JEE Main Physics
Sample Paper – 11

Duration: 60 Minutes | Maximum Marks: 100

Instructions

- **Section A** contains 20 Multiple Choice Questions (Q1–Q20). Each question has four options with only one correct answer. Correct answer: **+4** marks; Wrong answer: **−1** mark; Unattempted: **0** marks.
- **Section B** contains 10 Numerical Value Questions (Q21–Q30). Attempt **any 5** questions. Correct answer: **+4** marks; Wrong or unattempted: **0** marks (no negative marking).
- The syllabus is based on Class 11 & 12 NCERT Physics as per the JEE Main official syllabus.
- Use of personal calculators, log tables, and electronic devices is strictly prohibited.
- A simple on-screen virtual calculator is provided in the CBT interface.
- Rough work may be done in the space provided within the question paper. Do not write anything on the Answer Sheet that is not required.

SECTION A (Single Correct MCQ) Q1 – Q20 [+4 / −1]

Q1. A particle starts from rest and moves with a uniform acceleration of $a = 4\ \text{m/s}^2$. The displacement of the particle **during the 3rd second** of its motion (using $S_n = u + a\big(n - \frac{1}{2}\big)$) is:

(A) $4\ \text{m}$

(B) $8\ \text{m}$

(C) $10\ \text{m}$

(D) $12\ \text{m}$

Q2. A block of mass $m = 5\ \text{kg}$ rests on an inclined plane at angle $\theta = 37^\circ$ $(\sin 37^\circ = 0.6,\ \cos 37^\circ = 0.8)$. The coefficient of kinetic friction between the block and the plane is $\mu = 0.25$ ($g = 10$ m/s^2). The minimum force parallel to the incline required to push the block **up** the incline is:

(A) 30 N

(B) 40 N

(C) 50 N

(D) 20 N

Q3. A spring with force constant $k = 200$ N/m is compressed by $x = 0.1$ m from its natural length. The elastic potential energy stored in the spring is:

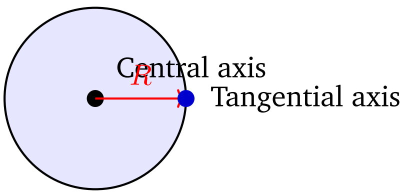
(A) 0.5 J

(B) 2 J

(C) 4 J

(D) 1 J

Q4. A solid cylinder of mass M and radius R has moment of inertia about its own central axis $I_{\text{cm}} = \frac{1}{2}MR^2$. Using the parallel axis theorem, the moment of inertia about an axis **tangential to its curved surface and parallel to the central axis** is:



$I_{\text{cm}} = \frac{1}{2}MR^2$ (central axis)
$I_{\text{tangent}} = I_{\text{cm}} + MR^2$

(A) $\dfrac{3}{2}MR^2$

(B) $\dfrac{1}{2}MR^2$

(C) $2MR^2$

(D) MR^2

Q5. A satellite of mass m orbits the Earth (mass M, radius R) at an orbital radius $r = 2R$. The gravitational potential energy of the satellite is $U = -\frac{GMm}{2R}$. The kinetic energy of the satellite in this orbit is $K = \frac{GMm}{4R}$. The **total mechanical energy** of the satellite is:

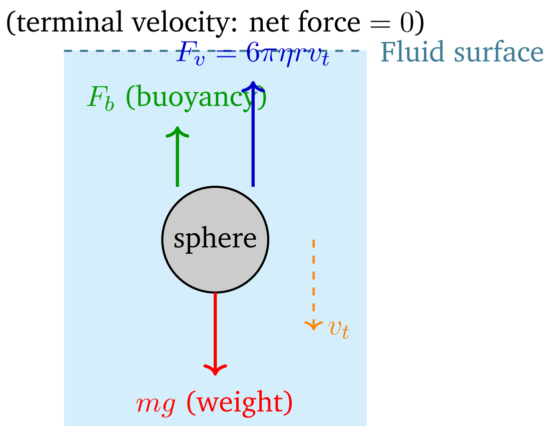
(A) $-\frac{GMm}{2R}$

(B) $+\frac{GMm}{4R}$

(C) $-\frac{GMm}{4R}$

(D) 0

Q6. A small sphere of radius r falls through a viscous fluid of viscosity η and reaches terminal velocity v_t. According to Stokes' law, the viscous drag force acting on the sphere at terminal velocity is:



(A) $4\pi\eta r v_t$

(B) $6\pi\eta r v_t$

(C) $2\pi\eta r^2 v_t$

(D) $3\pi\eta r v_t$

Q7. One mole of an ideal gas expands isothermally (at constant temperature T) from volume V_1 to volume $V_2 = 2V_1$. The work done **by** the gas during this process is: (R is the universal gas constant)

(A) 0

(B) $RT(V_2 - V_1)$

(C) $\dfrac{RT}{V_1}$

(D) $RT\ln 2$

Q8. A diatomic gas molecule (e.g. N_2) has $f = 5$ degrees of freedom at moderate temperatures. The **total mean kinetic energy** of one such molecule at absolute temperature T is: (k_B = Boltzmann constant)

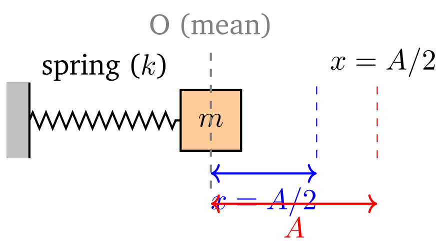
(A) $\frac{5}{2}k_BT$

(B) $\frac{3}{2}k_BT$

(C) $\frac{7}{2}k_BT$

(D) k_BT

Q9. A particle executes simple harmonic motion with amplitude A and angular frequency ω. The maximum speed is $v_{\max} = \omega A$. The speed of the particle when its displacement from the mean position is $x = A/2$ is:



(A) $v_{\max}$

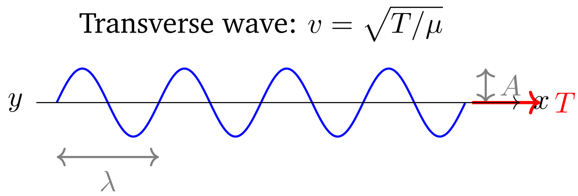
(B) $\frac{1}{2}v_{\max}$

(C) $\dfrac{\sqrt{3}}{2}v_{\max}$

(D) $\dfrac{v_{\max}}{\sqrt{2}}$

Q10. A transverse wave travels along a stretched string. The speed of the wave is $v = \sqrt{T/\mu}$, where T is the tension and μ is the linear mass density.

If the tension in the string is **quadrupled** while the linear mass density remains unchanged, the new wave speed becomes:



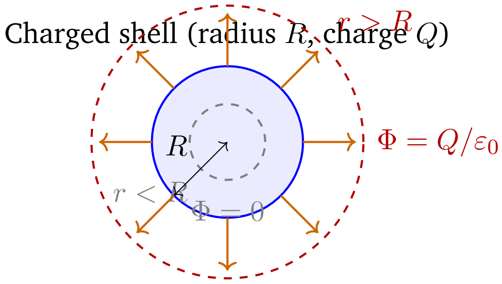
(A) $v/2$

(B) $2v$

(C) $4v$

(D) v

Q11. A uniformly charged thin spherical shell carries total charge Q and has radius R. Using Gauss's law, the total electric flux through a closed Gaussian spherical surface of radius $r > R$ (enclosing the entire shell) is:



(A) 0

(B) $\dfrac{Q}{2\varepsilon_0}$

(C) $\dfrac{Q}{4\pi\varepsilon_0 r^2}$

(D) $\dfrac{Q}{\varepsilon_0}$

Q12. In a potentiometer experiment, a standard cell of EMF $\varepsilon_1 = 1.02$ V balances against a length $L_1 = 51$ cm. An unknown cell balances against a length $L_2 = 40$ cm under identical conditions. The EMF of the unknown cell is:

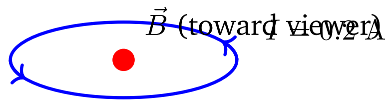
(A) 0.80 V

(B) 1.02 V

(C) 1.30 V

(D) 0.60 V

Q13. A circular coil has $N = 50$ turns, radius $R = 0.1$ m, and carries a current $I = 0.2$ A. The magnitude of the magnetic field at the **centre** of the coil is: (Use $\mu_0 = 4\pi \times 10^{-7}$ T $\cdot$ m/A)



$N = 50$ turns, $R = 0.1$ m

$$B = \frac{\mu_0 N I}{2R}$$

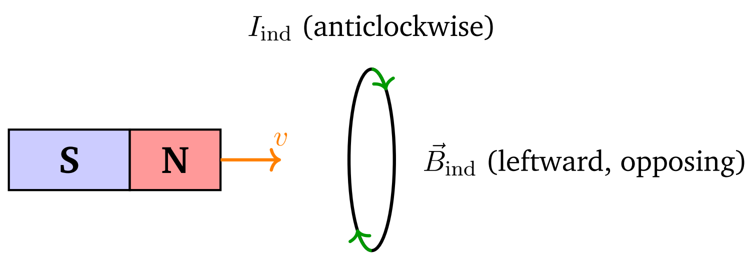
(A) $\pi \times 10^{-5}$ T

(B) $2\pi \times 10^{-4}$ T

(C) $2\pi \times 10^{-5}$ T

(D) $\pi \times 10^{-4}$ T

Q14. A bar magnet with its **North pole** facing right is moved toward a vertical conducting loop (as shown). By Lenz's law, the induced current in the loop, as viewed from the right (from the side the magnet approaches), flows in the **anticlockwise** direction to create an opposing North pole. Which statement correctly identifies the induced current direction *as viewed from the magnet's side*?



(A) Clockwise, creating a South pole facing the magnet

(B) Anticlockwise, creating a North pole facing the magnet (opposing approach)

(C) Clockwise, creating a North pole facing the magnet

(D) No current is induced since the magnet is outside the loop

Q15. In a series LCR circuit, the power factor is defined as $\cos\varphi = R/Z$, where $Z = \sqrt{R^2 + (X_L - X_C)^2}$ is the impedance. At the **resonance condition** ($X_L = X_C$), the power factor of the circuit is:

(A) 0

(B) 0.5

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

(D) 1

Q16. A glass prism has a small apex angle $A = 6^\circ$ and refractive index $\mu = 1.5$. For a ray passing through the prism near minimum deviation (small angle approximation $\delta \approx (\mu - 1)A$), the angle of deviation is:

(A) 3°

(B) 6°

(C) 9°

(D) 1.5°

Q17. A thin film of refractive index μ and thickness t is illuminated by monochromatic light of wavelength λ at normal incidence. The condition for **constructive interference** (bright fringe) in the **reflected** light (where one reflection involves a phase change of π) is:

(A) $2\mu t = n\lambda \quad (n = 1, 2, 3, \ldots)$

(B) $2\mu t = 0$

(C) $2\mu t = \left(n + \frac{1}{2}\right)\lambda \quad (n = 0, 1, 2, \ldots)$

(D) $\mu t = n\lambda$

Q18. A metal has a work function $\phi = 4.1$ eV. The **threshold frequency** ν_0 for the photoelectric effect from this metal is: (Use $h = 6.63 \times 10^{-34}$ J $\cdot$ s, 1 eV $= 1.6 \times 10^{-19}$ J)

(A) 6.63×10^{14} Hz

(B) 9.91×10^{14} Hz

(C) 1.60×10^{15} Hz

(D) 4.10×10^{14} Hz

Q19. In the Bohr model of the hydrogen atom, the radius of the nth orbit is $r_n = n^2 a_0$, where $a_0 = 0.529$ Å is the Bohr radius. The radius of the **3rd orbit** is:

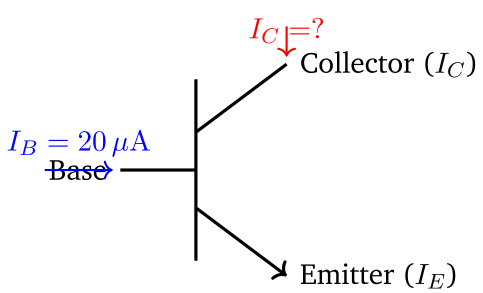
(A) a_0

(B) $3a_0$

(C) $4a_0$

(D) $9a_0$

Q20. In a common-emitter (CE) NPN transistor amplifier, the current gain is $\beta = I_C/I_B$. If the base current is $I_B = 20\ \mu$A and $\beta = 100$, the collector current I_C is:



$\beta = I_C/I_B = 100$

(A) 2 mA

(B) 0.2 mA

(C) 20 mA

(D) $200\ \mu$A

SECTION B (Numerical Value Questions)
Q21 – Q30 Attempt ANY 5 [+4 / 0]

Q21. A body starts with initial velocity $u = 10$ m/s and moves with uniform acceleration $a = 2$ m/s^2. Calculate the displacement of the body **in the 5th second** of its motion (in metres). Use $S_n = u + a(n - \frac{1}{2})$.

(Enter the exact numerical value as your answer.)

Q22. A spring is compressed by $x = 5$ cm $= 0.05$ m when a force of $F = 10$ N is applied to it. Calculate the spring constant k (in N/m).

(Enter the exact numerical value as your answer.)

Q23. The acceleration due to gravity at the surface of Earth is $g = 10$ m/s^2. At a height $h = R$ above the Earth's surface (where R is Earth's radius), using $g_h = g/(1 + h/R)^2$, calculate g_h in m/s^2.

(Enter the exact numerical value as your answer.)

Q24. Steam at $100°$C condenses into water at $100°$C. The specific latent heat of vaporisation of water is $L = 2.26$ kJ/g. Calculate the heat released when 10 g of steam condenses (in kJ).

(Enter the exact numerical value as your answer.)

Q25. A sound wave has a frequency of $f = 680$ Hz. If the speed of sound in air is $v = 340$ m/s, calculate the wavelength λ (in metres).

(Enter the exact numerical value as your answer.)

Q26. A uniformly charged ring of total charge $Q = 2\ \mu$C and radius $R = 0.1$ m lies in a plane. By symmetry, calculate the magnitude of the electric field at the **centre** of the ring (in N/C).

(Enter the exact numerical value as your answer.)

Q27. A battery has an EMF of $\mathcal{E} = 10$ V and internal resistance $r = 1\ \Omega$. It is connected to an external resistance $R = 4\ \Omega$. Calculate the **terminal**

voltage of the battery (in V).

(Enter the exact numerical value as your answer.)

Q28. A proton ($m = 1.67 \times 10^{-27}$ kg, $q = 1.6 \times 10^{-19}$ C) moves in a uniform magnetic field $B = 1$ T in a circle. Calculate the time period of revolution $T = 2\pi m/(qB)$ in nanoseconds (ns). (Use $\pi = 3.14159$)

(Enter the numerical value rounded to one decimal place.)

Q29. An object is placed 20 cm in front of a converging lens of focal length $f = 15$ cm. Using the lens formula $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$ (with sign convention $u = -20$ cm), calculate the magnitude of the linear magnification $|m| = |v/u|$.

(Enter the exact numerical value as your answer.)

Q30. Using the Rydberg formula for hydrogen, calculate the wavelength of light emitted in the transition $n = 2 \rightarrow n = 1$ (first line of the Lyman series) in nanometres. (Use $R_H = 1.097 \times 10^7$ m^{-1}; round to the nearest nm.)

(Enter the numerical value rounded to the nearest integer.)

DETAILED SOLUTIONS

Sol. Q1.

Solution

Topic: Kinematics — Displacement in the nth Second

The formula for displacement in the nth second of uniformly accelerated motion starting with initial velocity u and acceleration a is:

$$S_n = u + a\left(n - \frac{1}{2}\right)$$

Here $u = 0$ (starts from rest), $a = 4\ \mathrm{m/s^2}$, and $n = 3$:

$$S_3 = 0 + 4\left(3 - \frac{1}{2}\right) = 4 \times \frac{5}{2} = \mathbf{10}\ \mathrm{m}$$

Answer: (C)

Sol. Q2.

Solution

Topic: Laws of Motion — Force to Push Block Up Incline

When pushing the block *up* the rough incline, both the component of gravity along the incline and kinetic friction act *downward* along the incline. The applied force must overcome both:

$$F = mg\sin\theta + \mu mg\cos\theta = mg(\sin\theta + \mu\cos\theta)$$

Substituting $m = 5$ kg, $g = 10\ \mathrm{m/s^2}$, $\sin 37^\circ = 0.6$, $\cos 37^\circ = 0.8$, $\mu = 0.25$:

$$F = 5 \times 10 \times (0.6 + 0.25 \times 0.8) = 50 \times (0.6 + 0.2) = 50 \times 0.8 = \mathbf{40}\ \mathrm{N}$$

Answer: (B)

Sol. Q3.

Solution

Topic: Work-Energy Theorem — Elastic Potential Energy of a Spring

The elastic potential energy stored in a compressed (or stretched) spring is:

$$U = \frac{1}{2}kx^2 = \frac{1}{2} \times 200 \times (0.1)^2 = \frac{1}{2} \times 200 \times 0.01 = \mathbf{1}\ \text{J}$$

Answer: (D)

Sol. Q4.

Solution

Topic: Rotational Motion — Parallel Axis Theorem

The moment of inertia of a solid cylinder about its own central axis is $I_{\text{cm}} = \frac{1}{2}MR^2$.

By the parallel axis theorem, the moment of inertia about a parallel axis at distance d from the centre of mass is:

$$I = I_{\text{cm}} + Md^2$$

The tangential axis on the curved surface is at distance $d = R$ from the central axis. Therefore:

$$I_{\text{tangent}} = \frac{1}{2}MR^2 + MR^2 = \mathbf{\frac{3}{2}MR^2}$$

Answer: (A)

Sol. Q5.

Solution

Topic: Gravitation — Total Mechanical Energy of a Satellite

The total mechanical energy of the satellite is the sum of its kinetic energy and gravitational potential energy:

$$E_{\text{total}} = K + U = \frac{GMm}{4R} + \left(-\frac{GMm}{2R}\right) = \frac{GMm}{4R} - \frac{2GMm}{4R} = -\frac{GMm}{4R}$$

The negative sign indicates a bound orbit. Note that $|E_{\text{total}}| = K$ is always true for circular orbits.

$$E_{\text{total}} = -\mathbf{\frac{GMm}{4R}}$$

Answer: (C)

Sol. Q6.

Solution

Topic: Fluid Mechanics — Stokes' Law

When a sphere of radius r moves through a viscous fluid of viscosity η at speed v, Stokes showed that the viscous drag force is:

$$F_v = 6\pi\eta r v$$

At terminal velocity v_t, the net force on the sphere is zero:

$$mg = F_b + F_v \implies F_v = mg - F_b = 6\pi\eta r v_t$$

The viscous drag force at terminal velocity is $\mathbf{6\pi\eta r v_t}$.

Answer: (B)

Sol. Q7.

Solution

Topic: Thermodynamics — Work Done in Isothermal Expansion

For an isothermal expansion of an ideal gas, the internal energy does not change ($\Delta U = 0$). The work done *by* the gas is:

$$W = \int_{V_1}^{V_2} p\,dV = nRT\int_{V_1}^{V_2} \frac{dV}{V} = nRT\ln\frac{V_2}{V_1}$$

With $n = 1$ mole and $V_2 = 2V_1$:

$$W = RT\ln\frac{2V_1}{V_1} = \mathbf{RT}\ln\mathbf{2}$$

Answer: (D)

Sol. Q8.

Solution

Topic: Kinetic Theory — Mean Energy of a Diatomic Molecule

By the law of equipartition of energy, each degree of freedom contributes $\frac{1}{2}k_BT$ to the mean energy. A diatomic molecule (e.g. N_2) has $f = 5$ degrees of freedom at moderate temperature (3 translational + 2 rotational; vibrational modes are frozen out at moderate T). Therefore, the total mean kinetic energy is:

$$\langle E\rangle = \frac{f}{2}k_BT = \frac{5}{2}k_BT$$

The mean translational KE is only $\frac{3}{2}k_BT$; the **total** mean energy is $\mathbf{\frac{5}{2}k_BT}$.

Answer: (A)

Sol. Q9.

Solution

Topic: Simple Harmonic Motion — Velocity at a Given Displacement

The velocity in SHM as a function of displacement x is:

$$v = \omega\sqrt{A^2 - x^2}$$

At $x = A/2$:

$$v = \omega\sqrt{A^2 - \frac{A^2}{4}} = \omega\sqrt{\frac{3A^2}{4}} = \frac{\sqrt{3}}{2}\omega A = \frac{\sqrt{3}}{2}v_{\max}$$

Thus the speed at $x = A/2$ is $\mathbf{\frac{\sqrt{3}}{2}v_{\max}}$.

Answer: (C)

Sol. Q10.

Solution

Topic: Waves — Speed of Transverse Wave on a String

The speed of a transverse wave on a string is:

$$v = \sqrt{\frac{T}{\mu}}$$

If the tension T is quadrupled to $4T$ (while μ remains constant):

$$v' = \sqrt{\frac{4T}{\mu}} = 2\sqrt{\frac{T}{\mu}} = \mathbf{2v}$$

Quadrupling the tension *doubles* the wave speed.

Answer: (B)

Sol. Q11.

Solution

Topic: Electrostatics — Gauss's Law (Spherical Shell)

Gauss's law states that the total electric flux through any closed surface is equal to the net charge enclosed divided by ε_0:

$$\Phi_E = \oint \vec{E} \cdot d\vec{A} = \frac{Q_{\text{enc}}}{\varepsilon_0}$$

For a Gaussian sphere of radius $r > R$ enclosing the entire charged shell of charge Q:

$$Q_{\text{enc}} = Q \implies \Phi_E = \frac{\mathbf{Q}}{\boldsymbol{\varepsilon_0}}$$

For $r < R$ (inside the shell), $Q_{\text{enc}} = 0$ so $\Phi = 0$ and $E = 0$ inside the shell.

Answer: (D)

Sol. Q12.

Solution

Topic: Current Electricity — Potentiometer (Comparing EMFs)

In a potentiometer, the balancing length is proportional to the EMF of the cell:

$$\frac{\varepsilon_2}{\varepsilon_1} = \frac{L_2}{L_1}$$

$$\varepsilon_2 = \varepsilon_1 \times \frac{L_2}{L_1} = 1.02 \times \frac{40}{51} = 1.02 \times \frac{40}{51} = \frac{40.8}{51} = \mathbf{0.80}\ \text{V}$$

Answer: (A)

Sol. Q13.

Solution

Topic: Magnetic Effects of Current — Field at Centre of Circular Coil

The magnetic field at the centre of a circular coil of N turns, radius R, carrying current I is:

$$B = \frac{\mu_0 NI}{2R}$$

Substituting $\mu_0 = 4\pi \times 10^{-7}\ \mathrm{T \cdot m/A}$, $N = 50$, $I = 0.2\ \mathrm{A}$, $R = 0.1\ \mathrm{m}$:

$$B = \frac{4\pi \times 10^{-7} \times 50 \times 0.2}{2 \times 0.1} = \frac{4\pi \times 10^{-7} \times 10}{0.2} = \frac{4\pi \times 10^{-6}}{0.2} = 20\pi \times 10^{-6}\ \mathrm{T} = 2\pi \times 10^{-5}\ \mathrm{T}$$

$$B = \mathbf{2}\pi \times \mathbf{10^{-5}}\ \mathrm{T} \approx \mathbf{6.28} \times \mathbf{10^{-5}}\ \mathrm{T}$$

Answer: (C)

Sol. Q14.

Solution

Topic: Electromagnetic Induction — Lenz's Law

As the North pole of the bar magnet approaches the right face of the conducting loop, the magnetic flux through the loop (directed from left to right, i.e. in the direction of the approaching field) increases.

By Lenz's law, the induced current must oppose this increase. Therefore, the induced current must create a magnetic field *opposing* the incoming flux — i.e. pointing from right to left *through the loop*. This means the left face of the loop (facing the magnet) must behave as a North pole to repel the approaching magnet.

By the right-hand rule, to create a magnetic field pointing *leftward* (toward the magnet) through the loop, the induced current flows **anticlockwise** as viewed from the right side (the side the magnet approaches). This is equivalent to current flowing *anticlockwise as viewed from the magnet*.

Answer: (B)

Sol. Q15.

Solution

Topic: AC Circuits — Power Factor at Resonance

In a series LCR circuit, the impedance is:

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

At resonance, $X_L = X_C$, so $(X_L - X_C) = 0$, giving $Z = R$.

The power factor is:

$$\cos\varphi = \frac{R}{Z} = \frac{R}{R} = \mathbf{1}$$

At resonance, the circuit is purely resistive, the phase angle $\varphi = 0$, and all the voltage drives resistive current — maximum power is delivered.

Answer: (D)

Sol. Q16.

Solution

Topic: Ray Optics — Prism Deviation (Small Angle Approximation)

For a prism with small apex angle A and refractive index μ, the angle of deviation in the small-angle (paraxial) approximation is:

$$\delta \approx (\mu - 1)A$$

Substituting $\mu = 1.5$ and $A = 6°$:

$$\delta = (1.5 - 1) \times 6° = 0.5 \times 6° = \mathbf{3}°$$

Answer: (A)

Sol. Q17.

Solution

Topic: Wave Optics — Thin Film Constructive Interference (Reflected Light)

When light reflects from the outer surface of the thin film (air to glass), the reflected ray undergoes a phase change of π (reflection at a denser medium). The ray transmitted through the film and reflected at the inner surface (glass to air) undergoes *no* phase change. Thus effectively there is one phase reversal between the two interfering beams.

The path difference for normal incidence is $2\mu t$. For constructive interference in reflected light with one effective phase reversal, the condition is:

$$2\mu t = \left(n + \frac{1}{2}\right)\lambda = \frac{(2n+1)\lambda}{2}, \quad n = 0, 1, 2, \ldots$$

This can also be written as $2\mu t = \left(n + \frac{1}{2}\right)\lambda$ for $n = 0, 1, 2, \ldots$ which matches option **(C)**.

Answer: (C)

Sol. Q18.

Solution

Topic: Dual Nature of Matter and Radiation — Threshold Frequency

The threshold frequency ν_0 is the minimum frequency of light required to eject electrons from a metal surface. It is related to the work function ϕ by:

$$h\nu_0 = \phi \implies \nu_0 = \frac{\phi}{h} = \frac{4.1 \text{ eV} \times 1.6 \times 10^{-19} \text{ J/eV}}{6.63 \times 10^{-34} \text{ J} \cdot \text{s}}$$

$$\nu_0 = \frac{6.56 \times 10^{-19}}{6.63 \times 10^{-34}} = \frac{6.56}{6.63} \times 10^{15} \approx 0.9895 \times 10^{15} \text{ Hz} \approx \mathbf{9.91} \times \mathbf{10^{14}} \text{ Hz}$$

Answer: (B)

Sol. Q19.

Solution

Topic: Atoms — Bohr Model Orbital Radius

In the Bohr model of the hydrogen atom, the radius of the nth orbit is:

$$r_n = n^2 a_0$$

where $a_0 = 0.529$ Å is the Bohr radius (radius of the ground state, $n = 1$). For the 3rd orbit ($n = 3$):

$$r_3 = (3)^2 \times a_0 = \mathbf{9a_0} = 9 \times 0.529 \text{ Å} \approx 4.76 \text{ Å}$$

Answer: (D)

Sol. Q20.

Solution

Topic: Electronic Devices — Common-Emitter Transistor Current Gain

In a common-emitter (CE) configuration, the current gain β (also called h_{FE}) is defined as:

$$\beta = \frac{I_C}{I_B}$$

Given $\beta = 100$ and $I_B = 20\ \mu$A:

$$I_C = \beta \times I_B = 100 \times 20\ \mu\text{A} = 2000\ \mu\text{A} = \mathbf{2}\ \text{mA}$$

The emitter current is $I_E = I_B + I_C = 20\ \mu\text{A} + 2000\ \mu\text{A} = 2.02\ \text{mA}$.

Answer: (A)

Sol. Q21.

Solution

Topic: Kinematics — Displacement in the nth Second

Using $S_n = u + a\left(n - \frac{1}{2}\right)$ with $u = 10\ \text{m/s}$, $a = 2\ \text{m/s}^2$, $n = 5$:

$$S_5 = 10 + 2\left(5 - \frac{1}{2}\right) = 10 + 2 \times \frac{9}{2} = 10 + 9 = \mathbf{19}\ \text{m}$$

Answer: (19)

Sol. Q22.

Solution

Topic: Elasticity — Spring Constant

By Hooke's law, the restoring force of a spring is $F = kx$. Therefore:

$$k = \frac{F}{x} = \frac{10\ \text{N}}{0.05\ \text{m}} = \mathbf{200}\ \text{N/m}$$

Answer: (200)

Sol. Q23.

Solution

Topic: Gravitation — Acceleration Due to Gravity at Height $h = R$

The acceleration due to gravity at height h above the Earth's surface is:

$$g_h = \frac{g}{\left(1 + \frac{h}{R}\right)^2}$$

At $h = R$:

$$g_h = \frac{g}{(1+1)^2} = \frac{g}{4} = \frac{10}{4} = \mathbf{2.5}\ \mathrm{m/s^2}$$

Answer: (2.5)

Sol. Q24.

Solution

Topic: Heat Transfer — Latent Heat of Vaporisation

When steam at $100°\mathrm{C}$ condenses to water at $100°\mathrm{C}$, the heat released is:

$$Q = mL = 10\ \mathrm{g} \times 2.26\ \mathrm{kJ/g} = \mathbf{22.6}\ \mathrm{kJ}$$

Answer: (22.6)

Sol. Q25.

Solution

Topic: Waves — Wavelength of Sound

The relationship between wave speed v, frequency f, and wavelength λ is:

$$v = f\lambda \implies \lambda = \frac{v}{f} = \frac{340\ \mathrm{m/s}}{680\ \mathrm{Hz}} = \mathbf{0.5}\ \mathrm{m}$$

Answer: (0.5)

Sol. Q26.

Solution

Topic: Electrostatics — Electric Field at the Centre of a Charged Ring

For a uniformly charged ring, every charge element dq on the ring is at the same distance R from the centre. The electric field contribution from each element points radially outward from that element toward the centre. By symmetry, for every element dq on one side of the ring, there is an equal and opposite contribution from the diametrically opposite element dq'.

Therefore, the electric field at the **centre** of a uniformly charged ring is exactly:

$$E_{\text{centre}} = \mathbf{0}\ \text{N/C}$$

Answer: (0)

Sol. Q27.

Solution

Topic: Current Electricity — Terminal Voltage of a Battery

The current in the circuit is:

$$I = \frac{\mathcal{E}}{R + r} = \frac{10}{4 + 1} = \frac{10}{5} = 2\ \text{A}$$

The terminal voltage (voltage across the external resistor) is:

$$V_T = \mathcal{E} - Ir = 10 - 2 \times 1 = 8\ \text{V}$$

Equivalently, $V_T = IR = 2 \times 4 = \mathbf{8}$ V.

Answer: (8)

Sol. Q28.

Solution

Topic: Magnetism — Cyclotron Period of a Proton

The time period of revolution of a charged particle in a uniform magnetic field is:

$$T = \frac{2\pi m}{qB}$$

Substituting $m = 1.67 \times 10^{-27}$ kg, $q = 1.6 \times 10^{-19}$ C, $B = 1$ T:

$$T = \frac{2 \times 3.14159 \times 1.67 \times 10^{-27}}{1.6 \times 10^{-19} \times 1} = \frac{10.493 \times 10^{-27}}{1.6 \times 10^{-19}} = 6.558 \times 10^{-8}\ \text{s} = 65.6 \times 10^{-9}\ \text{s} \approx \mathbf{65.6}\ \text{ns}$$

Answer: (65.6)

Sol. Q29.

Solution

Topic: Ray Optics — Lens Formula and Magnification

Using the sign convention with $u = -20$ cm and $f = +15$ cm, the lens formula gives:

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \implies \frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{15} + \frac{1}{-20} = \frac{4}{60} - \frac{3}{60} = \frac{1}{60}$$

So $v = 60$ cm. The linear magnification is:

$$m = \frac{v}{u} = \frac{60}{-20} = -3$$

The negative sign indicates an inverted real image. The magnitude of magnification is $|\mathbf{m}| = \mathbf{3}$.

Answer: (3)

Sol. Q30.

Solution

Topic: Atoms — Lyman Series (First Line, $n = 2 \to n = 1$)

Using the Rydberg formula for hydrogen:

$$\frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = R_H\left(\frac{1}{1^2} - \frac{1}{2^2}\right) = R_H\left(1 - \frac{1}{4}\right) = \frac{3R_H}{4}$$

$$\lambda = \frac{4}{3R_H} = \frac{4}{3 \times 1.097 \times 10^7} = \frac{4}{3.291 \times 10^7} \approx 1.215 \times 10^{-7}\ \text{m} = \mathbf{122}\ \text{nm}$$

This is the first line of the Lyman series (ultraviolet region).

Answer: (122)

ANSWER KEY

Section A — MCQ Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	B	3	D	4	A	5	C
6	B	7	D	8	A	9	C	10	B
11	D	12	A	13	C	14	B	15	D
16	A	17	C	18	B	19	D	20	A

Section B — Numerical Answer Key

Q	Ans	Q	Ans
21	19	22	200
23	2.5	24	22.6
25	0.5	26	0
27	8	28	65.6
29	3	30	122