

# BITSAT Physics Sample Paper-20

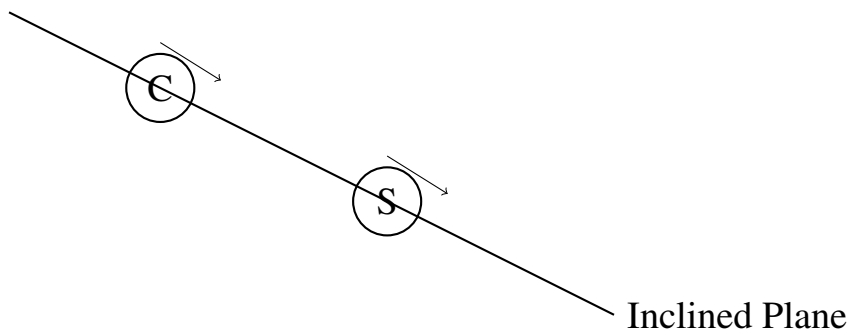
Duration: 40 Minutes

Maximum Marks: 90

## Instructions

- This paper contains **30** Multiple Choice Questions (Single Correct).
- Each correct answer carries **+3 marks**. Each incorrect answer carries **-1 mark**. Unattempted question carries **0 marks**.
- Only **one** option is correct for each question.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

**Q1.** A solid cylinder and a solid sphere, both having the same mass and radius, are released simultaneously from rest at the top of an inclined plane. Ignoring air resistance and assuming pure rolling throughout the motion, which of the following statements is correct regarding their accelerations?

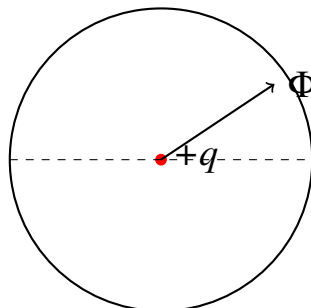


- (A) Both have equal acceleration
- (B) Cylinder has greater acceleration
- (C) Sphere has greater acceleration
- (D) Acceleration depends on length of incline

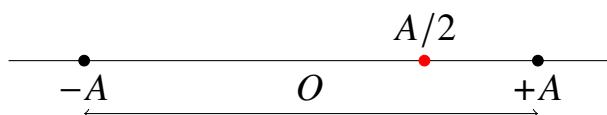


- Q2.** A charge  $+Q$  is uniformly distributed over a thin spherical shell of radius  $R$ . A point charge  $+q$  is placed at the centre of the shell. The electric flux through one hemisphere of the shell is:

$+Q$  uniformly distributed



- (A)  $\frac{q}{2\epsilon_0}$   
 (B)  $\frac{q + Q}{2\epsilon_0}$   
 (C)  $\frac{q}{\epsilon_0}$   
 (D) Zero
- Q3.** A particle executes simple harmonic motion along a straight line with amplitude  $A$ . When its displacement from the mean position is  $\frac{A}{2}$ , the ratio of its kinetic energy to potential energy is:



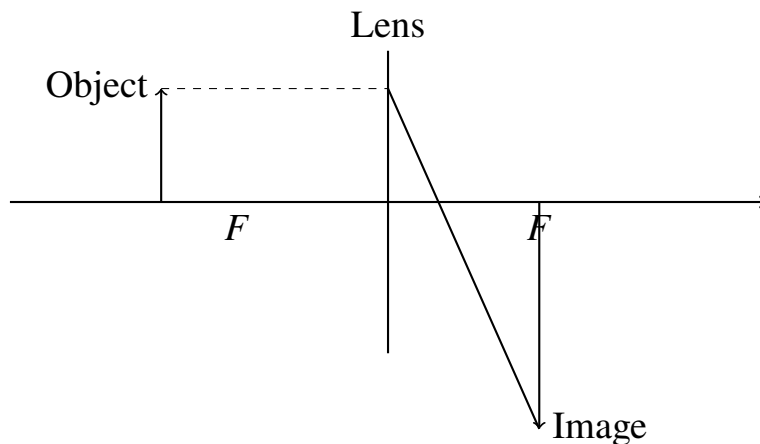
- (A) 1 : 1  
 (B) 3 : 1  
 (C) 1 : 3  
 (D) 2 : 1
- Q4.** A cell of emf  $E$  and internal resistance  $r$  is connected to an external resistance  $R$ . If the value of  $R$  is gradually increased from zero, then the power delivered to the external resistance:

- (A) Continuously increases



- (B) Continuously decreases
- (C) First increases and then decreases
- (D) Remains constant

**Q5.** An object is placed at a distance of 30 cm from a convex lens of focal length 20 cm. The nature and position of the image formed are:



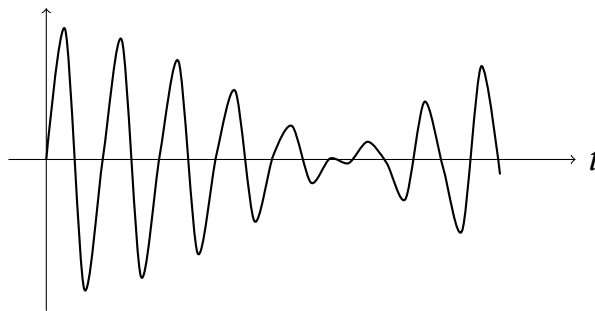
- (A) Virtual and erect at 60 cm
  - (B) Real and inverted at 60 cm
  - (C) Real and erect at 30 cm
  - (D) Virtual and inverted at 20 cm
- Q6.** A charged particle enters a uniform magnetic field with velocity making an angle  $\theta$  with the magnetic field lines. The path followed by the particle inside the magnetic field will be:
- (A) Circular
  - (B) Straight line
  - (C) Helical
  - (D) Parabolic
- Q7.** One mole of an ideal gas undergoes an isothermal expansion from volume  $V$  to  $2V$  at temperature  $T$ . The work done by the gas during the process is:
- (A)  $RT$



- (B)  $2RT$
- (C)  $RT \ln 2$
- (D) Zero

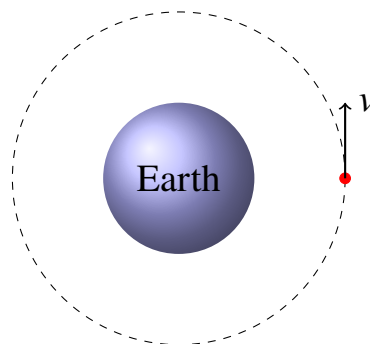
**Q8.** Two sound waves having equal amplitudes and slightly different frequencies superpose in a medium. The phenomenon of periodic variation in intensity heard by the observer is called:

Amplitude



- (A) Diffraction
- (B) Interference
- (C) Beats
- (D) Resonance

**Q9.** A satellite is moving in a circular orbit around Earth with speed  $v$ . If the orbital radius becomes four times the original radius, the new orbital speed becomes:

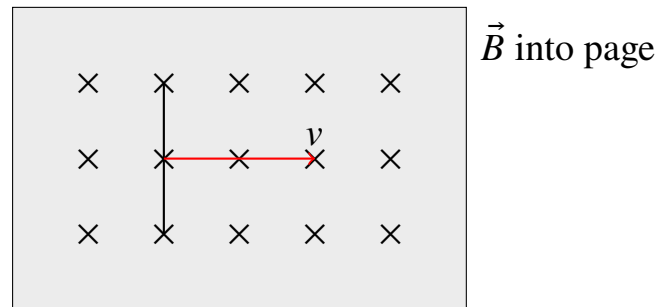


- (A)  $\frac{v}{4}$
- (B)  $\frac{v}{2}$
- (C)  $2v$



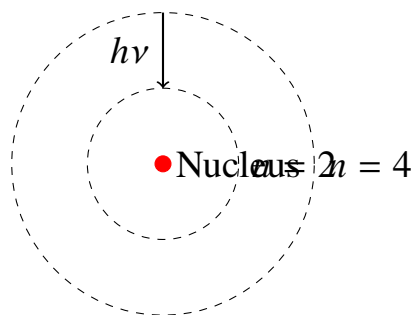
(D)  $4v$ 

**Q10.** A conducting rod moves perpendicular to a uniform magnetic field with constant velocity. If both the magnetic field strength and velocity are doubled, then the induced emf becomes:



- (A) Doubled
- (B) Four times
- (C) Half
- (D) Unchanged

**Q11.** In the Bohr model of hydrogen atom, an electron jumps from the fourth orbit to the second orbit. The emitted radiation belongs to which spectral series?



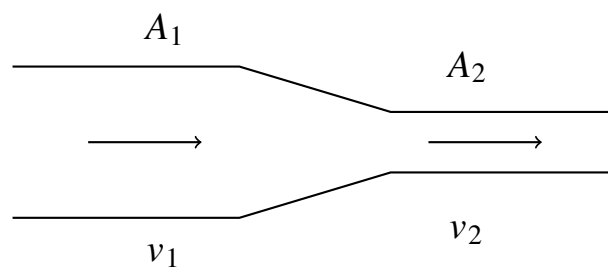
- (A) Lyman series
- (B) Balmer series
- (C) Paschen series
- (D) Brackett series



**Q12.** A parallel plate capacitor is connected to a battery and completely filled with a dielectric slab of dielectric constant  $K$ . Which of the following quantities remains unchanged?

- (A) Charge
- (B) Electric field
- (C) Capacitance
- (D) Stored energy

**Q13.** Water flows steadily through a horizontal pipe of varying cross-sectional area. If the area of cross section decreases, then according to Bernoulli's principle the pressure in that region:



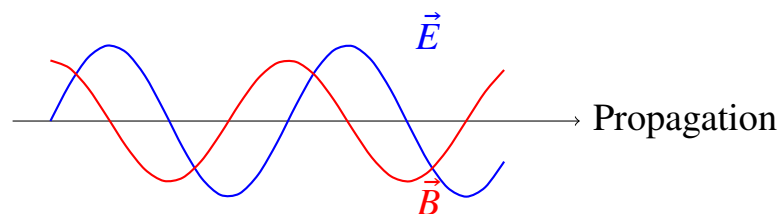
- (A) Increases
- (B) Decreases
- (C) Remains constant
- (D) First increases then decreases

**Q14.** A semiconductor diode is used as a rectifier in an electronic circuit. The primary function of the rectifier is to convert:

- (A) AC into DC
- (B) DC into AC
- (C) High voltage into low voltage
- (D) Low current into high current



- Q15.** In a purely inductive AC circuit, the current and voltage differ in phase by:
- (A)  $0^\circ$
  - (B)  $45^\circ$
  - (C)  $90^\circ$
  - (D)  $180^\circ$
- Q16.** A particle starts from rest and moves with constant acceleration. If it covers distances  $x_1$  and  $x_2$  in successive equal intervals of time, then:
- (A)  $x_1 = x_2$
  - (B)  $x_2 > x_1$
  - (C)  $x_1 > x_2$
  - (D) Relation cannot be determined
- Q17.** In an electromagnetic wave propagating through free space, the electric field and magnetic field are:



- (A) Parallel to each other
  - (B) Anti-parallel to each other
  - (C) Perpendicular to each other
  - (D) Randomly oriented
- Q18.** The binding energy per nucleon for nuclei of intermediate mass is maximum. This implies that such nuclei are:
- (A) Highly unstable
  - (B) Most stable
  - (C) Radioactive



(D) Easily fissionable

**Q19.** A wire is stretched by suspending a load from its lower end. Within elastic limit, stress is proportional to strain according to:

(A) Newton's law

(B) Hooke's law

(C) Ohm's law

(D) Pascal's law

**Q20.** A car moves along a circular track of radius  $R$  with constant speed  $v$ . If the speed of the car is doubled, the centripetal force required becomes:

(A) Doubled

(B) Four times

(C) Half

(D) Unchanged

**Q21.** A ray of light travels from glass to air. If the angle of incidence inside glass exceeds the critical angle, the phenomenon observed is:

(A) Dispersion

(B) Refraction

(C) Total internal reflection

(D) Polarization

**Q22.** During an adiabatic expansion of an ideal gas, which of the following quantities decreases?

(A) Temperature only

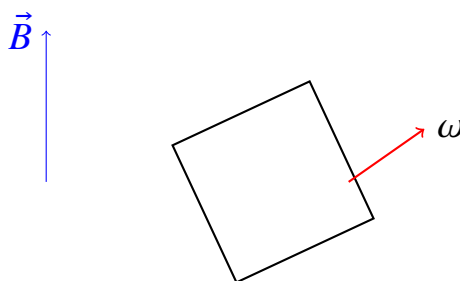
(B) Pressure only

(C) Internal energy only

(D) All of these



- Q23.** The potential energy of two point charges separated by a distance  $r$  is positive. This indicates that the force between the charges is:
- (A) Attractive
  - (B) Repulsive
  - (C) Zero
  - (D) Oscillatory
- Q24.** The wavelength associated with a moving electron decreases if:
- (A) Its velocity decreases
  - (B) Its momentum decreases
  - (C) Its kinetic energy increases
  - (D) Its mass decreases
- Q25.** A coil rotates in a uniform magnetic field with constant angular velocity. The induced emf produced in the coil varies with time as:



- (A) Linear function
  - (B) Exponential function
  - (C) Sinusoidal function
  - (D) Constant function
- Q26.** A black body at temperature  $T$  radiates maximum energy. If its absolute temperature is doubled, the radiated power becomes:
- (A) Doubled
  - (B) Four times



- (C) Eight times
- (D) Sixteen times

**Q27.** When a p-type semiconductor is formed by doping pure silicon, the majority charge carriers are:

- (A) Electrons
- (B) Holes
- (C) Protons
- (D) Neutrons

**Q28.** The total mechanical energy of a particle executing simple harmonic motion depends upon:

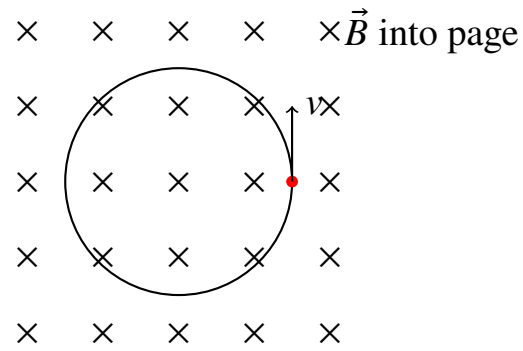
- (A) Displacement
- (B) Velocity
- (C) Amplitude
- (D) Time period only

**Q29.** A potentiometer wire carries a steady current. If the current through the wire increases, then the potential gradient along the wire:

- (A) Increases
- (B) Decreases
- (C) Remains constant
- (D) Becomes zero

**Q30.** A charged particle enters a magnetic field normally and moves in a circular path of radius  $r$ . If the magnetic field strength is increased, keeping velocity unchanged, the radius of the path:





- (A) Increases
- (B) Decreases
- (C) Remains unchanged
- (D) Becomes infinite



## Detailed Solutions

Q1.

## Solution

**Concept:** For an object of mass  $M$  and radius  $R$  rolling down an inclined plane of angle  $\theta$  without slipping, its acceleration  $a$  is given by:

$$a = \frac{g \sin \theta}{1 + \frac{I}{MR^2}}$$

where  $I$  is the moment of inertia of the object about its central axis. The body with a smaller moment of inertia ratio  $\frac{I}{MR^2}$  will have a greater acceleration.

**Solution:** Step 1: Write down the moments of inertia for both bodies:

$$\text{For a solid cylinder: } I_{\text{cylinder}} = \frac{1}{2}MR^2$$

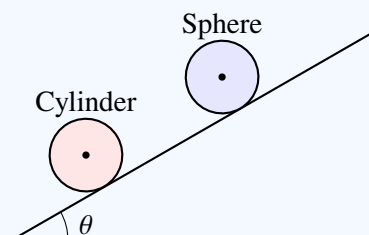
$$\text{For a solid sphere: } I_{\text{sphere}} = \frac{2}{5}MR^2$$

Step 2: Substitute these values into the rolling acceleration formula:

$$a_{\text{cylinder}} = \frac{g \sin \theta}{1 + \frac{1/2MR^2}{MR^2}} = \frac{g \sin \theta}{1.5} \approx 0.67g \sin \theta$$

$$a_{\text{sphere}} = \frac{g \sin \theta}{1 + \frac{2/5MR^2}{MR^2}} = \frac{g \sin \theta}{1.4} \approx 0.71g \sin \theta$$

Step 3: Compare the accelerations. Since  $0.71g \sin \theta > 0.67g \sin \theta$ , the solid sphere has a greater acceleration than the solid cylinder.



**Final Answer:** Sphere has greater acceleration

**Answer:** (C)

[Go Back to Question 1](#)



Q2.

**Solution**

**Concept:** Gauss's Law states that the total electric flux  $\Phi_{\text{total}}$  through a closed surface is equal to the net charge enclosed by the surface divided by the permittivity of free space  $\epsilon_0$ :

$$\Phi_{\text{total}} = \frac{Q_{\text{enclosed}}}{\epsilon_0}$$

**Solution:** Step 1: Consider a closed spherical Gaussian surface of radius slightly greater than  $R$ , concentric with the charged shell.

Step 2: The enclosed charge consists of:

$$+q \quad (\text{point charge at the center})$$

and

$$+Q \quad (\text{charge on the spherical shell})$$

Hence,

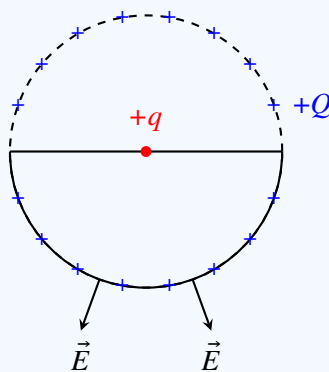
$$Q_{\text{enclosed}} = q + Q$$

Step 3: Applying Gauss's Law,

$$\Phi_{\text{total}} = \frac{Q_{\text{enclosed}}}{\epsilon_0} = \frac{q + Q}{\epsilon_0}$$

Step 4: Due to spherical symmetry, the electric flux is equally distributed through the two hemispheres of the spherical surface. Therefore, the flux through one hemisphere is:

$$\Phi_{\text{hemisphere}} = \frac{\Phi_{\text{total}}}{2} = \frac{q + Q}{2\epsilon_0}$$



**Final Answer:**  $\frac{q + Q}{2\epsilon_0}$

**Answer: (B)**

[Go Back to Question 2](#)



Q3.

**Solution**

**Concept:** For a particle of mass  $m$  executing simple harmonic motion (SHM) with amplitude  $A$  and angular frequency  $\omega$ : The potential energy  $U$  at displacement  $x$  is:

$$U = \frac{1}{2}m\omega^2x^2$$

The total energy  $E$  of the system is:

$$E = \frac{1}{2}m\omega^2A^2$$

The kinetic energy  $K$  at displacement  $x$  is:

$$K = E - U = \frac{1}{2}m\omega^2(A^2 - x^2)$$

**Solution:** Step 1: Write down the expressions for potential energy  $U$  and kinetic energy  $K$  using the spring constant  $k = m\omega^2$ :

$$U = \frac{1}{2}kx^2$$

$$K = \frac{1}{2}k(A^2 - x^2)$$

Step 2: Substitute the given displacement  $x = \frac{A}{2}$  into the expressions:

$$U = \frac{1}{2}k\left(\frac{A}{2}\right)^2 = \frac{1}{8}kA^2$$

$$K = \frac{1}{2}k\left(A^2 - \left(\frac{A}{2}\right)^2\right) = \frac{1}{2}k\left(\frac{3A^2}{4}\right) = \frac{3}{8}kA^2$$

Step 3: Calculate the ratio of kinetic energy  $K$  to potential energy  $U$ :

$$\frac{K}{U} = \frac{\frac{3}{8}kA^2}{\frac{1}{8}kA^2} = \frac{3}{1} = 3 : 1$$

**Final Answer:** 3 : 1

**Answer: (B)**

[Go Back to Question 3](#)



Q4.

**Solution**

**Concept:** The electrical power  $P$  delivered to an external resistance  $R$  connected to a cell of emf  $E$  and internal resistance  $r$  is:

$$P = I^2 R = \left( \frac{E}{R+r} \right)^2 R = \frac{E^2 R}{(R+r)^2}$$

According to the Maximum Power Transfer Theorem, the power delivered to the external resistance is maximized when the external resistance equals the internal resistance of the cell ( $R = r$ ).

**Solution:** Step 1: Write down the expression for power in terms of external resistance  $R$ :

$$P(R) = \frac{E^2 R}{(R+r)^2}$$

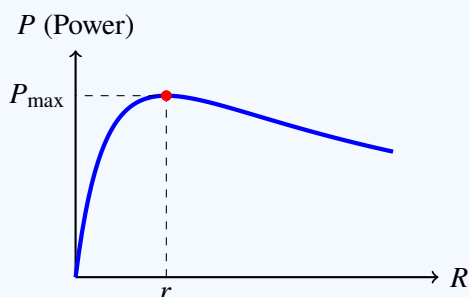
Step 2: Analyze the behavior of  $P(R)$  for extreme values of  $R$ : At  $R = 0$ :  $P(0) = 0$  As  $R \rightarrow \infty$ :

$$P(R) \approx \frac{E^2 R}{R^2} = \frac{E^2}{R} \rightarrow 0$$

Step 3: Differentiate  $P(R)$  with respect to  $R$  to find the point where power is maximized:

$$\frac{dP}{dR} = E^2 \frac{(R+r)^2 - 2R(R+r)}{(R+r)^4} = 0 \implies (R+r) - 2R = 0 \implies R = r$$

Step 4: Because the power is zero at  $R = 0$ , reaches a maximum value of  $P_{\max} = \frac{E^2}{4r}$  at  $R = r$ , and then decreases towards zero as  $R \rightarrow \infty$ , the power first increases and then decreases.



**Final Answer:** First increases and then decreases

**Answer:** (C)

[Go Back to Question 4](#)



Q5.

**Solution**

**Concept:** The relationship between the object distance  $u$ , image distance  $v$ , and focal length  $f$  of a lens is given by the lens formula:

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

The magnification  $m$  is given by:

$$m = \frac{v}{u}$$

If  $v$  is positive and  $m$  is negative, the image is real and inverted.

**Solution:** Step 1: Identify the given values with proper sign conventions: Focal length of the convex lens ( $f$ ) = +20 cm Object distance ( $u$ ) = -30 cm

Step 2: Set up the lens formula and substitute the values:

$$\frac{1}{v} - \frac{1}{-30} = \frac{1}{20} \implies \frac{1}{v} + \frac{1}{30} = \frac{1}{20}$$

Step 3: Solve for  $v$ :

$$\frac{1}{v} = \frac{1}{20} - \frac{1}{30} = \frac{3-2}{60} = \frac{1}{60} \implies v = +60 \text{ cm}$$

Step 4: Calculate the magnification  $m$  to determine the nature of the image:

$$m = \frac{v}{u} = \frac{60}{-30} = -2$$

Since  $v$  is positive, the image is real, and since the magnification is negative, the image is inverted.

**Final Answer:** Real and inverted at 60 cm

**Answer: (B)**

[Go Back to Question 5](#)



Q6.

**Solution**

**Concept:** When a charged particle moves in a magnetic field  $\vec{B}$ , the magnetic force  $\vec{F}$  is given by:

$$\vec{F} = q(\vec{v} \times \vec{B})$$

If the velocity vector makes an angle  $\theta$  with the magnetic field, we can resolve the velocity into two components: 1. Parallel component ( $v_{\parallel} = v \cos \theta$ ): Experiences no force and keeps the particle moving in a straight line. 2. Perpendicular component ( $v_{\perp} = v \sin \theta$ ): Experiences a perpendicular force causing circular motion.

**Solution:** Step 1: Resolve the velocity of the charged particle:

$$v_{\parallel} = v \cos \theta \quad \text{and} \quad v_{\perp} = v \sin \theta$$

Step 2: Analyze the effect of  $v_{\parallel}$ . Since the angle between  $v_{\parallel}$  and  $B$  is  $0^\circ$ , the force is:

$$F_{\parallel} = qv_{\parallel}B \sin(0^\circ) = 0$$

This component maintains a constant linear speed along the magnetic field lines.

Step 3: Analyze the effect of  $v_{\perp}$ . The force is:

$$F_{\perp} = qv_{\perp}B$$

This force is always perpendicular to  $v_{\perp}$ , causing the particle to execute a circular motion of radius  $r = \frac{mv_{\perp}}{qB}$  in the plane perpendicular to the field.

Step 4: Combine the linear motion along the field lines with the circular motion around them. The resulting path is a helix.



**Final Answer:**

**Answer:** (C)

[Go Back to Question 6](#)



Q7.

**Solution**

**Concept:** The work done  $W$  by an ideal gas during a quasi-static volume expansion from volume  $V_1$  to  $2V$  at constant temperature  $T$  (isothermal process) is given by:

$$W = \int_{V_1}^{V_2} P dV$$

Using the ideal gas equation  $PV = nRT$ , we substitute  $P = \frac{nRT}{V}$  into the integral.

**Solution:** Step 1: Set up the work integral for the isothermal expansion:

$$W = \int_V^{2V} \frac{nRT}{V} dV$$

Step 2: Since  $n$ ,  $R$ , and  $T$  are constant during an isothermal process, move them outside the integral:

$$W = nRT \int_V^{2V} \frac{dV}{V}$$

Step 3: Evaluate the integral:

$$W = nRT \left[ \ln V \right]_V^{2V} = nRT \ln \left( \frac{2V}{V} \right) = nRT \ln 2$$

Step 4: Substitute  $n = 1$  mole into the equation:

$$W = RT \ln 2$$

**Final Answer:**  $RT \ln 2$

**Answer:** (C)

[Go Back to Question 7](#)



Q8.

**Solution**

**Concept:** Beats occur due to the physical superposition of two wave trains of slightly different frequencies traveling in the same direction. The intensity of the combined wave at any fixed point fluctuates periodically.

**Solution:** Step 1: Let the two waves be represented by:

$$y_1 = A \sin(2\pi f_1 t) \quad \text{and} \quad y_2 = A \sin(2\pi f_2 t)$$

Step 2: Apply the superposition principle to find the resultant displacement:

$$y = y_1 + y_2 = 2A \cos \left[ 2\pi \left( \frac{f_1 - f_2}{2} \right) t \right] \sin \left[ 2\pi \left( \frac{f_1 + f_2}{2} \right) t \right]$$

Step 3: The amplitude of the resultant wave varies with time as:

$$A_{\text{resultant}} = 2A \cos \left[ 2\pi \left( \frac{f_1 - f_2}{2} \right) t \right]$$

Step 4: Since intensity is proportional to the square of the amplitude, the intensity fluctuates with a frequency equal to the difference in the two wave frequencies:

$$f_b = |f_1 - f_2|$$

This phenomenon of periodic variation in intensity is called beats.

**Final Answer:**

**Answer:** (C)

[Go Back to Question 8](#)



Q9.

**Solution**

**Concept:** For a satellite of mass  $m$  in a stable circular orbit of radius  $r$  around Earth of mass  $M$ , the required centripetal force is provided by the gravitational force:

$$\frac{mv^2}{r} = \frac{GMm}{r^2}$$

Solving for the orbital speed  $v$  yields:

$$v = \sqrt{\frac{GM}{r}}$$

**Solution:** Step 1: Write down the expression for the initial orbital speed  $v$ :

$$v = \sqrt{\frac{GM}{r}}$$

Step 2: Write down the expression for the new orbital speed  $v'$  when the radius is increased to  $r' = 4r$ :

$$v' = \sqrt{\frac{GM}{4r}}$$

Step 3: Factor out the constant term:

$$v' = \frac{1}{\sqrt{4}} \sqrt{\frac{GM}{r}} = \frac{1}{2}v = \frac{v}{2}$$

Thus, the new orbital speed becomes half of the original speed.

**Final Answer:**  $\frac{v}{2}$

**Answer: (B)**

[Go Back to Question 9](#)



Q10.

**Solution**

**Concept:** When a straight conducting rod of length  $L$  moves with a constant velocity  $v$  perpendicular to a uniform magnetic field  $B$ , a motional electromotive force (emf)  $\mathcal{E}$  is induced across its ends:

$$\mathcal{E} = BLv$$

**Solution:** Step 1: Write down the formula for the initial induced emf:

$$\mathcal{E} = BLv$$

Step 2: Express the new induced emf  $\mathcal{E}'$  when the magnetic field is doubled ( $B' = 2B$ ) and the velocity is doubled ( $v' = 2v$ ):

$$\mathcal{E}' = B'Lv' = (2B)L(2v)$$

Step 3: Simplify the expression:

$$\mathcal{E}' = 4BLv = 4\mathcal{E}$$

Thus, the induced emf increases to four times its original value.

**Final Answer:** Four times

**Answer:** (B)

[Go Back to Question 10](#)



Q11.

**Solution**

**Concept:** The hydrogen emission spectrum is divided into several spectral series determined by the principal quantum number  $n_f$  of the final energy level:

Lyman series:  $n_f = 1$

Balmer series:  $n_f = 2$

Paschen series:  $n_f = 3$

Brackett series:  $n_f = 4$

**Solution:** Step 1: Identify the initial and final orbits for the electron transition:

Initial orbit ( $n_i$ ) = 4

Final orbit ( $n_f$ ) = 2

Step 2: Compare the final energy level ( $n_f = 2$ ) with the definitions of spectral series.

Step 3: Since the electron de-excites to the second orbit ( $n_f = 2$ ), the emitted radiation belongs to the Balmer series.

**Final Answer:**

**Answer: (B)**

[Go Back to Question 11](#)



Q12.

**Solution**

**Concept:** When a parallel plate capacitor is connected to a battery, the potential difference  $V$  between its plates is held constant at the battery's emf ( $V = V_0$ ). The introduction of a dielectric slab changes the physical state of the capacitor as follows:

Capacitance:  $C = KC_0$

Charge:  $Q = CV = KC_0V_0$

Stored Energy:  $U = \frac{1}{2}CV^2 = \frac{1}{2}(KC_0)V_0^2$

Electric Field:  $E = \frac{V}{d}$

**Solution:** Step 1: Note that the capacitor remains connected to the battery, so the potential difference  $V$  across the plates remains constant ( $V = V_0$ ).

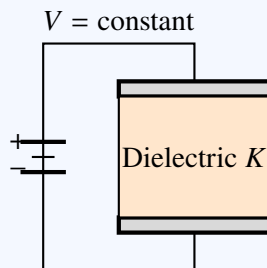
Step 2: The capacitance increases by a factor of  $K$  ( $C = KC_0$ ). Since  $Q = CV$ , the charge increases to  $Q = KQ_0$ .

Step 3: The stored electrostatic energy increases by a factor of  $K$  ( $U = KU_0$ ).

Step 4: The electric field between the plates is given by  $E = \frac{V}{d}$ . Since  $V$  is kept constant by the battery ( $V = V_0$ ) and the distance  $d$  between the plates is unchanged:

$$E = \frac{V_0}{d} = E_0$$

Thus, the electric field remains unchanged.



**Final Answer:**

**Answer: (B)**

[Go Back to Question 12](#)



Q13.

**Solution****Concept:** For the steady flow of an ideal fluid through a horizontal pipe: 1. **Equation of****Continuity:** The product of cross-sectional area  $A$  and flow velocity  $v$  remains constant:

$$A_1 v_1 = A_2 v_2$$

2. **Bernoulli's Principle:** For horizontal flow, the sum of pressure energy and kinetic energy per unit volume is constant:

$$P + \frac{1}{2} \rho v^2 = \text{constant}$$

**Solution:** Step 1: Apply the Equation of Continuity. If the cross-sectional area decreases ( $A_2 < A_1$ ), the flow velocity must increase ( $v_2 > v_1$ ) to keep the product  $Av$  constant:

$$v \propto \frac{1}{A}$$

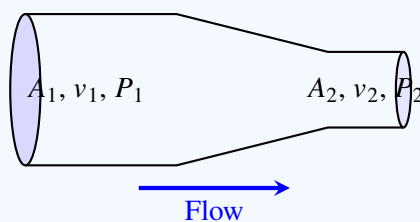
Step 2: Apply Bernoulli's Principle to the horizontal pipe:

$$P_1 + \frac{1}{2} \rho v_1^2 = P_2 + \frac{1}{2} \rho v_2^2$$

Step 3: Since  $v_2 > v_1$ , the kinetic energy term  $\frac{1}{2} \rho v^2$  increases. To maintain the equality, the static pressure  $P$  must decrease:

$$P_2 < P_1$$

Thus, in the region of decreased cross-sectional area, the pressure decreases.

**Final Answer:** **Answer: (B)**[Go Back to Question 13](#)

Q14.

**Solution**

**Concept:** A semiconductor diode allows electric current to flow in only one direction (when it is forward biased) and blocks current in the opposite direction (when it is reverse biased). This unidirectional conduction property is utilized to construct a **rectifier**, which converts alternating current (AC) into direct current (DC).

**Solution:** Step 1: Understand that alternating current (AC) periodically reverses its direction and changes its magnitude over time.

Step 2: When AC is applied to a p-n junction diode, the diode becomes forward biased during one half-cycle (allowing current to pass) and reverse biased during the other half-cycle (blocking current).

Step 3: This conversion of a bidirectional waveform into a unidirectional waveform is called rectification. Thus, a rectifier converts AC into DC.

**Final Answer:** AC into DC

**Answer:** (A)

[Go Back to Question 14](#)



Q15.

**Solution**

**Concept:** In a purely inductive AC circuit connected to an alternating voltage source  $v(t) = V_0 \sin(\omega t)$ , the self-induced back emf in the inductor opposes the change in current. This causes the alternating current  $i(t)$  to lag behind the applied voltage by a phase angle of  $90^\circ$  ( $\frac{\pi}{2}$  radians).

**Solution:** Step 1: Write down the expression for the alternating voltage across the inductor:

$$v(t) = V_0 \sin(\omega t)$$

Step 2: Relate voltage and current in an inductor using Faraday's law of induction:

$$v(t) = L \frac{di}{dt}$$

Step 3: Solve for current  $i(t)$  by integrating both sides:

$$i(t) = \frac{1}{L} \int V_0 \sin(\omega t) dt = -\frac{V_0}{\omega L} \cos(\omega t)$$

$$i(t) = I_0 \sin\left(\omega t - \frac{\pi}{2}\right) = I_0 \sin(\omega t - 90^\circ)$$

Step 4: Find the phase difference  $\Delta\phi$  between the voltage and the current:

$$\Delta\phi = \omega t - (\omega t - 90^\circ) = 90^\circ$$

**Final Answer:**

**Answer:** (C)

[Go Back to Question 15](#)



## Q16.

**Solution**

**Concept:** For a particle moving from rest with constant acceleration  $a$ , the position  $x$  at any time  $t$  is given by the second equation of motion:

$$x(t) = ut + \frac{1}{2}at^2$$

Since the particle starts from rest,  $u = 0$ , reducing the formula to:

$$x(t) = \frac{1}{2}at^2$$

**Solution:** Step 1: Calculate the distance  $x_1$  covered in the first time interval  $T$  (from  $t = 0$  to  $t = T$ ):

$$x_1 = \frac{1}{2}aT^2$$

Step 2: Calculate the total distance covered by the particle in time  $2T$  (from  $t = 0$  to  $t = 2T$ ):

$$x_{\text{total}} = \frac{1}{2}a(2T)^2 = 4\left(\frac{1}{2}aT^2\right) = 4x_1$$

Step 3: Determine the distance  $x_2$  covered in the second successive equal interval of time  $T$  (from  $t = T$  to  $t = 2T$ ):

$$x_2 = x_{\text{total}} - x_1 = 4x_1 - x_1 = 3x_1$$

Step 4: Compare  $x_1$  and  $x_2$ . Since  $x_2 = 3x_1$ , we have:

$$x_2 > x_1$$

**Final Answer:**  $x_2 > x_1$

**Answer: (B)**

[Go Back to Question 16](#)



Q17.

**Solution**

**Concept:** An electromagnetic wave is a transverse wave consisting of time-varying electric ( $\vec{E}$ ) and magnetic ( $\vec{B}$ ) fields. The direction of propagation of the wave is given by the Poynting vector direction, which is parallel to  $\vec{E} \times \vec{B}$ .

**Solution:** Step 1: Identify the mutual orientation of the fields. In a propagating electromagnetic wave, the electric field vector  $\vec{E}$  and the magnetic field vector  $\vec{B}$  oscillate in planes that are perpendicular to each other:

$$\vec{E} \cdot \vec{B} = 0$$

Step 2: Recall that both fields are also perpendicular to the direction of wave propagation:

$$\vec{E} \perp \vec{v} \quad \text{and} \quad \vec{B} \perp \vec{v}$$

Step 3: Therefore, the electric field and magnetic field in an electromagnetic wave are perpendicular to each other.

**Final Answer:**

**Answer: (C)**

[Go Back to Question 17](#)

Q18.

**Solution**

**Concept:** The binding energy per nucleon ( $\Delta E_{be}/A$ ) represents the average energy required to remove a single nucleon from a nucleus. It is a direct measure of nuclear stability: the higher the binding energy per nucleon, the more stable the nucleus.

**Solution:** Step 1: Analyze the binding energy curve. The binding energy per nucleon is relatively low for very light nuclei, increases to a maximum of about 8.8 MeV for intermediate mass nuclei (around iron,  $^{56}\text{Fe}$ ), and then gradually decreases for heavier nuclei.

Step 2: Since intermediate mass nuclei have the highest binding energy per nucleon, it requires the most energy per particle to break them apart.

Step 3: Consequently, these intermediate mass nuclei are the most stable nuclei found in nature.

**Final Answer:**

**Answer: (B)**

[Go Back to Question 18](#)



Q19.

**Solution**

**Concept:** Hooke's Law is a principle of physics that states that the force (or stress) needed to extend or compress a spring (or elastic material) by some distance (or strain) is proportional to that distance (or strain), provided the elastic limit of the material is not exceeded.

**Solution:** Step 1: Within the elastic limit of a solid material, the stress developed is directly proportional to the strain produced in it:

$$\text{Stress} \propto \text{Strain}$$

Step 2: Express this proportionality as an equation using a constant of proportionality  $E$  (the modulus of elasticity):

$$\text{Stress} = E \times \text{Strain}$$

Step 3: Identify the law. This relationship is Hooke's Law.

**Final Answer:**

**Answer: (B)**

[Go Back to Question 19](#)



Q20.

**Solution**

**Concept:** For a car of mass  $m$  moving in a circular path of radius  $R$  with speed  $v$ , the centripetal force  $F_c$  acting on the car is given by:

$$F_c = \frac{mv^2}{R}$$

Therefore, for a constant mass and radius, the centripetal force is directly proportional to the square of the speed:

$$F_c \propto v^2$$

**Solution:** Step 1: Write down the expression for the initial centripetal force:

$$F_c = \frac{mv^2}{R}$$

Step 2: Find the new centripetal force  $F'_c$  when the speed of the car is doubled ( $v' = 2v$ ):

$$F'_c = \frac{m(2v)^2}{R}$$

Step 3: Simplify the expression:

$$F'_c = \frac{m(4v^2)}{R} = 4 \left( \frac{mv^2}{R} \right) = 4F_c$$

Thus, the centripetal force required becomes four times the original value.

**Final Answer:**

**Answer: (B)**

[Go Back to Question 20](#)



Q21.

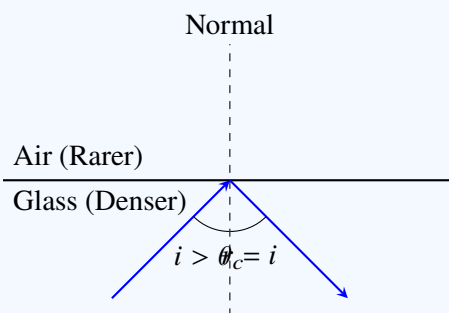
**Solution**

**Concept:** Total Internal Reflection (TIR) occurs when a light ray travels from an optically denser medium (like glass) to an optically rarer medium (like air). If the angle of incidence  $i$  inside the denser medium exceeds the critical angle  $\theta_c$ , the ray does not refract; instead, it is completely reflected back into the denser medium.

**Solution:** Step 1: Check the conditions for total internal reflection:

1. The light ray must travel from a denser medium to a rarer medium. (Here, the ray travels from glass to air, which satisfies this condition).
2. The angle of incidence  $i$  must be greater than the critical angle  $\theta_c$ . (Here,  $i > \theta_c$ , which satisfies this condition).

Step 2: Since both conditions are satisfied, the ray of light is completely reflected back into the glass. This phenomenon is called total internal reflection.



**Final Answer:** Total internal reflection

**Answer:** (C)

[Go Back to Question 21](#)



Q22.

**Solution**

**Concept:** An adiabatic process is one in which no heat is exchanged between the system and its surroundings ( $Q = 0$ ). According to the First Law of Thermodynamics:

$$\Delta U = Q - W \implies \Delta U = -W$$

where  $\Delta U$  is the change in internal energy and  $W$  is the work done by the system.

**Solution:** Step 1: Analyze internal energy. In an adiabatic expansion, the gas does positive work on its surroundings ( $W > 0$ ). Because  $\Delta U = -W$ , the change in internal energy is negative:

$$\Delta U < 0$$

This means the internal energy  $U$  of the gas decreases.

Step 2: Analyze temperature. Since the internal energy of an ideal gas depends only on its absolute temperature ( $U = nC_vT$ ), a decrease in internal energy directly causes a decrease in temperature  $T$ :

$$\Delta T < 0$$

Step 3: Analyze pressure. For an adiabatic process, the pressure and volume are related by  $PV^\gamma = \text{constant}$ . During expansion, volume  $V$  increases, which causes the pressure  $P$  to decrease:

$$P \propto \frac{1}{V^\gamma}$$

Step 4: Combine the results. Temperature, pressure, and internal energy all decrease during an adiabatic expansion.

**Final Answer:**

**Answer: (D)**

[Go Back to Question 22](#)



Q23.

**Solution**

**Concept:** The electrostatic potential energy  $U$  of two point charges  $q_1$  and  $q_2$  separated by a distance  $r$  in vacuum is:

$$U = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r}$$

According to Coulomb's Law, the electrostatic force  $F$  between them is:

$$F = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2}$$

A positive force value ( $F > 0$ ) represents repulsion, while a negative force value ( $F < 0$ ) represents attraction.

**Solution:** Step 1: Examine the condition given in the problem:

$$U > 0 \implies \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r} > 0$$

Step 2: Since  $r > 0$  and  $\epsilon_0 > 0$ , the product of the charges must be positive:

$$q_1 q_2 > 0$$

Step 3: A positive product  $q_1 q_2 > 0$  means that both charges are either positive or both negative. In other words, they are like charges.

Step 4: Like charges repel each other, so the electrostatic force between them is repulsive.

**Final Answer:**

**Answer: (B)**

[Go Back to Question 23](#)



Q24.

**Solution**

**Concept:** According to the de Broglie hypothesis, a moving particle of mass  $m$  and velocity  $v$  has an associated wave character. The de Broglie wavelength  $\lambda$  is given by:

$$\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{\sqrt{2mK}}$$

where  $h$  is Planck's constant,  $p$  is momentum, and  $K$  is kinetic energy.

**Solution:** Step 1: Write down the de Broglie wavelength relation in terms of the given parameters:

$$\lambda \propto \frac{1}{v}, \quad \lambda \propto \frac{1}{p}, \quad \lambda \propto \frac{1}{\sqrt{K}}, \quad \lambda \propto \frac{1}{m}$$

Step 2: Analyze the options to see which change decreases  $\lambda$ :

- (A) Velocity  $v$  decreases  $\implies \lambda$  increases.
- (B) Momentum  $p$  decreases  $\implies \lambda$  increases.
- (C) Kinetic energy  $K$  increases  $\implies \lambda$  decreases.
- (D) Mass  $m$  decreases  $\implies \lambda$  increases.

Step 3: Conclude that the wavelength decreases if the kinetic energy of the electron increases.

**Final Answer:** Its kinetic energy increases

**Answer:** (C)

[Go Back to Question 24](#)



Q25.

**Solution**

**Concept:** When a flat coil of area  $A$  and  $N$  turns rotates in a uniform magnetic field  $B$  with a constant angular velocity  $\omega$ , the magnetic flux  $\Phi(t)$  threading the coil at any time  $t$  is:

$$\Phi(t) = NBA \cos(\omega t)$$

According to Faraday's Law of Electromagnetic Induction, the induced electromotive force (emf) is:

$$\mathcal{E} = -\frac{d\Phi}{dt}$$

**Solution:** Step 1: Set up the differentiation of the magnetic flux with respect to time:

$$\mathcal{E} = -\frac{d}{dt} (NBA \cos(\omega t))$$

Step 2: Calculate the derivative:

$$\mathcal{E} = -NBA \left( -\omega \sin(\omega t) \right) = NBA\omega \sin(\omega t)$$

Step 3: Write the induced emf in standard AC form:

$$\mathcal{E} = \mathcal{E}_0 \sin(\omega t)$$

where  $\mathcal{E}_0 = NBA\omega$  is the peak value of the induced emf.

Step 4: Since the induced emf is proportional to  $\sin(\omega t)$ , it varies as a sinusoidal function of time.

**Final Answer:** Sinusoidal function

Answer: (C)

[Go Back to Question 25](#)



Q26.

**Solution**

**Concept:** The Stefan-Boltzmann Law states that the total radiant energy emitted per second (radiated power  $P$ ) from the surface of a black body is directly proportional to the fourth power of its absolute temperature  $T$ :

$$P = \sigma AT^4$$

where  $\sigma$  is Stefan's constant and  $A$  is the surface area of the body.

**Solution:** Step 1: Write down the proportional relationship between the radiated power  $P$  and absolute temperature  $T$ :

$$P \propto T^4$$

Step 2: Express the initial radiated power  $P_1$  at temperature  $T_1 = T$ :

$$P_1 = kT^4$$

Step 3: Express the new radiated power  $P_2$  when the absolute temperature is doubled ( $T_2 = 2T$ ):

$$P_2 = k(2T)^4 = 16(kT^4)$$

Step 4: Substitute  $P_1$  into the equation:

$$P_2 = 16P_1$$

Thus, the radiated power increases by a factor of sixteen.

**Final Answer:**

**Answer: (D)**

[Go Back to Question 26](#)



Q27.

**Solution**

**Concept:** When an intrinsic semiconductor like Silicon (group IV element) is doped with a trivalent impurity (group III element, e.g., Boron, Aluminum, or Indium), a p-type semiconductor is created. The trivalent impurity atoms require four electrons to form stable covalent bonds with surrounding silicon atoms but only have three, creating a vacancy or a electron "hole".

**Solution:** Step 1: Understand the doping process for a p-type semiconductor. Each trivalent impurity atom added creates a hole without releasing a free electron.

Step 2: Compare the concentration of charge carriers:

The concentration of holes ( $n_h$ ) becomes extremely high because of the dopant atoms. The concentration of free electrons ( $n_e$ ) remains very low, representing only those produced by thermal generation.

Step 3: Since  $n_h \gg n_e$ , the majority charge carriers in a p-type semiconductor are holes.

**Final Answer:**

**Answer: (B)**

[Go Back to Question 27](#)



Q28.

**Solution**

**Concept:** The total mechanical energy  $E$  of a particle executing simple harmonic motion (SHM) is the sum of its kinetic energy  $K$  and its potential energy  $U$ :

$$E = K + U$$

For a particle of mass  $m$ , angular frequency  $\omega$ , displacement  $x$ , and amplitude  $A$ :

$$K = \frac{1}{2}m\omega^2(A^2 - x^2) \quad \text{and} \quad U = \frac{1}{2}m\omega^2x^2$$

**Solution:** Step 1: Sum the kinetic and potential energies to find the total mechanical energy  $E$ :

$$E = \frac{1}{2}m\omega^2(A^2 - x^2) + \frac{1}{2}m\omega^2x^2 = \frac{1}{2}m\omega^2A^2$$

Step 2: Analyze the terms in the final expression  $E = \frac{1}{2}m\omega^2A^2$ :

$m$  is the mass of the particle.

$\omega$  is the angular frequency (which is constant for a given SHM).  $A$  is the maximum displacement, i.e., the amplitude.

Step 3: Observe that the total mechanical energy is independent of the instantaneous displacement  $x$  and velocity  $v$ , and depends directly on the amplitude  $A$ .

**Final Answer:**

**Answer:** (C)

[Go Back to Question 28](#)



Q29.

**Solution**

**Concept:** The potential gradient  $k$  along a potentiometer wire of length  $L$  and resistance  $R$  carrying a current  $I$  is defined as the potential drop per unit length:

$$k = \frac{V}{L}$$

By Ohm's law,  $V = IR$ . Substituting the resistance formula  $R = \rho \frac{L}{A}$  yields:

$$k = \frac{IR}{L} = \frac{I \left( \rho \frac{L}{A} \right)}{L} = \frac{I\rho}{A}$$

**Solution:** Step 1: Write down the formula for the potential gradient  $k$  of the wire:

$$k = \frac{I\rho}{A}$$

where  $\rho$  is the resistivity and  $A$  is the cross-sectional area of the wire.

Step 2: For a given potentiometer wire, both  $\rho$  and  $A$  are constants, which means the potential gradient is directly proportional to the current flowing through it:

$$k \propto I$$

Step 3: Since the potential gradient is directly proportional to the current, an increase in the current  $I$  results in an increase in the potential gradient  $k$ .

**Final Answer:**

**Answer:** (A)

[Go Back to Question 29](#)



Q30.

**Solution**

**Concept:** When a charged particle of mass  $m$  and charge  $q$  enters a magnetic field  $B$  perpendicularly, the magnetic Lorentz force acts as the centripetal force keeping the particle in a circular path:

$$qvB = \frac{mv^2}{r}$$

where  $v$  is the velocity and  $r$  is the radius of the path.

**Solution:** Step 1: Rearrange the centripetal force equation to solve for the radius  $r$ :

$$r = \frac{mv}{qB}$$

Step 2: Identify the relationship between the radius  $r$  and the magnetic field strength  $B$  when the velocity  $v$  remains constant:

$$r \propto \frac{1}{B}$$

Step 3: Since the radius is inversely proportional to the magnetic field strength, increasing  $B$  causes the radius of the path  $r$  to decrease.

**Final Answer:**

**Answer:** (B)

[Go Back to Question 30](#)



**Answer Key**

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	B	3	B	4	C	5	B
6	C	7	C	8	C	9	B	10	B
11	B	12	B	13	B	14	A	15	C
16	B	17	C	18	B	19	B	20	B
21	C	22	D	23	B	24	C	25	C
26	D	27	B	28	C	29	A	30	B

