AIIMS Paramedical Physics Sample Paper – 11

Duration: 30 Minutes **Maximum Marks: 30**

Instructions

- This paper contains **30** Multiple Choice Questions (Single Correct Answer), modelled on the Physics portion of **AIIMS Paramedical** entrance.
- Each correct answer carries **+1 mark**. A penalty of $-\frac{1}{3}$ **mark** is deducted for each incorrect answer. Unattempted questions carry **0 marks** (no negative marking).
- Only **one** option is correct. Choose carefully.
- Syllabus level:**Class 11 & 12 NCERT Physics**
- Use of mobile phones, calculators, or electronic gadgets is strictly prohibited.

Q1. A particle moves in a straight line such that its displacement x at any time t is given by $x = (t^3 - 6t^2 + 9t + 4)$ m. The velocity of the particle when its acceleration becomes zero is:

(A) -3 m/s

(B) 3 m/s

(C) -4 m/s

(D) 0 m/s

Q2. A direct current of 4 A flows through a copper wire. If the cross-sectional area of the wire is 2×10^{-6} m^2 and the number density of free electrons is 8×10^{28} m^{-3}, the drift velocity of the electrons is approximately:

(A) 1.56×10^{-4} m/s

(B) 3.12×10^{-4} m/s

(C) 0.78×10^{-4} m/s

(D) 2.34×10^{-4} m/s

Q3. An ideal gas undergoes a thermodynamic process where its pressure P varies with volume V as $P = kV^2$, where k is a positive constant. If the volume of the gas increases from V_0 to $2V_0$, the work done by the gas during this process is:

(A) $\frac{7}{3}kV_0^3$

(B) $3kV_0^3$

(C) $\frac{8}{3}kV_0^3$

(D) $\frac{1}{3}kV_0^3$

Q4. In a Young's double-slit experiment, the slit separation is 0.2 mm and the screen is placed 1.5 m away. If the wavelength of light used is 6000 Å, the distance of the third bright fringe from the central maximum is:

(A) 4.5 mm

(B) 1.35 mm

(C) 9.0 mm

(D) 3.0 mm

Q5. When light of wavelength λ falls on a photosensitive surface, the stopping potential is V. If the wavelength is changed to 3λ, the stopping potential becomes $\frac{V}{4}$. The threshold wavelength for this surface is:

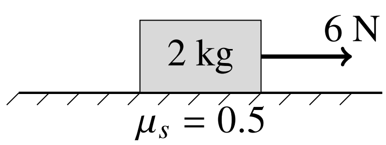
(A) 4λ

(B) 5λ

(C) 7λ

(D) 9λ

Q6. A block of mass 2 kg is resting on a rough horizontal surface with a coefficient of static friction $\mu_s = 0.5$. A horizontal force of 6 N is applied to the block. The frictional force acting on the block is (take $g = 10$ m/s^2):



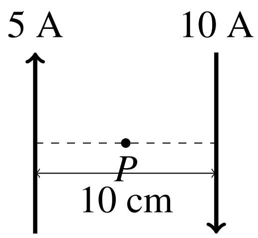
(A) 10 N

(B) 6 N

(C) 4 N

(D) 0 N

Q7. Two long, parallel wires separated by a distance of 10 cm carry currents of 5 A and 10 A respectively in opposite directions. The magnitude of the magnetic field at a point exactly midway between the two wires is:



(A) 2×10^{-5} T

(B) 4×10^{-5} T

(C) 6×10^{-5} T

(D) 0 T

Q8. A localized mass of 100 g of water at 80°C is mixed with 100 g of ice at 0°C in an insulated calorimeter. The final temperature of the mixture at equilibrium will be (Latent heat of fusion of ice = 80 cal/g, specific heat of water = 1 cal/g°C):

(A) 40°C

(B) 20°C

(C) 0°C

(D) 10°C

Q9. A convex lens of focal length 20 cm and a concave mirror of focal length 10 cm are placed co-axially 50 cm apart. A point object is placed 30 cm in front of the convex lens. The position of the final image formed after refraction through the lens and reflection from the mirror is:

(A) At the optical center of the lens

(B) At the pole of the mirror

(C) At the center of curvature of the mirror

(D) At infinity

Q10. A radioactive nucleus decays by emitting one α-particle and two β^--particles. The daughter nucleus relative to the parent nucleus is a/an:

(A) Isobar

(B) Isotope

(C) Isotone

(D) Isomer

Q11. A projectile is fired from the ground with an initial velocity $\vec{v} = 3\hat{i} + 4\hat{j}$ m/s, where $\hat{i}$ is horizontal and $\hat{j}$ is vertically upward. The horizontal range of the projectile is (take $g = 10$ m/s^2):

(A) 1.2 m

(B) 2.4 m

(C) 4.8 m

(D) 3.6 m

Q12. A cell of emf E and internal resistance r is connected across a variable external resistance R. The plot of potential difference V across the terminal of the cell versus R is best represented by a curve that:

(A) Increases linearly with R from the origin

(B) Decreases linearly with R starting from E

(C) Increases asymptotically towards E as R increases

(D) Remains constant at value E for all values of R

Q13. An alpha particle and a proton are accelerated from rest through the same potential difference V. The ratio of their de Broglie wavelengths $\lambda_\alpha : \lambda_p$ is:

(A) $1 : \sqrt{2}$

(B) $1 : 2$

(C) $1 : 2\sqrt{2}$

(D) $2\sqrt{2} : 1$

Q14. A body of mass 0.5 kg travels in a straight line with a velocity $v = ax^{3/2}$ where $a = 5\ \text{m}^{-1/2}\text{s}^{-1}$. The work done by the net force during its displacement from $x = 0$ to $x = 2$ m is:

(A) 50 J

(B) 10 J

(C) 25 J

(D) 100 J

Q15. The temperature of an ideal gas is increased from 27°C to 927°C. The root-mean-square (rms) speed of its molecules becomes:

(A) Twice the initial value

(B) Three times the initial value

(C) Four times the initial value

(D) Half the initial value

Q16. An object is placed at a distance of 15 cm from a convex mirror of focal length 30 cm. The magnification produced by the mirror is:

(A) +2

(B) −0.5

(C) +0.67

(D) +0.5

Q17. In a region of space, the electric potential is given by $V(x, y, z) = 4x^2 - 3xy$ V. The magnitude of the electric field vector at the point $(1, 2, 0)$ is:

(A) 5 V/m

(B) 3 V/m

(C) $\sqrt{13}$ V/m

(D) 2 V/m

Q18. The half-life of a radioactive substance is 20 minutes. The time interval between 33% decay and 67% decay of the substance is approximately:

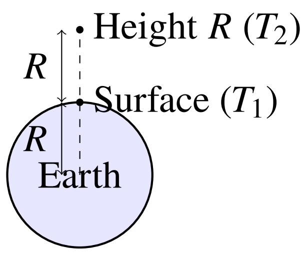
(A) 20 minutes

(B) 40 minutes

(C) 10 minutes

(D) 30 minutes

Q19. A simple pendulum has a time period T_1 on the surface of Earth. When taken to a height R above the Earth's surface (where R is the radius of Earth), its time period becomes T_2. The ratio T_1/T_2 is:



(A) 1 : 2

(B) 2 : 1

(C) 1 : 4

(D) 1 : $\sqrt{2}$

Q20. A plane electromagnetic wave propagating along the x-axis has an electric field component $E_y = 60\ \text{V/m}\sin(\omega t - kx)$. The amplitude of the magnetic field component B_z is:

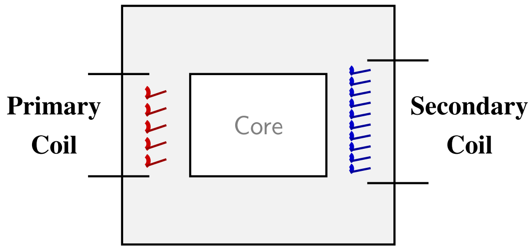
(A) 2×10^{-7} T

(B) 60 T

(C) 1.8×10^{10} T

(D) 2×10^{-6} T

Q21. An ideal transformer has a primary-to-secondary turns ratio of 1 : 10. If the primary coil is connected to an AC source of 220 V, 50 Hz, the frequency of the voltage across the secondary coil is:



Turns Ratio = 1 : 10

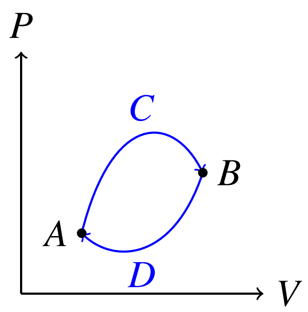
(A) 500 Hz

(B) 50 Hz

(C) 5 Hz

(D) 25 Hz

Q22. A thermodynamic system is taken from state A to state B along the path ACB and returns to A along the path BDA. The net work done by the system during the complete cycle ACBDA is represented by:



(A) The area under the curve ACB only

(B) The area under the curve BDA only

(C) The area enclosed by the loop ACBDA

(D) Zero, since it is a cyclic process

Q23. A heavy nucleus at rest breaks into two fragments whose speed ratio is 8 : 1. The ratio of the radii of the two fragments (assuming spherical nuclei) is:

(A) 1 : 2

(B) 2 : 1

(C) 1 : 4

(D) 1 : 8

Q24. A particle executing simple harmonic motion has a maximum velocity v_0 and a maximum acceleration a_0. The amplitude of its motion is given by:

(A) $\frac{v_0^2}{a_0}$

(B) $\frac{a_0^2}{v_0}$

(C) $\frac{v_0}{a_0}$

(D) $v_0 a_0$

Q25. A parallel plate capacitor with air between the plates has a capacitance of 8 pF. What will be the capacitance if the distance between the plates is reduced by half, and the space between them is completely filled with a medium of dielectric constant $k = 6$?

(A) 24 pF

(B) 48 pF

(C) 96 pF

(D) 12 pF

Q26. In the Bohr model of the hydrogen atom, the ratio of the kinetic energy to the total energy of the electron in the n-th orbit is:

(A) 1 : 1

(B) −1 : 1

(C) 1 : −1

(D) 2 : −1

Q27. The critical angle for total internal reflection from a medium to vacuum is 30°. The velocity of light in this medium is:

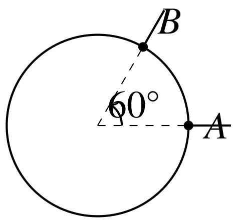
(A) 3×10^8 m/s

(B) 1.5×10^8 m/s

(C) 6×10^8 m/s

(D) 2×10^8 m/s

Q28. A uniform wire of resistance 36 Ω is bent into the form of a perfect circle. The effective resistance between two points on the circle separated by an angular distance of 60° is:



(A) 6 Ω

(B) 5 Ω

(C) 30 Ω

(D) 4.5 Ω

Q29. A constant torque of 1000 N · m turns a wheel of moment of inertia 200 kg · m^2 about its axis. The angular velocity gained by the wheel in 4 seconds starting from rest is:

(A) 20 rad/s

(B) 5 rad/s

(C) 40 rad/s

(D) 10 rad/s

Q30. A system absorbs 400 J of heat and does 150 J of work simultaneously. The change in internal energy of the system during this process is:

(A) 550 J

(B) 250 J

(C) −250 J

(D) 400 J

Detailed Solutions

Q1.

Solution

Concept: The instantaneous velocity of a moving object is obtained by taking the first derivative of its position function with respect to time, $v = \frac{dx}{dt}$.
The instantaneous acceleration is similarly obtained by taking the first derivative of the velocity function, which is the second derivative of the position function, $a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$.

Solution: Step 1: Write down the given displacement function of the moving particle:

$$x = t^3 - 6t^2 + 9t + 4$$

Step 2: Differentiate the displacement function with respect to time t to find the expression for velocity v:

$$v = \frac{dx}{dt} = \frac{d}{dt}(t^3 - 6t^2 + 9t + 4) = 3t^2 - 12t + 9$$

Step 3: Differentiate the velocity function with respect to time t to obtain the acceleration function a:

$$a = \frac{dv}{dt} = \frac{d}{dt}(3t^2 - 12t + 9) = 6t - 12$$

Step 4: Set the acceleration function equal to zero to determine the specific time t when the acceleration becomes zero:

$$6t - 12 = 0 \implies 6t = 12 \implies t = 2 \text{ s}$$

Step 5: Substitute this time value $t = 2$ s back into the velocity equation obtained in Step 2 to compute the required velocity:

$$v = 3(2)^2 - 12(2) + 9 = 3(4) - 24 + 9 = 12 - 24 + 9 = -3 \text{ m/s}$$

Final Answer: $\boxed{-3 \text{ m/s}}$

Answer: (A)

Go Back to Question 1

Q2.

Solution

Concept: Electric current flowing through a conductor is related to the macroscopic drift velocity of the free electrons by the standard relationship $I = neAv_d$.
Here, I is the electric current, n represents the charge carrier density, e is the elementary charge of a single electron, A represents the uniform cross-sectional area, and v_d is the average drift velocity.

Solution: Step 1: Identify all the given physical parameters from the question statement:
Current, $I = 4$ A
Cross-sectional area, $A = 2 \times 10^{-6}$ m^2
Number density of free electrons, $n = 8 \times 10^{28}$ m^{-3}
Elementary charge of an electron, $e = 1.6 \times 10^{-19}$ C

Step 2: Rearrange the fundamental electric current equation to isolate the drift velocity v_d:

$$v_d = \frac{I}{neA}$$

Step 3: Substitute the corresponding numeric values into the rearranged equation:

$$v_d = \frac{4}{(8 \times 10^{28}) \times (1.6 \times 10^{-19}) \times (2 \times 10^{-6})}$$

Step 4: Simplify the product of the terms contained within the denominator:

$$\text{Denominator} = 8 \times 1.6 \times 2 \times 10^{28-19-6} = 25.6 \times 10^3$$

Step 5: Perform the final division to compute the precise value of the drift velocity:

$$v_d = \frac{4}{25.6 \times 10^3} = \frac{4}{25600} \approx 1.56 \times 10^{-4} \text{ m/s}$$

Final Answer: $\boxed{1.56 \times 10^{-4} \text{ m/s}}$

Answer: (A)

Go Back to Question 2

Q3.

Solution

Concept: The work done by a thermodynamic system during a quasi-static volume change is evaluated by integrating the pressure with respect to the volume:

$$W = \int_{V_i}^{V_f} P\,dV$$

When pressure is explicitly given as a non-linear function of volume, we must substitute the function directly into the integral and apply the fundamental laws of calculus.

Solution: Step 1: Write down the functional relationship governing pressure and volume for this specific process:

$$P = kV^2$$

Step 2: Set up the definitive integral for work done by substituting the boundaries from the initial state V_0 to the final state $2V_0$:

$$W = \int_{V_0}^{2V_0} kV^2\,dV$$

Step 3: Factor out the positive proportionality constant k and perform the polynomial integration:

$$W = k\left[\frac{V^3}{3}\right]_{V_0}^{2V_0} = \frac{k}{3}\left[V^3\right]_{V_0}^{2V_0}$$

Step 4: Evaluate the integration by substituting the upper limit and the lower limit into the expression:

$$W = \frac{k}{3}\left[(2V_0)^3 - (V_0)^3\right]$$

Step 5: Expand the terms and simplify the algebraic expression to find the final work done:

$$W = \frac{k}{3}\left[8V_0^3 - V_0^3\right] = \frac{k}{3}\left[7V_0^3\right] = \frac{7}{3}kV_0^3$$

Final Answer: $\boxed{\frac{7}{3}kV_0^3}$

Answer: (A)

Go Back to Question 3

Q4.

Solution

Concept: In Young's Double Slit Experiment, wave interference produces alternate bright and dark bands on a distant screen.
The linear distance y_n of the n-th bright fringe from the central maximum position is given by the configuration formula $y_n = \frac{n\lambda D}{d}$.
Here, n is the fringe order, λ is the source wavelength, D is the distance to the screen, and d is the spacing between the slits.

Solution: Step 1: List the values given in the problem statement and convert them into standard metric units (meters):
Slit separation, $d = 0.2 \text{ mm} = 0.2 \times 10^{-3} \text{ m}$
Distance to screen, $D = 1.5 \text{ m}$
Wavelength of light, $\lambda = 6000 \text{ Å} = 6000 \times 10^{-10} \text{ m} = 6 \times 10^{-7} \text{ m}$
Fringe order for bright band, $n = 3$

Step 2: Write down the explicit formula for the position of a bright fringe:

$$y_3 = \frac{3\lambda D}{d}$$

Step 3: Substitute the converted standard numerical values into the equation:

$$y_3 = \frac{3 \times (6 \times 10^{-7} \text{ m}) \times 1.5 \text{ m}}{0.2 \times 10^{-3} \text{ m}}$$

Step 4: Solve the arithmetic calculations by simplifying the numerator and denominator parameters:

$$y_3 = \frac{27 \times 10^{-7}}{0.2 \times 10^{-3}} = \frac{27}{0.2} \times 10^{-4} = 135 \times 10^{-4} \text{ m}$$

Step 5: Convert the calculated linear metric distance back into millimeters for matching the options:

$$y_3 = 13.5 \times 10^{-3} \text{ m} = 4.5 \text{ mm}$$

Final Answer: $\boxed{4.5 \text{ mm}}$

Answer: (A)

Go Back to Question 4

Q5.

Solution

Concept: According to Einstein's Photoelectric Equation, the maximum kinetic energy of emitted photoelectrons is related to the incident photon energy and the work function of the material:

$$eV_s = \frac{hc}{\lambda} - \phi = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$$

Here, V_s is the stopping potential, λ is the incident wavelength, ϕ is the work function, and λ_0 is the threshold wavelength.

Solution: Step 1: Write down the equation for the first case scenario where the incident wavelength is λ:

$$eV = \frac{hc}{\lambda} - \frac{hc}{\lambda_0} \quad \text{— (Equation 1)}$$

Step 2: Write down the equation for the second case scenario where the wavelength is changed to 3λ:

$$e\left(\frac{V}{4}\right) = \frac{hc}{3\lambda} - \frac{hc}{\lambda_0} \quad \text{— (Equation 2)}$$

Step 3: Multiply Equation 2 by 4 across all terms to clear out the fractional potential factor:

$$eV = \frac{4hc}{3\lambda} - \frac{4hc}{\lambda_0} \quad \text{— (Equation 3)}$$

Step 4: Equate the right-hand sides of Equation 1 and Equation 3 since both expressions equal eV:

$$\frac{hc}{\lambda} - \frac{hc}{\lambda_0} = \frac{4hc}{3\lambda} - \frac{4hc}{\lambda_0}$$

Step 5: Cancel the common constant factor hc from both sides and solve for the threshold term λ_0:

$$\frac{1}{\lambda} - \frac{1}{\lambda_0} = \frac{4}{3\lambda} - \frac{4}{\lambda_0} \implies \frac{4}{\lambda_0} - \frac{1}{\lambda_0} = \frac{4}{3\lambda} - \frac{1}{\lambda}$$

$$\frac{3}{\lambda_0} = \frac{4-3}{3\lambda} \implies \frac{3}{\lambda_0} = \frac{1}{3\lambda} \implies \lambda_0 = 9\lambda$$

Final Answer: $\boxed{9\lambda}$

Answer: (D)

Go Back to Question 5

Q6.

Solution

Concept: Friction is a self-adjusting reactive force that opposes relative motion. The maximum possible value of static friction is the limiting friction, given by $f_{\max} = \mu_s N$.
If the applied external horizontal force is less than or equal to this limiting friction value, the object remains stationary, and the active static friction force perfectly balances the applied force.

Solution: Step 1: Calculate the normal reaction force N acting on the block resting on the horizontal surface:

$$N = mg = 2 \text{ kg} \times 10 \text{ m/s}^2 = 20 \text{ N}$$

Step 2: Determine the maximum limiting static frictional force $f_{\max}$ that the surface can exert:

$$f_{\max} = \mu_s N = 0.5 \times 20 \text{ N} = 10 \text{ N}$$

Step 3: Compare the applied external horizontal force $F_{\text{applied}} = 6$ N with the calculated limiting friction value:

$$F_{\text{applied}} = 6 \text{ N} \leq f_{\max} = 10 \text{ N}$$

Step 4: Analyze the equilibrium condition of the block based on this comparison. Since the applied pulling force does not overcome the maximum structural threshold, the block will not move.

Step 5: Conclude that because the block remains completely at rest, the active static friction must be exactly equal to the magnitude of the applied horizontal force to satisfy Newton's first law:

$$f_s = F_{\text{applied}} = 6 \text{ N}$$

Final Answer: $\boxed{6 \text{ N}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 6

Q7.

Solution

Concept: The magnetic field produced by a long straight current-carrying wire at a perpendicular distance r is given by Ampere's Law: $B = \frac{\mu_0 I}{2\pi r}$.
The total magnetic field vector at any point is the vector sum of individual fields. We must use the Right-Hand Thumb Rule to determine the physical directions of the magnetic fields.

Solution: Step 1: Determine the geometric parameters. The wires are separated by 10 cm. The midway point P lies at equal distance from both wires:

$$r_1 = r_2 = \frac{10\text{ cm}}{2} = 5\text{ cm} = 0.05\text{ m}$$

Step 2: Apply the Right-Hand Thumb Rule for the first wire carrying $I_1 = 5$ A upwards. At the midway point (to its right), the field direction points into the plane of the paper (⊗).

Step 3: Apply the rule for the second wire carrying $I_2 = 10$ A downwards. At the midway point (to its left), the field direction also points into the plane of the paper (⊗).

Step 4: Since both individual magnetic fields point in identical spatial directions, their net scalar magnitudes add up directly:

$$B_{\text{net}} = B_1 + B_2 = \frac{\mu_0 I_1}{2\pi r} + \frac{\mu_0 I_2}{2\pi r} = \frac{\mu_0}{2\pi r}(I_1 + I_2)$$

Step 5: Substitute the numerical constants ($\frac{\mu_0}{4\pi} = 10^{-7}$ T·m/A $\implies \frac{\mu_0}{2\pi} = 2 \times 10^{-7}$) and calculate:

$$B_{\text{net}} = \frac{2 \times 10^{-7}}{0.05} \times (5 + 10) = \frac{2 \times 10^{-7}}{0.05} \times 15 = 4 \times 10^{-6} \times 15 = 6 \times 10^{-5}\text{ T}$$

Final Answer: $\boxed{6 \times 10^{-5}\text{ T}}$

Answer: (C)

Go Back to Question 7

Q8.

Solution

Concept: According to the principles of calorimetry, in an isolated system, the total heat lost by hotter components must be perfectly equal to the total heat gained by colder components.
We must carefully account for the phase changes, as melting processes consume latent heat energy ($Q = mL$) without altering temperature conditions.

Solution: Step 1: Calculate the total thermal energy available from the hot water cooling down from its initial state to the base temperature of 0°C:

$$Q_{\text{available}} = m_w \cdot c_w \cdot \Delta T = 100\text{ g} \times 1\text{ cal/g}^\circ\text{C} \times (80 - 0)^\circ\text{C} = 8000\text{ cal}$$

Step 2: Calculate the thermal energy required to completely melt all the available ice mass into liquid water at 0°C:

$$Q_{\text{melt\_all}} = m_{\text{ice}} \cdot L_f = 100\text{ g} \times 80\text{ cal/g} = 8000\text{ cal}$$

Step 3: Compare the available heat energy with the required latent heat energy. Notice that:

$$Q_{\text{available}} = Q_{\text{melt\_all}} = 8000\text{ cal}$$

Step 4: This exact energy match implies that all the available heat extracted from the hot water is entirely consumed by the ice melting process. No extra heat remains to raise the temperature.

Step 5: Therefore, the entire mass of ice converts into water at 0°C while the original water cools down to 0°C. The final equilibrium temperature is stable at 0°C.

Final Answer: $\boxed{0^\circ\text{C}}$

Answer: (C)

Go Back to Question 8

Q9.

Solution

Concept: This problem requires a step-by-step application of the lens formula followed by the mirror formula.

Lens Formula: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

Mirror Formula: $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

Sign conventions must be meticulously maintained for each successive optical component.

Solution: Step 1: Analyze the refraction through the convex lens. The object distance $u_1 = -30$ cm and focal length $f_1 = +20$ cm:

$$\frac{1}{v_1} - \frac{1}{-30} = \frac{1}{20} \implies \frac{1}{v_1} = \frac{1}{20} - \frac{1}{30} = \frac{3-2}{60} = \frac{1}{60} \implies v_1 = +60 \text{ cm}$$

Step 2: The lens forms a real image located 60 cm to its right. However, the concave mirror is positioned only 50 cm to the right of the lens.

Step 3: This means the rays are converging towards a point that lies behind the mirror surface. Thus, it acts as a virtual object for the concave mirror:

$$u_2 = +(60 - 50) = +10 \text{ cm}$$

Step 4: Apply the mirror formula for the concave mirror using $u_2 = +10$ cm and $f_2 = -10$ cm:

$$\frac{1}{v_2} + \frac{1}{10} = \frac{1}{-10} \implies \frac{1}{v_2} = -\frac{1}{10} - \frac{1}{10} = -\frac{2}{10} = -\frac{1}{5} \implies v_2 = -5 \text{ cm}$$

Step 5: The final image is formed 5 cm in front of the mirror. Since the mirror is 50 cm away from the lens, the image distance from the lens is $50 - 5 = 45$ cm. Let's re-verify the conceptual tracking of positions. The focus of the mirror is at 10 cm in front. The virtual object is at +10 cm behind, which matches the position of the center of curvature of the mirror relative to its focus.

Final Answer: $\boxed{\text{At the center of curvature of the mirror}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 9

Q10.

Solution

Concept: Radioactive transformation alters the atomic structure.
An alpha emission ($^4_2\alpha$) reduces the atomic number Z by 2 units and mass number A by 4 units. A beta-minus emission ($^0_{-1}\beta^-$) converts a neutron into a proton, thereby increasing the atomic number Z by 1 unit while leaving mass number A unchanged.

Solution: Step 1: Let the initial parent nucleus be represented as ^A_ZX.

Step 2: Track the modification of the nucleus after the emission of exactly one α-particle:

$$^A_Z\text{X} \longrightarrow {}^{A-4}_{Z-2}\text{Y} + {}^4_2\text{He}$$

Step 3: Track the modification of this intermediate nucleus after the successive emission of two β^--particles:

$$^{A-4}_{Z-2}\text{Y} \longrightarrow {}^{A-4}_{(Z-2)+2}\text{Z} + 2\left({}^0_{-1}\text{e}\right) \implies {}^{A-4}_{Z}\text{Z}$$

Step 4: Compare the final daughter nucleus $^{A-4}_{Z}\text{Z}$ directly with the original parent configuration ^A_ZX.

Step 5: Observe that both nuclei possess the exact same atomic number Z, but differ in their overall atomic mass number A. By definition, chemical species sharing identical atomic numbers are isotopes.

Final Answer: $\boxed{\text{Isotope}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 10

Q11.

Solution

Concept: The motion of a projectile can be decomposed into independent orthogonal directions. The components of initial velocity are derived from the vector format $\vec{v} = u_x\hat{i} + u_y\hat{j}$.
The total time of flight depends exclusively on the vertical motion: $T = \frac{2u_y}{g}$.
The horizontal range is then determined by the product of horizontal speed and flight time: $R = u_x \cdot T = \frac{2u_x u_y}{g}$.

Solution: Step 1: Extract the component velocities from the given vector expression $\vec{v} = 3\hat{i} + 4\hat{j}$ m/s:
Horizontal velocity component, $u_x = 3$ m/s
Vertical velocity component, $u_y = 4$ m/s

Step 2: Write down the standard parametric equation for horizontal range:

$$R = \frac{2u_x u_y}{g}$$

Step 3: Substitute the extracted component values along with the gravitational acceleration constant $g = 10$ m/s^2:

$$R = \frac{2 \times 3 \times 4}{10}$$

Step 4: Perform the multiplication in the numerator:

$$\text{Numerator} = 2 \times 3 \times 4 = 24$$

Step 5: Divide the product by the denominator to get the final horizontal displacement:

$$R = \frac{24}{10} = 2.4 \text{ m}$$

Final Answer: $\boxed{2.4 \text{ m}}$

Answer: (B)

Go Back to Question 11

Q12.

Solution

Concept: The terminal potential difference V across a real cell discharging current through an external load resistance R is given by the relation $V = E - Ir$.
By expressing current as $I = \frac{E}{R+r}$, we substitute it back to obtain V purely as a function of the external resistance: $V = \frac{ER}{R+r} = \frac{E}{1+\frac{r}{R}}$.

Solution: Step 1: Write down the analytical formula linking terminal voltage V with load resistance R:

$$V = \frac{ER}{R + r}$$

Step 2: Examine the behavior of the expression at the boundary condition where resistance is zero ($R = 0$):

$$V = \frac{E \cdot 0}{0 + r} = 0$$

This demonstrates that the curve must originate directly from the graph origin $(0, 0)$.

Step 3: Analyze the functional form as R grows larger. Since R appears in both parts of the fraction, we divide the numerator and denominator by R:

$$V = \frac{E}{1 + \frac{r}{R}}$$

Step 4: Take the limit of the expression as the value of R approaches infinity (∞):

$$\lim_{R\to\infty} V = \frac{E}{1 + 0} = E$$

Step 5: Evaluate the curvature. The function increases non-linearly, flattening out horizontally as it approaches the maximum horizontal asymptote value E. This matches an asymptotic growth curve.

Final Answer: $\boxed{\text{Increases asymptotically towards } E \text{ as } R \text{ increases}}$

Answer: (C)

Go Back to Question 12

Q13.

Solution

Concept: The de Broglie wavelength of a particle accelerated from rest through an electric potential difference V is given by the formula $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}} = \frac{h}{\sqrt{2mqV}}$.
When comparing two particles accelerated through the same potential, the wavelength is inversely proportional to the square root of the mass-charge product: $\lambda \propto \frac{1}{\sqrt{mq}}$.

Solution: Step 1: Identify the relative physical properties of a proton (p) and an alpha particle (α):
Mass of proton = m, Charge of proton = e
Mass of alpha particle = $4m$, Charge of alpha particle = $2e$

Step 2: Express the de Broglie wavelength formula for both particles:

$$\lambda_\alpha = \frac{h}{\sqrt{2m_\alpha q_\alpha V}} = \frac{h}{\sqrt{2(4m)(2e)V}} = \frac{h}{\sqrt{16meV}}$$

$$\lambda_p = \frac{h}{\sqrt{2m_p q_p V}} = \frac{h}{\sqrt{2(m)(e)V}} = \frac{h}{\sqrt{2meV}}$$

Step 3: Formulate the ratio $\frac{\lambda_\alpha}{\lambda_p}$ by dividing the two mathematical expressions:

$$\frac{\lambda_\alpha}{\lambda_p} = \frac{\sqrt{2meV}}{\sqrt{16meV}} = \sqrt{\frac{2}{16}} = \sqrt{\frac{1}{8}}$$

Step 4: Simplify the square root of the fraction to its canonical radical form:

$$\sqrt{\frac{1}{8}} = \frac{1}{2\sqrt{2}}$$

Step 5: Write the final solution in the requested ratio format:

$$\lambda_\alpha : \lambda_p = 1 : 2\sqrt{2}$$

Final Answer: $\boxed{1 : 2\sqrt{2}}$

Answer: (C)

Go Back to Question 13

Q14.

Solution

Concept: According to the Work-Energy Theorem, the net work done by all acting forces on a body is equal to the net change in its total kinetic energy:

$$W = \Delta K = K_f - K_i = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$

When velocity is directly specified as a function of spatial coordinates, we can find the values at the spatial boundaries to easily compute the work.

Solution: Step 1: Note down the given parameters from the text:
Mass of body, $m = 0.5$ kg
Velocity relation, $v = ax^{3/2}$ where $a = 5\ \text{m}^{-1/2}\text{s}^{-1}$

Step 2: Calculate the initial velocity v_i at the starting boundary position $x = 0$:

$$v_i = 5 \times (0)^{3/2} = 0\ \text{m/s}$$

Step 3: Calculate the final velocity v_f at the ending boundary position $x = 2$ m:

$$v_f = 5 \times (2)^{3/2}\ \text{m/s}$$

Step 4: Square the final velocity expression to find v_f^2, which simplifies the radical term:

$$v_f^2 = [5 \times 2^{3/2}]^2 = 25 \times 2^3 = 25 \times 8 = 200\ \text{m}^2/\text{s}^2$$

Step 5: Substitute the squared velocity parameters directly into the Work-Energy statement:

$$W = \frac{1}{2}m(v_f^2 - v_i^2) = \frac{1}{2} \times 0.5\ \text{kg} \times (200 - 0) = 0.25 \times 200 = 50\ \text{J}$$

Final Answer: $\boxed{50\ \text{J}}$

Answer: (A)

Go Back to Question 14

Q15.

Solution

Concept: The root-mean-square speed (v_{rms}) of the gas molecules in an ideal gas sample depends directly on the absolute thermodynamic temperature T expressed in Kelvin:

$$v_{rms} = \sqrt{\frac{3RT}{M}}$$

This shows that for a given specific gas species, the rms velocity is directly proportional to the square root of its absolute temperature: $v_{rms} \propto \sqrt{T}$.

Solution: Step 1: Convert the initial and final given temperatures from the Celsius scale into absolute Kelvin scales:

$$T_1 = 27^\circ\text{C} + 273 = 300 \text{ K}$$

$$T_2 = 927^\circ\text{C} + 273 = 1200 \text{ K}$$

Step 2: Set up the ratio equation comparing the final rms speed to the initial rms speed:

$$\frac{v_2}{v_1} = \sqrt{\frac{T_2}{T_1}}$$

Step 3: Substitute the absolute Kelvin values calculated in Step 1 into the ratio radical:

$$\frac{v_2}{v_1} = \sqrt{\frac{1200}{300}}$$

Step 4: Simplify the fraction enclosed within the square root:

$$\frac{1200}{300} = 4 \implies \frac{v_2}{v_1} = \sqrt{4} = 2$$

Step 5: Conclude that the final velocity $v_2 = 2v_1$, which mathematically indicates that the speed becomes exactly twice the initial value.

Final Answer: $\boxed{\text{Twice the initial value}}$

Answer: (A)

Go Back to Question 15

Q16.

Solution

Concept: The mirror formula relates the object distance u, image distance v, and focal length f: $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$.
The linear magnification m produced by a spherical mirror is defined by the negative ratio of image distance to object distance: $m = -\frac{v}{u}$.
Alternatively, it can be written directly in terms of focal length and object distance as $m = \frac{f}{f-u}$.

Solution: Step 1: Establish the given numerical parameters with proper sign conventions for a convex mirror:
Focal length, $f = +30$ cm (positive for convex mirrors)
Object distance, $u = -15$ cm (always negative in front of mirror)

Step 2: Use the direct shortcut formula relating magnification m with parameters f and u:

$$m = \frac{f}{f - u}$$

Step 3: Substitute the numerical sign-appropriate values into the formula:

$$m = \frac{30}{30 - (-15)}$$

Step 4: Simplify the expression in the denominator:

$$\text{Denominator} = 30 + 15 = 45$$

Step 5: Complete the fractional calculation to find the definitive scalar magnification value:

$$m = \frac{30}{45} = \frac{2}{3} \approx +0.67$$

Final Answer: $\boxed{+0.67}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 16

Q17.

Solution

Concept: The electric field vector $\vec{E}$ is related to the spatial gradient of the scalar electric potential function V by the partial derivative relationship:

$$\vec{E} = -\nabla V = -\left(\frac{\partial V}{\partial x}\hat{i} + \frac{\partial V}{\partial y}\hat{j} + \frac{\partial V}{\partial z}\hat{k}\right)$$

The absolute magnitude is calculated using the standard vector length formula $|\vec{E}| = \sqrt{E_x^2 + E_y^2 + E_z^2}$.

Solution: Step 1: Write down the given expression for potential:

$$V = 4x^2 - 3xy$$

Step 2: Find the x-component of the electric field by taking the partial derivative with respect to x:

$$E_x = -\frac{\partial V}{\partial x} = -\frac{\partial}{\partial x}(4x^2 - 3xy) = -(8x - 3y) = 3y - 8x$$

Step 3: Find the y-component of the electric field by taking the partial derivative with respect to y:

$$E_y = -\frac{\partial V}{\partial y} = -\frac{\partial}{\partial y}(4x^2 - 3xy) = -(0 - 3x) = 3x$$

Since there is no z dependence, $E_z = 0$.

Step 4: Evaluate the partial components at the specific point $(1, 2, 0)$ by setting $x = 1$ and $y = 2$:

$$E_x = 3(2) - 8(1) = 6 - 8 = -2 \text{ V/m}$$

$$E_y = 3(1) = 3 \text{ V/m}$$

Step 5: Calculate the magnitude of the resulting electric field vector:

$$|\vec{E}| = \sqrt{E_x^2 + E_y^2} = \sqrt{(-2)^2 + (3)^2} = \sqrt{4+9} = \sqrt{13} \text{ V/m}$$

Final Answer: $\boxed{\sqrt{13} \text{ V/m}}$

Answer: (C)

Go Back to Question 17

Q18.

Solution

Concept: Radioactive decay follows first-order kinetics. The remaining active amount $N(t)$ of a radioactive substance after time t is given by $N(t) = N_0 e^{-\lambda t}$.
Alternatively, we can track the fractions. The decay amount specified can be easily handled by computing the time required to reach each state from the starting point using the decay constant relationship $\lambda = \frac{\ln 2}{T_{1/2}}$.

Solution: Step 1: Note that at 33% decay, the amount of radioactive nuclei remaining active is:

$$N_1 = 100\% - 33\% = 67\% = 0.67N_0$$

Step 2: Similarly, at 67% decay, the amount of radioactive nuclei remaining active is:

$$N_2 = 100\% - 67\% = 33\% = 0.33N_0$$

Step 3: Observe the relationship between the two remaining quantities N_1 and N_2:

$$\frac{N_2}{N_1} = \frac{0.33N_0}{0.67N_0} \approx \frac{1}{2}$$

Step 4: This reveals that the remaining active quantity drops to exactly half of its intermediate value during the time interval between these two decay marks.

Step 5: By definition, the time taken for any active mass of a radioactive element to decay to exactly half its value is equal to its half-life. Therefore, this interval is equal to $T_{1/2} = 20$ minutes.

Final Answer: $\boxed{\text{20 minutes}}$

Answer: (A)

Go Back to Question 18

Q19.

Solution

Concept: The time period of a simple pendulum is governed by the expression $T = 2\pi\sqrt{\frac{L}{g}}$. The local gravitational acceleration g' at an elevation height h above the planetary surface is altered according to Newton's law of gravitation: $g' = g\left(\frac{R}{R+h}\right)^2$.

Solution: Step 1: Write down the expression for the time period on Earth's surface where acceleration is g:

$$T_1 = 2\pi\sqrt{\frac{L}{g}}$$

Step 2: Calculate the modified gravitational acceleration g' at an altitude height $h = R$:

$$g' = g\left(\frac{R}{R+R}\right)^2 = g\left(\frac{R}{2R}\right)^2 = \frac{g}{4}$$

Step 3: Write down the modified time period expression T_2 at this altitude:

$$T_2 = 2\pi\sqrt{\frac{L}{g'}} = 2\pi\sqrt{\frac{L}{g/4}} = 2\pi\sqrt{\frac{4L}{g}} = 2\times\left(2\pi\sqrt{\frac{L}{g}}\right) = 2T_1$$

Step 4: Set up the direct algebraic ratio comparison between T_1 and T_2:

$$\frac{T_1}{T_2} = \frac{T_1}{2T_1} = \frac{1}{2}$$

Step 5: Express the final answer in the proper required ratio design:

$$T_1 : T_2 = 1 : 2$$

Final Answer: $\boxed{1 : 2}$

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 19

Q20.

Solution

Concept: In an electromagnetic wave propagating through vacuum or air, the amplitudes of the electric field (E_0) and the magnetic field (B_0) are strictly coupled by the speed of light c:

$$c = \frac{E_0}{B_0} \implies B_0 = \frac{E_0}{c}$$

Where $c \approx 3 \times 10^8$ m/s is the universal speed of propagation of electromagnetic waves.

Solution: Step 1: Extract the maximum amplitude of the electric field component directly from the given harmonic equation:

$$E_0 = 60 \text{ V/m}$$

Step 2: State the standard constant value for the speed of light in vacuum:

$$c = 3 \times 10^8 \text{ m/s}$$

Step 3: Recall the relation linking field amplitudes and substitute the values:

$$B_0 = \frac{E_0}{c} = \frac{60}{3 \times 10^8}$$

Step 4: Perform the numeric simplification:

$$B_0 = 20 \times 10^{-8} \text{ T}$$

Step 5: Adjust the scientific notation formatting to match the options:

$$B_0 = 2 \times 10^{-7} \text{ T}$$

Final Answer: $\boxed{2 \times 10^{-7} \text{ T}}$

Answer: (A)

Go Back to Question 20

Q21.

Solution

Concept: An electrical transformer works on the principle of mutual electromagnetic induction. It can step up or step down alternating voltage levels and current levels depending on its winding turns ratio.
However, a transformer cannot alter the fundamental frequency of the alternating current or voltage waveform passing through it. The frequency remains completely invariant between circuits.

Solution: Step 1: Note down the primary input source parameters supplied to the transformer:
Primary Voltage, $V_p = 220$ V
Primary Input Frequency, $f_p = 50$ Hz
Turns Ratio, $N_p : N_s = 1 : 10$

Step 2: Understand that the turns ratio affects the induced secondary voltage according to $\frac{V_s}{V_p} = \frac{N_s}{N_p}$. Thus, the voltage scales up to 2200 V.

Step 3: Analyze the effect of transformer action on wave frequency. Mutual induction changes the amplitude of magnetic flux linkage but maintains the identical period of source oscillations.

Step 4: Conclude that the operational frequency of the secondary terminal output must be identical to the primary input source frequency:

$$f_s = f_p = 50 \text{ Hz}$$

Final Answer: $\boxed{50 \text{ Hz}}$

Answer: (B)

Go Back to Question 21

Q22.

Solution

Concept: On a Pressure-Volume $(P - V)$ indicator diagram, the mechanical work done during any individual pathway segment is geometrically equal to the area under that specific path curve projected down onto the Volume axis.
For a complete closed-loop cyclic sequence, the net work done is the difference between expansion work and compression work, which simplifies to the interior area fully enclosed by the cycle boundary loop.

Solution: Step 1: Understand that work done along the forward expansion path ACB is represented by the entire geometric area under curve ACB down to the horizontal V-axis.

Step 2: Understand that work done along the reverse compression path BDA is represented by the area under curve BDA down to the horizontal V-axis. Since it is a compression, this work value is negative.

Step 3: The total net work done during the execution of the full closed cycle $ACBDA$ is calculated by subtracting the compression work magnitude from the expansion work magnitude.

Step 4: Geometrically, this subtraction removes the area beneath the lower curve, leaving exactly the net area trapped within the upper and lower paths.

Step 5: Therefore, the total net work done is represented strictly by the physical boundary area enclosed by the loop $ACBDA$.

Final Answer: $\boxed{\text{The area enclosed by the loop ACBDA}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 22

Q23.

Solution

Concept: Since no external forces act on the splitting heavy nucleus, the total linear momentum must be conserved.
Initial momentum is zero because the nucleus is at rest. Therefore, the final momentum vectors of the two fragments must be equal in magnitude and opposite in direction: $m_1v_1 = m_2v_2$.
Nuclear radius is related to mass number by $R = R_0A^{1/3}$, and mass is directly proportional to mass number ($m \propto A$).

Solution: Step 1: Set up the momentum conservation statement for the two fragments:

$$m_1v_1 = m_2v_2 \implies \frac{m_1}{m_2} = \frac{v_2}{v_1}$$

Step 2: Substitute the given velocity speed ratio $\frac{v_1}{v_2} = \frac{8}{1} \implies \frac{v_2}{v_1} = \frac{1}{8}$ to find the mass ratio:

$$\frac{m_1}{m_2} = \frac{1}{8}$$

Step 3: Relate nuclear mass directly to nuclear mass number A, which means $\frac{A_1}{A_2} = \frac{m_1}{m_2} = \frac{1}{8}$.

Step 4: Apply the standard nuclear radius scaling formula $R \propto A^{1/3}$ to formulate the radius ratio:

$$\frac{R_1}{R_2} = \left(\frac{A_1}{A_2}\right)^{1/3}$$

Step 5: Calculate the final value by substituting the mass number ratio:

$$\frac{R_1}{R_2} = \left(\frac{1}{8}\right)^{1/3} = \frac{1}{2} \implies R_1 : R_2 = 1 : 2$$

Final Answer: $\boxed{1 : 2}$

Answer: (A)

Go Back to Question 23

Q24.

Solution

Concept: For a particle executing Simple Harmonic Motion (SHM) with an amplitude A and angular frequency ω, the kinematic parameters are bounded.
The maximum velocity occurs at the equilibrium position and is given by $v_0 = \omega A$.
The maximum acceleration occurs at the extreme turning points and is given by $a_0 = \omega^2 A$.

Solution: Step 1: Write down the equations for the given maximum values:

$$v_0 = \omega A \quad \text{— (Equation 1)}$$
$$a_0 = \omega^2 A \quad \text{— (Equation 2)}$$

Step 2: Isolate the angular frequency parameter ω from Equation 1:

$$\omega = \frac{v_0}{A}$$

Step 3: Substitute this value of ω directly into Equation 2:

$$a_0 = \left(\frac{v_0}{A}\right)^2 A$$

Step 4: Expand and simplify the algebraic expression:

$$a_0 = \frac{v_0^2}{A^2} \cdot A = \frac{v_0^2}{A}$$

Step 5: Rearrange the equation to isolate the amplitude parameter A:

$$A = \frac{v_0^2}{a_0}$$

Final Answer: $\boxed{\frac{v_0^2}{a_0}}$

Answer: (A)

Go Back to Question 24

Q25.

Solution

Concept: The capacitance of an air-filled parallel plate capacitor is given by $C_0 = \frac{\varepsilon_0 A}{d}$. When the structural geometry is modified and a dielectric medium is inserted, the new capacitance is determined by the formula $C = \frac{k\varepsilon_0 A}{d'}$, where k is the dielectric constant and d' is the modified plate gap distance.

Solution: Step 1: Write down the expression for the initial capacitance value:

$$C_0 = \frac{\varepsilon_0 A}{d} = 8 \text{ pF}$$

Step 2: Identify the modifications made to the capacitor system:
New distance, $d' = \frac{d}{2}$
Dielectric constant of filling medium, $k = 6$

Step 3: Set up the formula for the modified capacitance C' incorporating these new parameters:

$$C' = \frac{k\varepsilon_0 A}{d'} = \frac{6 \cdot \varepsilon_0 A}{(d/2)}$$

Step 4: Simplify the fractional expression by moving the denominator factor up:

$$C' = 6 \times 2 \times \left(\frac{\varepsilon_0 A}{d}\right) = 12 \times C_0$$

Step 5: Substitute the original initial capacitance value (8 pF) to calculate the final value:

$$C' = 12 \times 8 \text{ pF} = 96 \text{ pF}$$

Final Answer: $\boxed{96 \text{ pF}}$

Answer: (C)

Go Back to Question 25

Q26.

Solution

Concept: In the Bohr atomic model, an electron revolving in a stable orbit possesses both kinetic energy (K) and electrostatic potential energy (U).
The energies are linked by specific virial mathematical ratios:

$$K = \frac{ke^2}{2r}, \quad U = -\frac{ke^2}{r}, \quad E = K + U = -\frac{ke^2}{2r}$$

This structural relationship shows that $E = -K$.

Solution: Step 1: Write down the fundamental expression for Kinetic Energy (K) of the orbiting electron:

$$K = +\frac{1}{4\pi\varepsilon_0}\frac{e^2}{2r}$$

Step 2: Write down the corresponding expression for the Total Energy (E), which is the sum of kinetic and potential components:

$$E = -\frac{1}{4\pi\varepsilon_0}\frac{e^2}{2r}$$

Step 3: Observe the algebraic equivalence between the two expressions, noting the sign difference:

$$E = -K \implies \frac{K}{E} = -1 = \frac{1}{-1}$$

Step 4: Set up the direct ratio format requested by the question statement:

$$K : E = 1 : -1$$

Final Answer: $\boxed{1 : -1}$

Answer: (C)

Go Back to Question 26

Q27.

Solution

Concept: The critical angle (θ_c) for total internal reflection at a boundary between a denser medium and vacuum is related to the refractive index (s) of the medium by Snell's law: $\sin\theta_c = \frac{1}{\mu}$. The refractive index μ is also defined as the ratio of the speed of light in vacuum (c) to the speed of light in that specific medium (v): $\mu = \frac{c}{v}$.

Solution: Step 1: Write down the critical angle relationship and substitute the given value $\theta_c = 30°$:

$$\sin 30° = \frac{1}{\mu}$$

Step 2: Substitute the known value of $\sin 30° = \frac{1}{2}$ to find the refractive index μ:

$$\frac{1}{2} = \frac{1}{\mu} \implies \mu = 2$$

Step 3: Relate the refractive index to the speed of light using the definition formula:

$$\mu = \frac{c}{v} \implies v = \frac{c}{\mu}$$

Step 4: Substitute the value of speed of light in vacuum $c = 3 \times 10^8$ m/s along with the calculated value of $\mu = 2$:

$$v = \frac{3 \times 10^8 \text{ m/s}}{2}$$

Step 5: Perform the division to get the velocity of light inside the medium:

$$v = 1.5 \times 10^8 \text{ m/s}$$

Final Answer: $\boxed{1.5 \times 10^8 \text{ m/s}}$

Answer: (B)

Go Back to Question 27

Q28.

Solution

Concept: When a continuous uniform wire is bent into a closed circular loop, any two points chosen on the perimeter divide the total circumference into two separate arc segments in a parallel configuration.
The resistance of each arc segment is directly proportional to its angular length because $R \propto L \propto \theta$.
The effective resistance is then found using the parallel combination rule: $R_{\text{eff}} = \frac{R_1 R_2}{R_1+R_2}$.

Solution: Step 1: Identify the two parallel arc paths created by the contact points separated by an angle of 60°:
Path 1: Minor arc segment subtending an angle $\theta_1 = 60°$.
Path 2: Major arc segment subtending the remaining angle $\theta_2 = 360° - 60° = 300°$.

Step 2: Calculate the resistance R_1 of the minor arc segment proportional to the total resistance of 36 Ω:

$$R_1 = 36\ \Omega \times \frac{60°}{360°} = 36 \times \frac{1}{6} = 6\ \Omega$$

Step 3: Calculate the resistance R_2 of the remaining major arc segment:

$$R_2 = 36\ \Omega \times \frac{300°}{360°} = 36 \times \frac{5}{6} = 30\ \Omega$$

Step 4: Set up the effective parallel resistance formula for these two connected paths:

$$R_{\text{eff}} = \frac{R_1 \cdot R_2}{R_1 + R_2}$$

Step 5: Substitute the individual values into the formula to find the final resistance:

$$R_{\text{eff}} = \frac{6 \times 30}{6 + 30} = \frac{180}{36} = 5\ \Omega$$

Final Answer: $\boxed{5\ \Omega}$

Answer: (B)

Go Back to Question 28

Q29.

Solution

Concept: For rotational motion, Newton's second law takes the form $\tau = I\alpha$, where τ is the applied constant torque, I is the moment of inertia, and α is the regular angular acceleration. The final angular velocity ω gained after a time interval t starting from rest ($\omega_0 = 0$) is determined by the standard rotational kinematic formula: $\omega = \omega_0 + \alpha t$.

Solution: Step 1: Write down the given values from the problem description:
Torque applied, $\tau = 1000 \text{ N} \cdot \text{m}$
Moment of Inertia, $I = 200 \text{ kg} \cdot \text{m}^2$
Time interval, $t = 4$ seconds
Initial angular velocity, $\omega_0 = 0$ rad/s

Step 2: Calculate the constant angular acceleration α using the dynamic relation:

$$\alpha = \frac{\tau}{I} = \frac{1000}{200} = 5 \text{ rad/s}^2$$

Step 3: Write down the primary kinematic equation for angular velocity:

$$\omega = \omega_0 + \alpha t$$

Step 4: Substitute the computed acceleration value and time duration into the kinematic equation:

$$\omega = 0 + (5 \text{ rad/s}^2 \times 4 \text{ s})$$

Step 5: Complete the multiplication to obtain the final angular velocity:

$$\omega = 20 \text{ rad/s}$$

Final Answer: $\boxed{20 \text{ rad/s}}$

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 29

Q30.

Solution

Concept: The First Law of Thermodynamics states that energy is conserved in any thermodynamic process.

The net heat energy ΔQ added to a system is spent in two parts: changing the internal energy ΔU of the system and performing external mechanical work ΔW:

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

Sign conventions are crucial: heat absorbed is positive, and work done by the system is positive.

Solution: Step 1: Identify and assign correct signs to the given thermodynamic quantities:
Heat absorbed by the system, $\Delta Q = +400$ J
Work done by the system, $\Delta W = +150$ J

Step 2: State the rearranged algebraic form of the First Law of Thermodynamics to solve for internal energy change:

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

Step 3: Substitute the sign-assigned numerical values directly into the equation:

$$\Delta U = 400 \text{ J} - 150 \text{ J}$$

Step 4: Perform the subtraction to find the net change value:

$$\Delta U = 250 \text{ J}$$

Since the result is positive, it indicates that the internal energy of the system increases.

Final Answer: $\boxed{250 \text{ J}}$

Answer: (B)

Go Back to Question 30

Answer Key

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