GAT-B Physics

Sample Paper – 4

Duration: 23 Minutes **Maximum Marks: 15**

Instructions

- This paper contains **15 Multiple Choice Questions** (Single Correct Answer), modelled on the Physics portion of **GAT-B** Section A.
- Each correct answer carries **+1 mark**. There is a deduction of **0.5 mark** for each wrong answer. Unattempted questions carry zero marks.
- Only **one** option is correct per question.
- Syllabus level: **Class 11 & 12 (NCERT) Physics** — Mechanics, Thermodynamics, Waves, Optics, Electricity & Magnetism, Modern Physics.
- Personal calculators, mobile phones, and other electronic gadgets are strictly prohibited. A simple on-screen calculator is provided in the CBT interface.

Q1. The dimensional formula of **surface tension** is:

(A) $[\mathrm{M\,L\,T^{-2}}]$

(B) $[\mathrm{M\,L^2\,T^{-2}}]$

(C) $[\mathrm{M\,T^{-2}}]$

(D) $[\mathrm{M\,L^{-1}\,T^{-2}}]$

Q2. A stone is thrown **horizontally** from the edge of a cliff $80\,\mathrm{m}$ high with a speed of $20\,\mathrm{m\,s^{-1}}$. Taking $g = 10\,\mathrm{m\,s^{-2}}$, the horizontal distance from the base of the cliff at which the stone strikes the ground is:

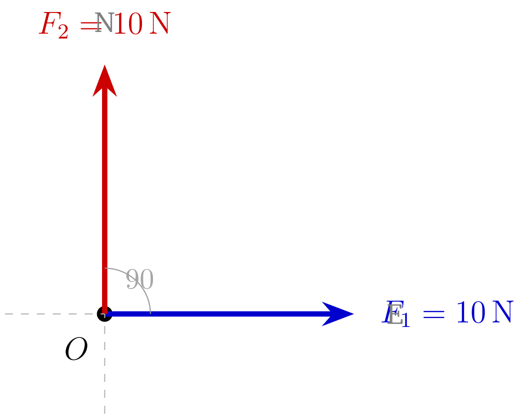
(A) $40\,\mathrm{m}$

(B) $80\,\mathrm{m}$

(C) $100\,\mathrm{m}$

(D) $160\,\mathrm{m}$

Q3. Three coplanar concurrent forces act on a particle in equilibrium. Two of the forces, $F_1 = 10\,\mathrm{N}$ directed East and $F_2 = 10\,\mathrm{N}$ directed North, are shown in the figure. The magnitude of the third force F_3 needed for equilibrium is:



(A) $10\,\mathrm{N}$

(B) $20\,\mathrm{N}$

(C) $5\sqrt{2}\,\mathrm{N}$

(D) $10\sqrt{2}\,\mathrm{N}$

Q4. A ball of mass $4\,\mathrm{kg}$ moving at $6\,\mathrm{m\,s^{-1}}$ collides head-on with a stationary ball of mass $2\,\mathrm{kg}$. The coefficient of restitution between them is $e = 0.5$. The speed of the $4\,\mathrm{kg}$ ball *after* the collision is:

(A) $3\,\mathrm{m\,s^{-1}}$

(B) $4\,\mathrm{m\,s^{-1}}$

(C) $2\,\mathrm{m\,s^{-1}}$

(D) $5\,\mathrm{m\,s^{-1}}$

Q5. The acceleration due to gravity at depth d below Earth's surface (radius R, uniform density) is $g_d = g_0\left(1 - \dfrac{d}{R}\right)$. At what depth is g_d exactly **half** the surface value g_0?

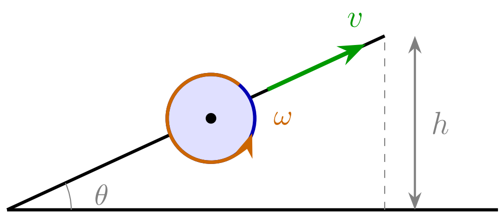
(A) $\dfrac{R}{4}$

(B) $\dfrac{R}{3}$

(C) $\dfrac{R}{2}$

(D) $\dfrac{2R}{3}$

Q6. A **solid sphere** of mass M and radius R starts from rest and rolls *without slipping* down a smooth inclined plane of vertical height h, as shown. The speed of its centre of mass at the bottom of the incline is:



(A) $\sqrt{2gh}$

(B) $\sqrt{\dfrac{10gh}{7}}$

(C) $\sqrt{\dfrac{4gh}{3}}$

(D) $\sqrt{\dfrac{5gh}{3}}$

Q7. A Carnot engine absorbs $Q_H = 1200\,\mathrm{J}$ of heat from a source at $T_H = 600\,\mathrm{K}$ and rejects heat to a sink at $T_C = 300\,\mathrm{K}$. The **work done** by the engine per cycle is:

(A) $400\,\mathrm{J}$

(B) $800\,\mathrm{J}$

(C) $300\,\mathrm{J}$

(D) $600\,\mathrm{J}$

Q8. For a **diatomic ideal gas** at room temperature (vibrational modes frozen), the ratio of specific heats $\gamma = C_p/C_v$ is:

(A) 1.40

(B) 1.67

(C) 1.30

(D) 1.50

Q9. A charge $q = +2\,\mu\mathrm{C}$ is moved slowly from point A (electric potential $V_A = 100\,\mathrm{V}$) to point B (electric potential $V_B = 400\,\mathrm{V}$). The work done *by the external agent* is:

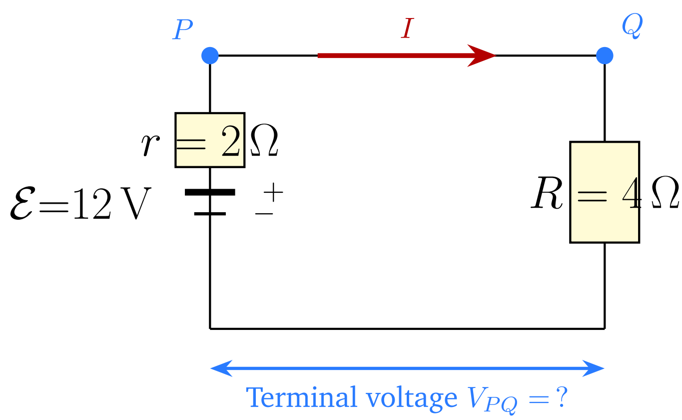
(A) $0.2\,\mathrm{mJ}$

(B) $0.4\,\mathrm{mJ}$

(C) $0.6\,\mathrm{mJ}$

(D) $1.2\,\mathrm{mJ}$

Q10. A battery of emf $\mathcal{E} = 12\,\mathrm{V}$ with internal resistance $r = 2\,\Omega$ is connected to an external resistance $R = 4\,\Omega$, as shown in the circuit. The **terminal voltage** of the battery is:



(A) $12\,\mathrm{V}$

(B) $8\,\mathrm{V}$

(C) $6\,\mathrm{V}$

(D) $10\,\mathrm{V}$

Q11. An inductor of self-inductance $L = 0.5\,\mathrm{H}$ is connected in series with a resistor $R = 100\,\Omega$ to form an LR circuit. The **time constant** τ of this circuit is:

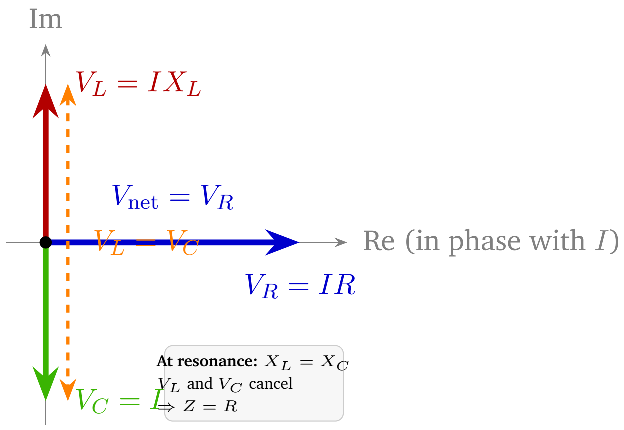
(A) $50\,\mathrm{ms}$

(B) $0.5\,\mathrm{ms}$

(C) $0.2\,\mathrm{ms}$

(D) $5\,\mathrm{ms}$

Q12. A series LCR circuit has $L = 2\,\mathrm{H}$, $C = 50\,\mu\mathrm{F}$, and $R = 100\,\Omega$. It is driven by an ac source of frequency $f = \dfrac{50}{\pi}\,\mathrm{Hz}$. The phasor diagram for the voltages is shown below. The impedance Z of the circuit is:



(A) $100\,\Omega$

(B) $200\,\Omega$

(C) $283\,\Omega$

(D) $400\,\Omega$

Q13. In a **single-slit diffraction** experiment, monochromatic light of wavelength $\lambda = 500\,\text{nm}$ passes through a slit of width $a = 0.2\,\text{mm}$. A screen is placed $D = 2\,\text{m}$ away. The **width of the central bright maximum** on the screen is:

(A) $0.5\,\text{cm}$

(B) $2.0\,\text{cm}$

(C) $1.0\,\text{cm}$

(D) $4.0\,\text{cm}$

Q14. The binding energy per nucleon is **maximum** for which of the following nuclides? (Approximate values: ^{1}H $\approx 0\,\text{MeV}$; ^{4}He $\approx 7.1\,\text{MeV}$; ^{56}Fe $\approx 8.8\,\text{MeV}$; ^{238}U $\approx 7.6\,\text{MeV}$ per nucleon.)

(A) ^{1}H (hydrogen-1)

(B) ^{56}Fe (iron-56)

(C) ^{238}U (uranium-238)

(D) ^{4}He (helium-4)

Q15. In a **common-emitter** configuration of an NPN transistor, the base current is $I_B = 50\,\mu\text{A}$ and the collector current is $I_C = 4\,\text{mA}$. The **current gain** β (or h_{FE}) of the transistor is:

(A) 40

(B) 60

(C) 100

(D) 80

Detailed Solutions

Q1.

Solution

Concept — Dimensional Analysis (Surface Tension): Surface tension is defined as force per unit length (or equivalently, energy per unit area):

$$[\text{Surface tension}] = \frac{[F]}{[l]} = \frac{[\mathrm{M\,L\,T^{-2}}]}{[\mathrm{L}]} = [\mathrm{M\,T^{-2}}]$$

Step 1 — Verify via energy/area route:

$$[\text{Surface tension}] = \frac{[\text{Energy}]}{[\text{Area}]} = \frac{[\mathrm{M\,L^2\,T^{-2}}]}{[\mathrm{L^2}]} = [\mathrm{M\,T^{-2}}] \quad \checkmark$$

Why other options are wrong:

- Option A: $[\mathrm{M\,L\,T^{-2}}]$ is the dimension of *force* (newton) — one extra $[\mathrm{L}]$ factor.
- Option B: $[\mathrm{M\,L^2\,T^{-2}}]$ is the dimension of *energy* (joule) — two extra $[\mathrm{L}]$ factors.
- Option D: $[\mathrm{M\,L^{-1}\,T^{-2}}]$ is the dimension of *pressure/stress* — has $[\mathrm{L^{-1}}]$.

Final Answer: Surface tension $= [\mathrm{M\,T^{-2}}] \Rightarrow \boxed{\mathrm{C}}$

Answer: (C) Go Back to Q1

Q2.

Solution

Concept — Horizontal Projectile Motion: When a body is projected horizontally, its vertical and horizontal motions are completely independent. There is no initial vertical velocity.

Step 1 — Time of flight (vertical free fall):

$$h = \tfrac{1}{2}g\,t^2 \implies 80 = \tfrac{1}{2}(10)\,t^2 \implies t^2 = 16 \implies t = 4\,\mathrm{s}$$

Step 2 — Horizontal range:

$$R = u_x \cdot t = 20\,\mathrm{m\,s^{-1}} \times 4\,\mathrm{s} = \mathbf{80}\,\mathrm{m}$$

Why other options are wrong:

- Option A (40 m): Arises from using $t = 2\,\text{s}$ — forgot to square-root properly.
- Option C (100 m): Incorrect formula; perhaps uses $\sqrt{2h/g}$ as range directly.
- Option D (160 m): Uses $t = 8\,\text{s}$ — doubled the correct time.

Final Answer: Horizontal range $= 80\,\text{m} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q2

Q3.

Solution

Concept — Equilibrium of Concurrent Forces (Vector Cancellation): For a particle in equilibrium, the vector sum of all forces equals zero: $\vec{F}_1 + \vec{F}_2 + \vec{F}_3 = \vec{0}$, so $\vec{F}_3 = -(\vec{F}_1 + \vec{F}_2)$.

Step 1 — Find the resultant of F_1 and F_2:

$$|\vec{F}_1 + \vec{F}_2| = \sqrt{F_1^2 + F_2^2} = \sqrt{10^2 + 10^2} = \sqrt{200} = 10\sqrt{2}\,\text{N}$$

(direction: 45 NE, since F_1 is East and F_2 is North with equal magnitudes).

Step 2 — Magnitude of F_3: $F_3 = |\vec{F}_1 + \vec{F}_2| = 10\sqrt{2}\,\text{N}$, directed 45 SW (opposite to resultant).

Why other options are wrong:

- Option A (10 N): Magnitude of each individual force — ignores vector addition.
- Option B (20 N): Arithmetic sum $10 + 10$ — not valid for perpendicular vectors.
- Option C ($5\sqrt{2}\,\text{N}$): Confuses $\sqrt{50}$ with $\sqrt{200}$; the diagonal of a 10-10 right triangle is $\sqrt{200} = 10\sqrt{2}$, not $\sqrt{50} = 5\sqrt{2}$.

Final Answer: $F_3 = 10\sqrt{2}\,\text{N} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q3

Q4.

Solution

Concept — Partially Inelastic Collision (Coefficient of Restitution): Two equations govern the collision: (i) conservation of linear momentum and (ii) Newton's law of restitution.

Step 1 — Set up equations: Let v_1 and v_2 be velocities of the 4 kg and 2 kg balls after collision.

$$\text{(Momentum)} \quad m_1u_1 = m_1v_1 + m_2v_2 \quad \Rightarrow 4(6) = 4v_1 + 2v_2 \Rightarrow 24 = 4v_1 + 2v_2 \quad (1)$$

$$\text{(Restitution)} \quad e\,(u_1 - u_2) = v_2 - v_1 \quad \Rightarrow 0.5 \times 6 = v_2 - v_1 \Rightarrow v_2 - v_1 = 3 \quad (2)$$

Step 2 — Solve the system: From (2): $v_2 = v_1 + 3$. Substituting in (1):

$$24 = 4v_1 + 2(v_1 + 3) = 6v_1 + 6 \implies v_1 = \frac{18}{6} = \mathbf{3}\,\mathrm{m\,s^{-1}}$$

(Also: $v_2 = 3 + 3 = 6\,\mathrm{m\,s^{-1}}$; verify momentum: $4(3) + 2(6) = 24$ ✓)

Why other options are wrong:

- Option B (4 m/s): Uses only momentum conservation, ignoring e.
- Option C (2 m/s): Sign error in the restitution equation ($v_1 - v_2 = 3$ used instead of $v_2 - v_1 = 3$).
- Option D (5 m/s): Arithmetic error when solving the simultaneous equations.

Final Answer: $v_1 = 3\,\mathrm{m\,s^{-1}} \Rightarrow \boxed{\text{A}}$

$\boxed{\text{Answer: (A)}}$ Go Back to Q4

Q5.

Solution

Concept — Variation of g with Depth (Linear Decrease): Inside a uniform-density Earth, gravity decreases linearly with depth:

$$g_d = g_0\left(1 - \frac{d}{R}\right)$$

Step 1 — Apply the half-value condition:

$$g_0\left(1-\frac{d}{R}\right)=\frac{g_0}{2} \implies 1-\frac{d}{R}=\frac{1}{2} \implies \frac{d}{R}=\frac{1}{2} \implies \boxed{d=\frac{R}{2}}$$

Why other options are wrong:

- Option A ($R/4$): Gives $g_d = \frac{3}{4}\,g_0$ (75% of surface value), not 50%.
- Option B ($R/3$): Gives $g_d = \frac{2}{3}\,g_0$ (67% of surface value).
- Option D ($2R/3$): Gives $g_d = \frac{1}{3}\,g_0$ (only 33% of surface value).

Final Answer: $d = R/2 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q5

Q6.

Solution

Concept — Rolling Without Slipping (Energy Conservation): Total mechanical energy is conserved. For rolling without slipping, $v_{\text{cm}} = R\omega$.

Step 1 — Moment of inertia of a solid sphere:

$$I = \frac{2}{5}MR^2$$

Step 2 — Apply energy conservation ($K_{\text{rot}} + K_{\text{trans}} = Mgh$):

$$Mgh = \frac{1}{2}Mv^2 + \frac{1}{2}I\omega^2 = \frac{1}{2}Mv^2 + \frac{1}{2}\cdot\frac{2}{5}MR^2\cdot\frac{v^2}{R^2} = \frac{1}{2}Mv^2 + \frac{1}{5}Mv^2 = \frac{7}{10}Mv^2$$

$$\Rightarrow \quad v^2 = \frac{10gh}{7} \quad \Rightarrow \quad v = \sqrt{\frac{10gh}{7}}$$

Why other options are wrong:

- Option A ($\sqrt{2gh}$): Ignores rotational kinetic energy entirely (point-particle result).
- Option C ($\sqrt{4gh/3}$): Correct formula for a *solid cylinder* ($I = \frac{1}{2}MR^2$, giving $Mgh = \frac{3}{4}Mv^2$).
- Option D ($\sqrt{5gh/3}$): Does not correspond to any standard rolling body formula.

Final Answer: $v = \sqrt{10gh/7} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q6

Q7.

Solution

Concept — Carnot Engine Efficiency (Second Law of Thermodynamics): The Carnot engine has the maximum possible efficiency for a heat engine operating between two temperatures:

$$\eta_{\text{Carnot}} = 1 - \frac{T_C}{T_H}$$

Step 1 — Compute efficiency:

$$\eta = 1 - \frac{300\,\text{K}}{600\,\text{K}} = 1 - 0.5 = 0.50\ (50\%)$$

Step 2 — Compute work done per cycle:

$$W = \eta Q_H = 0.50 \times 1200\,\text{J} = \mathbf{600}\,\text{J}$$

(Heat rejected to cold reservoir: $Q_C = Q_H - W = 600\,\text{J}$, consistent with $Q_C/Q_H = T_C/T_H = 1/2$.)

Why other options are wrong:

- Option A (400 J): Corresponds to $\eta = 1/3$ — incorrect temperature ratio.
- Option B (800 J): Confuses work with heat absorbed; $W > Q_H/2$ is impossible by the second law here.
- Option C (300 J): This equals $Q_C/2$ or $Q_H/4$ — arises from wrong formula.

Final Answer: $W = 600\,\text{J} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q7

Q8.

Solution

Concept — Equipartition Theorem and Specific Heat Ratio γ: Each quadratic degree of freedom contributes $\frac{1}{2}k_BT$ to average energy per molecule, giving $C_v = (f/2)R$ per mole.

Step 1 — Degrees of freedom for diatomic gas at room temperature: $f = 5$: three translational (x, y, z) + two rotational (about two axes perpendicular to the bond). Vibrational modes are frozen at room temperature.

Step 2 — Compute C_v, C_p, and γ:

$$C_v = \frac{f}{2}R = \frac{5}{2}R, \quad C_p = C_v + R = \frac{7}{2}R$$

$$\gamma = \frac{C_p}{C_v} = \frac{7/2}{5/2} = \frac{7}{5} = \mathbf{1.40}$$

Why other options are wrong:

- Option B (1.67): $\gamma = 5/3$ applies to *monatomic* ideal gases ($f = 3$, e.g. Ar, He).
- Option C (1.30): Would require $f \approx 6.7$ degrees of freedom — no standard gas at room temperature.
- Option D (1.50): Corresponds to $f = 4$ — not a physically realised mode count for common gases.

Final Answer: $\gamma = 1.40 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q8

Q9.

Solution

Concept — Work Done by External Agent in Moving a Charge: The work done by an external agent to move a charge q quasi-statically between two points at potentials V_A and V_B is:

$$W_{\text{ext}} = q(V_B - V_A)$$

(Positive when a positive charge moves to a higher potential.)

Step 1 — Substitute values:

$$W_{\text{ext}} = 2 \times 10^{-6}\,\text{C} \times (400 - 100)\,\text{V} = 2 \times 10^{-6} \times 300 = 6 \times 10^{-4}\,\text{J} = \mathbf{0.6}\,\text{mJ}$$

Why other options are wrong:

- Option A (0.2 mJ): Uses $\Delta V = 100\,\text{V}$ (only V_A) instead of the difference $V_B - V_A = 300\,\text{V}$.
- Option B (0.4 mJ): Uses $\Delta V = 200\,\text{V}$ — arithmetic error.
- Option D (1.2 mJ): Uses $q = 4\,\mu\text{C}$ (double the given charge).

Final Answer: $W_{\text{ext}} = 0.6\,\text{mJ} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q9

Q10.

Solution

Concept — Terminal Voltage of a Battery (EMF and Internal Resistance): When a battery of emf $\mathcal{E}$ and internal resistance r supplies current I to an external circuit, the terminal voltage is:

$$V_T = \mathcal{E} - I\,r$$

Step 1 — Calculate the current:

$$I = \frac{\mathcal{E}}{R + r} = \frac{12}{4 + 2} = \frac{12}{6} = 2\,\mathrm{A}$$

Step 2 — Calculate the terminal voltage:

$$V_T = \mathcal{E} - I\,r = 12 - 2 \times 2 = 12 - 4 = \mathbf{8}\,\mathrm{V}$$

(Cross-check: $V_T = I\,R = 2 \times 4 = 8\,\mathrm{V}\ \checkmark$)

Why other options are wrong:

- Option A ($12\,\mathrm{V}$): This is the *emf* $\mathcal{E}$, not the terminal voltage. Terminal voltage equals emf only when $I = 0$ (open circuit).
- Option C ($6\,\mathrm{V}$): Equals $\mathcal{E}/2$ — no physical basis; arises from ignoring which resistance the voltage is measured across.
- Option D ($10\,\mathrm{V}$): Uses $I\,r = 2\,\mathrm{V}$ (implies $r = 1\,\Omega$, not the given $2\,\Omega$).

Final Answer: Terminal voltage $= 8\,\mathrm{V} \Rightarrow \boxed{\mathrm{B}}$

Answer: (B) Go Back to Q10

Q11.

Solution

Concept — Time Constant of an LR Circuit: When a dc voltage is applied to a series LR circuit, the current builds up exponentially. The characteristic time scale is the time constant:

$$\tau = \frac{L}{R}$$

After one time constant, the current reaches $(1 - e^{-1}) \approx 63.2\%$ of its final steady-state value.

Step 1 — Substitute values:

$$\tau = \frac{L}{R} = \frac{0.5\,\mathrm{H}}{100\,\Omega} = 5 \times 10^{-3}\,\mathrm{s} = \mathbf{5}\,\mathrm{ms}$$

Why other options are wrong:

- Option A (50 ms): Off by a factor of 10; would require $L = 5\,\mathrm{H}$ or $R = 10\,\Omega$.
- Option B (0.5 ms): Off by a factor of 10 in the other direction; perhaps divided by 10 erroneously.
- Option C (0.2 ms): Mistakenly computes $R/L = 200\,\mathrm{s}^{-1}$ and then takes its reciprocal in wrong units ($1/200\,\mathrm{s} = 5\,\mathrm{ms}$, actually); 0.2 ms corresponds to $R = 2500\,\Omega$ with $L = 0.5\,\mathrm{H}$.

Final Answer: $\tau = 5\,\mathrm{ms} \Rightarrow \boxed{\mathrm{D}}$

Answer: (D) **Go Back to Q11**

Q12.

Solution

Concept — Series LCR Circuit at Resonance: At resonance, inductive and capacitive reactances are equal ($X_L = X_C$), they cancel in the phasor diagram, and impedance is minimum and purely resistive.

Step 1 — Compute angular frequency:

$$\omega = 2\pi f = 2\pi \cdot \frac{50}{\pi} = 100\,\mathrm{rad\,s^{-1}}$$

Step 2 — Compute individual reactances:

$$X_L = \omega L = 100 \times 2 = 200\,\Omega$$

$$X_C = \frac{1}{\omega C} = \frac{1}{100 \times 50 \times 10^{-6}} = \frac{1}{5 \times 10^{-3}} = 200\,\Omega$$

Since $X_L = X_C = 200\,\Omega$, the circuit is **at resonance**.

Step 3 — Impedance at resonance:

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{(100)^2 + (200 - 200)^2} = \sqrt{10{,}000} = \mathbf{100\,\Omega}$$

Why other options are wrong:

- Option B ($200\,\Omega$): The value of X_L (or X_C) alone — not the overall impedance.
- Option C ($283\,\Omega$): $\approx 200\sqrt{2}\,\Omega$ — as if X_L and X_C added rather than subtracted.
- Option D ($400\,\Omega$): $X_L + X_C = 400\,\Omega$ — simple arithmetic sum, ignores the phasor subtraction.

Final Answer: $Z = 100\,\Omega \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q12

Q13.

Solution

Concept — Single-Slit Diffraction (Central Maximum Width): First minima occur where $a \sin\theta = \pm\lambda$. For small angles ($\sin\theta \approx \theta$), the angular half-width is $\theta_1 = \lambda/a$. The *full* width of the central maximum on a screen at distance D is:

$$W = 2D \tan\theta_1 \approx \frac{2\lambda D}{a}$$

Step 1 — Substitute values: $\lambda = 500\,\text{nm} = 5 \times 10^{-7}\,\text{m}$, $D = 2\,\text{m}$, $a = 0.2\,\text{mm} = 2 \times 10^{-4}\,\text{m}$.

$$W = \frac{2 \times 5 \times 10^{-7} \times 2}{2 \times 10^{-4}} = \frac{2 \times 10^{-6}}{2 \times 10^{-4}} = 1 \times 10^{-2}\,\text{m} = \mathbf{1.0}\,\text{cm}$$

Why other options are wrong:

- Option A (0.5 cm): Uses the half-width $\lambda D/a$ instead of the full width $2\lambda D/a$.
- Option B (2.0 cm): Doubles the correct answer — perhaps misread a as $0.1\,\text{mm}$.

- Option D (4.0 cm): Four times the correct answer — perhaps used $a = 0.05\,\text{mm}$ or made two successive factor-of-2 errors.

Final Answer: Width of central maximum $= 1.0\,\text{cm} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q13

Q14.

Solution

Concept — Binding Energy per Nucleon and the Stability Valley: The binding energy per nucleon (BE/A) measures how tightly nucleons are bound. It rises steeply from hydrogen, peaks around $A \approx 56$ (iron group), and slowly decreases for heavier nuclei. This is why both *fission* (of heavy nuclei) and *fusion* (of light nuclei) release energy.

Step 1 — Compare the given nuclides:

Nuclide	Mass number A	BE/nucleon (approx.)
^{1}H	1	$\approx 0\,\text{MeV}$ (no binding; single proton)
^{4}He	4	$\approx 7.1\,\text{MeV}$
^{56}Fe	56	$\approx 8.8\,\text{MeV}$ **(maximum)**
^{238}U	238	$\approx 7.6\,\text{MeV}$

Why other options are wrong:

- Option A (^{1}H): A free proton has essentially zero binding energy per nucleon.
- Option C (^{238}U): BE/A $\approx 7.6\,\text{MeV}$ — below the iron peak; this is why U can undergo fission to release energy.
- Option D (^{4}He): BE/A $\approx 7.1\,\text{MeV}$ — significantly less than iron, despite the alpha particle's exceptional stability among light nuclei.

Final Answer: ^{56}Fe has the maximum binding energy per nucleon $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q14

Q15.

Solution

Concept — Common-Emitter Transistor: Current Gain β: In a common-emitter (CE) configuration, the dc current gain β (also written h_{FE}) is defined as:

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

The emitter current satisfies $I_E = I_C + I_B$.

Step 1 — Convert units:

$$I_B = 50\,\mu\text{A} = 50 \times 10^{-6}\,\text{A}, \qquad I_C = 4\,\text{mA} = 4 \times 10^{-3}\,\text{A}$$

Step 2 — Compute β:

$$\beta = \frac{I_C}{I_B} = \frac{4 \times 10^{-3}}{50 \times 10^{-6}} = \frac{4000}{50} = \mathbf{80}$$

Step 3 — Check emitter current:

$$I_E = I_C + I_B = 4.000\,\text{mA} + 0.050\,\text{mA} = 4.05\,\text{mA}\checkmark$$

Why other options are wrong:

- Option A (40): Corresponds to $I_B = 100\,\mu\text{A}$ with the same I_C — double the given base current.
- Option B (60): Pure arithmetic error; $4000/50 \neq 60$.
- Option C (100): Would require $I_C = 5\,\text{mA}$ for $I_B = 50\,\mu\text{A}$ — 25% more than the given collector current.

Final Answer: $\beta = 80 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q15

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