	increases	decreases
C	decreases	increases
D	decreases	decreases

11 Which statement explains why the thermodynamic temperature scale is considered more fundamental than the Celsius temperature scale?

A The thermodynamic temperature scale is determined using the triple point of water instead of ice point, which is more reproducible.

B The thermodynamic temperature scale is independent of the properties of materials.

C The thermodynamic temperature scale can measure a greater range of temperatures.

D The thermodynamic temperature scale is related to the random kinetic energy of the particles.

12 A 20 W filament lamp has been operating normally for an hour so that its temperature is constant.

When the first law of thermodynamics is used to quantitatively describe the filament of the lamp after this time, which row correctly describes the application of the first law?

	rate of increase of internal energy / W	rate of heating the filament / W	rate of doing work on filament / W
A	+20	+20	0
B	+20	0	+20
C	0	+20	–20
D	0	–20	+20

13 Which of the following examples least likely demonstrates resonance occurring?

A The rear-view mirror of a car vibrates when the car goes over a speed bump.

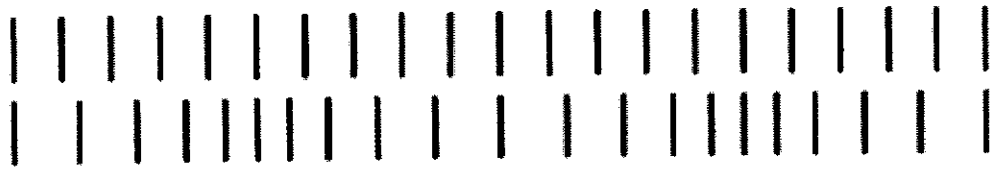
B Air is blown over the reed of a clarinet producing a sound.

C A suspension bridge blown by gusts of wind.

D An ornament placed on a loudspeaker cabinet vibrates when a particular note sounds.

14 The top row of bars represents a set of particles inside the Earth and at rest.

The lower row represents the same particles at one instant as a longitudinal wave passes from left to right through the Earth.



What should be measured to determine the amplitude of the oscillations of the particles in the lower row as the wave passes?

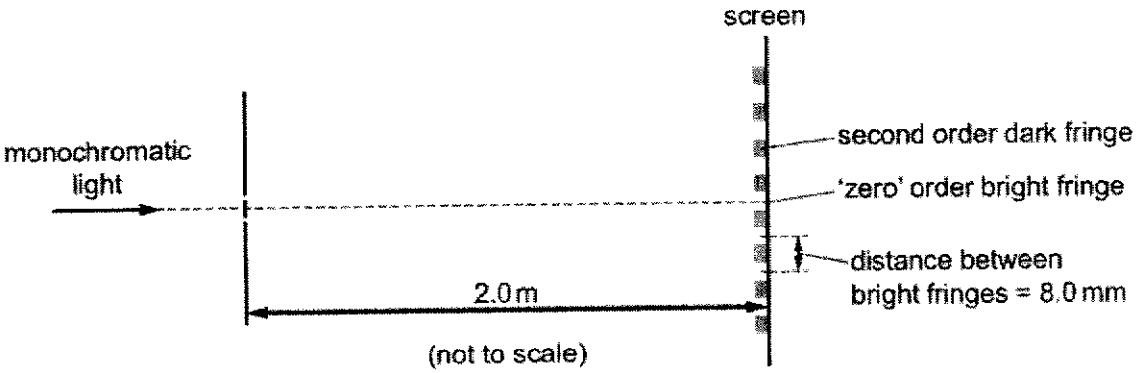
A half the maximum displacement of the particles from their position at rest

B half the maximum distance apart of the particles

C the maximum displacement of the particles from their position at rest

D the maximum distance apart of the particles

15 Monochromatic light is incident on a pair of narrow slits a distance of 0.1 mm apart. A series of bright and dark fringes are observed on a screen a distance of 2.0 m away. The distance between adjacent bright fringes is 8.0 mm.



What is the path difference between the light waves from the two slits that meet at the second order dark fringe?

A 2.0×10^{-7} m

B 4.0×10^{-7} m

C 6.0×10^{-7} m

D 8.0×10^{-7} m

16 A musical instrument called a bugle is a long tube with a mouthpiece at one end. The other end is an open end and flared, as shown.

A musician maintains stationary sound waves with a node at the mouthpiece and an antinode at the other end. The lowest frequency of sound that the bugle can produce is 92 Hz.

Which different frequencies of sound can be produced by the bugle?

A 92 Hz, 138 Hz, 184 Hz, 230 Hz, 276 Hz

B 92 Hz, 184 Hz, 276 Hz, 368 Hz, 460 Hz

C 92 Hz, 276 Hz, 460 Hz, 644 Hz, 828 Hz

D 92 Hz, 276 Hz, 828 Hz, 2484 Hz, 7452 Hz

17 Free electrons flow along a copper wire X of radius 5.0×10^{-5} m with an average drift speed of 2.8×10^{-2} m s^{-1}. The current in the wire is 3.0 A.

There is a current of 2.0 A in a copper wire Y of radius 1.0×10^{-4} m.

What is the average drift speed of the free electrons in copper wire Y?

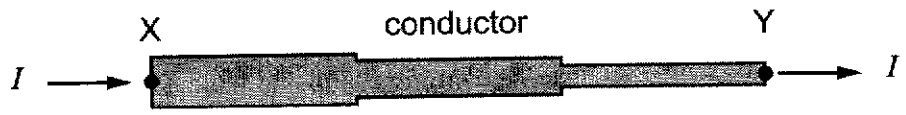
A 4.7×10^{-3} m s^{-1}

B 9.3×10^{-3} m s^{-1}

C 1.1×10^{-2} m s^{-1}

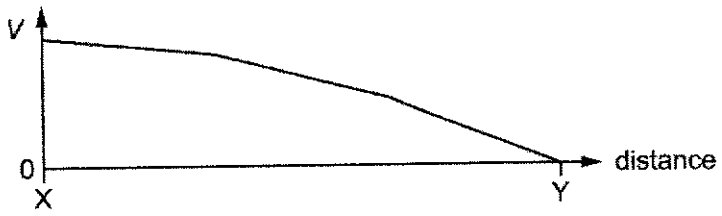
D 1.9×10^{-2} m s^{-1}

18 A conductor consists of three wires connected in series. The wires are all made of the same metal but have different cross-sectional areas. There is a current I in the conductor.

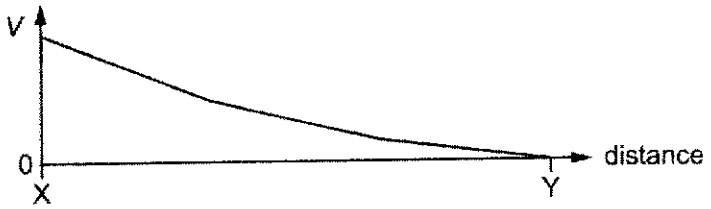


Point Y on the conductor is at zero potential. Which graph best shows the variation of potential V with distance along the conductor?

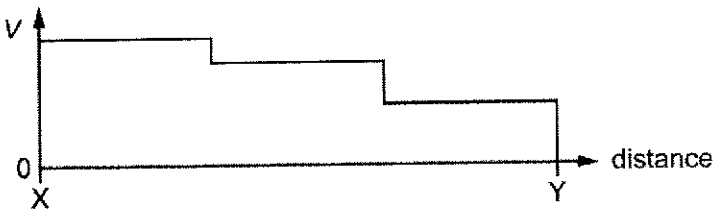
A



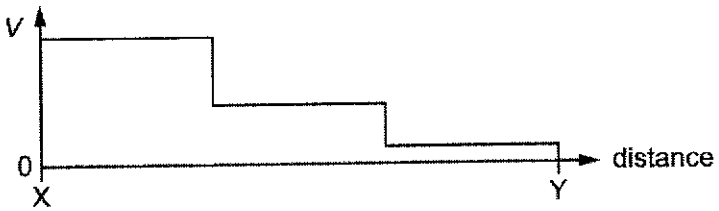
B



C

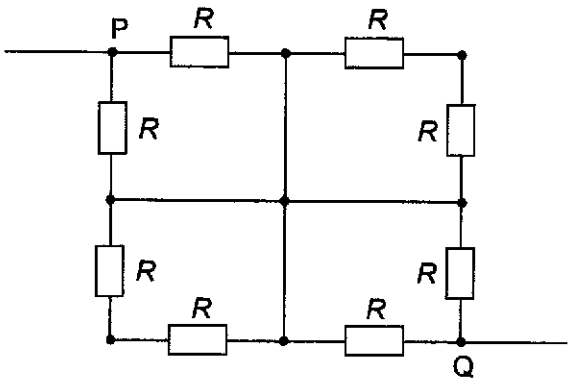


D



19 Eight identical resistors, each of resistance R, are connected in a network as shown below.

What is the effective resistance between the terminals P and Q?

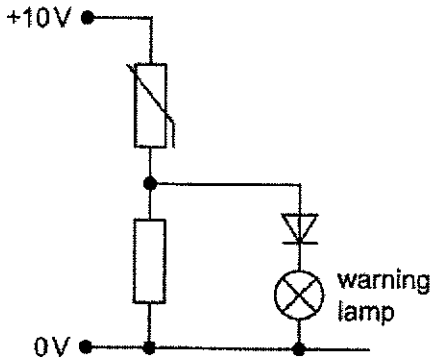


A $\frac{R}{8}$ **B** $\frac{R}{2}$ **C** R **D** $2R$

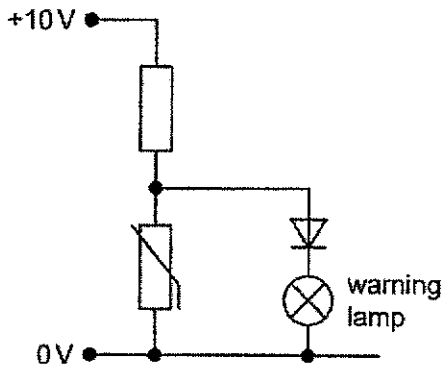
20 A circuit is needed which switches on a warning lamp when the temperature of a thermistor is too high.

Which of the following circuits is suitable?

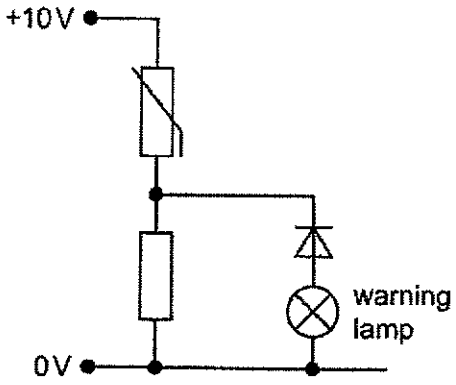
A



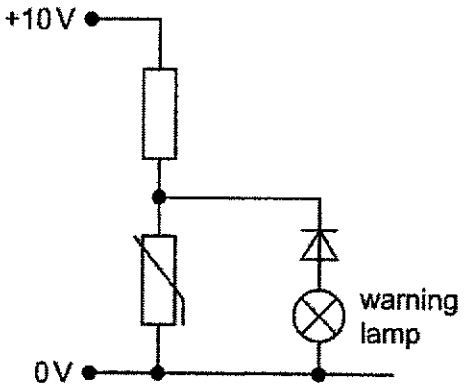
B



C

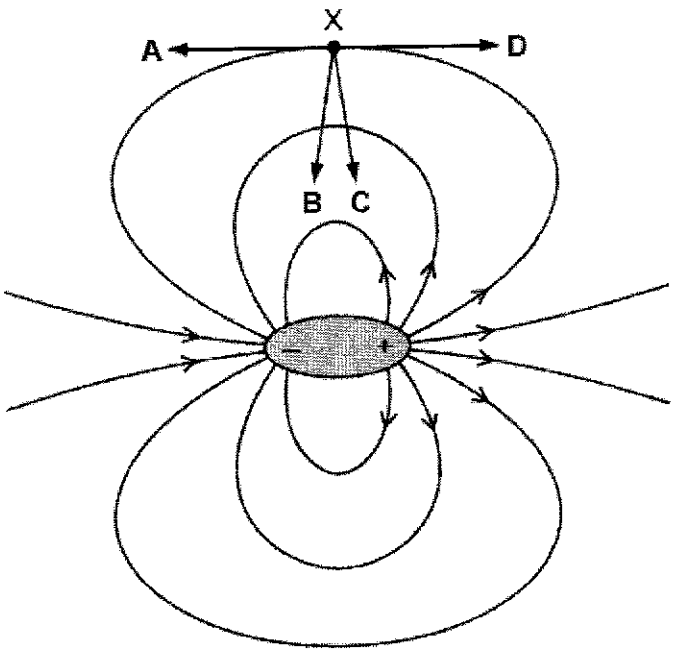


D



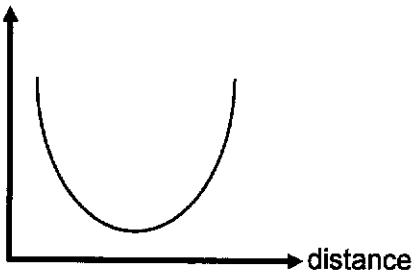
21 An electric dipole is a pair of one negative charge and one positive charge of equal magnitude. The electric field of an electric dipole is shown below.

What is the direction of the force that acts on an electron placed at point X?

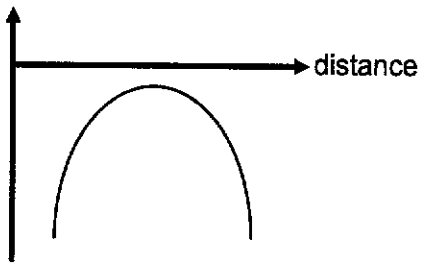


22 Two point charges of equal magnitude and opposite signs are separated by a distance. Which of the following graphs represents how the electric potential and electric field strength vary along a line joining the two point charges?

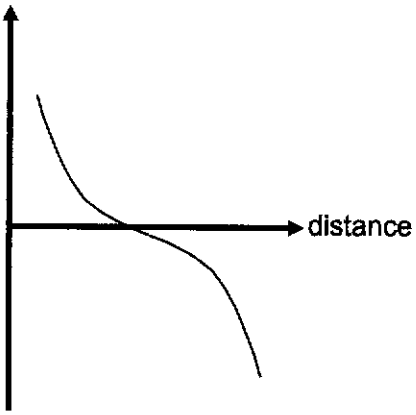
I



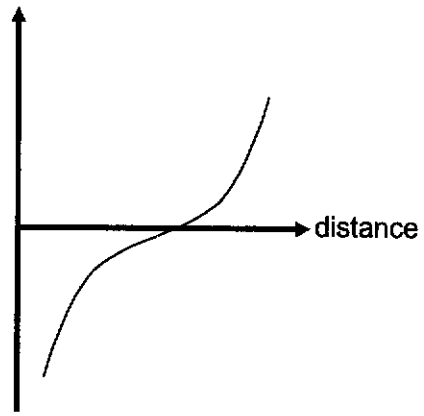
II



III

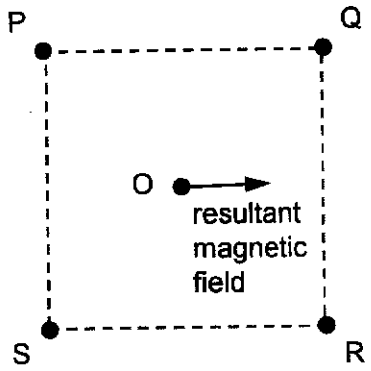


IV



	electric potential	electric field strength
A	I	IV
B	II	III
C	III	II
D	IV	II

23 Four parallel conductors, carrying equal currents, pass vertically through the four corners of a square PQRS. In two conductors, the current is directed into the page and, in the other two, it is directed out of the page.

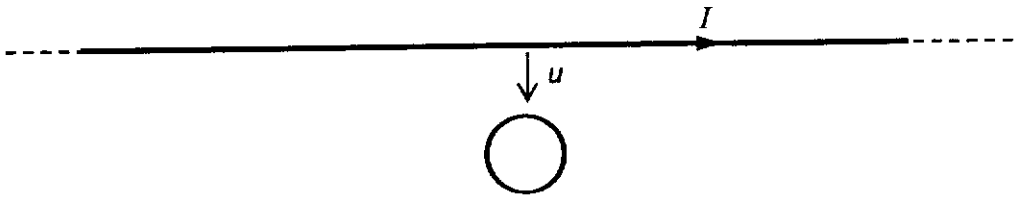


Due to the current in the four conductors, the resultant magnetic field at O is in the direction shown.

Which of the following must be the directions of the currents in each of the four conductors?

	into the page	out of the page
A	P, Q	R, S
B	P, S	Q, R
C	Q, S	P, R
D	R, S	P, Q

24 A long straight wire is in the plane of a flat coil. The straight wire carries a constant current I as shown and is moved at a constant speed u towards the flat coil.



Which statement describing the current in the flat coil is true?

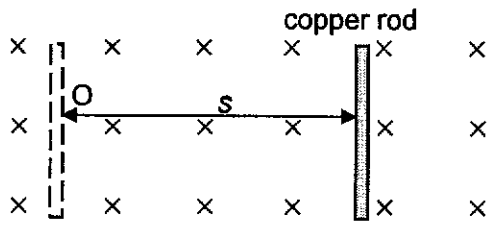
A The current is increasing.

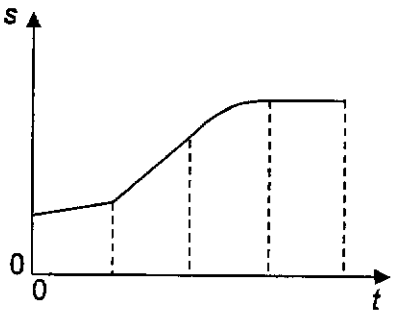
B The current is decreasing.

C The current is always constant.

D The current always changes direction.

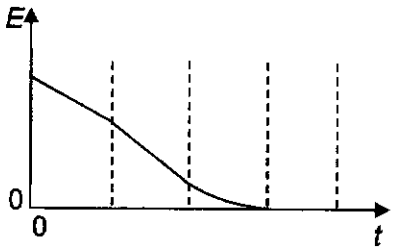
25 A copper rod is moved perpendicular to a uniform magnetic field as shown in the diagram. The graph on the right shows the variation with time t of the distance s of the copper rod from point O.



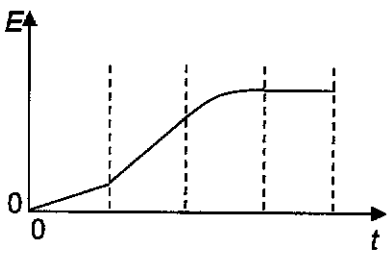


Which graph best shows the variation with time t of the e.m.f. E induced across the rod?

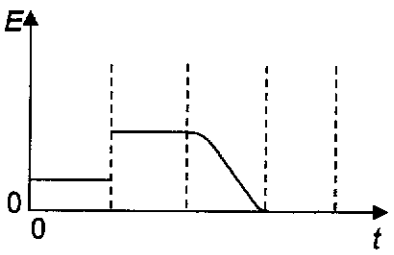
A



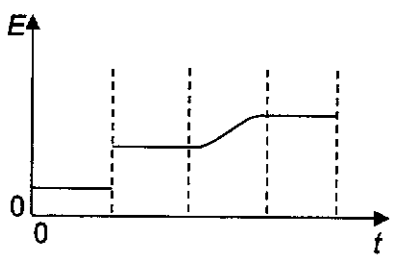
B



C



D



26 A sinusoidal alternating supply of peak voltage 100 V is connected to a diode and a 100 Ω resistor in series.

The diode is ideal with a zero forward resistance and an infinite reverse resistance.

What is the value of the mean current in the resistor?

A less than 0.5 A

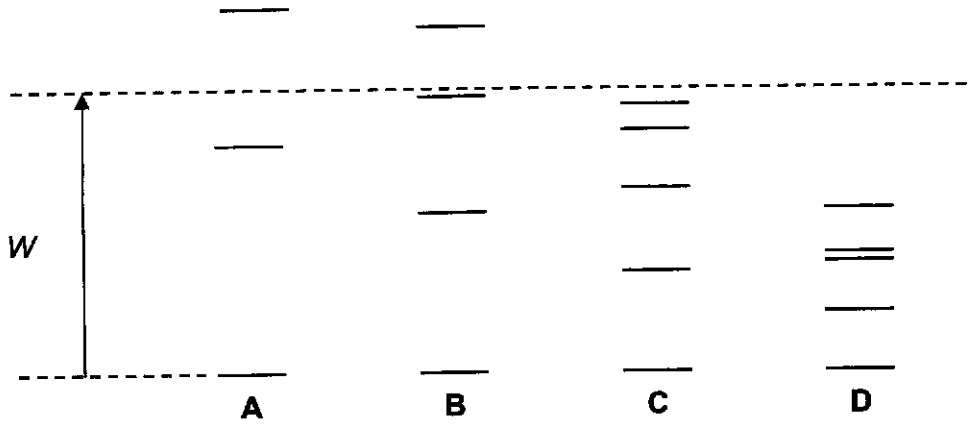
B 0.5 A

C 0.7 A

D 1 A

27 The diagram shows the electron energy levels, referred to the ground state (the lowest energy level) as zero, for four different isolated atoms.

Which atom can produce radiation of the shortest wavelength when atoms in the ground state are bombarded with electrons of energy *W*?



28 λ_0 is the de Broglie wavelength of an electron accelerated from rest through a potential difference of 1 kV.

λ_1 is the de Broglie wavelength of another electron accelerated from rest through a potential difference of 100 kV.

What is the value of the ratio $\frac{\lambda_0}{\lambda_1}$?

A 0.1 **B** 1 **C** 10 **D** 100

29 The rest-masses of deuteron ${}^{2}_{1}H$, proton and neutron are 2.0150 u, 1.0086 u and 1.0097 u respectively. Which one of the following reactions takes place so that the deuteron may disintegrate to a proton and neutron?

A Releasing a photon of energy 2 MeV.

B Releasing a photon of energy 3 MeV.

C Capturing a photon of energy 2 MeV.

D Capturing a photon of energy 3 MeV.

30 Which combination of successive emissions produces a final nucleus with the same proton number as the starting nucleus?

A $\alpha\,\alpha\,\beta$

B $\alpha\,\beta\,\beta$

C $\alpha\,\beta\,\gamma$

D $\beta\,\gamma\,\beta$

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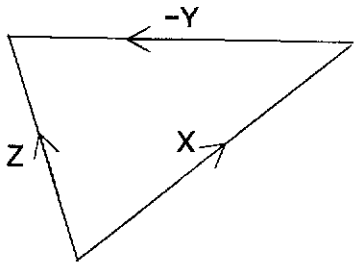
Anderson Serangoon Junior College 2024
JC2 H2 Physics Preliminary Examination Mark Scheme

Paper 1 (30 marks)

1	**D** intensity $I = \frac{E}{At}$ units of $I = \frac{kg\ ms^{-2}\ m}{m^2\ s}$ $= kg\ s^{-3}$
2	**A** Z = X + (–Y) as shown by the vector triangle below.  This is equivalent to option A.
3	**C** Constant speed up to t_1 means s increases at a constant rate, hence a straight line with positive gradient. As speed decreases at constant rate, distance travelled increases at a decreasing rate (decreasing gradient) and reaches a constant (zero gradient) when speed is zero.
4	**D** The vertical component of acceleration is the acceleration of free fall which is a constant in the absence of air resistance.
5	**C** Action-reaction must be of the same type. Weight is the gravitational force on the man due to the Earth.
6	**D** Consider vertical equilibrium of the object in water, taking upwards as positive $P + V\rho_{water}\, g - W = 0$ $\rho_{water} = \frac{W - P}{Vg}$

	Consider vertical equilibrium of the object in oil, taking upwards as positive $Q + V\rho_{oil}\, g - W = 0$ $\rho_{oil} = \frac{W - Q}{Vg}$ $\frac{\rho_{oil}}{\rho_{water}} = \frac{W - Q}{W - P}$
7	**A** By Conservation of Energy, loss in KE = Gain in GPE. ➔ $\Delta E = \Delta mgh = mg\Delta h$ Hence E varies linearly with height, i.e. a straight line. Since y is vertical displacement, at maximum height (largest y value) E = 0. Hence the answer is A.
8	**B** Total work done by man = Work done against friction + gain in GPE (since KE is constant) Work done against friction = 1500 – mgh = 1500 – 5.0 x 9.81 x 12 = 911. 4 J Average friction = work done against friction / distance travelled along plane $= 911.4 / (\frac{12}{\sin 30°}) = 37.9 \approx 38$ N
9	**B** Period = $2\pi / (\pi/2) = 4$ s. After 6s, the marble would have completed 1.5 cycles, so directly opposite P, so displacement = 2r = 2 x 0.80 m = 1.6 m.
10	**C** Let *m* be the mass of the satellite and *M* be the mass of Earth. GPE of orbiting satellite = $-\frac{GMm}{r}$ and KE = $\frac{GMm}{2r}$ When satellite moves closer to the surface of Earth, *r* decrease. From the equations, GPE becomes more negative, so GPE decreases. KE increases, hence orbital speed increases.
11	**B** According to definition for thermodynamic temperature scale.
12	**D** As the temperature has stabilised, the rate of increase of internal energy (ΔU) = 0.

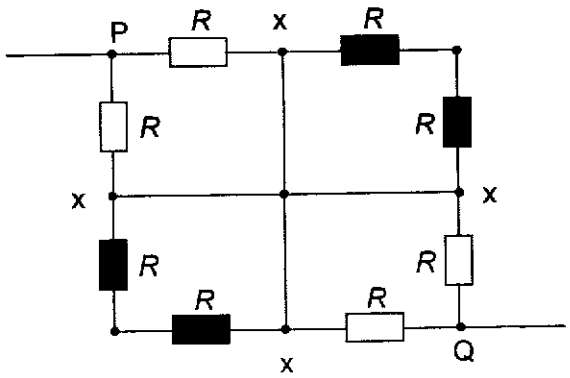
	The filament is hotter than its surroundings, loses heat (Q). Thus, rate of heating the filament is negative. Positive work (W) is done on the filament by electric current (recall the potential difference across a component in a circuit as the work done to drive a unit charge through the component).
13	**A** Option A implies a <u>once off</u> energy transfer to the rear-view mirror when the car goes over a speed bump (i.e. no external <u>periodic</u> driving force). The rest of the options allow for resonance to occur when the driving frequency matches the natural frequency of the oscillating system.
14	**C** Option C follows the definition of amplitude of oscillation.
15	**C** Using $x = \lambda D/a$, $\lambda = (0.008)(0.0001) / (2.0) = 4.0 \times 10^{-7}$ m Since the two sources are in phase at the slits and destructive interference occurs at the screen when their path difference = $(n + ½)\lambda$ At 2nd order dark fringe, n = 1 Thus, path difference = $(1 + ½)\lambda = 1.5 (4.0 \times 10^{-7}) = 6.0 \times 10^{-7}$ m
16	**C** Only the odd number harmonics can be formed in the bugle. Hence, the different frequencies follow the expression $(2n+1)f$. 
17	**A** For wire X, $n = \frac{I}{vAq} = \frac{3.0}{(2.8\times10^{-2})\times\pi(5.0\times10^{-5})^2\times(1.6\times10^{-19})} = 8.526\times10^{28}\ \text{m}^{-3}$ n remains the same since wire X and Y are made from the same material. For wire Y, $v = \frac{I}{nAq} = \frac{2.0}{(8.526\times10^{28})\times\pi(1.0\times10^{-4})^2\times(1.6\times10^{-19})} = 4.7\times10^{-3}\ \text{m s}^{-1}$

18 **A**

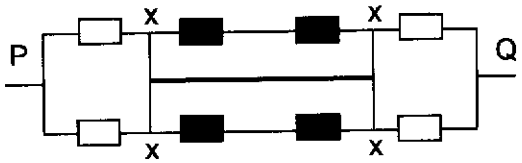
Resistance, $R = \frac{\rho l}{A}$ and potential drop across each wire $V = IR = I\left(\frac{\rho l}{A}\right) = I\rho\left(\frac{l}{A}\right)$

Since current and resistivity are constants, the potential drop increases with distance from X (i.e. length of wire in this case), and the smaller the cross-sectional area A, the larger is the drop per unit length of wire. So the last segment has the largest potential drop per unit length.

19 **C**



The above circuit can be redrawn as:



No current passes through the resistors in black as all current will pass through the bold wire (zero resistance).

This simplifies the circuit to a series connection of two sets of parallel resistors. So resistance across PQ = $R/2 + R/2 = R$

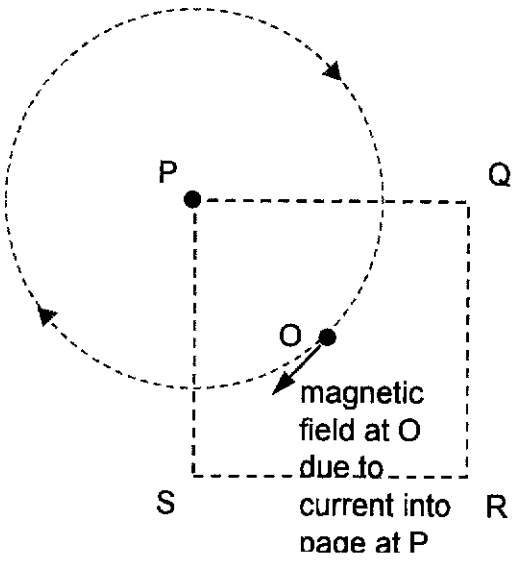
20 **A**

Since the thermistor's resistance decreases as its temperature increases, in accordance with the potential divider principle, the potential difference (p.d.) across it decreases with increasing temperature.

The thermistor and the fixed resistor are in series thus their potential differences add up to 10 V. Therefore the p.d. across the fixed resistor increases as the p.d. across the thermistor decreases due to increase in temperature.

When the p.d. across the fixed resistance exceeds the built-in p.d. of the diode (0.3 – 0.7 V) the diode becomes forward biased and current starts to flow downwards through the lamp to light it up.

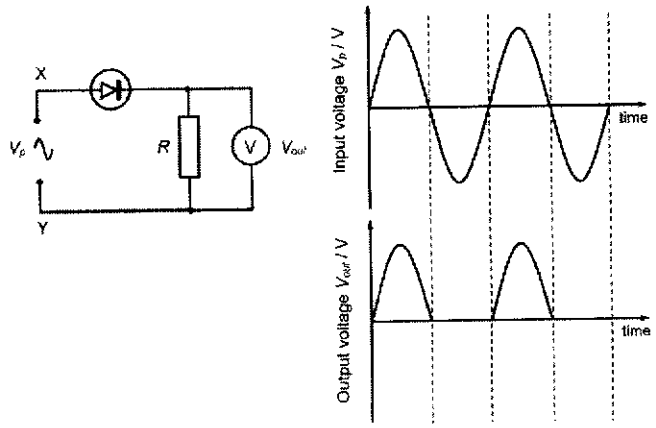
Option C is wrong as the diode is always in reverse bias hence the lamp will not light up as current will not flow through the diode even if the p.d. in the fixed resistor exceeds the diode's built-in potential difference.

21	**D** The direction of electric field line at a point indicates the direction of electric force on a positive test charge placed at the point. Since an electron is a negative charge, it will experience an electric force in the direction opposite to that of the electric field.
22	**D** Since charges are of opposite signs and potential is a scalar, at the centre of the two point charges, the resultant potential is 0 (hence can be III or IV). Since charges are of opposite signs and electric field radiates outwards from positive charge and towards negative charges, the electric field along the line joining the two point charges acts along only a certain direction (hence can be I or II). Given that $E = -\frac{dV}{dr}$, the combination of III for electric potential and II for electric field strength is wrong and hence D is the correct answer.
23	**D** The magnetic field lines due to current in a conductor is made up of concentric circles centered about the conductor. The direction of the field can be found using the Right Hand Grip Rule. At O, the direction of the magnetic field is tangential to the circular field lines. For example, due to a current at P that is into the page, the direction of the magnetic field at O points towards S. Apply this to the options and D is the answer. 
24	**A** As the long straight wire moves towards the flat coil, the magnetic flux density in the area enclosed by the coil increases. Since $B = \frac{\mu_0 I}{2\pi d}$, for each speed, magnetic flux density inside the coil increases at an increasing rate. This results in the increasing rate of change of magnetic flux linkage leading to increasing induced e.m.f. in the coil. Thus, current increases.
25	**C** For a straight conductor moving perpendicularly in a uniform magnetic field, $E = Blv$. Since, B (magnetic flux density) and l (length of conductor) are constant, $E \propto v$.

From *s-t* graph, the *v-t* graph is similar to the graph in C. Hence, answer is C.

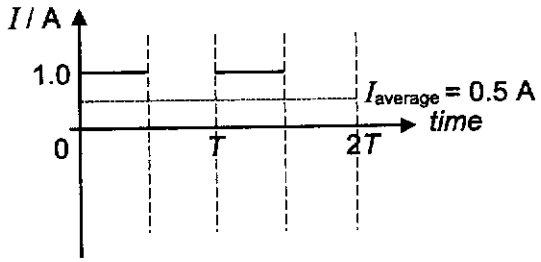
26 **A**

The input and output voltage due to single diode rectification is as shown below.

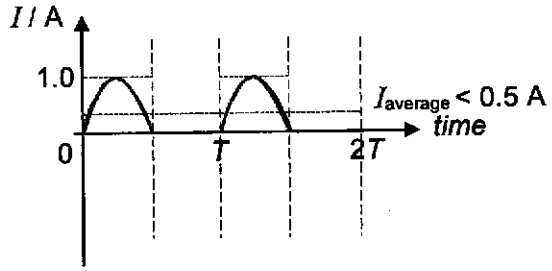


Since the peak voltage is 100 V and R = 100 Ω, the peak current is 1.0 A.

Consider a current which varies with time in the following manner with respect to time. The average current would be 0.5 A as the 1.0 A current is averaged out equally over one period.

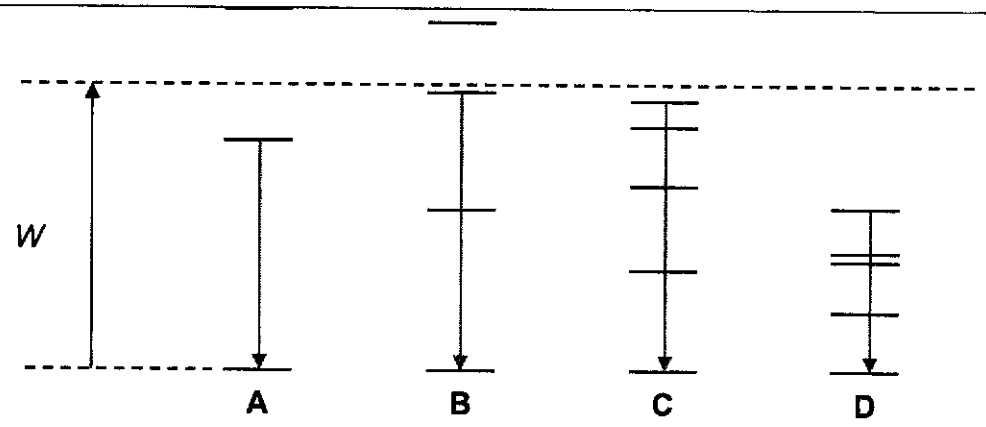


For a single diode rectified sinusoidal current, the mean will be less than 0.5 A as for most of the time the instantaneous current is less than 1.0 A as shown below.



27 **B**

To achieve shortest wavelength, this implies that the photon emitted has the highest frequency. Since energy of a photon is *hf* and is equal to the energy difference between two levels, the highest possible transition possible for each atom is shown in the diagram below. Hence atom B will give the greatest energy difference.

	
28	**C** $q\Delta V$ = gain in KE $q\Delta V = p^2/2m - 0$ $\Rightarrow \quad p = \sqrt{(2mq\Delta V)}$ Using de Broglie's equation, $\lambda = h/p \quad = \quad h/\sqrt{(2qm\Delta V)}$ Since m and q are the same for both cases, $\lambda \propto 1/\sqrt{V}$. $\lambda_0/\ \lambda_1 = \sqrt{(100/1)} = 10$
29	**D** Total mass of reactant is less than total mass of products, so energy has to be supplied for the reaction to take place. Energy supplied = $(1.0086 + 1.0097 - 2.0150)\ u\ c^2 / (1.6 \times 10^{-19}) = 3$ MeV
30	**B** The proton number decreases by 2 during alpha decay, and increases by 1 during beta decay.