JEE Main Physics
Sample Paper – 1

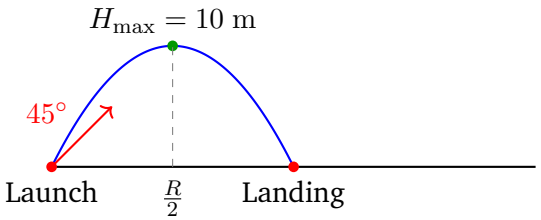
Duration: 60 Minutes | Maximum Marks: 100

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 ball is projected from the ground at an angle of 45° with the horizontal. Its initial speed is $20\ \text{m/s}$ and $g = 10\ \text{m/s}^2$. The maximum height reached by the ball is:



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

(B) $20\ \text{m}$

(C) $5\ \text{m}$

(D) $14.1\ \text{m}$

Q2. A block of mass $M = 4\ \text{kg}$ rests in equilibrium on a smooth inclined plane making an angle of 30° with the horizontal ($g = 10\ \text{m/s}^2$). The friction force acting on the block is:

(A) $10\ \text{N}$

(B) $20\ \text{N}$

(C) $40\ \text{N}$

(D) $34.6\ \text{N}$

Q3. A spring of spring constant $k = 500\ \text{N/m}$ is compressed by $x = 0.2\ \text{m}$. A ball of mass $m = 0.1\ \text{kg}$ is attached to the spring and released from rest. The speed of the ball when the spring returns to its natural length is:

(A) $5\ \text{m/s}$

(B) $10\ \text{m/s}$

(C) $10\sqrt{2}\ \text{m/s}$

(D) $20\ \text{m/s}$

Q4. A solid cylinder of mass M and radius R ($I = \frac{1}{2}MR^2$) rolls without slipping down an inclined plane of inclination angle θ. The linear acceleration of its centre of mass is:

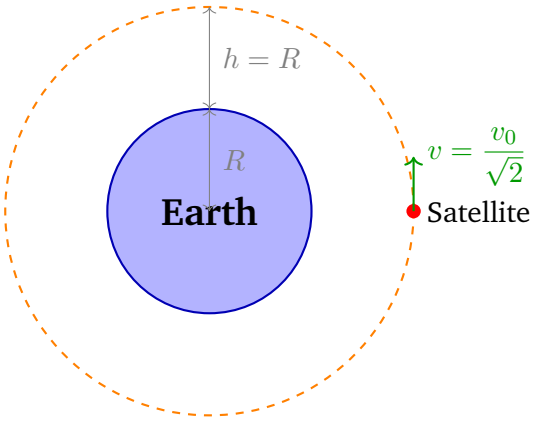
(A) $g\sin\theta$

(B) $\dfrac{g\sin\theta}{2}$

(C) $\dfrac{g\sin\theta}{3}$

(D) $\dfrac{2g\sin\theta}{3}$

Q5. A satellite is placed in a circular orbit at a height $h = R$ above the surface of the Earth (where R is the Earth's radius). If $v_0 = \sqrt{gR}$ denotes the first cosmic speed, the orbital speed of the satellite is:



(A) $\frac{v_0}{\sqrt{2}}$

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

(C) $v_0\sqrt{2}$

(D) $2v_0$

Q6. Water ($T = 0.07$ N/m, $\rho = 1000$ kg/m^3, contact angle $= 0°$, $g = 10$ m/s^2) rises in a capillary tube of radius $r = 1$ mm. The height of the water column in the capillary tube is:

(A) 2.8 cm

(B) 1.4 cm

(C) 0.7 cm

(D) 0.28 cm

Q7. An ideal gas absorbs $Q = 500$ J of heat and performs $W = 200$ J of work on the surroundings. The increase in the internal energy of the gas is:

(A) 700 J

(B) 200 J

(C) 300 J

(D) 500 J

Q8. A simple pendulum has a time period $T = 2$ s on the surface of the Earth ($g = 10$ m/s^2). The length of the pendulum is:

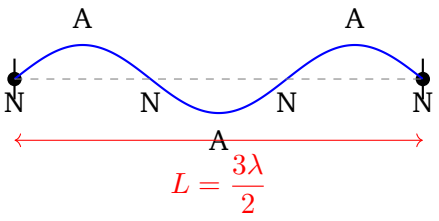
(A) π m

(B) $\dfrac{1}{\pi}$ m

(C) 2π m

(D) $\dfrac{10}{\pi^2}$ m

Q9. A string fixed at both ends vibrates in its third harmonic. If the wavelength of each component wave is λ, the length of the string is:



(A) $\dfrac{3\lambda}{2}$

(B) λ

(C) $\dfrac{2\lambda}{3}$

(D) 3λ

Q10. Two point charges $q_1 = +2\ \mu\text{C}$ and $q_2 = -8\ \mu\text{C}$ are separated by a distance of 0.3 m in vacuum. The magnitude of the Coulomb force between them is:

(A) 0.8 N

(B) 1.6 N

(C) 3.2 N

(D) 0.4 N

Q11. A parallel-plate capacitor with air between the plates has capacitance C_0. If the separation between the plates is halved (area kept fixed, no dielectric inserted), the new capacitance is:

(A) $\dfrac{C_0}{4}$

(B) $\frac{C_0}{2}$

(C) $2C_0$

(D) $4C_0$

Q12. A nichrome wire has resistivity $\rho = 1.1 \times 10^{-6}\ \Omega \cdot \mathrm{m}$, length $L = 2\ \mathrm{m}$, and cross-sectional area $A = 0.5\ \mathrm{mm}^2$. The resistance of the wire is:

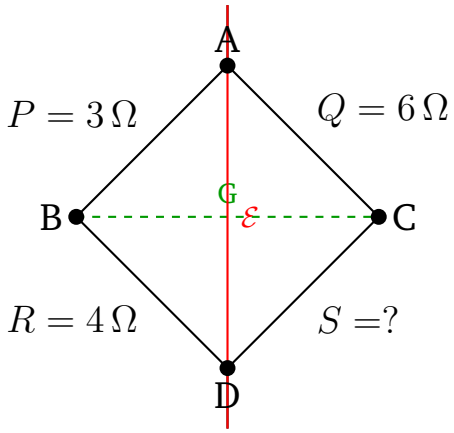
(A) $1.1\ \Omega$

(B) $2.2\ \Omega$

(C) $8.8\ \Omega$

(D) $4.4\ \Omega$

Q13. In a Wheatstone bridge, $P = 3\ \Omega$, $Q = 6\ \Omega$, and $R = 4\ \Omega$. For the bridge to be balanced, the value of S must be:



(A) $8\ \Omega$

(B) $2\ \Omega$

(C) $6\ \Omega$

(D) $12\ \Omega$

Q14. A straight conductor of length $l = 0.5\ \mathrm{m}$ carrying a current $I = 2\ \mathrm{A}$ is placed perpendicular to a uniform magnetic field of magnitude $B = 0.8\ \mathrm{T}$. The magnetic force on the conductor is:

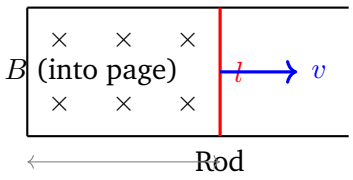
(A) 0.4 N

(B) 0.8 N

(C) 1.6 N

(D) 0.2 N

Q15. A conducting rod of length $l = 0.5$ m moves with velocity $v = 4$ m/s perpendicular to both its own length and to a uniform magnetic field $B = 0.5$ T directed into the page. The motional EMF induced across the rod is:



(A) 2 V

(B) 0.5 V

(C) 1 V

(D) 4 V

Q16. In a series LCR circuit, resonance occurs when:

(A) The impedance of the circuit is maximum

(B) The current in the circuit is minimum

(C) The inductive reactance equals the resistance

(D) The inductive reactance equals the capacitive reactance

Q17. In an electromagnetic wave propagating in vacuum, the amplitude of the magnetic field is $B_0 = 2 \times 10^{-8}$ T. The amplitude of the electric field E_0 is: (speed of light $c = 3 \times 10^8$ m/s)

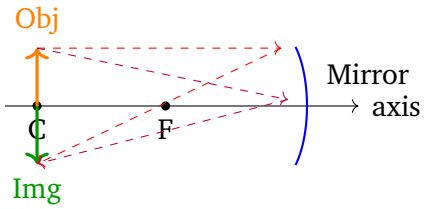
(A) 6 V/m

(B) 3 V/m

(C) $12\ \mathrm{V/m}$

(D) $1.5\ \mathrm{V/m}$

Q18. An object is placed at the centre of curvature of a concave mirror ($R = 40\ \mathrm{cm}$, so $f = 20\ \mathrm{cm}$). Using the mirror formula, the image formed is:



(A) Virtual and erect

(B) Real, inverted, same size as the object

(C) Real, erect, and magnified

(D) Virtual and inverted

Q19. In the photoelectric effect, light of wavelength $\lambda = 248\ \mathrm{nm}$ falls on a metal surface whose work function is $\phi = 2\ \mathrm{eV}$. The maximum kinetic energy of the emitted photoelectrons is: (use $hc = 1240\ \mathrm{eV \cdot nm}$)

(A) $1\ \mathrm{eV}$

(B) $2\ \mathrm{eV}$

(C) $3\ \mathrm{eV}$

(D) $5\ \mathrm{eV}$

Q20. In the Bohr model of hydrogen, the energy of the n-th level is $E_n = -13.6/n^2\ \mathrm{eV}$. The energy of the photon emitted in the transition from $n = 3$ to $n = 2$ (the Hα line of the Balmer series) is:

(A) $0.66\ \mathrm{eV}$

(B) $3.4\ \mathrm{eV}$

(C) $13.6\ \mathrm{eV}$

(D) $1.9\ \mathrm{eV}$

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

Q21. A ball is projected horizontally from a height $H = 45\ \text{m}$ above the ground with an initial horizontal speed $v_0 = 20\ \text{m/s}$ ($g = 10\ \text{m/s}^2$). Calculate the horizontal range R (in metres) covered by the ball before it hits the ground.

(Enter the exact numerical value as your answer.)

Q22. A Carnot engine operates between a hot reservoir at temperature $T_H = 400\ \text{K}$ and a cold reservoir at temperature $T_L = 100\ \text{K}$. Calculate the efficiency of the engine (in %).

(Enter the exact numerical value as your answer.)

Q23. A capacitor of capacitance $C = 2\ \mu\text{F}$ is charged to a potential difference $V = 100\ \text{V}$. Calculate the charge stored on the capacitor (in μC).

(Enter the exact numerical value as your answer.)

Q24. Two resistors of $6\ \Omega$ and $3\ \Omega$ are connected in parallel, and this parallel combination is connected in series with a $1\ \Omega$ resistor. Calculate the equivalent resistance (in Ω) of the entire combination.

(Enter the exact numerical value as your answer.)

Q25. A charged particle of mass $m = 10^{-26}\ \text{kg}$ and charge $q = 10^{-19}\ \text{C}$ enters a uniform magnetic field $B = 0.1\ \text{T}$ with velocity $v = 2 \times 10^6\ \text{m/s}$ perpendicular to the field. Calculate the radius (in m) of the circular path traced by the particle.

(Enter the exact numerical value as your answer.)

Q26. A concave mirror forms a real image. An object is placed at $u = -30\ \text{cm}$ from the mirror and the image forms at $v = -60\ \text{cm}$. Using the mirror formula, find the magnitude of the focal length (in cm) of the mirror.

(Enter the exact numerical value as your answer.)

Q27. An electron ($m = 9.1 \times 10^{-31}$ kg) moves with a speed $v = 7.27 \times 10^{5}$ m/s. Given Planck's constant $h = 6.63 \times 10^{-34}$ J $\cdot$ s, calculate its de Broglie wavelength (in Å).

(Enter the exact numerical value as your answer.)

Q28. A stretched string vibrates at its 4th harmonic with a frequency of 200 Hz. What is the fundamental frequency (in Hz) of the string?

(Enter the exact numerical value as your answer.)

Q29. A planet has an escape velocity $v_e = 8$ km/s and a radius $R = 4 \times 10^{6}$ m. Using $v_e = \sqrt{2gR}$, calculate the surface gravitational acceleration g (in m/s^2) on the planet.

(Enter the exact numerical value as your answer.)

Q30. Calculate the energy (in eV) of a photon of wavelength $\lambda = 248$ nm. Use the relation $E = hc/\lambda$ with $hc = 1240$ eV $\cdot$ nm.

(Enter the exact numerical value as your answer.)

DETAILED SOLUTIONS

Sol. Q1.

Solution

Topic: Kinematics — Projectile Motion

The maximum height in projectile motion is:

$$H_{\max} = \frac{v_0^2 \sin^2\theta}{2g} = \frac{(20)^2 \times \sin^2 45^\circ}{2 \times 10} = \frac{400 \times 0.5}{20} = \frac{200}{20} = \mathbf{10}\ \text{m}$$

Answer: (A)

Sol. Q2.

Solution

Topic: Laws of Motion — Equilibrium on an Incline

For the block in equilibrium on the inclined plane, the net force along the plane is zero. Therefore the friction force exactly balances the component of gravity along the incline:

$$f = Mg\sin 30^\circ = 4 \times 10 \times 0.5 = \mathbf{20}\ \text{N}$$

The friction acts up the incline.

Answer: (B)

Sol. Q3.

Solution

Topic: Work-Energy Theorem — Spring Potential Energy

By conservation of energy, all the elastic potential energy converts to kinetic energy:

$$\frac{1}{2}kx^2 = \frac{1}{2}mv^2 \implies v = x\sqrt{\frac{k}{m}} = 0.2\times\sqrt{\frac{500}{0.1}} = 0.2\times\sqrt{5000} = 0.2\times 50\sqrt{2} = \mathbf{10\sqrt{2}}\ \text{m/s}$$

Answer: (C)

Sol. Q4.

Solution

Topic: Rotational Motion — Rolling Without Slipping

For rolling without slipping, the equation of motion gives:

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

For a solid cylinder $I = \frac{1}{2}MR^2$, so $\dfrac{I}{MR^2} = \dfrac{1}{2}$. Thus:

$$a = \frac{g\sin\theta}{1+\frac{1}{2}} = \frac{g\sin\theta}{\frac{3}{2}} = \frac{\mathbf{2g}\sin\theta}{\mathbf{3}}$$

Answer: (D)

Sol. Q5.

Solution

Topic: Gravitation — Orbital Speed of Satellite

The satellite orbits at height $h = R$, so its orbital radius is $r = R + R = 2R$. Using the orbital speed formula:

$$v = \sqrt{\frac{GM}{2R}} = \sqrt{\frac{gR^2}{2R}} = \sqrt{\frac{gR}{2}} = \frac{\sqrt{gR}}{\sqrt{2}} = \frac{\mathbf{v_0}}{\sqrt{\mathbf{2}}}$$

where $v_0 = \sqrt{gR}$ is the first cosmic speed (orbital speed at Earth's surface).

Answer: (A)

Sol. Q6.

Solution

Topic: Surface Tension — Capillary Rise

The capillary rise formula is:

$$h = \frac{2T\cos\theta}{\rho g r} = \frac{2 \times 0.07 \times \cos 0^\circ}{1000 \times 10 \times 10^{-3}} = \frac{0.14}{10} = 0.014 \text{ m} = \mathbf{1.4} \text{ cm}$$

Answer: (B)

Sol. Q7.

Solution

Topic: Thermodynamics — First Law

By the first law of thermodynamics:

$$\Delta U = Q - W = 500 - 200 = \mathbf{300}\ \text{J}$$

where Q is the heat absorbed by the gas and W is the work done by the gas on the surroundings.

Answer: (C)

Sol. Q8.

Solution

Topic: Oscillations — Simple Pendulum

The time period of a simple pendulum is $T = 2\pi\sqrt{L/g}$. Solving for L:

$$L = g\left(\frac{T}{2\pi}\right)^2 = 10 \times \left(\frac{2}{2\pi}\right)^2 = 10 \times \frac{1}{\pi^2} = \frac{\mathbf{10}}{\boldsymbol{\pi^2}}\ \text{m}$$

Answer: (D)

Sol. Q9.

Solution

Topic: Waves — Standing Waves on a String

For a string fixed at both ends, the n-th harmonic has n half-wavelengths fitting in the length L:

$$L = \frac{n\lambda}{2}$$

For the third harmonic ($n = 3$):

$$L = \frac{3\lambda}{2}$$

Answer: (A)

Sol. Q10.

Solution

Topic: Electrostatics — Coulomb's Law

$$F = k\frac{|q_1||q_2|}{r^2} = \frac{9 \times 10^9 \times 2 \times 10^{-6} \times 8 \times 10^{-6}}{(0.3)^2} = \frac{9 \times 10^9 \times 16 \times 10^{-12}}{0.09} = \frac{144 \times 10^{-3}}{0.09} = \mathbf{1.6}\ \text{N}$$

Answer: (B)

Sol. Q11.

Solution

Topic: Capacitors — Effect of Plate Separation

For a parallel plate capacitor, $C = \varepsilon_0 A/d$. If the separation is halved to $d' = d/2$:

$$C' = \frac{\varepsilon_0 A}{d/2} = \frac{2\varepsilon_0 A}{d} = \mathbf{2C_0}$$

Answer: (C)

Sol. Q12.

Solution

Topic: Current Electricity — Resistance of a Wire

$$R = \frac{\rho L}{A} = \frac{1.1 \times 10^{-6} \times 2}{0.5 \times 10^{-6}} = \frac{2.2 \times 10^{-6}}{0.5 \times 10^{-6}} = \mathbf{4.4\ \Omega}$$

Answer: (D)

Sol. Q13.

Solution

Topic: Kirchhoff's Laws — Wheatstone Bridge

The Wheatstone bridge is balanced when:

$$\frac{P}{Q} = \frac{R}{S} \implies S = \frac{QR}{P} = \frac{6 \times 4}{3} = \mathbf{8\ \Omega}$$

Answer: (A)

Sol. Q14.

Solution

Topic: Magnetic Force on a Current-Carrying Conductor

For a straight conductor perpendicular to the field:

$$F = BIl = 0.8 \times 2 \times 0.5 = \mathbf{0.8}\ \text{N}$$

Answer: (B)

Sol. Q15.

Solution

Topic: Electromagnetic Induction — Motional EMF

The motional EMF induced in the rod is:

$$\mathcal{E} = Bvl = 0.5 \times 4 \times 0.5 = \mathbf{1}\ \text{V}$$

Answer: (C)

Sol. Q16.

Solution

Topic: AC Circuits — Series LCR Resonance

At resonance in a series LCR circuit, the inductive reactance $X_L = \omega L$ equals the capacitive reactance $X_C = 1/(\omega C)$. As a result, the net reactance is zero, the impedance $Z = R$ is at its minimum value, and the current is at its maximum. Options A, B, and C are all incorrect descriptions of resonance.

Answer: (D)

Sol. Q17.

Solution

Topic: Electromagnetic Waves — Relation between E and B

In a vacuum, the amplitudes of the electric and magnetic fields in an electromagnetic wave are related by:

$$E_0 = cB_0 = 3 \times 10^8 \times 2 \times 10^{-8} = \mathbf{6}\ \text{V/m}$$

Answer: (A)

Sol. Q18.

Solution

Topic: Ray Optics — Concave Mirror Formula

Given $f = -20$ cm (concave mirror) and $u = -40$ cm (object at C). Mirror

formula:

$$\frac{1}{v}+\frac{1}{u}=\frac{1}{f} \implies \frac{1}{v}=\frac{1}{f}-\frac{1}{u}=\frac{1}{-20}-\frac{1}{-40}=-\frac{1}{20}+\frac{1}{40}=-\frac{1}{40}$$

$$\therefore \quad v=-40 \text{ cm}$$

Magnification $m=-v/u=-(-40)/(-40)=-1$. The image is **real, inverted, and of the same size** as the object, formed at C.

Answer: (B)

Sol. Q19.

Solution

Topic: Dual Nature of Radiation — Photoelectric Effect

Energy of incident photon:

$$E=\frac{hc}{\lambda}=\frac{1240 \text{ eV}\cdot\text{nm}}{248 \text{ nm}}=5 \text{ eV}$$

Maximum kinetic energy of photoelectrons:

$$KE_{\max}=E-\phi=5-2=\mathbf{3} \text{ eV}$$

Answer: (C)

Sol. Q20.

Solution

Topic: Atoms — Bohr Model (Hydrogen Spectrum)

Energy of the $n=2$ level: $E_2=-13.6/4=-3.4$ eV

Energy of the $n=3$ level: $E_3=-13.6/9\approx-1.51$ eV

Energy of the emitted photon (transition $3\to2$):

$$\Delta E=E_3-E_2=-1.51-(-3.4)=1.89 \text{ eV}\approx\mathbf{1.9} \text{ eV}$$

This corresponds to the Hα line (red) of the Balmer series.

Answer: (D)

Sol. Q21.

Solution

Topic: Kinematics — Horizontal Projectile

Time to reach the ground from height $H = 45$ m:

$$H = \frac{1}{2}gt^2 \implies t = \sqrt{\frac{2H}{g}} = \sqrt{\frac{2 \times 45}{10}} = \sqrt{9} = 3 \text{ s}$$

Horizontal range:

$$R = v_0 t = 20 \times 3 = \mathbf{60} \text{ m}$$

Answer: (60)

Sol. Q22.

Solution

Topic: Thermodynamics — Carnot Efficiency

$$\eta = \left(1 - \frac{T_L}{T_H}\right) \times 100\% = \left(1 - \frac{100}{400}\right) \times 100\% = (1 - 0.25) \times 100\% = \mathbf{75}\%$$

Answer: (75)

Sol. Q23.

Solution

Topic: Capacitors — Charge Stored

$$Q = CV = 2\ \mu\text{F} \times 100\ \text{V} = \mathbf{200}\ \mu\text{C}$$

Answer: (200)

Sol. Q24.

Solution

Topic: Current Electricity — Combination of Resistors

Parallel combination of $6\ \Omega$ and $3\ \Omega$:

$$R_{\parallel} = \frac{6 \times 3}{6 + 3} = \frac{18}{9} = 2\ \Omega$$

Series with $1\ \Omega$:

$$R_{\text{total}} = 2 + 1 = \mathbf{3\ \Omega}$$

Answer: (3)

Sol. Q25.

Solution

Topic: Magnetic Force — Radius of Circular Motion

The radius of circular motion of a charged particle in a magnetic field is:

$$r = \frac{mv}{qB} = \frac{10^{-26} \times 2 \times 10^{6}}{10^{-19} \times 0.1} = \frac{2 \times 10^{-20}}{10^{-20}} = \mathbf{2}\ \text{m}$$

Answer: (2)

Sol. Q26.

Solution

Topic: Ray Optics — Mirror Formula

Using the mirror formula:

$$\frac{1}{f} = \frac{1}{v} + \frac{1}{u} = \frac{1}{-60} + \frac{1}{-30} = -\frac{1}{60} - \frac{2}{60} = -\frac{3}{60} = -\frac{1}{20}$$

$$\therefore \quad |f| = \mathbf{20}\ \text{cm}$$

Answer: (20)

Sol. Q27.

Solution

Topic: Dual Nature — de Broglie Wavelength

$$\lambda = \frac{h}{mv} = \frac{6.63 \times 10^{-34}}{9.1 \times 10^{-31} \times 7.27 \times 10^{5}} = \frac{6.63 \times 10^{-34}}{6.616 \times 10^{-25}} \approx 1.0 \times 10^{-9}\ \text{m} = \mathbf{10}\ \text{Å}$$

Answer: (10)

Sol. Q28.

Solution

Topic: Waves — Harmonics

The n-th harmonic has frequency $f_n = nf_1$, where f_1 is the fundamental fre-

quency. For the 4th harmonic:

$$f_1 = \frac{f_4}{4} = \frac{200}{4} = \mathbf{50}\ \text{Hz}$$

Answer: (50)

Sol. Q29.

Solution

Topic: Gravitation — Escape Velocity and Surface Gravity

Using $v_e = \sqrt{2gR}$:

$$g = \frac{v_e^2}{2R} = \frac{(8 \times 10^3)^2}{2 \times 4 \times 10^6} = \frac{64 \times 10^6}{8 \times 10^6} = \mathbf{8}\ \text{m/s}^2$$

Answer: (8)

Sol. Q30.

Solution

Topic: Dual Nature — Photon Energy

$$E = \frac{hc}{\lambda} = \frac{1240\ \text{eV} \cdot \text{nm}}{248\ \text{nm}} = \mathbf{5}\ \text{eV}$$

Answer: (5)

ANSWER KEY

Section A — MCQ Answer Key

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

Section B — Numerical Answer Key

Q	Ans	Q	Ans
21	60	22	75
23	200	24	3
25	2	26	20
27	10	28	50
29	8	30	5