

H2 PHYSICS

Exam papers with worked solutions
(Selected from Top JC)

SET C

PAPER 1

Compiled by

THE PHYSICS CAFE

READ THESE INSTRUCTIONS FIRST

Do not open the booklet until you are told to do so.

Write with soft pencil.

Write your name, class index number and class at the top of this page and on the Answer Sheet in the spaces provided unless this has been done for you.

There are forty questions in this section. 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 answers 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.

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,	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$ $(1/(36\pi)) \times 10^{-9} \text{ F m}^{-1}$
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,

$$s = ut + \frac{1}{2} at^2$$

$$v^2 = u^2 + 2as$$

work done on/by a gas,

$$W = p\Delta V$$

hydrostatic pressure,

$$p = \rho gh$$

gravitational potential,

$$\phi = -Gm/r$$

displacement of particle in s.h.m.,

$$x = x_0 \sin \omega t$$

velocity of particle in s.h.m.,

$$v = v_0 \cos \omega t$$
$$= \pm \omega \sqrt{x_0^2 - x^2}$$

resistors in series,

$$R = R_1 + R_2 + \dots$$

resistors in parallel,

$$1/R = 1/R_1 + 1/R_2 + \dots$$

electrical potential,

$$V = Q/(4\pi\epsilon_0 r)$$

alternating current /voltage,

$$x = x_0 \sin \omega t$$

transmission coefficient,

$$T = \exp(-2kd)$$

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

radioactive decay,

$$x = x_0 \exp(-\lambda t)$$

decay constant,

$$\lambda = \frac{0.693}{t_{1/2}}$$

- 1 The equation relating current I through a semiconductor diode to the applied potential difference V at temperature T is

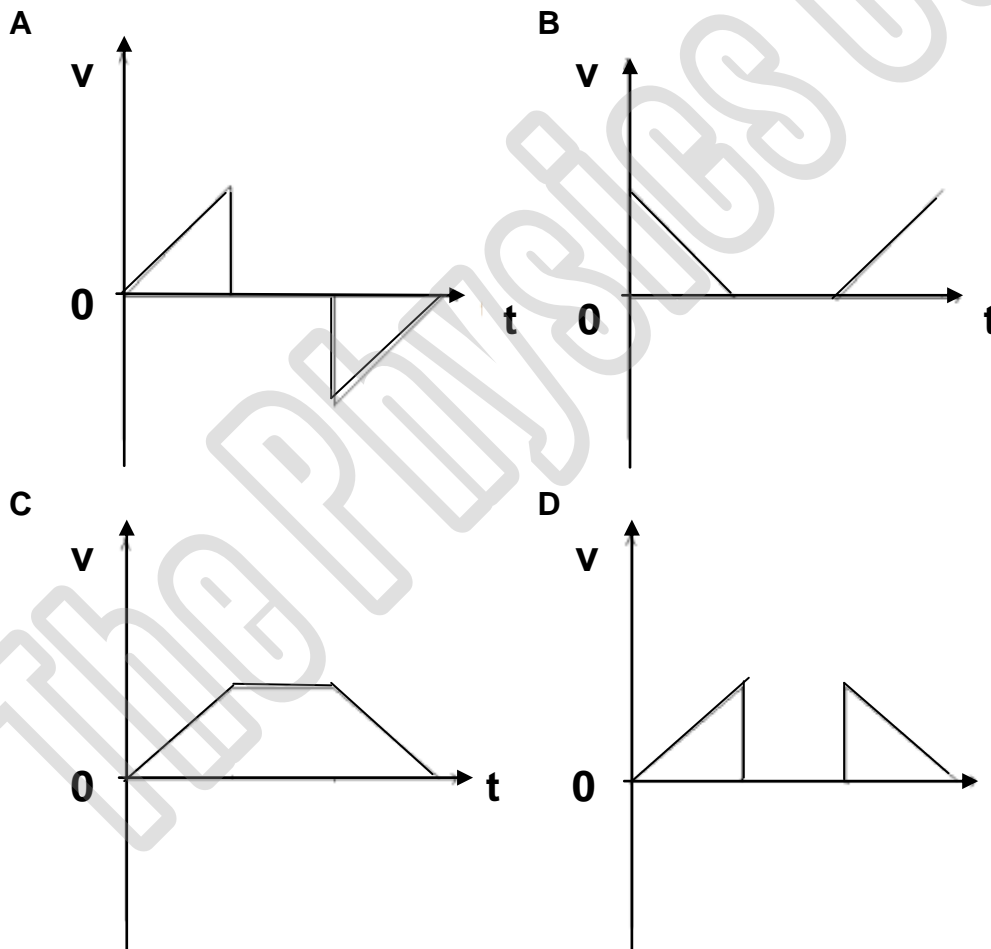
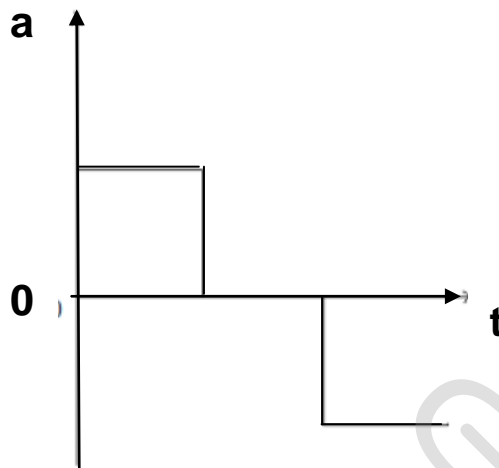
$$I = I_0 \exp\left(-\frac{qV}{kT}\right)$$

where q is the electron charge, and k is a constant. If I_0 is a characteristic constant of the diode with the same units as current I , what will be the units of k ? [Hint: $E = qV$ where E is energy]

- A** $\text{kg m}^2 \text{s}^{-2} \text{K}^{-1} \text{A}^{-1}$ **B** $\text{kg m s}^{-2} \text{K}^{-1} \text{A}^{-1}$
C $\text{kg m}^2 \text{s}^{-2} \text{K}^{-1}$ **D** $\text{kg m s}^{-2} \text{K}^{-1}$
- 2 A student measures the potential difference across and current through a resistor as 6.234 V and 202 mA respectively. The student then calculates the resistance using a graphic calculator. How should the student express the answer to the most appropriate precision?

- A** 31Ω **B** 30.9Ω
C 30.86Ω **D** 30.861386Ω

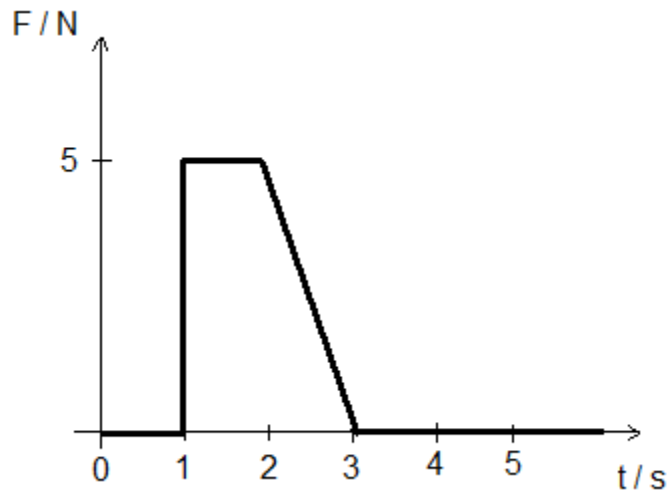
- 3 A car is accelerated from rest following the acceleration-time graph shown below. Which is its velocity-time graph?



- 4 A rock is dropped from rest into a well. The sound of the splash is heard 2.40 s later and the speed of the sound in air is taken as 336 m s^{-1} . Based on the above information, the water surface below the top of the well is calculated to be

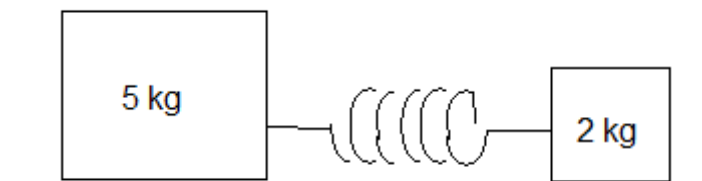
A 24.4 m **B** 25.4 m **C** 26.4 m **D** 27.4 m

- 5 The graph shows the variation of force F acting on a body of mass 2.0 kg with time t .



What is the change in momentum of the body during this period of 4 s.

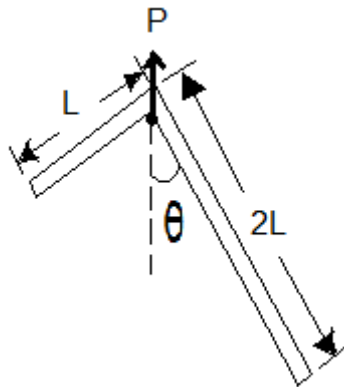
- A** 2.5 N s **B** 3.8 N s
C 7.5 N s **D** 15.0 N s
- 6 A light spring is permanently connected between two blocks of wood on a frictionless surface. The masses of the blocks are 2.0 kg and 5.0 kg and they can move freely along a straight horizontal track. The spring is compressed and then the blocks are released simultaneously from rest.



When the acceleration of the heavier block is 10 m s^{-2} , the acceleration of the lighter block will be

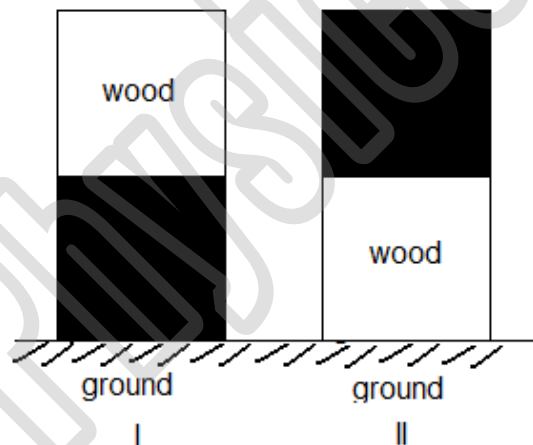
- A** 5 m s^{-2} **B** 10 m s^{-2}
C 20 m s^{-2} **D** 25 m s^{-2}

- 7 A right-angle rule hangs at rest from a peg P as shown below. It is made from a metal sheet of uniform density. One arm is L cm long while the other is $2L$ cm long.



The angle θ at which it will hang is

- A** 8° **B** 14° **C** 42° **D** 76°
- 8 Two blocks, one made of wood and the other of copper, are arranged at rest on the ground as depicted in combination I and II below.



Which one of the following statements is correct?

- A** The force by the ground on the copper block in **I** is greater than the force by the ground on the wooden block in **II** because the copper block, being denser than the wooden block, exerts more force on the ground.
- B** The force by the wooden block on the copper block in **I** is the same as that by the copper block on the wooden block in **II** by virtue of Newton's 3rd law.
- C** The force by the copper block on the wooden block in **I** is greater than that by the wooden block on the copper block in **II**.
- D** The force by the wooden block on the copper block is equal to the weight of the wooden block in **I** while the force by the copper block on the wooden block is equal to the weight of the copper block in **II**.

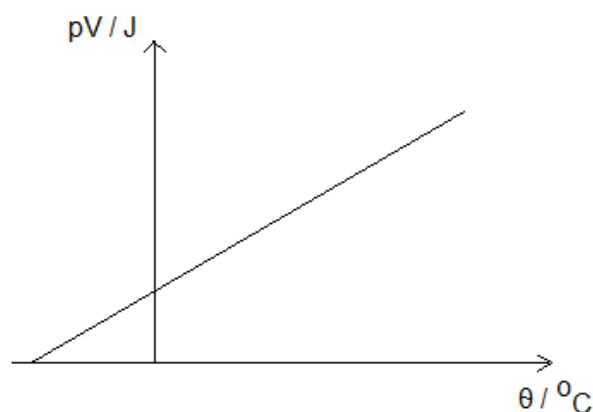
- 9 A box of weight 100 N is pushed 10 m up a slope inclined at 30° with the horizontal by a force of 150 N. The frictional force opposing the motion is 60 N. How much of the work done is converted into kinetic energy and how much into internal energy of the box?

	Kinetic Energy / J	Internal Energy / J
A	400	600
B	900	600
C	600	400
D	600	900

- 10 A small metal sphere of mass m is falling vertically through a viscous fluid. When it reaches a constant velocity v , which one of the following statements is false?

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

- 11 The graph shows the relationship between the product of pressure and volume, pV , and temperature, θ , in degree Celsius for 1 mole of an ideal gas for which the molar gas constant is R .



Which one of the following expressions gives the gradient of this graph?

A $\frac{1}{273.15}$ **B** $\frac{pV}{\theta}$ **C** $\frac{pV}{\theta - 273.15}$ **D** R

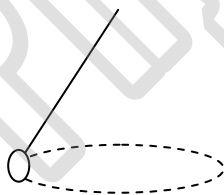
12 A raindrop of mass m falls to the ground at its terminal speed v . The specific heat capacity of water is c and the acceleration of free fall is g . Given that 25% of the energy is retained in the raindrop when it strikes the ground, what is the rise in the temperature of the raindrop?

A $\frac{mv^2}{8c}$ **B** $\frac{v^2}{4mc}$ **C** $\frac{mg}{4c}$ **D** $\frac{v^2}{8c}$

13 Jasvin noticed that her clock is not accurate. She observed that the minute hand of the clock travels at an angular velocity of $1.744 \times 10^{-3} \text{ rad s}^{-1}$. Will her clock be behind or ahead of time and by how much if the minute hand travelled a total of 48π radians? (Take $\pi = 3.142$)

- A** 0.134 seconds ahead of time **B** 1.28 seconds behind time
C 8.04 seconds ahead of time **D** 77.0 seconds behind time

14 A pendulum bob is swung in such a way that it performs uniform circular motion as shown in the diagram below.



Which one of the following statements about the motion is correct?

- A** The kinetic energy of the bob is constant because no work is done on it.
B The bob is in equilibrium because the tension in the string balances its weight.
C The momentum of the bob is conserved because there is no net force acting on it.
D The acceleration is constant because the tension is constant.

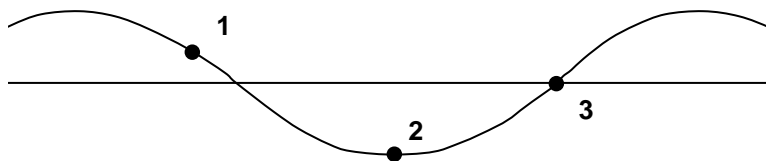
15 The acceleration of free fall on the surface of the Earth is about 6 times its value on the surface of the Moon. The mean density of the Earth is about $\frac{5}{3}$ times the mean density of the Moon. Using the data, what is the best value of the ratio of the radius of the Earth to the radius of the Moon?

- A** 1.9 **B** 3.2 **C** 3.6 **D** 6.0

16 Star X of mass $2M$ and Star Y of mass M perform circular motion about their common centre of mass under their gravitational attraction. What is the ratio $\frac{\text{Force acting on X}}{\text{Force acting on Y}}$, ignoring the effects of any other bodies?

- A** 0.5 **B** 1 **C** 2 **D** 4

17 The diagram below shows the shape at a particular instant of a transverse water wave traveling from left to right.



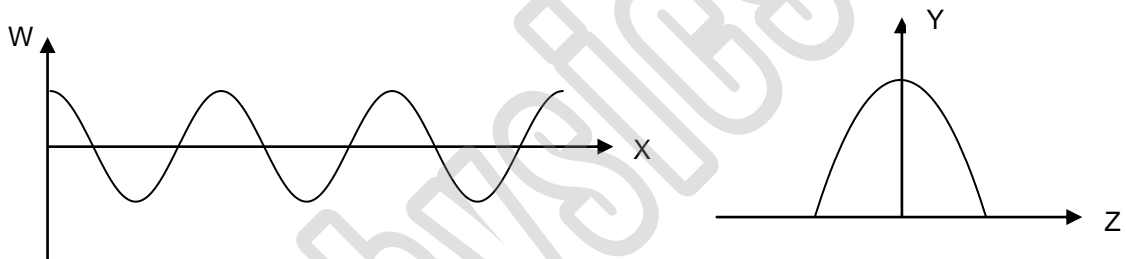
Which one of the following correctly shows the instantaneous directions of the velocities of the points 1, 2 and 3 on the wave?

- | | 1 | 2 | 3 |
|----------|------------|------------|------------|
| A | stationary | → | → |
| B | ↓ | ↑ | stationary |
| C | ↑ | stationary | ↓ |
| D | ↓ | stationary | ↓ |

18 Which one of the following summarises the change in wave characteristics when going from infra-red to X-rays in the electromagnetic spectrum?

	Frequency	Wavelength	Speed
A	Increases	Decreases	Remains constant
B	Decreases	Increases	Decreases
C	Increases	Increases	Increases
D	Decreases	Increases	Remains constant

19 A particle undergoes simple harmonic motion in a frictionless environment. The following graphs are plotted to represent its motion. Identify the quantities **W**, **X**, **Y** and **Z** on the axes.



	W	X	Y	Z
A	displacement	time	velocity	displacement
B	displacement	time	kinetic energy	displacement
C	potential energy	displacement	kinetic energy	time
D	kinetic energy	displacement	potential energy	displacement

20 The motion of a piston in a certain car engine is approximately simple harmonic with amplitude 40.0 mm. The frequency of oscillation is 120 Hz. What is the magnitude of the maximum acceleration and maximum speed of the piston?

	Acceleration _{max} / (m s ⁻²)	Velocity _{max} / (m s ⁻¹)
A	1.14 × 10 ⁴	30.2
B	1.14 × 10 ⁴	15.1
C	2.27 × 10 ⁴	30.2
D	2.27 × 10 ⁴	15.1

21 Monochromatic light falls on two gratings, **P** and **Q**, in turn. **Q** is more finely ruled than **P**. All other factors are constant. In each case, the students measure m_P and m_Q , the number of the highest order observed, and I_P and I_Q , the intensity of the diffracted beams from **P** and **Q** respectively. He should find that

A $m_P < m_Q$ and $I_P = I_Q$

C $m_P > m_Q$ and $I_P > I_Q$

B $m_P < m_Q$ and $I_P > I_Q$

D $m_P > m_Q$ and $I_P < I_Q$

22 Two sources, **S**₁ and **S**₂, emit coherent waves of amplitudes A and $2A$ respectively. **P** is a point 6 m from **S**₁ and 3 m from **S**₂. If the two sources operate exactly out of phase, and the resultant amplitude of the wave at **P** is A , which of the following is **not** a possible wavelength of the waves?

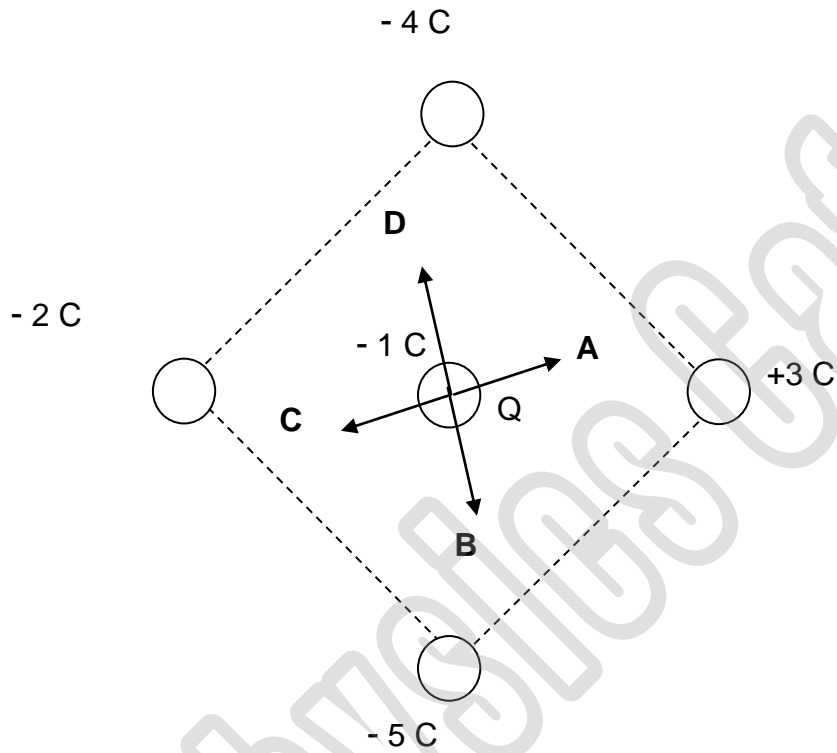
A 0.75 m

B 1.5 m

C 3.0 m

D 6.0 m

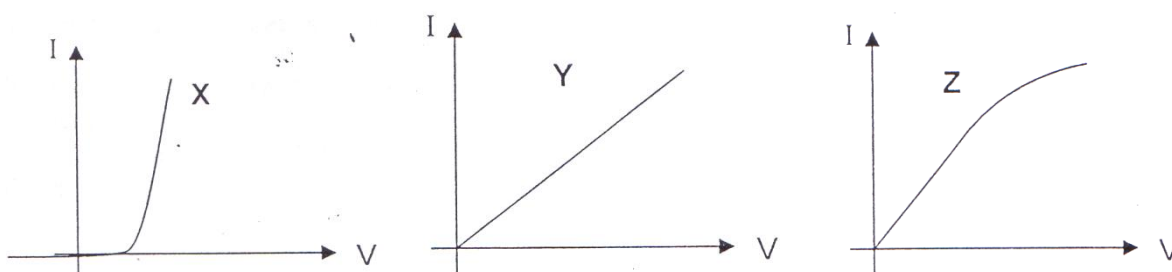
- 23 Four charges (-2 C , $+3\text{ C}$, -4 C and -5 C) are located at the corners of a square. A negatively charged particle (-1 C) lies at Q, the centre of the square. Determine the direction of the net electric field strength at position Q due to the four charges at the corners of the square.



24 Which of the following scenarios would result in an increase in electric potential energy?

- A** Moving a negative charge from a point 1 m away from another negative charge to infinity.
- B** Moving a positive charge from a point 1 m away from another positive charge to infinity.
- C** Moving a positive charge from infinity to a point 1 m away from another positive charge.
- D** Moving a negative charge from infinity to a point 1 m away from a positive charge.

25 The graphs show the variation of current I with potential difference V for three circuit elements.

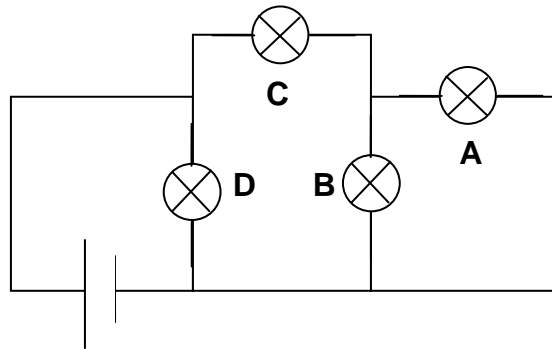


The three circuit elements are a tungsten filament lamp, a copper wire at constant temperature and a semiconductor diode.

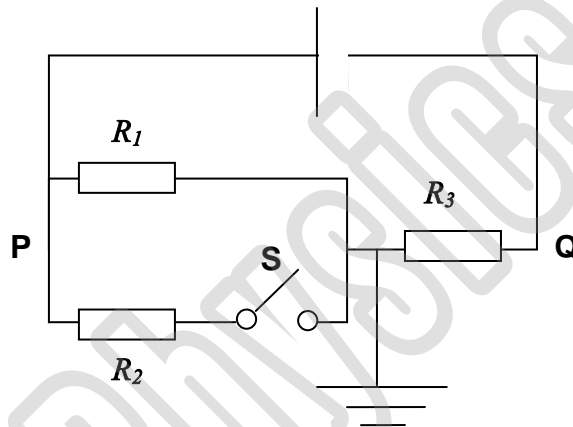
Which of the following correctly identifies these graphs?

	Tungsten filament lamp	Copper wire	Semiconductor diode
A	X	Y	Z
B	Y	Z	X
C	X	Z	Y
D	Z	Y	X

26 Four identical bulbs **A**, **B**, **C** and **D** are connected in the circuit as shown. Determine the brightest bulb.



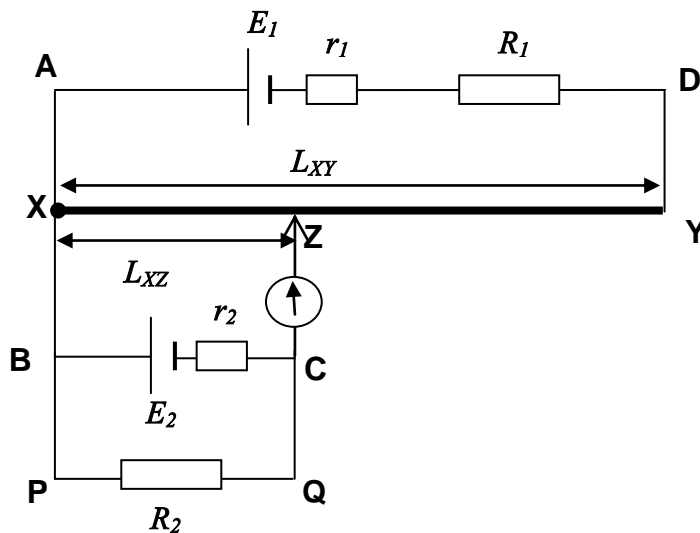
27 A group of resistors are connected as shown to a battery of constant e.m.f. with negligible internal resistance.



What happens to the electric potential at **P** and at **Q** when the switch **S** is closed?

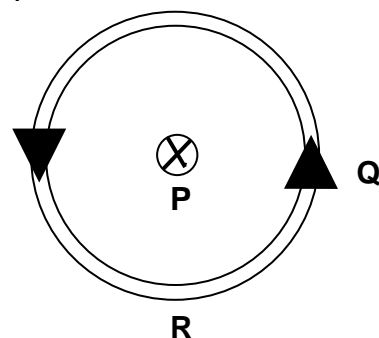
	Potential at P	Potential at Q
A	Decreased	Decreased
B	Increased	Increased
C	Increased	Decreased
D	Unchanged	Unchanged

28 Given the circuit below, what is a possible way of increasing the balance length?



- A Decrease R_1
- B Increase the resistivity of Wire **XY**
- C Increase the cross sectional area of Wire **XY**
- D Decrease R_2

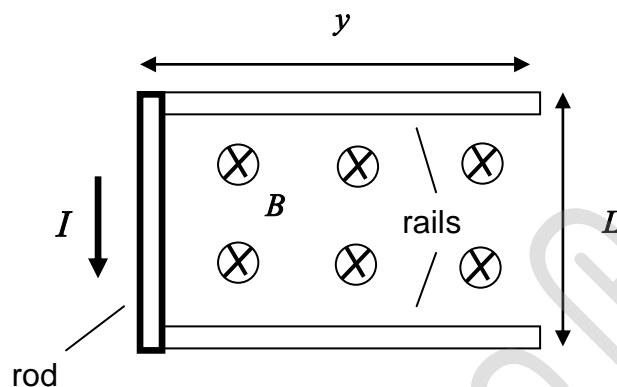
29 A long straight wire **P** is placed along the axis of a flat circular coil **Q**. The wire **P** carries current into the page while the coil **Q** carries current in anti-clockwise direction as shown in the figure. What can be deduced about the direction of the force acting on point **R** of coil **Q** due to current in **P**?



- A Force acts perpendicular to the plane of the coil.
- B Force acts in the direction **RP**.
- C Force acts in the direction **PR**.

D No force acts at **R** due to current in **P**.

- 30 A rod of mass m rest on two parallel rails at a distance L apart. Each rail has length y , resistivity ρ and cross sectional area A . The rod carries current I in the direction shown and rolls along the rails under the influence of the induced force. If the rod starts from rest, what is its final speed as it leaves the rails if there is a uniform magnetic field B directed into the page.



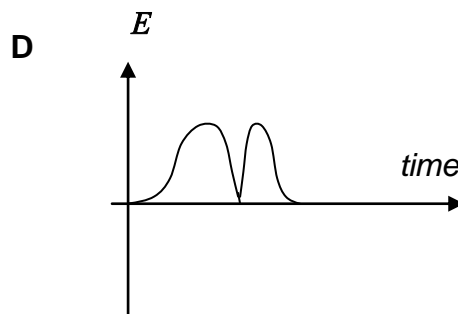
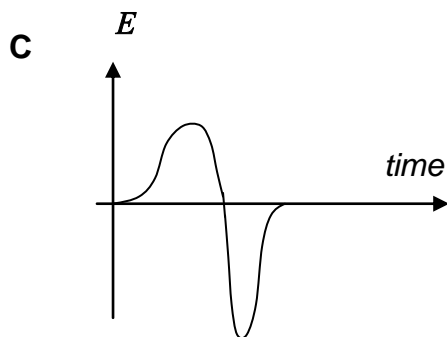
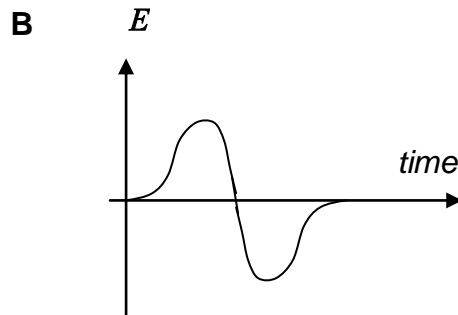
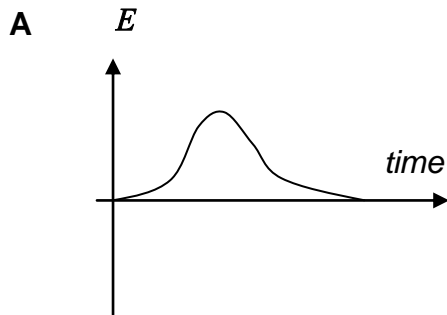
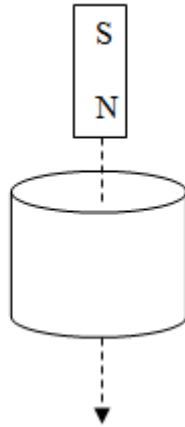
A $\sqrt{\frac{2BILy}{m}}$

B $\sqrt{\frac{2BIy}{m}}$

C $\sqrt{\frac{2BIL}{m}}$

D $\frac{I\rho y}{2ABL}$

- 31 A solenoid with its axis vertical is held firmly in a clamp and its terminals are connected to a data recorder. A bar magnet with its axis along the axis of solenoid is released from rest from a position above the solenoid so that it drops through the solenoid. The data recorder is used to measure the induced e.m.f. at millisecond intervals. Which graph shown below best represents the variation of the induced e.m.f. E with time?



- 32 A sinusoidal magnetic field B is applied perpendicular to the plane of a small flat coil of copper wire. The equation for the changing flux density is given by

$$B = B_0 \sin \frac{2\pi t}{T}$$

where B_0 is the amplitude and T is the period of the sinusoidal magnetic field.

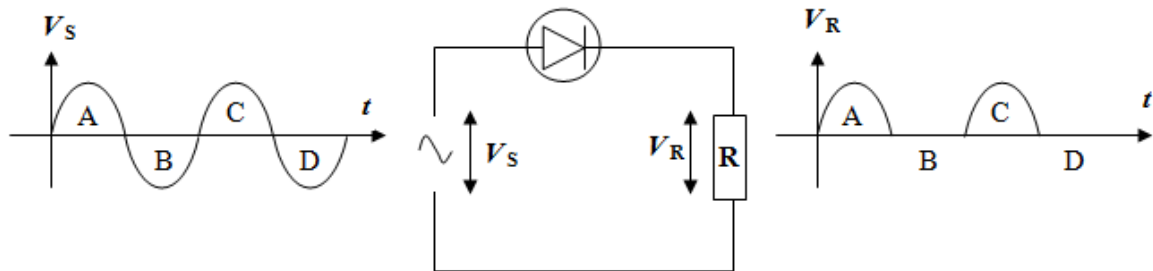
At which time, t , is the magnitude of the e.m.f. induced in the coil a maximum?

- A** $\frac{T}{8}$ **B** $\frac{T}{4}$ **C** $\frac{3T}{8}$ **D** $\frac{T}{2}$

- 33 An alternating supply of 4.0 V is connected across a resistive load such that the average power dissipated across it is P . What is the equivalent d.c. voltage applied across the same load, which can give rise to an average power dissipation of $3P$?

- A** 6.9 V **B** 8.5 V **C** 12 V **D** 17 V

- 34 An alternating supply is applied to an external resistor R with a diode connected in series with it. The time t variation of the supply voltage V_S and the p.d. across the resistor V_R are shown in the diagram.



Which of the following statements is *incorrect*?

- A** Half-wave rectification takes place so that the voltage applied to the resistor is uni-directional.
- B** The period of the V_R - t graph is half of that of the V_S - t graph
- C** The time interval corresponding to **B** and **D** on the graph represent the stage when the diode is reverse-biased to the current flow.
- D** Root-mean-square voltage corresponding to the resistor R is half of the peak voltage applied across it.
- 35 An electron has uncertainty of 5.0×10^{-12} in its position. If its momentum is measured with an uncertainty of 1.00 %, what is its minimum kinetic energy?
- A** 3.8 MeV
- B** 6.6 MeV
- C** 38 MeV
- D** 66.0 MeV
- 36 Which of the following changes to an X-ray tube will produce X-rays of lower wavelengths?
- A** apply a lower voltage across the tube
- B** use an anode with a higher work function
- C** use a cathode with a lower work function
- D** decrease the accelerating potential in the tube

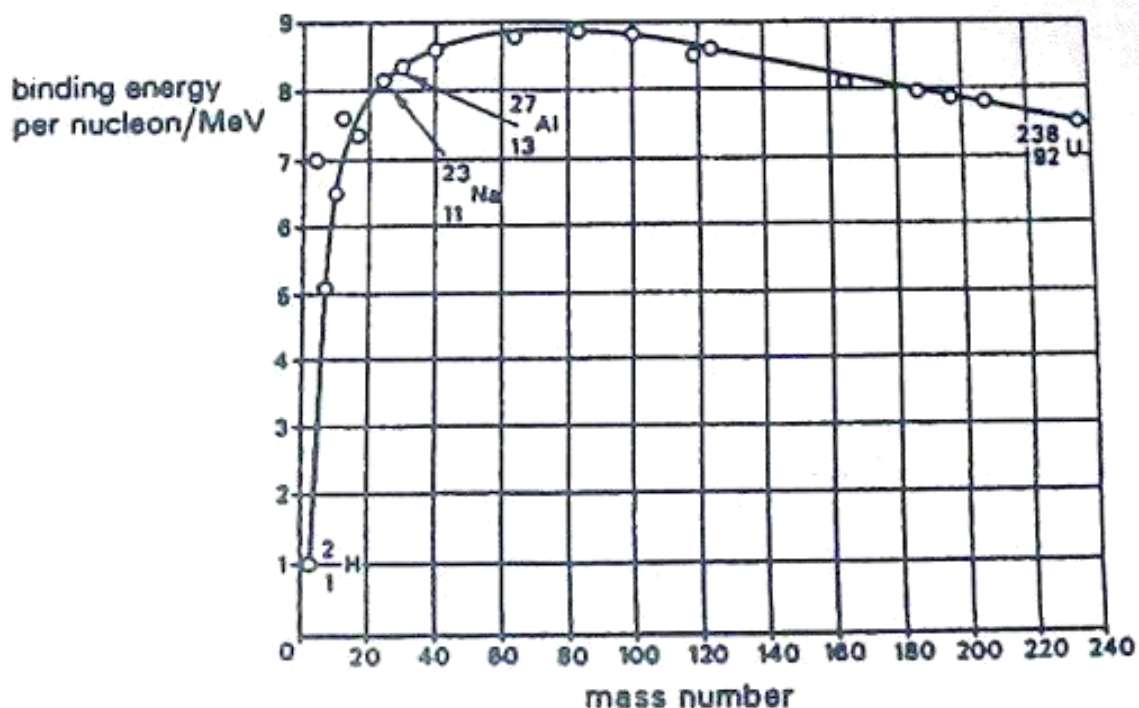
37 Which of the following best describes the meaning of population inversion?

- A** Electrons are able to stay in such a state for a longer period.
- B** The number of electrons at a higher energy level exceeds the number of electrons at a lower energy level.
- C** The number of electrons at a lower energy level exceeds the number of electrons at a higher energy level.
- D** An atom in an excited state undergoes a transition to the ground state and emits a photon.

38 Which of the statements is correct for a p-type semiconductor?

- A** There are excess holes in the valence band.
- B** There are excess holes in the conduction band.
- C** There are excess electrons in the conduction band.
- D** There are excess electrons in the valence band.

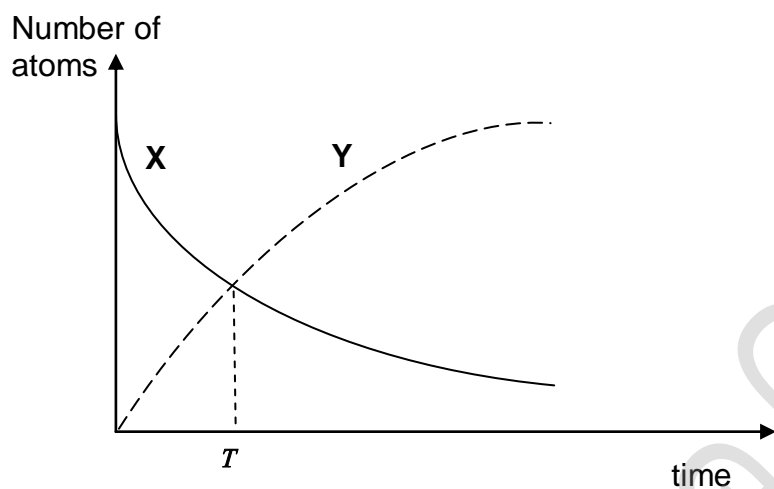
39 The diagram shows a graph of the binding energy per nucleon for a number of naturally-occurring nuclides plotted against their mass number.



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

- A Of the nuclides plotted, ^2_1H is the most stable
- B Energy will be released if a nucleus with a mass number greater than about 80 undergoes fusion with any other nucleus.
- C Energy will be released if a nucleus with a mass number less than about 80 undergoes fission as a result of particle bombardment.
- D $^{27}_{13}\text{Al}$ will not spontaneously emit an alpha particle to become $^{23}_{11}\text{Na}$.

40 The graph represents the decay of a newly-prepared sample of radioactive nuclide **X** to a stable nuclide **Y**. The half-life of **X** is τ . The growth curve for **Y** intersects the decay curve for **X** at time T .



What is time T ?

A $\tau/2$

B $\ln(\tau/2)$

C τ

D $\ln(2\tau)$

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