JEE Main Physics
Sample Paper – 7

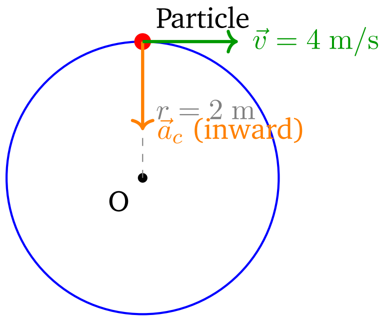
Duration: 60 Minutes | Maximum Marks: 100

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 moves in a circular path of radius $r = 2$ m at a constant speed $v = 4$ m/s. The magnitude of its centripetal acceleration is:



Uniform circular motion

(A) $4\ \mathrm{m/s^2}$

(B) $2\ \mathrm{m/s^2}$

(C) $8\ \mathrm{m/s^2}$

(D) $16\ \mathrm{m/s^2}$

Q2. A ball of mass $m = 0.5$ kg is attached to a string of length $l = 1$ m and rotates in a horizontal circle with angular velocity $\omega = 4$ rad/s. The tension in the string is:

(A) 2 N

(B) 4 N

(C) 6 N

(D) 8 N

Q3. A car of mass 1000 kg moves at a constant speed of $v = 20$ m/s. The engine delivers power $P = 80$ kW. The total resistive (friction) force acting on the car is:

(A) 4000 N

(B) 2000 N

(C) 8000 N

(D) 1600 N

Q4. A thin uniform rod of mass M and length L has moment of inertia $I_{\text{end}} = ML^2/3$ about an axis through one **end** perpendicular to the rod, and $I_{\text{centre}} = ML^2/12$ about an axis through its **centre**. The ratio $I_{\text{end}}/I_{\text{centre}}$ is:

(A) 2

(B) 4

(C) 6

(D) 8

Q5. Planet X has an orbital radius 4 times that of Earth. Using Kepler's third law ($T^2 \propto R^3$), the orbital period of Planet X compared to Earth's period T_E is:

(A) $4\,T_E$

(B) $4\sqrt{4}\,T_E$

(C) $8\,T_E$

(D) $16\,T_E$

Q6. A steel wire of length $L = 2$ m and cross-sectional area $A = 10^{-6}$ m^2 has Young's modulus $Y = 2 \times 10^{11}$ Pa. When a force $F = 100$ N is applied along its length, the extension produced is:

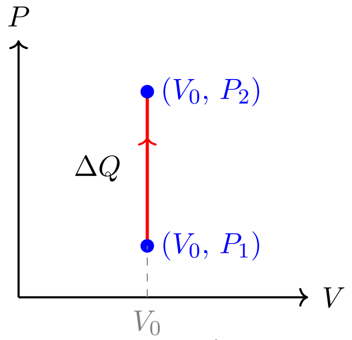
(A) 0.1 mm

(B) 0.5 mm

(C) 0.25 mm

(D) 1 mm

Q7. One mole of a monatomic ideal gas ($C_V = \frac{3}{2}R$, $R = 8.314\ \mathrm{J\,mol^{-1}K^{-1}}$) is heated at **constant volume** through a temperature rise $\Delta T = 40$ K. The heat absorbed by the gas is closest to:



Isochoric (constant volume) process

(A) 500 J

(B) 300 J

(C) 750 J

(D) 1000 J

Q8. A liquid column of length $L = 0.1$ m in each arm of a U-tube (total liquid length $= 2L$) oscillates with simple harmonic motion. The period of oscillation is ($g = 10$ m/s^2):

(A) π s

(B) 0.2π s

(C) 0.4π s

(D) 2π s

Q9. A pipe closed at one end has a length $L = 0.85$ m. Taking the speed of sound as $v = 340$ m/s, the fundamental frequency of the pipe is:

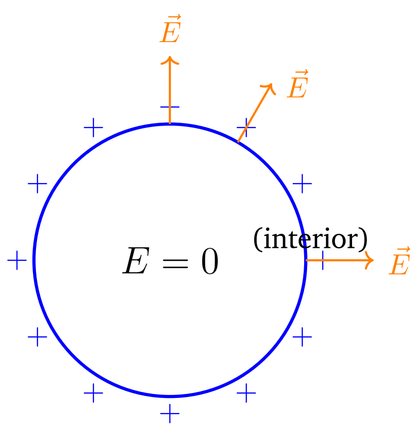
(A) 200 Hz

(B) 50 Hz

(C) 100 Hz

(D) 400 Hz

Q10. A hollow metallic sphere (shell) carries a total charge $+Q$ uniformly distributed on its surface. By Gauss's law, the electric field at any point **inside** the shell is:



Charged spherical shell

(A) $\dfrac{kQ}{R^2}$ (same as on surface)

(B) $\frac{kQ}{r^2}$ (where r is distance from centre)

(C) $\frac{kQ}{2R^2}$

(D) Zero

Q11. A copper wire has resistance $R_0 = 10\ \Omega$ at $T_0 = 0°\text{C}$. If the temperature coefficient of resistance $\alpha = 4 \times 10^{-3}\ °\text{C}^{-1}$, the resistance at $T = 100°\text{C}$ is:

(A) $14\ \Omega$

(B) $10.4\ \Omega$

(C) $40\ \Omega$

(D) $11\ \Omega$

Q12. Two long parallel wires each carry a current $I = 10\ \text{A}$ in the **same direction** and are separated by a distance $d = 0.1\ \text{m}$. The force per unit length between the wires is ($\mu_0 = 4\pi \times 10^{-7}\ \text{T}\cdot\text{m/A}$):

(A) $4 \times 10^{-4}\ \text{N/m}$, repulsive

(B) $2 \times 10^{-4}\ \text{N/m}$, attractive

(C) $1 \times 10^{-4}\ \text{N/m}$, attractive

(D) $2 \times 10^{-3}\ \text{N/m}$, repulsive

Q13. Two coils have mutual inductance $M = 0.5\ \text{H}$. If the current in the primary coil changes at a rate $dI/dt = 4\ \text{A/s}$, the magnitude of the EMF induced in the secondary coil is:

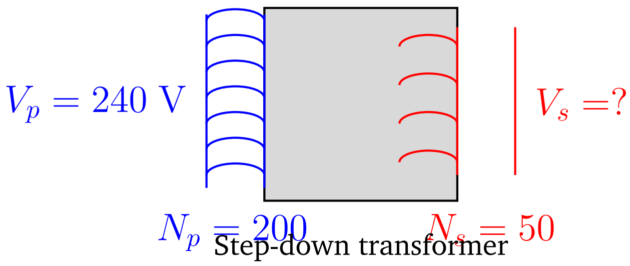
(A) $0.5\ \text{V}$

(B) $4\ \text{V}$

(C) $2\ \text{V}$

(D) $8\ \text{V}$

Q14. A transformer has $N_p = 200$ turns in the primary and $N_s = 50$ turns in the secondary. An input (primary) voltage of $V_p = 240\ \text{V}$ is applied. The output (secondary) voltage is:



(A) 960 V

(B) 120 V

(C) 48 V

(D) 60 V

Q15. In an electromagnetic wave propagating through vacuum, the electric field $\vec{E}$, the magnetic field $\vec{B}$, and the direction of propagation $\hat{k}$ satisfy:

(A) $\vec{E} \perp \vec{B}$ and both are perpendicular to the direction of propagation (transverse wave)

(B) $\vec{E} \parallel \vec{B}$ and both are parallel to the direction of propagation (longitudinal wave)

(C) $\vec{E} \perp \vec{B}$ but $\vec{E}$ is parallel to the direction of propagation

(D) $\vec{E} \parallel \vec{B}$ and both are perpendicular to the direction of propagation

Q16. An object lies at the bottom of a container filled with water ($\mu = 4/3$) to a depth of $d = 8$ cm. The apparent depth of the object as seen from directly above is:

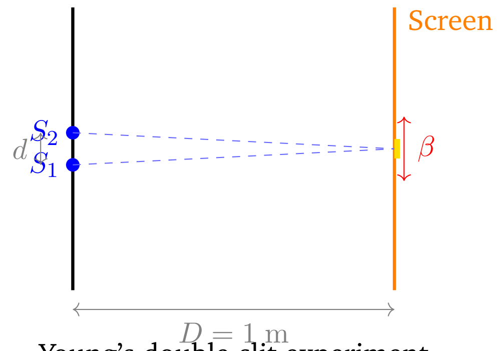
(A) 8 cm

(B) 6 cm

(C) 10.7 cm

(D) 4 cm

Q17. In Young's double-slit experiment, the slit separation is $d = 0.5$ mm, the wavelength of light used is $\lambda = 500$ nm, and the screen is placed at a distance $D = 1$ m from the slits. The fringe width β is:



Young's double-slit experiment

(A) 0.5 mm

(B) 2 mm

(C) 1 mm

(D) 0.25 mm

Q18. In Bohr's model of the hydrogen atom, the angular momentum of the electron in the $n = 2$ orbit is (h is Planck's constant):

(A) $\frac{h}{2\pi}$

(B) $\frac{h}{4\pi}$

(C) $\frac{h}{2}$

(D) $\frac{h}{\pi}$

Q19. The masses are: proton $m_p = 1.007276$ u, neutron $m_n = 1.008665$ u, deuterium nucleus $m_d = 2.013553$ u. The binding energy of the deuterium nucleus is ($1\text{ u} = 931.5\text{ MeV/c}^2$):

(A) 2.22 MeV

(B) 1.11 MeV

(C) 4.44 MeV

(D) 0.56 MeV

Q20. In a p-n junction diode under **forward bias**, the width of the depletion region:

(A) Increases

(B) Decreases

(C) Remains unchanged

(D) First increases then decreases

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

Q21. A particle of mass $m = 2$ kg moves in a circular path of radius $r = 1.5$ m with a speed $v = 3$ m/s. Calculate the centripetal force (in N) acting on the particle.

(Enter the exact numerical value as your answer.)

Q22. A spring of spring constant $k = 500$ N/m has a mass $M = 5$ kg suspended from it at rest ($g = 10$ m/s^2). Calculate the extension of the spring (in cm).

(Enter the exact numerical value as your answer.)

Q23. A vehicle engine exerts a driving force $F = 5000$ N when the vehicle moves at a constant speed of $v = 18$ km/h. Calculate the power of the engine (in kW).

(Enter the exact numerical value as your answer.)

Q24. Two moles of a diatomic ideal gas ($C_V = 12.5\ \mathrm{J\,mol^{-1}K^{-1}}$) are heated at constant volume through a temperature rise $\Delta T = 80$ K. Calculate the heat absorbed (in J).

(Enter the exact numerical value as your answer.)

Q25. In a Young's double-slit experiment, the slit separation is $d = 0.2$ mm, the wavelength is $\lambda = 600$ nm, and the screen distance is $D = 2$ m. Calculate the fringe width β (in mm).

(Enter the exact numerical value as your answer.)

Q26. An object is placed at the bottom of a pool filled with a liquid of refractive index $\mu = 1.5$ to a real depth of 12 cm. Calculate the apparent depth (in cm) as seen from directly above.

(Enter the exact numerical value as your answer.)

Q27. Calculate the energy (in eV) of a photon of wavelength $\lambda = 124$ nm. Use $hc = 1240$ eV $\cdot$ nm.

(Enter the exact numerical value as your answer.)

Q28. A step-up transformer has $N_p = 100$ turns in the primary and $N_s = 1000$ turns in the secondary. The primary voltage is $V_p = 220$ V and the primary current is $I_p = 0.5$ A. Assuming an ideal transformer, calculate the secondary current (in mA).

(Enter the exact numerical value as your answer.)

Q29. The total binding energy of a helium-4 nucleus (^4_2He) is 28.3 MeV. Calculate the binding energy per nucleon (in MeV), rounded to two decimal places.

(Enter the exact numerical value as your answer.)

Q30. A copper wire has resistance $R_0 = 5\ \Omega$ at $0°\text{C}$. Given temperature coefficient $\alpha = 4 \times 10^{-3}\ °\text{C}^{-1}$, calculate the resistance (in Ω) at $T = 200°\text{C}$.

(Enter the exact numerical value as your answer.)

DETAILED SOLUTIONS

Sol. Q1.

Solution

Topic: Kinematics — Uniform Circular Motion

For a particle moving in a circle of radius r at constant speed v, the centripetal acceleration is directed toward the centre and has magnitude:

$$a_c = \frac{v^2}{r} = \frac{(4)^2}{2} = \frac{16}{2} = \mathbf{8}\ \mathrm{m/s^2}$$

The velocity is tangent to the circle and the centripetal acceleration points radially inward at every instant.

Answer: (C)

Sol. Q2.

Solution

Topic: Laws of Motion — Tension in Horizontal Circular Motion

For a ball of mass m rotating in a horizontal circle of radius r (equal to the string length l) at angular velocity ω, the tension in the string provides the centripetal force:

$$T = m\omega^2 r = 0.5 \times (4)^2 \times 1 = 0.5 \times 16 \times 1 = \mathbf{8}\ \mathrm{N}$$

Answer: (D)

Sol. Q3.

Solution

Topic: Work-Energy / Power — Engine Force

At constant speed, the driving force from the engine exactly equals the total resistive force F_r. Using $P = F_r \cdot v$:

$$F_r = \frac{P}{v} = \frac{80{,}000\ \mathrm{W}}{20\ \mathrm{m/s}} = \mathbf{4000}\ \mathrm{N}$$

Answer: (A)

Sol. Q4.

Solution

Topic: Rotational Motion — Moment of Inertia Ratio

Given:

$$I_{\text{end}} = \frac{ML^2}{3}, \qquad I_{\text{centre}} = \frac{ML^2}{12}$$

The ratio is:

$$\frac{I_{\text{end}}}{I_{\text{centre}}} = \frac{ML^2/3}{ML^2/12} = \frac{12}{3} = \mathbf{4}$$

This result is also consistent with the parallel-axis theorem: $I_{\text{end}} = I_{\text{centre}} + M(L/2)^2 = ML^2/12 + ML^2/4 = ML^2/3$.

Answer: (B)

Sol. Q5.

Solution

Topic: Gravitation — Kepler's Third Law

Kepler's third law states $T^2 \propto R^3$, so:

$$\frac{T_X}{T_E} = \left(\frac{R_X}{R_E}\right)^{3/2} = (4)^{3/2} = \left(2^2\right)^{3/2} = 2^3 = 8$$

Therefore $T_X = \mathbf{8\ T_E}$ (i.e., 8 Earth years).

Answer: (C)

Sol. Q6.

Solution

Topic: Properties of Matter — Young's Modulus and Wire Extension

The extension of a wire under axial load is:

$$\Delta L = \frac{FL}{AY} = \frac{100 \times 2}{10^{-6} \times 2 \times 10^{11}} = \frac{200}{2 \times 10^5} = 10^{-3}\ \text{m} = \mathbf{1}\ \text{mm}$$

Answer: (D)

Sol. Q7.

Solution

Topic: Thermodynamics — Isochoric (Constant Volume) Process

For an isochoric process, no work is done ($W = 0$), so all heat goes into raising the internal energy. For a monatomic ideal gas with $C_V = \frac{3}{2}R$:

$$Q = nC_V\Delta T = 1 \times \frac{3}{2} \times 8.314 \times 40 = \frac{3}{2} \times 332.56 = 498.84 \text{ J} \approx \mathbf{500} \text{ J}$$

Answer: (A)

Sol. Q8.

Solution

Topic: SHM — Oscillation of Liquid in a U-tube

For a liquid column oscillating in a U-tube, the restoring force is due to the pressure difference in the displaced column. The period is:

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

where $L = 0.1$ m is the length of liquid in each arm. Substituting:

$$T = 2\pi\sqrt{\frac{0.1}{10}} = 2\pi\sqrt{0.01} = 2\pi \times 0.1 = \mathbf{0.2}\pi \text{ s}$$

Answer: (B)

Sol. Q9.

Solution

Topic: Waves — Fundamental Frequency of a Closed Pipe

A pipe closed at one end supports standing waves with a node at the closed end and an antinode at the open end. The fundamental (first harmonic) has wavelength $\lambda_1 = 4L$. The fundamental frequency is:

$$f_1 = \frac{v}{4L} = \frac{340}{4 \times 0.85} = \frac{340}{3.4} = \mathbf{100} \text{ Hz}$$

Answer: (C)

Sol. Q10.

Solution

Topic: Electrostatics — Gauss's Law for a Spherical Shell

For a Gaussian surface of any radius $r < R$ (inside the shell), the enclosed charge is zero. By Gauss's law:

$$\oint \vec{E} \cdot d\vec{A} = \frac{Q_{\text{enc}}}{\varepsilon_0} = \frac{0}{\varepsilon_0} = 0$$

By symmetry E is uniform over the Gaussian surface, so $E = \mathbf{0}$ everywhere inside the shell.

Answer: (D)

Sol. Q11.

Solution

Topic: Current Electricity — Temperature Dependence of Resistance

The resistance at temperature T is:

$$R = R_0(1+\alpha T) = 10 \times (1+4\times10^{-3}\times100) = 10\times(1+0.4) = 10\times1.4 = \mathbf{14\ \Omega}$$

Answer: (A)

Sol. Q12.

Solution

Topic: Magnetism — Force Between Parallel Current-Carrying Wires

The force per unit length between two long parallel wires carrying currents $I_1 = I_2 = I$ separated by distance d is:

$$\frac{F}{L} = \frac{\mu_0 I^2}{2\pi d} = \frac{4\pi\times10^{-7}\times(10)^2}{2\pi\times0.1} = \frac{4\pi\times10^{-7}\times100}{2\pi\times0.1} = \frac{4\times10^{-5}}{0.2} = \mathbf{2\times10^{-4}}\ \text{N/m}$$

Wires carrying current in the **same direction attract** each other.

Answer: (B)

Sol. Q13.

Solution

Topic: Electromagnetic Induction — Mutual Inductance

By Faraday's law, the EMF induced in the secondary coil due to a changing current in the primary is:

$$|\mathcal{E}| = M\left|\frac{dI}{dt}\right| = 0.5\times4 = \mathbf{2}\ \text{V}$$

Answer: (C)

Sol. Q14.

Solution

Topic: AC Circuits — Transformer Voltage Ratio

For an ideal transformer, the ratio of voltages equals the ratio of turns:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} \implies V_s = V_p \times \frac{N_s}{N_p} = 240 \times \frac{50}{200} = 240 \times 0.25 = \mathbf{60}\text{ V}$$

Since $N_s < N_p$, this is a step-down transformer.

Answer: (D)

Sol. Q15.

Solution

Topic: Electromagnetic Waves — Transverse Nature

Electromagnetic waves are **transverse** waves. The electric field $\vec{E}$, magnetic field $\vec{B}$, and direction of propagation $\hat{k}$ are mutually perpendicular:

$$\hat{k} = \hat{E} \times \hat{B}$$

Therefore $\vec{E} \perp \vec{B}$, and both are perpendicular to the direction of propagation. Options B, C, and D are all incorrect descriptions.

Answer: (A)

Sol. Q16.

Solution

Topic: Ray Optics — Apparent Depth Due to Refraction

When viewed from a medium of lower refractive index (air, $\mu_1 = 1$) into a denser medium (water, $\mu_2 = 4/3$), the apparent depth is:

$$d_{\text{app}} = \frac{d_{\text{real}}}{\mu} = \frac{8}{4/3} = 8 \times \frac{3}{4} = \mathbf{6}\text{ cm}$$

Answer: (B)

Sol. Q17.

Solution

Topic: Wave Optics — Young's Double-Slit Fringe Width

The fringe width in YDSE is:

$$\beta = \frac{\lambda D}{d} = \frac{500 \times 10^{-9} \times 1}{0.5 \times 10^{-3}} = \frac{5 \times 10^{-7}}{5 \times 10^{-4}} = 1 \times 10^{-3}\ \text{m} = \mathbf{1}\ \text{mm}$$

Answer: (C)

Sol. Q18.

Solution

Topic: Atoms — Bohr Model Angular Momentum Quantisation

In the Bohr model, the angular momentum of the electron in the n-th orbit is quantised as:

$$L_n = n\hbar = \frac{nh}{2\pi}$$

For $n = 2$:

$$L_2 = \frac{2h}{2\pi} = \frac{h}{\pi}$$

Answer: (D)

Sol. Q19.

Solution

Topic: Nuclei — Binding Energy of Deuterium

The mass defect for deuterium ($^2_1$H, 1 proton + 1 neutron):

$$\Delta m = m_p + m_n - m_d = 1.007276 + 1.008665 - 2.013553 = 0.002388\ \text{u}$$

Binding energy:

$$BE = \Delta m \times 931.5\ \text{MeV/u} = 0.002388 \times 931.5 = \mathbf{2.22}\ \text{MeV}$$

Answer: (A)

Sol. Q20.

Solution

Topic: Semiconductors — p-n Junction Under Forward Bias

In a p-n junction at equilibrium, the built-in electric field across the depletion region opposes carrier diffusion. When forward bias is applied, the external voltage opposes the built-in potential. This reduces the net electric field, allowing more carriers to diffuse across, thereby **narrowing (decreasing) the depletion region width**. Reverse bias would widen it.

Answer: (B)

Sol. Q21.

Solution

Topic: Circular Motion — Centripetal Force

$$F_c = \frac{mv^2}{r} = \frac{2 \times (3)^2}{1.5} = \frac{2 \times 9}{1.5} = \frac{18}{1.5} = \mathbf{12}\ \text{N}$$

Answer: (12)

Sol. Q22.

Solution

Topic: Elasticity — Spring Extension Under Load

At equilibrium, the spring force equals the weight of the suspended mass:

$$kx = Mg \implies x = \frac{Mg}{k} = \frac{5 \times 10}{500} = \frac{50}{500} = 0.1\ \text{m} = \mathbf{10}\ \text{cm}$$

Answer: (10)

Sol. Q23.

Solution

Topic: Work-Energy / Power — Engine Power

First convert speed: $v = 18\ \text{km/h} = 18 \times \frac{1000}{3600} = 5\ \text{m/s}$.

Power:

$$P = Fv = 5000 \times 5 = 25{,}000\ \text{W} = \mathbf{25}\ \text{kW}$$

Answer: (25)

Sol. Q24.

Solution

Topic: Thermodynamics — Heat at Constant Volume

$$Q = nC_V\Delta T = 2 \times 12.5 \times 80 = 25 \times 80 = \mathbf{2000}\ \text{J}$$

Answer: (2000)

Sol. Q25.

Solution

Topic: Wave Optics — YDSE Fringe Width

$$\beta = \frac{\lambda D}{d} = \frac{600 \times 10^{-9} \times 2}{0.2 \times 10^{-3}} = \frac{1.2 \times 10^{-6}}{2 \times 10^{-4}} = 6 \times 10^{-3} \text{ m} = \mathbf{6} \text{ mm}$$

Answer: (6)

Sol. Q26.

Solution

Topic: Ray Optics — Apparent Depth

$$d_{\text{app}} = \frac{d_{\text{real}}}{\mu} = \frac{12}{1.5} = \mathbf{8} \text{ cm}$$

Answer: (8)

Sol. Q27.

Solution

Topic: Dual Nature of Radiation — Photon Energy

$$E = \frac{hc}{\lambda} = \frac{1240 \text{ eV} \cdot \text{nm}}{124 \text{ nm}} = \mathbf{10} \text{ eV}$$

Answer: (10)

Sol. Q28.

Solution

Topic: AC Circuits — Ideal Transformer Current

The turns ratio is $N_s/N_p = 1000/100 = 10$ (step-up). For an ideal transformer, power in = power out:

$$V_p I_p = V_s I_s \implies I_s = \frac{I_p \times N_p}{N_s} = \frac{0.5 \times 100}{1000} = 0.05 \text{ A} = \mathbf{50} \text{ mA}$$

Answer: (50)

Sol. Q29.

Solution

Topic: Nuclei — Binding Energy Per Nucleon

For ${}^4_2\text{He}$ (mass number $A = 4$):

$$\frac{BE}{A} = \frac{28.3\text{ MeV}}{4} = \mathbf{7.07}\text{ MeV}$$

Answer: (7.07)

Sol. Q30.

Solution

Topic: Current Electricity — Resistance at Higher Temperature

$$R = R_0(1+\alpha T) = 5\times(1+4\times10^{-3}\times200) = 5\times(1+0.8) = 5\times1.8 = \mathbf{9\ \Omega}$$

Answer: (9)

ANSWER KEY

Section A — MCQ Answer Key

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

Section B — Numerical Answer Key

Q	Ans	Q	Ans
21	12	22	10
23	25	24	2000
25	6	26	8
27	10	28	50
29	7.07	30	9