PGIMER BSc Nursing Physics

Sample Paper – 6

Duration: 23 Minutes **Maximum Marks: 25**

Instructions

- This paper contains **25** Multiple Choice Questions (Single Correct Answer), modelled on the Physics portion of the **PGIMER BSc Nursing** entrance exam.
- Each correct answer carries **+1 mark**. **0.25 mark** is deducted for every incorrect answer. Unattempted questions carry **0 marks**.
- Only **one** option is correct. Choose carefully.
- Syllabus level: **Class 11 and 12 (NCERT) Physics**.
- The exam is conducted as a computer-based test. Personal calculators, mobile phones, log tables, and other electronic gadgets are strictly prohibited.

Q1. Newton's law of gravitation is $F = \frac{Gm_1m_2}{r^2}$, where F is the gravitational force, m_1 and m_2 are masses and r is the separation. The dimensional formula of the gravitational constant G is:

(A) $[ML^2T^{-2}]$

(B) $[M^{-1}L^2T^{-2}]$

(C) $[M^{-1}L^3T^{-2}]$

(D) $[ML^3T^{-2}]$

Q2. The displacement of a particle moving along a straight line is given by $x(t) = 3t^2 + 2t + 1$, where x is in metres and t is in seconds. The velocity of the particle at $t = 2$ s is:

(A) 12 m s^{-1}

(B) 14 m s^{-1}

(C) 16 m s^{-1}

(D) 10 m s^{-1}

Q3. A projectile is launched with an initial speed of 20 m s^{-1} at an angle of 30° above the horizontal. Taking $g = 10 \text{ m s}^{-2}$, the maximum height reached is $\left(H = \dfrac{u^2 \sin^2\theta}{2g}\right)$:

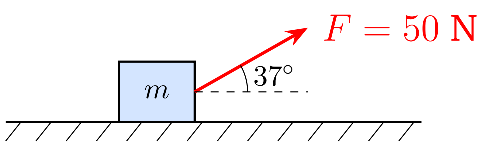
(A) 10 m

(B) 5 m

(C) 2.5 m

(D) 20 m

Q4. A block of mass 10 kg resting on a smooth horizontal surface is pulled by a force of 50 N applied at 37° above the horizontal ($\cos 37^\circ = 0.8$), as shown. The horizontal acceleration of the block is:



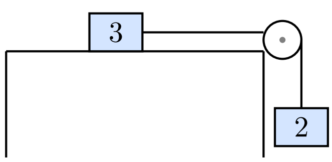
(A) 4 m s^{-2}

(B) 5 m s^{-2}

(C) 3 m s^{-2}

(D) 2.5 m s^{-2}

Q5. A block of mass 3 kg lying on a smooth horizontal table is connected by a light inextensible string passing over a frictionless pulley at the edge of the table to a hanging block of mass 2 kg, as shown. Taking $g = 10 \text{ m s}^{-2}$, the acceleration of the system is:



(A) 2 m s^{-2}

(B) 4 m s^{-2}

(C) 5 m s^{-2}

(D) 6 m s^{-2}

Q6. A body of mass 2 kg moves with a linear momentum of magnitude 20 kg m s^{-1}. Using the relation $K = \frac{p^2}{2m}$, the kinetic energy of the body is:

(A) 200 J

(B) 50 J

(C) 400 J

(D) 100 J

Q7. The moment of inertia of a uniform circular disc of mass 4 kg and radius 0.5 m about an axis passing through its centre and perpendicular to its plane is $\left(I = \frac{1}{2}MR^2\right)$:

(A) 1.0 kg m^2

(B) 2.0 kg m^2

(C) 0.25 kg m^2

(D) 0.5 kg m^2

Q8. The weight of a body on the surface of the Earth is 600 N. The body is taken to the surface of a planet whose mass is twice that of the Earth and whose radius is twice that of the Earth. Using $g = \frac{GM}{R^2}$, the weight of the body on that planet is:

(A) 300 N

(B) 600 N

(C) 150 N

(D) 1200 N

Q9. A tank is open to the atmosphere ($P_0 = 1.0 \times 10^5$ Pa). The pressure at a depth of 5 m below the surface of the water ($\rho = 1000$ kg m^{-3}, $g = 10$ m s^{-2}) is $(P = P_0 + \rho g h)$:

(A) 5×10^4 Pa

(B) 1.0×10^5 Pa

(C) 1.5×10^5 Pa

(D) 2.0×10^5 Pa

Q10. In one cycle, a heat engine absorbs 500 J of heat from a hot reservoir and rejects 400 J to a cold reservoir. The efficiency of the engine is $\left(\eta = 1 - \frac{Q_2}{Q_1}\right)$:

(A) 80%

(B) 40%

(C) 20%

(D) 25%

Q11. For the molecules of an ideal gas, the most probable speed is $v_{mp} = \sqrt{\frac{2RT}{M}}$ and the root-mean-square speed is $v_{rms} = \sqrt{\frac{3RT}{M}}$. The ratio $\frac{v_{mp}}{v_{rms}}$ is:

(A) $\sqrt{\frac{2}{3}}$

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

(C) $\sqrt{2}$

(D) $\sqrt{3}$

Q12. A block of mass 2 kg is connected to two identical springs, each of force constant 100 N m^{-1}, joined in parallel. Taking $\pi = 3.14$, the time period of oscillation is $\left(T = 2\pi\sqrt{\frac{m}{k_{\text{eff}}}}\right)$:

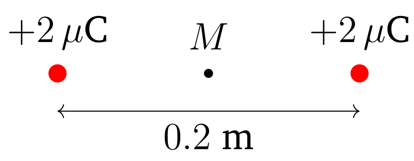
(A) 0.31 s

(B) 1.26 s

(C) 0.44 s

(D) 0.63 s

Q13. Two equal point charges, each of $+2\ \mu$C, are fixed at points 0.2 m apart in vacuum. The magnitude of the net electric field at the midpoint M of the line joining them is:



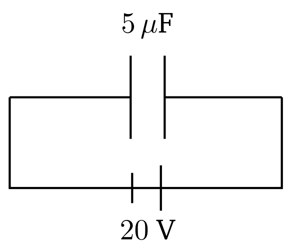
(A) Zero

(B) 9×10^5 N C^{-1}

(C) 1.8×10^6 N C^{-1}

(D) 3.6×10^6 N C^{-1}

Q14. A capacitor of capacitance $5\ \mu$F is connected across a battery of 20 V, as shown. The charge stored on the capacitor is $(Q = CV)$:



(A) $20\ \mu$C

(B) $50\ \mu$C

(C) $100\ \mu$C

(D) $25\ \mu$C

Q15. Two cells, each of emf 2 V and internal resistance $0.5\ \Omega$, are connected in series with each other and with an external resistance of $3\ \Omega$. The current drawn from the combination is:

(A) 1 A

(B) 2 A

(C) 0.5 A

(D) 4 A

Q16. A potential difference of 10 V is maintained across a resistor of $5\ \Omega$. The power dissipated in the resistor is $\left(P = \dfrac{V^2}{R}\right)$:

(A) 10 W

(B) 20 W

(C) 50 W

(D) 2 W

Q17. A particle of charge 1.6×10^{-19} C and mass 1.6×10^{-27} kg moves in a uniform magnetic field of 0.2 T. Taking $\pi = 3.14$, its cyclotron frequency is $\left(f = \dfrac{qB}{2\pi m}\right)$:

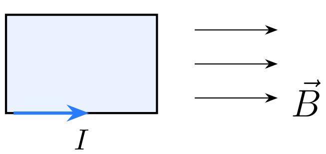
(A) 1.6×10^6 Hz

(B) 6.4×10^6 Hz

(C) 3.2×10^6 Hz

(D) 2.0×10^6 Hz

Q18. A rectangular coil of 100 turns and area $0.01\ \text{m}^2$ carries a current of 2 A. Its plane is parallel to a uniform magnetic field of 0.5 T, as shown. The torque on the coil is $(\tau = NIAB\sin\theta)$:



(A) 0.5 N m

(B) 2.0 N m

(C) 0.25 N m

(D) 1.0 N m

Q19. A capacitor of capacitance $10\ \mu$F is connected to an AC source of rms voltage 100 V and angular frequency 1000 rad s^{-1}. The rms current through the capacitor is $\left(X_C = \frac{1}{\omega C}\right)$:

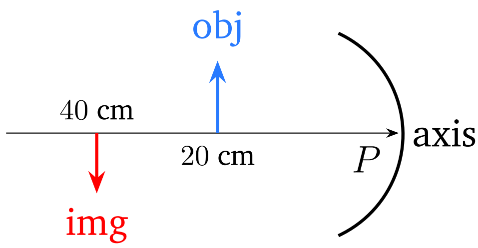
(A) 0.5 A

(B) 2 A

(C) 10 A

(D) 1 A

Q20. An object placed 20 cm in front of a concave mirror forms a real image at 40 cm from the mirror, as shown schematically. The magnification produced is $\left(m = -\frac{v}{u}\right)$:



(A) -1

(B) -2

(C) $+2$

(D) -0.5

Q21. In an interference experiment, the intensities of the two interfering waves are in the ratio $4:1$. The ratio of the maximum to the minimum resultant intensity is $\left(\frac{I_{\max}}{I_{\min}} = \frac{(\sqrt{I_1}+\sqrt{I_2})^2}{(\sqrt{I_1}-\sqrt{I_2})^2}\right)$:

(A) $9:1$

(B) $3:1$

(C) $4:1$

(D) $16:1$

Q22. A photon has an energy of 3×10^{-19} J. Taking the speed of light $c = 3 \times 10^8$ m s^{-1}, the magnitude of the momentum of the photon is $\left(p = \frac{E}{c}\right)$:

(A) 3×10^{-19} kg m s^{-1}

(B) 9×10^{-27} kg m s^{-1}

(C) 1×10^{-27} kg m s^{-1}

(D) 3×10^{-27} kg m s^{-1}

Q23. For the hydrogen atom, the Rydberg constant is $R = 1.097 \times 10^7$ m^{-1}. The shortest wavelength (series limit) of the Lyman series, given by $\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{\infty}\right)$, is approximately:

(A) 91 nm

(B) 122 nm

(C) 365 nm

(D) 656 nm

Q24. A radioactive sample has a half-life of 6.93 hours. Using $\tau = \frac{T_{1/2}}{0.693}$, the mean life of the sample is:

(A) 6.93 hours

(B) 10 hours

(C) 4.8 hours

(D) 20 hours

Q25. As the temperature of an intrinsic (pure) semiconductor is raised, its electrical conductivity:

(A) decreases

(B) remains constant

(C) first increases, then decreases

(D) increases

Detailed Solutions

Q1.

Solution

Concept — Dimensional analysis: The dimensions of a constant are found by isolating it in its defining equation and substituting the dimensions of the known quantities.

Step 1 — Rearrange the law of gravitation: From $F = \dfrac{Gm_1m_2}{r^2}$, solve for G:

$$G = \frac{Fr^2}{m_1m_2}.$$

Step 2 — Write the dimensions of each quantity: Force: $[F] = [MLT^{-2}]$.

Distance squared: $[r^2] = [L^2]$.

Product of masses: $[m_1m_2] = [M^2]$.

Step 3 — Substitute and simplify:

$$[G] = \frac{[MLT^{-2}]\,[L^2]}{[M^2]}.$$

$$[G] = \frac{[ML^3T^{-2}]}{[M^2]} = [M^{1-2}L^3T^{-2}].$$

$$[G] = [M^{-1}L^3T^{-2}].$$

Why other options are wrong:

- Option A $[ML^2T^{-2}]$: this is the dimension of energy, not G.
- Option B $[M^{-1}L^2T^{-2}]$: the power of length is wrong (should be 3).
- Option D $[ML^3T^{-2}]$: the power of mass is wrong (should be -1).

Final Answer: The dimensional formula of G is $[M^{-1}L^3T^{-2}] \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q1

Q2.

Solution

Concept — Velocity from displacement: The instantaneous velocity is the time derivative of the displacement, $v = \frac{dx}{dt}$.

Step 1 — Write the displacement equation:

$$x(t) = 3t^2 + 2t + 1.$$

Step 2 — Differentiate term by term:

$$\frac{d}{dt}(3t^2) = 6t.$$

$$\frac{d}{dt}(2t) = 2.$$

$$\frac{d}{dt}(1) = 0.$$

Step 3 — Form the velocity expression:

$$v(t) = 6t + 2.$$

Step 4 — Substitute $t = 2$ s:

$$v(2) = 6 \times 2 + 2 = 12 + 2 = 14 \text{ m s}^{-1}.$$

Why other options are wrong:

- Option A (12 m s^{-1}): drops the constant term $+2$.
- Option C (16 m s^{-1}): arithmetic slip in adding.
- Option D (10 m s^{-1}): uses $t = 4/3$ or wrong substitution.

Final Answer: Velocity at $t = 2$ s is 14 m s^{-1} $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q2

Q3.

Solution

Concept — Maximum height of a projectile: Only the vertical component of velocity decides the height; at the top this component is zero, giving $H = \dfrac{u^2 \sin^2\theta}{2g}$.

Step 1 — List the values: Initial speed $u = 20$ m s^{-1}.

Angle $\theta = 30^\circ$, so $\sin 30^\circ = 0.5$.

Acceleration $g = 10$ m s^{-2}.

Step 2 — Substitute into the formula:

$$H = \frac{u^2 \sin^2\theta}{2g} = \frac{(20)^2 \times (0.5)^2}{2 \times 10}.$$

Step 3 — Evaluate the numerator:

$$(20)^2 = 400, \qquad (0.5)^2 = 0.25.$$

$$400 \times 0.25 = 100.$$

Step 4 — Divide by $2g$:

$$H = \frac{100}{20} = 5 \text{ m}.$$

Why other options are wrong:

- Option A (10 m): forgets to square the $\sin\theta$ factor.
- Option C (2.5 m): divides by an extra factor of 2.
- Option D (20 m): uses $\sin\theta = 1$ (vertical launch).

Final Answer: Maximum height $= 5$ m $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q3

Q4.

Solution

Concept — Force applied at an angle: On a smooth surface only the horizontal component of the applied force produces acceleration.

Step 1 — Resolve the applied force: The horizontal component is

$$F_x = F\cos\theta = 50 \times \cos 37^\circ = 50 \times 0.8 = 40 \text{ N}.$$

Step 2 — Note that the surface is smooth: There is no friction, so the horizontal component is the only horizontal force.

Step 3 — Apply Newton's second law:

$$a = \frac{F_x}{m} = \frac{40}{10} = 4 \text{ m s}^{-2}.$$

Why other options are wrong:

- Option B (5 m s^{-2}): uses the full force 50 N without resolving.
- Option C (3 m s^{-2}): uses $\sin 37^\circ = 0.6$ instead of $\cos 37^\circ$.
- Option D (2.5 m s^{-2}): halves the correct result.

Final Answer: Acceleration $= 4$ m s^{-2} $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q4

Q5.

Solution

Concept — Block on a table connected to a hanging block: The weight of the hanging block drives the system; both blocks share the same magnitude of acceleration through the inextensible string.

Step 1 — Identify the driving force: The only external force pulling the system is the weight of the hanging block:

$$F = m_2 g = 2 \times 10 = 20 \text{ N}.$$

Step 2 — Identify the total mass being accelerated: The table block (3 kg) and the hanging block (2 kg) move together:

$$m_{\text{total}} = m_1 + m_2 = 3 + 2 = 5 \text{ kg}.$$

Step 3 — Apply Newton's second law to the whole system:

$$a = \frac{m_2 g}{m_1 + m_2} = \frac{2 \times 10}{3 + 2} = \frac{20}{5} = 4 \text{ m s}^{-2}.$$

Why other options are wrong:

- Option A (2 m s^{-2}): uses the difference of masses, as in an Atwood machine.
- Option C (5 m s^{-2}): divides $m_2 g$ by m_2 only $(20/\ldots)$ wrongly using mass 4.
- Option D (6 m s^{-2}): uses $m_1 g$ as the driving force.

Final Answer: Acceleration $= 4$ m s^{-2} $\Rightarrow \boxed{\text{B}}$

Answer: (B) **Go Back to Q5**

Q6.

Solution

Concept — Kinetic energy and momentum: Since $p = mv$ and $K = \frac{1}{2}mv^2$, eliminating v gives $K = \frac{p^2}{2m}$.

Step 1 — List the values: Momentum $p = 20$ kg m s^{-1}.

Mass $m = 2$ kg.

Step 2 — Square the momentum:

$$p^2 = (20)^2 = 400 \text{ kg}^2 \text{ m}^2 \text{ s}^{-2}.$$

Step 3 — Substitute into the formula:

$$K = \frac{p^2}{2m} = \frac{400}{2 \times 2} = \frac{400}{4} = 100 \text{ J}.$$

Why other options are wrong:

- Option A (200 J): forgets the factor of 2 in the denominator.
- Option B (50 J): divides by an extra factor of 2.
- Option C (400 J): uses p^2 alone without dividing by $2m$.

Final Answer: Kinetic energy $= 100$ J $\Rightarrow \boxed{\text{D}}$

Answer: (D) **Go Back to Q6**

Q7.

Solution

Concept — Moment of inertia of a disc: For a uniform circular disc about its central perpendicular axis, $I = \frac{1}{2}MR^2$.

Step 1 — List the values: Mass $M = 4$ kg.

Radius $R = 0.5$ m, so $R^2 = 0.25$ m^2.

Step 2 — Substitute into the formula:

$$I = \frac{1}{2}MR^2 = \frac{1}{2} \times 4 \times 0.25.$$

Step 3 — Simplify:

$$I = \frac{1}{2} \times 4 \times 0.25 = 2 \times 0.25 = 0.5 \text{ kg m}^2.$$

Why other options are wrong:

- Option A (1.0 kg m^2): uses MR^2 without the $\frac{1}{2}$ factor.
- Option B (2.0 kg m^2): forgets to square the radius.
- Option C (0.25 kg m^2): leaves out the mass.

Final Answer: Moment of inertia $= 0.5$ kg m$^2 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q7

Q8.

Solution

Concept — Surface gravity of a planet: The acceleration due to gravity at a planet's surface is $g = \frac{GM}{R^2}$, so $g \propto \frac{M}{R^2}$.

Step 1 — Form the ratio of the two surface gravities:

$$\frac{g_p}{g_e} = \frac{M_p}{M_e} \times \left(\frac{R_e}{R_p}\right)^2.$$

Step 2 — Put in the given factors: Mass: $M_p = 2M_e$, so $\frac{M_p}{M_e} = 2$.

Radius: $R_p = 2R_e$, so $\left(\frac{R_e}{R_p}\right)^2 = \left(\frac{1}{2}\right)^2 = \frac{1}{4}$.

Step 3 — Combine the factors:

$$\frac{g_p}{g_e} = 2 \times \frac{1}{4} = \frac{1}{2}.$$

Step 4 — Scale the weight: Weight is proportional to g, so

$$W_p = \frac{1}{2}W_e = \frac{1}{2} \times 600 = 300 \text{ N}.$$

Why other options are wrong:

- Option B (600 N): assumes the same gravity on both planets.
- Option C (150 N): divides by 4 instead of 2.
- Option D (1200 N): ignores the radius factor and only doubles.

Final Answer: Weight on the planet $= 300$ N $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q8

Q9.

Solution

Concept — Pressure at a depth: The absolute pressure at depth h in a liquid open to the atmosphere is $P = P_0 + \rho g h$.

Step 1 — List the values: Atmospheric pressure $P_0 = 1.0 \times 10^5$ Pa.

Density $\rho = 1000$ kg m^{-3}.

$g = 10$ m s^{-2}, depth $h = 5$ m.

Step 2 — Compute the liquid (gauge) pressure:

$$\rho g h = 1000 \times 10 \times 5 = 50000 = 5 \times 10^4 \text{ Pa}.$$

Step 3 — Add the atmospheric pressure:

$$P = P_0 + \rho g h = 1.0 \times 10^5 + 0.5 \times 10^5.$$

$$P = 1.5 \times 10^5 \text{ Pa}.$$

Why other options are wrong:

- Option A (5×10^4 Pa): gives only the gauge pressure, omitting P_0.

- Option B (1.0×10^5 Pa): omits the column of liquid entirely.
- Option D (2.0×10^5 Pa): overstates the liquid pressure.

Final Answer: Pressure $= 1.5 \times 10^5$ Pa $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q9

Q10.

Solution

Concept — Efficiency of a heat engine: The efficiency is the useful work output divided by the heat absorbed, $\eta = 1 - \dfrac{Q_2}{Q_1}$.

Step 1 — List the values: Heat absorbed $Q_1 = 500$ J.

Heat rejected $Q_2 = 400$ J.

Step 2 — Form the ratio:

$$\frac{Q_2}{Q_1} = \frac{400}{500} = 0.8.$$

Step 3 — Apply the efficiency formula:

$$\eta = 1 - 0.8 = 0.2.$$

Step 4 — Express as a percentage:

$$\eta = 0.2 \times 100\% = 20\%.$$

Why other options are wrong:

- Option A (80%): takes the ratio Q_2/Q_1 directly without subtracting from 1.
- Option B (40%): uses wrong heat values.
- Option D (25%): uses Q_2/Q_1 as $300/400$ by mistake.

Final Answer: Efficiency $= 20\% \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q10

Q11.

Solution

Concept — Characteristic speeds of a gas: The most probable speed and the rms speed differ only in the numerical factor under the root, so their ratio is a pure number.

Step 1 — Write the two speeds:

$$v_{mp} = \sqrt{\frac{2RT}{M}}, \qquad v_{rms} = \sqrt{\frac{3RT}{M}}.$$

Step 2 — Form the ratio:

$$\frac{v_{mp}}{v_{rms}} = \frac{\sqrt{2RT/M}}{\sqrt{3RT/M}}.$$

Step 3 — Cancel the common factor RT/M:

$$\frac{v_{mp}}{v_{rms}} = \sqrt{\frac{2}{3}} \approx 0.816.$$

Why other options are wrong:

- Option B ($\sqrt{3/2}$): is the inverse ratio v_{rms}/v_{mp}.
- Option C ($\sqrt{2}$): keeps only the numerator factor.
- Option D ($\sqrt{3}$): keeps only the denominator factor.

Final Answer: The ratio $v_{mp}/v_{rms} = \sqrt{2/3} \Rightarrow \boxed{\text{A}}$

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

Q12.

Solution

Concept — Springs in parallel: When two springs are joined in parallel, the effective force constant is the sum, $k_{\text{eff}} = k_1 + k_2$.

Step 1 — Find the effective force constant:

$$k_{\text{eff}} = 100 + 100 = 200 \text{ N m}^{-1}.$$

Step 2 — Compute the ratio inside the root:

$$\frac{m}{k_{\text{eff}}} = \frac{2}{200} = 0.01\ \text{s}^2.$$

$$\sqrt{\frac{m}{k_{\text{eff}}}} = \sqrt{0.01} = 0.1\ \text{s}.$$

Step 3 — Multiply by 2π:

$$T = 2\pi\sqrt{\frac{m}{k_{\text{eff}}}} = 2 \times 3.14 \times 0.1.$$

$$T = 0.628 \approx 0.63\ \text{s}.$$

Why other options are wrong:

- Option A $(0.31\ \text{s})$: uses π instead of 2π.
- Option B $(1.26\ \text{s})$: uses a single spring $(k = 100)$, doubling the period.
- Option C $(0.44\ \text{s})$: mixes up the series and parallel combinations.

Final Answer: Time period ≈ 0.63 s $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q12

Q13.

Solution

Concept — Superposition of electric fields: The net field at a point is the vector sum of the fields due to each charge. At the midpoint of two equal like charges, symmetry plays the deciding role.

Step 1 — Field due to each charge at the midpoint: The midpoint M is equidistant from both charges. Each $+2\ \mu$C charge produces a field of the same magnitude at M.

Step 2 — Find the directions: The field of a positive charge points away from it. The left charge pushes its field to the right at M; the right charge pushes its field to the left at M.

Step 3 — Add the two fields: The two fields are equal in magnitude but opposite in direction, so they cancel:

$$E_{\text{net}} = E_{\text{left}} - E_{\text{right}} = 0.$$

Why other options are wrong:

- Options B, C and D give non-zero values; they would be correct only if the two fields added in the same direction (which happens for unlike charges), or if the point were not the midpoint.

Final Answer: The net field at the midpoint is zero $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q13

Q14.

Solution

Concept — Charge on a capacitor: The charge stored is the product of capacitance and the applied voltage, $Q = CV$.

Step 1 — List the values: Capacitance $C = 5\ \mu\text{F} = 5 \times 10^{-6}$ F.

Voltage $V = 20$ V.

Step 2 — Substitute into the formula:

$$Q = CV = (5 \times 10^{-6}) \times 20.$$

Step 3 — Simplify:

$$Q = 100 \times 10^{-6}\ \text{C} = 100\ \mu\text{C}.$$

Why other options are wrong:

- Option A ($20\ \mu$C): uses the voltage alone, ignoring the capacitance value.
- Option B ($50\ \mu$C): multiplies by 10 instead of 20.
- Option D ($25\ \mu$C): divides instead of multiplying somewhere.

Final Answer: Charge stored $= 100\ \mu\text{C} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q14

Q15.

Solution

Concept — Cells in series: When cells are joined in series, their emfs add and their internal resistances add. The current then follows from Ohm's law for the whole loop.

Step 1 — Net emf of the series combination:

$$\varepsilon_{\text{net}} = 2 + 2 = 4 \text{ V}.$$

(If the same two cells were in parallel, the net emf would be only 2 V.)

Step 2 — Total internal resistance:

$$r_{\text{net}} = 0.5 + 0.5 = 1 \ \Omega.$$

Step 3 — Total resistance of the circuit:

$$R_{\text{total}} = R + r_{\text{net}} = 3 + 1 = 4 \ \Omega.$$

Step 4 — Apply Ohm's law:

$$I = \frac{\varepsilon_{\text{net}}}{R_{\text{total}}} = \frac{4}{4} = 1 \text{ A}.$$

Why other options are wrong:

- Option B (2 A): ignores the internal resistance.
- Option C (0.5 A): uses a single cell's emf of 2 V.
- Option D (4 A): forgets to divide by the total resistance.

Final Answer: Current $= 1$ A $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q15

Q16.

Solution

Concept — Power dissipated in a resistor: When a voltage V is applied across a resistance R, the power dissipated is $P = \frac{V^2}{R}$.

Step 1 — List the values: Voltage $V = 10$ V, so $V^2 = 100$ V^2.

Resistance $R = 5\ \Omega$.

Step 2 — Substitute into the formula:

$$P = \frac{V^2}{R} = \frac{100}{5}.$$

Step 3 — Simplify:

$$P = 20\ \text{W}.$$

Why other options are wrong:

- Option A (10 W): uses V instead of V^2.
- Option C (50 W): multiplies V^2 by R wrongly.
- Option D (2 W): inverts the formula.

Final Answer: Power dissipated $= 20$ W $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q16

Q17.

Solution

Concept — Cyclotron frequency: A charged particle in a magnetic field circles with frequency $f = \frac{qB}{2\pi m}$, independent of its speed.

Step 1 — List the values: Charge $q = 1.6 \times 10^{-19}$ C.

Magnetic field $B = 0.2$ T.

Mass $m = 1.6 \times 10^{-27}$ kg.

Step 2 — Evaluate the numerator qB:

$$qB = (1.6 \times 10^{-19}) \times 0.2 = 3.2 \times 10^{-20}.$$

Step 3 — Evaluate the denominator $2\pi m$:

$$2\pi m = 2 \times 3.14 \times (1.6 \times 10^{-27}) = 1.005 \times 10^{-26}.$$

Step 4 — Divide:

$$f = \frac{3.2 \times 10^{-20}}{1.005 \times 10^{-26}} \approx 3.2 \times 10^{6} \text{ Hz}.$$

Why other options are wrong:

- Option A (1.6×10^{6} Hz): halves the correct value.
- Option B (6.4×10^{6} Hz): doubles the correct value.
- Option D (2.0×10^{6} Hz): drops the factor from $B = 0.2$ T.

Final Answer: Cyclotron frequency $\approx 3.2 \times 10^{6}$ Hz $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q17

Q18.

Solution

Concept — Torque on a current loop: A coil of N turns carrying current I, of area A, in a field B feels a torque $\tau = NIAB\sin\theta$, where θ is the angle between the field and the normal to the coil.

Step 1 — Identify the angle: The plane of the coil is *parallel* to the field, so the normal to the coil is perpendicular to the field, giving $\theta = 90^\circ$ and $\sin\theta = 1$ (the torque is maximum).

Step 2 — List the values: $N = 100$, $I = 2$ A, $A = 0.01$ m^2, $B = 0.5$ T.

Step 3 — Substitute into the formula:

$$\tau = NIAB\sin\theta = 100 \times 2 \times 0.01 \times 0.5 \times 1.$$

Step 4 — Simplify step by step:

$$100 \times 2 = 200.$$

$$200 \times 0.01 = 2.$$

$$2 \times 0.5 = 1.0 \text{ N m}.$$

Why other options are wrong:

- Option A (0.5 N m): leaves out a factor of 2 from the current.
- Option B (2.0 N m): drops the field value 0.5.
- Option C (0.25 N m): uses the wrong area or an extra halving.

Final Answer: Torque $= 1.0$ N m $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q18

Q19.

Solution

Concept — Capacitor in an AC circuit: A capacitor offers a reactance $X_C = \dfrac{1}{\omega C}$, and the rms current is $I = \dfrac{V}{X_C}$.

Step 1 — List the values: Capacitance $C = 10\ \mu\text{F} = 10 \times 10^{-6}$ F.

Angular frequency $\omega = 1000$ rad s^{-1}.

rms voltage $V = 100$ V.

Step 2 — Compute the capacitive reactance:

$$X_C = \frac{1}{\omega C} = \frac{1}{1000 \times 10 \times 10^{-6}}.$$

$$\omega C = 1000 \times 10 \times 10^{-6} = 10^{-2}.$$

$$X_C = \frac{1}{10^{-2}} = 100\ \Omega.$$

Step 3 — Compute the rms current:

$$I = \frac{V}{X_C} = \frac{100}{100} = 1\ \text{A}.$$

Why other options are wrong:

- Option A (0.5 A): uses twice the reactance.
- Option B (2 A): uses half the reactance.
- Option C (10 A): drops a power of ten in X_C.

Final Answer: rms current $= 1$ A $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q19

Q20.

Solution

Concept — Magnification of a mirror: The linear magnification is $m = -\frac{v}{u}$, using the sign convention that distances measured against the incident light are negative.

Step 1 — Assign signs to the data: Object distance $u = -20$ cm.

The image is real (formed in front of the mirror), so $v = -40$ cm.

Step 2 — Substitute into the magnification formula:

$$m = -\frac{v}{u} = -\frac{(-40)}{(-20)}.$$

Step 3 — Simplify the fraction:

$$\frac{-40}{-20} = 2.$$

$$m = -(2) = -2.$$

Step 4 — Interpret the result: The negative sign shows the image is inverted, and the magnitude 2 shows it is twice the size of the object.

Why other options are wrong:

- Option A (-1): would need equal object and image distances.
- Option C $(+2)$: wrong sign; a real image from a concave mirror is inverted.
- Option D (-0.5): inverts the ratio v/u.

Final Answer: Magnification $= -2 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q20

Q21.

Solution

Concept — Maximum and minimum intensity in interference: The extreme intensities depend on the amplitudes, $\frac{I_{\max}}{I_{\min}} = \frac{(\sqrt{I_1} + \sqrt{I_2})^2}{(\sqrt{I_1} - \sqrt{I_2})^2}$.

Step 1 — Use the given intensity ratio:

$$\frac{I_1}{I_2} = \frac{4}{1}.$$

So the amplitude ratio is

$$\frac{\sqrt{I_1}}{\sqrt{I_2}} = \sqrt{4} = 2.$$

Step 2 — Substitute amplitudes $\sqrt{I_1} = 2$ and $\sqrt{I_2} = 1$:

$$\frac{I_{max}}{I_{min}} = \frac{(2+1)^2}{(2-1)^2}.$$

Step 3 — Simplify:

$$\frac{I_{max}}{I_{min}} = \frac{(3)^2}{(1)^2} = \frac{9}{1}.$$

Why other options are wrong:

- Option B $(3 : 1)$: uses the amplitude sum without squaring.
- Option C $(4 : 1)$: simply repeats the intensity ratio.
- Option D $(16 : 1)$: squares the intensity ratio instead of using amplitudes.

Final Answer: $\frac{I_{max}}{I_{min}} = 9 : 1 \Rightarrow \boxed{A}$

Answer: (A) Go Back to Q21

Q22.

Solution

Concept — Momentum of a photon: A photon of energy E carries momentum $p = \frac{E}{c}$ (equivalently $p = h/\lambda$).

Step 1 — List the values: Photon energy $E = 3 \times 10^{-19}$ J.

Speed of light $c = 3 \times 10^8$ m s^{-1}.

Step 2 — Substitute into the formula:

$$p = \frac{E}{c} = \frac{3 \times 10^{-19}}{3 \times 10^8}.$$

Step 3 — Simplify:

$$p = \frac{3}{3} \times 10^{-19-8} = 1 \times 10^{-27} \text{ kg m s}^{-1}.$$

Why other options are wrong:

- Option A (3×10^{-19}): uses the energy value without dividing by c.
- Option B (9×10^{-27}): multiplies by c instead of dividing.
- Option D (3×10^{-27}): keeps the factor 3 instead of cancelling it.

Final Answer: Momentum $= 1 \times 10^{-27}$ kg m s^{-1} $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q22

Q23.

Solution

Concept — Series limit of the Lyman series: The shortest wavelength of a series corresponds to the transition from $n = \infty$ to the lowest level. For the Lyman series the lower level is $n_1 = 1$.

Step 1 — Write the Rydberg formula at the series limit:

$$\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{\infty}\right) = R.$$

Step 2 — Substitute the Rydberg constant:

$$\frac{1}{\lambda} = 1.097 \times 10^7 \text{ m}^{-1}.$$

Step 3 — Invert to get the wavelength:

$$\lambda = \frac{1}{1.097 \times 10^7} \approx 9.11 \times 10^{-8} \text{ m}.$$

Step 4 — Convert to nanometres:

$$\lambda \approx 91 \text{ nm}.$$

Why other options are wrong:

- Option B (122 nm): is the longest Lyman line ($n = 2 \to 1$), not the series limit.
- Option C (365 nm): is the series limit of the Balmer series.
- Option D (656 nm): is the H-alpha Balmer line.

Final Answer: Shortest Lyman wavelength ≈ 91 nm $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q23

Q24.

Solution

Concept — Mean life and half-life: The mean life is related to the half-life by $\tau = \frac{1}{\lambda} = \frac{T_{1/2}}{0.693}$.

Step 1 — List the value: Half-life $T_{1/2} = 6.93$ hours.

Step 2 — Substitute into the relation:

$$\tau = \frac{T_{1/2}}{0.693} = \frac{6.93}{0.693}.$$

Step 3 — Simplify:

$$\tau = 10 \text{ hours}.$$

Why other options are wrong:

- Option A (6.93 hours): equates mean life with the half-life, which is wrong.
- Option C (4.8 hours): multiplies by 0.693 instead of dividing.
- Option D (20 hours): doubles the correct value.

Final Answer: Mean life $= 10$ hours $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q24

Q25.

Solution

Concept — Conductivity of an intrinsic semiconductor: In a pure semiconductor the number of free charge carriers depends strongly on temperature.

Step 1 — Effect of temperature on carriers: Raising the temperature supplies thermal energy that breaks more covalent bonds, freeing additional electron-hole pairs.

Step 2 — Effect on conductivity: More carriers means the carrier concentration n_i rises sharply (roughly exponentially) with temperature, and conductivity $\sigma = n_i e(\mu_e + \mu_h)$ grows even though the mobilities fall slightly.

Step 3 — Conclusion: The increase in carrier number dominates, so the conductivity of an intrinsic semiconductor increases with temperature. (This is opposite to a metal, whose conductivity falls as temperature rises.)

Why other options are wrong:

- Option A (decreases): describes a metallic conductor, not a semiconductor.
- Option B (remains constant): ignores the strong temperature dependence of n_i.
- Option C (first increases, then decreases): there is no such turning point for an intrinsic semiconductor.

Final Answer: The conductivity increases with temperature $\Rightarrow \boxed{D}$

Answer: (D) **Go Back to Q25**

Answer Key

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