AIIMS B.Sc Nursing Physics

Sample Paper – 4

Duration: 36 Minutes **Maximum Marks: 30**

Instructions

- This paper contains **30 Multiple Choice Questions (single correct answer)**, modelled on the Physics section of the **AIIMS B.Sc Nursing** entrance.
- Each correct answer carries **+1 mark**. $\frac{1}{3}$ **mark is deducted** for every wrong answer, and an unattempted question gets **0 marks**.
- Only **one** option is correct. Choose carefully, since the questions are mostly numerical.
- Personal calculators, log tables, mobile phones, and other electronic gadgets are strictly prohibited.

Q1. Two point charges separated by a fixed distance in air experience a force F. When the same charges, kept at the same separation, are immersed in a liquid of dielectric constant $K = 5$, the force between them becomes:

(A) $F/5$

(B) $5F$

(C) $F/25$

(D) F

Q2. Two point charges $q_1 = 2\ \mu$C and $q_2 = 3\ \mu$C are held 6 m apart in vacuum. The electrostatic potential energy of the pair is (take $k = 9 \times 10^9$ N m^{2}C^{-2}):

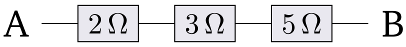
(A) 54×10^{-3} J

(B) 18×10^{-3} J

(C) 3×10^{-3} J

(D) 9×10^{-3} J

Q3. Three resistors of $2\,\Omega$, $3\,\Omega$ and $5\,\Omega$ are joined end to end in series, as shown. The equivalent resistance between A and B is:



(A) $0.97\,\Omega$

(B) $30\,\Omega$

(C) $10\,\Omega$

(D) $5\,\Omega$

Q4. A metal wire has a resistance of $20\,\Omega$ at 0 °C. Its temperature coefficient of resistance is 0.004 °C^{-1}. The resistance of the wire at 50 °C is:

(A) $20\,\Omega$

(B) $22\,\Omega$

(C) $28\,\Omega$

(D) $24\,\Omega$

Q5. A current of 3 A flows through a resistor of $4\,\Omega$. The power dissipated as heat in the resistor is:

(A) 36 W

(B) 12 W

(C) 48 W

(D) 9 W

Q6. The dimensional formula of pressure is:

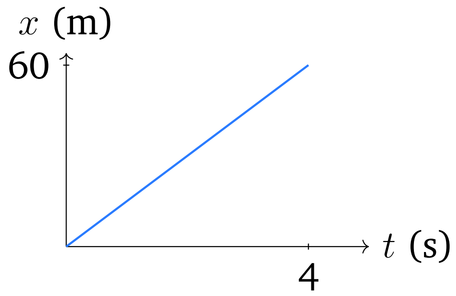
(A) $[MLT^{-2}]$

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

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

(D) $[ML^{-1}T^{-1}]$

Q7. The displacement–time graph of a body moving in a straight line is shown. The velocity of the body is:



(A) 4 m/s

(B) 60 m/s

(C) 15 m/s

(D) 30 m/s

Q8. A projectile is launched with a speed of 20 m/s at an angle of 45° to the horizontal. Its horizontal range is (take $g = 10$ m/s^2):

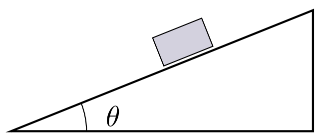
(A) 20 m

(B) 80 m

(C) 10 m

(D) 40 m

Q9. A car of mass m moves on a circular road of radius r. For a frictionless banked road inclined at angle θ, the maximum safe speed is given by:



(A) $\sqrt{rg\tan\theta}$

(B) $\sqrt{rg\sin\theta}$

(C) $rg\tan\theta$

(D) $\sqrt{\dfrac{rg}{\tan\theta}}$

Q10. A gun of mass 4 kg fires a bullet of mass 20 g with a muzzle speed of 400 m/s. The recoil speed of the gun is:

(A) 4 m/s

(B) 2 m/s

(C) 20 m/s

(D) 0.5 m/s

Q11. A man lifts a 10 kg box vertically through a height of 2 m at constant speed. The work done against gravity is (take $g = 10$ m/s^2):

(A) 20 J

(B) 100 J

(C) 200 J

(D) 400 J

Q12. At the Earth's surface $g = 10$ m/s^2. The acceleration due to gravity at a depth equal to half the radius of the Earth is:

(A) 10 m/s^2

(B) 2.5 m/s^2

(C) 7.5 m/s^2

(D) 5 m/s^2

Q13. A wire of cross-sectional area 2 mm^2 carries a stretching force of 40 N. The tensile stress in the wire is:

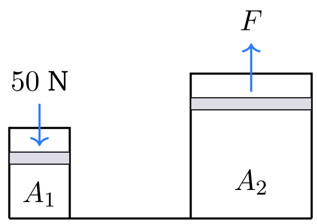
(A) 2×10^7 Pa

(B) 20 Pa

(C) 8×10^7 Pa

(D) 2×10^{-7} Pa

Q14. In a hydraulic lift the small piston has area 0.01 m^2 and the large piston has area 0.20 m^2. A force of 50 N applied on the small piston can support a maximum load of:



(A) 250 N

(B) 1000 N

(C) 500 N

(D) 2000 N

Q15. According to Newton's law of cooling, the rate of loss of heat of a hot body is directly proportional to:

(A) the absolute temperature of the body alone

(B) the fourth power of the body's temperature

(C) the difference between the body's temperature and that of its surroundings

(D) the specific heat of the body

Q16. Equal masses of water at 20 °C and 80 °C are mixed together (no heat lost to surroundings). The final temperature of the mixture is:

(A) 40 °C

(B) 60 °C

(C) 100 °C

(D) 50 °C

Q17. A gas at a constant pressure of 2×10^5 Pa expands from a volume of 1×10^{-3} m^3 to 3×10^{-3} m^3. The work done by the gas is:

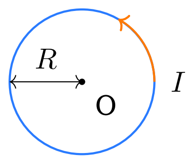
(A) 400 J

(B) 200 J

(C) 600 J

(D) 800 J

Q18. A circular coil of a single turn and radius 0.1 m carries a current of 2 A, as shown. The magnetic field at the centre of the coil is (take $\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}):



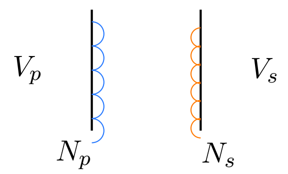
(A) $2\pi \times 10^{-6}$ T

(B) $4\pi \times 10^{-6}$ T

(C) $\pi \times 10^{-6}$ T

(D) $8\pi \times 10^{-6}$ T

Q19. An ideal transformer has 100 turns in its primary and 500 turns in its secondary, as shown. If the primary is fed with 220 V, the secondary voltage is:



(A) 44 V

(B) 220 V

(C) 1100 V

(D) 550 V

Q20. In an LC circuit the resonant (natural) frequency of oscillation is given by:

(A) $2\pi\sqrt{LC}$

(B) $\dfrac{1}{\sqrt{LC}}$

(C) $\dfrac{\sqrt{LC}}{2\pi}$

(D) $\dfrac{1}{2\pi\sqrt{LC}}$

Q21. An object is placed 20 cm in front of a concave mirror that forms a real image 40 cm from the mirror. The magnification of the image is:

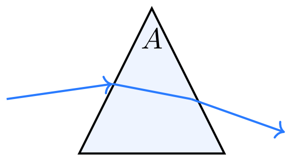
(A) -2

(B) $+2$

(C) -0.5

(D) $+0.5$

Q22. A ray of light passes through a thin prism of refracting angle 6° made of glass of refractive index 1.5. The angle of deviation produced by the prism is:



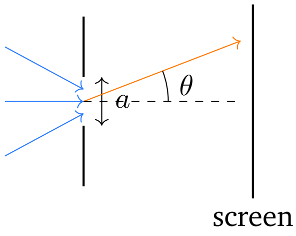
(A) 6°

(B) 1.5°

(C) 9°

(D) 3°

Q23. In a single-slit diffraction experiment, monochromatic light of wavelength λ falls on a slit of width a. The condition for the first dark fringe (minimum) on the screen is:



(A) $a \sin\theta = \frac{\lambda}{2}$

(B) $a \sin\theta = \lambda$

(C) $a \sin\theta = 2\lambda$

(D) $a \cos\theta = \lambda$

Q24. In the photoelectric effect, if the intensity of the incident light is increased while keeping its frequency fixed, the stopping potential will:

(A) increase

(B) decrease

(C) remain unchanged

(D) become zero

Q25. A radioactive sample has a half-life of 5 years. The fraction of the original sample that remains undecayed after 15 years is:

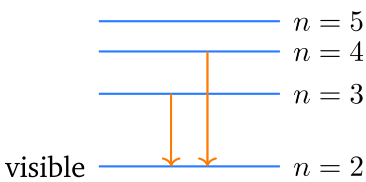
(A) $\frac{1}{2}$

(B) $\frac{1}{4}$

(C) $\frac{1}{16}$

(D) $\frac{1}{8}$

Q26. In the hydrogen atom, spectral lines that lie in the visible region and arise from transitions ending at the level $n = 2$ belong to the:



(A) Balmer series

(B) Lyman series

(C) Paschen series

(D) Brackett series

Q27. A particle executes simple harmonic motion with amplitude 0.05 m and angular frequency 10 rad/s. The maximum acceleration of the particle is:

(A) 0.5 m/s^2

(B) 5 m/s^2

(C) 50 m/s^2

(D) 2.5 m/s^2

Q28. A stretched string of length 0.5 m and linear mass density 0.01 kg/m is held under a tension of 100 N. The fundamental frequency of vibration of the string is:

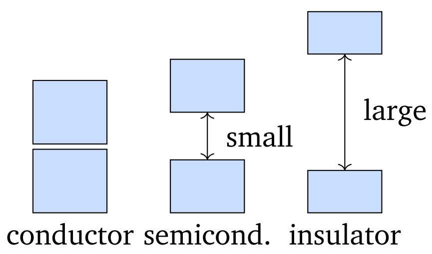
(A) 50 Hz

(B) 200 Hz

(C) 100 Hz

(D) 400 Hz

Q29. The energy band gaps of a conductor, a semiconductor and an insulator are compared in the figure. Which statement about the band gap E_g is correct?



(A) E_g is largest for a conductor

(B) E_g is the same for all three

(C) a semiconductor has a larger gap than an insulator

(D) the gap is zero (or overlapping) for a conductor, small for a semiconductor and large for an insulator

Q30. A full-wave rectifier is used with an a.c. input of frequency 50 Hz. The fundamental frequency of the ripple in its output (number of output pulses per second) is:

(A) 100 Hz

(B) 50 Hz

(C) 25 Hz

(D) 200 Hz

Detailed Solutions

Q1.

Solution

Concept — Coulomb's law in a dielectric medium: The electrostatic force between two point charges in vacuum is $F = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r^2}$. When the charges are immersed in a medium, the permittivity becomes $\varepsilon = K\varepsilon_0$, where K is the dielectric constant (also called relative permittivity). Since $F \propto \frac{1}{\varepsilon}$, the force in the medium becomes $F' = \frac{1}{4\pi K\varepsilon_0}\frac{q_1q_2}{r^2} = \frac{F}{K}$. Here q_1, q_2 are the charges, r is the fixed separation, and K is the dimensionless dielectric constant of the liquid.

Given: Force in air $= F$; dielectric constant $K = 5$; separation r unchanged; charges unchanged.

Step 1 — Write the relation between the two forces: Because the charges and the separation are identical in both cases, the only changed quantity is the permittivity of the surrounding medium. Hence $F' = \frac{F}{K}$.

Step 2 — Substitute the given value of K: $F' = \frac{F}{5}$.

Step 3 — Interpret the result: The dielectric reduces the effective field between the charges, so the force drops to one-fifth of its value in air. Dielectrics always weaken the inter-charge force ($K > 1$), they never strengthen it.

Why each other option is wrong:

- (B) $5F$ multiplies by K instead of dividing; this would mean the medium increases the force, which is physically impossible for a dielectric.
- (C) $F/25$ uses $K^2 = 25$; the dielectric constant enters to the first power only, not squared.
- (D) F assumes the medium has no effect, i.e. $K = 1$ (vacuum), contradicting $K = 5$.

Key point: In any dielectric the Coulomb force is divided by K (to the first power), so a larger K always means a weaker force.

Final Answer: $F/5 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q1

Q2.

Solution

Concept — Electrostatic potential energy of a pair of point charges: The work done in assembling two point charges from infinity to a separation r is stored as potential energy, $U = \frac{kq_1q_2}{r}$, where $k = \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^{2}C^{-2}, q_1 and q_2 are the charges (with their signs), and r is the separation. For two like (positive) charges U is positive, meaning energy is needed to bring them together.

Given: $q_1 = 2\ \mu$C $= 2 \times 10^{-6}$ C; $q_2 = 3\ \mu$C $= 3 \times 10^{-6}$ C; $r = 6$ m; $k = 9 \times 10^9$ N m^{2}C^{-2}.

Step 1 — Write the formula and substitute: $U = \frac{kq_1q_2}{r} = \frac{(9 \times 10^9)(2 \times 10^{-6})(3 \times 10^{-6})}{6}$.

Step 2 — Evaluate the numerator: $q_1q_2 = (2 \times 10^{-6})(3 \times 10^{-6}) = 6 \times 10^{-12}$ C^2; then $kq_1q_2 = (9 \times 10^9)(6 \times 10^{-12}) = 54 \times 10^{-3}$ N m^2 $= 54 \times 10^{-3}$ J m.

Step 3 — Divide by r: $U = \frac{54 \times 10^{-3}}{6} = 9 \times 10^{-3}$ J $= 9$ mJ.

Why each other option is wrong:

- (A) 54×10^{-3} J is the numerator kq_1q_2 before dividing by $r = 6$ m.
- (B) 18×10^{-3} J results from dividing by 3 instead of 6 (treating μ wrongly), doubling the correct value.
- (C) 3×10^{-3} J divides by an extra factor of 3, i.e. by 18 instead of 6.

Key point: Potential energy goes as $1/r$ (not $1/r^2$ like the force); always convert μC to coulombs ($\times 10^{-6}$) before substituting.

Final Answer: $U = 9 \times 10^{-3}$ J $= 9$ mJ $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q2

Q3.

Solution

Concept — Resistors in series: When resistors are joined end to end, the same current flows through each one and the total potential drop is the sum of the individual drops. Hence the equivalent (total) resistance is the simple algebraic sum, $R = R_1 + R_2 + R_3$. The equivalent series resistance is always larger than the largest individual resistor.

Given: $R_1 = 2\,\Omega$, $R_2 = 3\,\Omega$, $R_3 = 5\,\Omega$, all in series between A and B.

Step 1 — Write the formula and substitute: $R = R_1 + R_2 + R_3 = 2\,\Omega + 3\,\Omega + 5\,\Omega$.

Step 2 — Add the values: $R = 10\,\Omega$.

Step 3 — Sanity check: $10\,\Omega$ exceeds the largest resistor ($5\,\Omega$), as a series combination must, so the answer is consistent.

Why each other option is wrong:

- (A) $0.97\,\Omega$ is the equivalent of the same three resistors in *parallel* ($\frac{1}{R} = \frac{1}{2} + \frac{1}{3} + \frac{1}{5}$), not in series.
- (B) $30\,\Omega$ comes from multiplying the resistances ($2 \times 3 \times 5$), which has no physical basis.
- (D) $5\,\Omega$ keeps only the largest resistor and ignores the other two.

Key point: Series resistances add directly; only parallel resistances need reciprocals.

Final Answer: $R = 10\,\Omega \Rightarrow \boxed{C}$

Answer: (C) Go Back to Q3

Q4.

Solution

Concept — Variation of resistance with temperature: For a metallic conductor the resistance rises almost linearly with temperature, $R = R_0(1 + \alpha\,\Delta T)$, where R_0 is the resistance at the reference temperature (0 °C here), α is the temperature coefficient of resistance (units °C^{-1}), and $\Delta T = T - 0$ is the temperature rise. A positive α means resistance increases with temperature, which is typical of metals.

Given: $R_0 = 20\,\Omega$ at 0 °C; $\alpha = 0.004$ °C^{-1}; final temperature $T = 50$ °C, so $\Delta T = 50$ °C.

Step 1 — Write the formula and substitute: $R = R_0(1 + \alpha\,\Delta T) = 20\,[\,1 + (0.004)(50)\,]$.

Step 2 — Evaluate the bracket: $\alpha\,\Delta T = (0.004)(50) = 0.20$, so $R = 20\,(1+0.20) = 20 \times 1.20$.

Step 3 — Multiply: $R = 24\,\Omega$.

Why each other option is wrong:

- (A) $20\,\Omega$ is the value at 0 °C and ignores the 50 °C rise entirely.

- (B) $22\,\Omega$ uses $\Delta T = 25$ °C (only half the actual rise).
- (C) $28\,\Omega$ doubles the increment, taking $\alpha\,\Delta T = 0.40$ instead of 0.20.

Key point: ΔT is measured from the reference temperature at which R_0 is quoted (here 0 °C), so $\Delta T = 50$ °C.

Final Answer: $R = 24\,\Omega \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q4

Q5.

Solution

Concept — Joule heating (power dissipated in a resistor): When a current I passes through a resistance R, electrical energy is converted into heat at a rate $P = I^2R$. This is one of three equivalent forms ($P = VI = I^2R = V^2/R$); the form $P = I^2R$ is most direct when current and resistance are given. Here I is the current in amperes, R the resistance in ohms, and P the power in watts.

Given: $I = 3$ A; $R = 4\,\Omega$.

Step 1 — Write the formula and substitute: $P = I^2R = (3\text{ A})^2(4\,\Omega)$.

Step 2 — Square the current: $(3)^2 = 9\text{ A}^2$, so $P = 9 \times 4$.

Step 3 — Multiply: $P = 36$ W (since $\text{A}^2 \cdot \Omega = \text{W}$).

Why each other option is wrong:

- (B) 12 W uses $P = IR = 3 \times 4$, which is not a power formula (it gives the voltage, 12 V).
- (C) 48 W comes from a wrong combination such as IR^2 or $4^2 \times 3$; the current, not the resistance, is squared.
- (D) 9 W keeps only I^2 and drops the resistance factor entirely.

Key point: In $P = I^2R$ it is the *current* that is squared, not the resistance.

Final Answer: $P = 36$ W $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q5

Q6.

Solution

Concept — Dimensional formula of pressure: Pressure is defined as force per unit area, $P = \frac{F}{A}$. To find its dimensions, write the dimensions of force and of area and divide. Force has dimensions $[MLT^{-2}]$ (mass × acceleration) and area has dimensions $[L^2]$. Dividing gives the dimensional formula of pressure.

Step 1 — Write the dimensions of the numerator and denominator: $[\text{force}] = [MLT^{-2}]$ and $[\text{area}] = [L^2]$.

Step 2 — Divide: $[P] = \frac{[MLT^{-2}]}{[L^2]} = [M\,L^{1-2}\,T^{-2}]$.

Step 3 — Simplify the powers of L: $L^{1-2} = L^{-1}$, so $[P] = [ML^{-1}T^{-2}]$. (Check: the SI unit pascal = $\text{N/m}^2 = \text{kg}\,\text{m}^{-1}\,\text{s}^{-2}$, which matches.)

Why each other option is wrong:

- (A) $[MLT^{-2}]$ is the dimension of *force*, not pressure (area not divided out).
- (C) $[ML^2T^{-2}]$ is the dimension of *energy/work* (force × distance).
- (D) $[ML^{-1}T^{-1}]$ is the dimension of *coefficient of viscosity*, differing by one power of time.

Key point: Pressure = force ÷ area, so its formula is force's formula with L reduced by two powers, giving L^{-1}.

Final Answer: $[ML^{-1}T^{-2}] \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q6

Q7.

Solution

Concept — Velocity from a displacement–time graph: For motion in a straight line, the velocity equals the slope (gradient) of the displacement–time graph, $v = \frac{\Delta x}{\Delta t}$, where Δx is the change in displacement and Δt the corresponding time interval. A straight line means constant slope, hence uniform (constant) velocity.

Given: The line passes through the origin and reaches $x = 60$ m at $t = 4$ s (read from the graph).

Step 1 — Identify the two points and the changes: From $(0, 0)$ to $(4\text{ s}, 60\text{ m})$, $\Delta x = 60 - 0 = 60$ m and $\Delta t = 4 - 0 = 4$ s.

Step 2 — Compute the slope: $v = \dfrac{\Delta x}{\Delta t} = \dfrac{60\text{ m}}{4\text{ s}}$.

Step 3 — Evaluate: $v = 15$ m/s, constant throughout because the graph is a straight line.

Why each other option is wrong:

- (A) 4 m/s is just the time-axis reading (4 s) misused as a speed.
- (B) 60 m/s is just the displacement-axis reading (60 m) misused as a speed.
- (D) 30 m/s comes from dividing 60 by 2 instead of by 4, doubling the true slope.

Key point: Velocity is the *slope* ($\Delta x/\Delta t$), never a single axis value on its own.

Final Answer: $v = 15$ m/s $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q7

Q8.

Solution

Concept — Horizontal range of a projectile: For a projectile launched on level ground with speed u at angle θ to the horizontal, the horizontal range is $R = \dfrac{u^2 \sin 2\theta}{g}$, where g is the acceleration due to gravity. The range is maximum at $\theta = 45^\circ$ because $\sin 2\theta = \sin 90^\circ = 1$ is then largest.

Given: $u = 20$ m/s; $\theta = 45^\circ$; $g = 10$ m/s^2.

Step 1 — Write the formula and find $\sin 2\theta$: $2\theta = 90^\circ$, so $\sin 2\theta = \sin 90^\circ = 1$; thus $R = \dfrac{u^2 \cdot 1}{g} = \dfrac{u^2}{g}$.

Step 2 — Substitute the numbers: $R = \dfrac{(20\text{ m/s})^2}{10\text{ m/s}^2} = \dfrac{400\text{ m}^2/\text{s}^2}{10\text{ m/s}^2}$.

Step 3 — Evaluate: $R = 40$ m.

Why each other option is wrong:

- (A) 20 m is half the range; it comes from forgetting that at 45° the full u^2/g applies (or using $\sin\theta = \frac{1}{\sqrt{2}}$ incorrectly).
- (B) 80 m doubles the correct value, e.g. by using $2u^2/g$.
- (C) 10 m drops the square on u, using $u/g\times$ something instead of u^2/g.

Key point: At $\theta = 45^\circ$ the range simplifies to u^2/g, which is also the maximum possible range for that speed.

Final Answer: $R = 40$ m $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q8

Q9.

Solution

Concept — Frictionless banked road: On a road banked at angle θ with no friction, the only forces on the car are its weight mg (down) and the normal reaction N (perpendicular to the road). The vertical component balances gravity, $N\cos\theta = mg$, while the horizontal component supplies the centripetal force, $N\sin\theta = \frac{mv^2}{r}$. Dividing these two equations eliminates N and m, giving $\tan\theta = \frac{v^2}{rg}$, where r is the radius of the turn and g the acceleration due to gravity.

Step 1 — Combine the two force equations: Dividing $N\sin\theta = \frac{mv^2}{r}$ by $N\cos\theta = mg$ gives $\tan\theta = \frac{v^2}{rg}$.

Step 2 — Solve for v^2: Cross-multiplying, $v^2 = rg\tan\theta$.

Step 3 — Take the square root: $v_{\max} = \sqrt{rg\tan\theta}$.

Why each other option is wrong:

- (B) $\sqrt{rg\sin\theta}$ uses $\sin\theta$ instead of $\tan\theta$; the correct ratio comes from dividing the horizontal by the vertical force equation.
- (C) $rg\tan\theta$ is actually v^2, not v; it omits the square root and so has the wrong units (velocity-squared).
- (D) $\sqrt{rg/\tan\theta}$ inverts the tangent, which would wrongly predict a smaller safe speed for a steeper bank.

Key point: For a frictionless bank the safe speed is fixed by the angle alone through $\tan\theta = v^2/rg$; remember the square root when solving for v.

Final Answer: $v_{\max} = \sqrt{rg\tan\theta} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q9

Q10.

Solution

Concept — Conservation of linear momentum (recoil): Before firing, the gun–bullet system is at rest, so its total momentum is zero. No external horizontal force acts during the firing, so total momentum stays zero afterwards: $m_g v_g = m_b v_b$ in magnitude (the gun recoils opposite to the bullet). Here m_g, v_g are the gun's mass and recoil speed and m_b, v_b the bullet's mass and muzzle speed.

Given: $m_g = 4$ kg; $m_b = 20$ g $= 0.02$ kg; $v_b = 400$ m/s.

Step 1 — Apply momentum conservation: $m_g v_g = m_b v_b \Rightarrow v_g = \dfrac{m_b v_b}{m_g}$.

Step 2 — Substitute the numbers: $v_g = \dfrac{(0.02\text{ kg})(400\text{ m/s})}{4\text{ kg}} = \dfrac{8\text{ kg m/s}}{4\text{ kg}}$.

Step 3 — Evaluate: $v_g = 2$ m/s (directed opposite to the bullet).

Why each other option is wrong:

- (A) 4 m/s comes from forgetting to convert 20 g to 0.02 kg (using $m_b = 0.04$ or a wrong ratio).
- (C) 20 m/s uses a badly inverted or mis-scaled mass ratio, far too large for so heavy a gun.
- (D) 0.5 m/s divides by an extra factor of 4, underestimating the recoil.

Key point: The heavy gun recoils slowly and the light bullet flies fast, in inverse proportion to their masses; always convert grams to kilograms first.

Final Answer: $v_g = 2$ m/s $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q10

Q11.

Solution

Concept — Work done against gravity: When a body is raised vertically at constant speed, there is no change in kinetic energy, so the work done by the lifting force exactly equals the gain in gravitational potential energy, $W = mgh$. Here m is the mass, g the acceleration due to gravity, and h the height through which the body is raised.

Given: $m = 10$ kg; $h = 2$ m; $g = 10$ m/s^2; motion at constant speed (so $\Delta KE = 0$).

Step 1 — Write the formula and substitute: $W = mgh = (10\text{ kg})(10\text{ m/s}^2)(2\text{ m})$.

Step 2 — Multiply step by step: $mg = 10 \times 10 = 100$ N (the weight), then $W = 100$ N $\times$ 2 m.

Step 3 — Evaluate: $W = 200$ J.

Why each other option is wrong:

- (A) 20 J drops a factor of 10, e.g. by using $mg = 10$ instead of 100 N.
- (B) 100 J uses $g = 5$ m/s^2 (or omits the height factor), half the correct value.
- (D) 400 J doubles the height (uses $h = 4$ m) or doubles the mass.

Key point: At constant speed the applied force just balances the weight, so work done = weight $\times$ height = mgh.

Final Answer: $W = 200$ J $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q11

Q12.

Solution

Concept — Variation of g with depth: Inside the Earth, only the mass enclosed within the radius at which you stand contributes to gravity (the outer shell exerts no net pull). Assuming uniform density, this gives $g' = g\left(1 - \frac{d}{R}\right)$, where g is the surface value, d the depth below the surface, and R the Earth's radius. Gravity therefore decreases linearly with depth and falls to zero at the centre.

Given: $g = 10$ m/s^2 at the surface; depth $d = \frac{R}{2}$ (half the Earth's radius).

Step 1 — Write the formula and substitute $d = R/2$: $g' = g\left(1 - \frac{R/2}{R}\right) = g\left(1 - \frac{1}{2}\right)$.

Step 2 — Simplify the bracket: $1 - \frac{1}{2} = \frac{1}{2}$, so $g' = \frac{g}{2}$.

Step 3 — Evaluate: $g' = \frac{10}{2} = 5$ m/s^2.

Why each other option is wrong:

- (A) 10 m/s^2 ignores the depth and just repeats the surface value.
- (B) 2.5 m/s^2 corresponds to $d = \frac{3R}{4}$, not $\frac{R}{2}$.
- (C) 7.5 m/s^2 corresponds to $d = \frac{R}{4}$, a shallower depth than given.

Key point: With depth, g falls *linearly* as $(1 - d/R)$; do not confuse this with the height formula $g' = g/(1 + h/R)^2$.

Final Answer: $g' = 5$ m/s^2 $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q12

Q13.

Solution

Concept — Tensile stress: Tensile stress is the internal restoring force per unit cross-sectional area developed when a wire is stretched, $\sigma = \frac{F}{A}$, where F is the stretching (tensile) force and A the cross-sectional area perpendicular to the force. Its SI unit is the pascal (Pa $=$ N/m^2). The area must be in m^2, so mm^2 must be converted first.

Given: $F = 40$ N; $A = 2$ mm^2.

Step 1 — Convert the area to SI units: $1 \text{ mm}^2 = (10^{-3} \text{ m})^2 = 10^{-6} \text{ m}^2$, so $A = 2 \text{ mm}^2 = 2 \times 10^{-6} \text{ m}^2$.

Step 2 — Write the formula and substitute: $\sigma = \frac{F}{A} = \frac{40 \text{ N}}{2 \times 10^{-6} \text{ m}^2}$.

Step 3 — Evaluate: $\sigma = \frac{40}{2} \times 10^6 = 20 \times 10^6 = 2 \times 10^7$ Pa.

Why each other option is wrong:

- (B) 20 Pa forgets to convert mm^2 to m^2, dropping the factor 10^6.
- (C) 8×10^7 Pa uses a wrong area (e.g. 0.5 mm^2) or a wrong force.
- (D) 2×10^{-7} Pa inverts the ratio, dividing area by force instead of force by area.

Key point: Always convert mm^2 to m^2 using the factor 10^{-6} (square of 10^{-3}) before dividing.

Final Answer: Stress $= 2 \times 10^7$ Pa $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q13

Q14.

Solution

Concept — Pascal's law (hydraulic lift): Pascal's law states that pressure applied to an enclosed incompressible fluid is transmitted undiminished to every part of the fluid. So the pressure under the small piston equals that under the large piston, $\frac{F_1}{A_1} = \frac{F_2}{A_2}$. Rearranging gives the force multiplication, $F_2 = F_1 \frac{A_2}{A_1}$, where A_1, A_2 are the piston areas and F_1, F_2 the corresponding forces.

Given: small piston $A_1 = 0.01$ m^2; large piston $A_2 = 0.20$ m^2; applied force $F_1 = 50$ N.

Step 1 — Find the area ratio: $\frac{A_2}{A_1} = \frac{0.20}{0.01} = 20.$

Step 2 — Write the formula and substitute: $F_2 = F_1 \frac{A_2}{A_1} = 50 \text{ N} \times 20.$

Step 3 — Evaluate: $F_2 = 1000$ N.

Why each other option is wrong:

- (A) 250 N uses an area ratio of 5 instead of 20 (a misread of the areas).
- (C) 500 N uses a ratio of 10, half the correct value.
- (D) 2000 N doubles the correct result, e.g. by using a ratio of 40.

Key point: A hydraulic lift multiplies force by the ratio of piston areas A_2/A_1; the larger piston supports the larger load.

Final Answer: $F_2 = 1000 \text{ N} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q14

Q15.

Solution

Concept — Newton's law of cooling: Newton's law of cooling states that for a body whose temperature is not far above its surroundings, the rate at which it loses heat is directly proportional to the difference between its own temperature and that of the surroundings, $\frac{dQ}{dt} \propto (T - T_s)$, where T is the body's temperature and T_s is the surrounding (ambient) temperature. The quantity $(T - T_s)$ is called the excess temperature and is the driving cause of cooling.

Step 1 — Identify the controlling quantity: The law makes the heat-loss rate depend on the *excess* temperature $(T - T_s)$, not on T alone. When the body and surroundings are at the same temperature, $(T - T_s) = 0$ and cooling stops, which fixes the form of the law.

Step 2 — Match to the options: The option stating "the difference between the body's temperature and that of its surroundings" is exactly $(T - T_s)$.

Why each other option is wrong:

- (A) "Absolute temperature of the body alone" would never let cooling stop at thermal equilibrium, so it cannot be the rate's sole controller.
- (B) "Fourth power of the body's temperature" is the Stefan–Boltzmann radiation law ($E \propto T^4$), valid for radiation over large temperature ranges, not Newton's cooling.
- (D) "Specific heat of the body" affects how quickly the temperature *changes* for a given heat loss, but it is not what the rate of heat loss is proportional to.

Key point: Newton's cooling rate $\propto (T - T_s)$; it is a small-difference approximation distinct from the T^4 Stefan–Boltzmann law.

Final Answer: Temperature difference $\Rightarrow$ C

Answer: (C) **Go Back to Q15**

Q16.

Solution

Concept — Calorimetry (principle of mixtures): When two bodies at different temperatures are mixed with no heat lost to the surroundings, heat lost by the hotter body equals heat gained by the colder body: $m_1 c(T_1 - T) = m_2 c(T - T_2)$, where c is the specific heat, T_1, T_2 the initial temperatures and T the common final temperature. For equal masses of the same liquid, $m_1 = m_2$ and the c cancels, so the final temperature is simply the arithmetic mean of the two initial temperatures.

Given: equal masses of water; initial temperatures $T_1 = 80$ °C and $T_2 = 20$ °C; no heat lost.

Step 1 — Apply heat balance with $m_1 = m_2$ and same c: $80 - T = T - 20$, so $80 + 20 = 2T$.

Step 2 — Solve for T: $T = \dfrac{80 + 20}{2} = \dfrac{100}{2}$.

Step 3 — Evaluate: $T = 50$ °C.

Why each other option is wrong:

- (A) 40 °C is not the midpoint of 20 and 80; it would require unequal masses favouring the cold water.
- (B) 60 °C is also off the midpoint; it would need more hot water than cold.
- (C) 100 °C is higher than either starting temperature, which is impossible without an external heat source.

Key point: For equal masses of the same substance the final temperature is just the average of the two; the result must lie strictly between the two starting temperatures.

Final Answer: $T = 50$ °C $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q16

Q17.

Solution

Concept — Work done in an isobaric (constant-pressure) process: When a gas expands at constant pressure P, the work done *by* the gas is $W = P\,\Delta V = P(V_f - V_i)$, where V_i and V_f are the initial and final volumes. The work is positive for expansion ($V_f > V_i$). Pressure must be in pascals and volume in m^3 so that the product gives joules.

Given: $P = 2 \times 10^5$ Pa; $V_i = 1 \times 10^{-3}$ m^3; $V_f = 3 \times 10^{-3}$ m^3.

Step 1 — Find the volume change: $\Delta V = V_f - V_i = (3-1) \times 10^{-3} = 2 \times 10^{-3}$ m^3.

Step 2 — Write the formula and substitute: $W = P\,\Delta V = (2 \times 10^5 \text{ Pa})(2 \times 10^{-3} \text{ m}^3)$.

Step 3 — Evaluate: $W = 4 \times 10^2 = 400$ J (positive, as the gas expands).

Why each other option is wrong:

- (B) 200 J uses $\Delta V = 1 \times 10^{-3}$ m^3, i.e. only half the actual change.
- (C) 600 J uses $\Delta V = 3 \times 10^{-3}$ m^3 (the final volume) instead of the change.
- (D) 800 J doubles the volume change to 4×10^{-3} m^3.

Key point: Use the *change* in volume $\Delta V = V_f - V_i$, not the final volume, in $W = P\,\Delta V$.

Final Answer: $W = 400$ J $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q17

Q18.

Solution

Concept — Magnetic field at the centre of a circular coil: A single circular loop of radius R carrying current I produces a magnetic field at its centre of $B = \frac{\mu_0 I}{2R}$, where $\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1} is the permeability of free space. For N turns the field is N times larger; here $N = 1$.

Given: $N = 1$ turn; $R = 0.1$ m; $I = 2$ A; $\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}.

Step 1 — Write the formula and substitute: $B = \frac{\mu_0 I}{2R} = \frac{(4\pi \times 10^{-7})(2)}{2(0.1)}$.

Step 2 — Simplify numerator and denominator: Numerator $= 8\pi \times 10^{-7}$; denominator $= 2 \times 0.1 = 0.2$.

Step 3 — Divide: $B = \frac{8\pi \times 10^{-7}}{0.2} = 40\pi \times 10^{-7} = 4\pi \times 10^{-6}$ T.

Why each other option is wrong:

- (A) $2\pi \times 10^{-6}$ T is half the value, e.g. from using $R = 0.2$ m or an extra factor of 2.
- (C) $\pi \times 10^{-6}$ T is one-quarter, from a doubled denominator error.
- (D) $8\pi \times 10^{-6}$ T forgets the factor $2R$ in the denominator (divides by R alone, or omits the 2).

Key point: The centre-of-coil field carries a factor of $2R$ in the denominator, $B = \mu_0 I/(2R)$; do not drop the 2.

Final Answer: $B = 4\pi \times 10^{-6}$ T $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q18

Q19.

Solution

Concept — Ideal transformer turns ratio: In an ideal transformer the induced voltage in each winding is proportional to its number of turns, so $\frac{V_s}{V_p} = \frac{N_s}{N_p}$, where V_p, N_p are the primary voltage and turns and V_s, N_s those of the secondary. If $N_s > N_p$ the device is a step-up transformer ($V_s > V_p$).

Given: $N_p = 100$ turns; $N_s = 500$ turns; $V_p = 220$ V.

Step 1 — Find the turns ratio: $\frac{N_s}{N_p} = \frac{500}{100} = 5$ (greater than 1, so step-up).

Step 2 — Write the formula and substitute: $V_s = V_p \frac{N_s}{N_p} = 220 \text{ V} \times 5$.

Step 3 — Evaluate: $V_s = 1100$ V.

Why each other option is wrong:

- (A) 44 V inverts the ratio (uses $N_p/N_s = 1/5$), treating a step-up as a step-down transformer.
- (B) 220 V ignores the turns entirely, assuming a 1:1 ratio.
- (D) 550 V uses a ratio of 2.5 instead of 5.

Key point: Secondary voltage scales with the turns ratio N_s/N_p; more secondary turns means a higher output voltage (step-up).

Final Answer: $V_s = 1100 \text{ V} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q19

Q20.

Solution

Concept — Natural frequency of an LC circuit: An inductor L and capacitor C connected together exchange energy back and forth, producing electrical oscillations. At resonance the inductive reactance $X_L = \omega L$ equals the capacitive reactance $X_C = \frac{1}{\omega C}$. Setting them equal, $\omega L = \frac{1}{\omega C}$, gives the angular frequency $\omega = \frac{1}{\sqrt{LC}}$, and the ordinary frequency is $f = \frac{\omega}{2\pi}$.

Step 1 — Equate the reactances: $\omega L = \frac{1}{\omega C} \Rightarrow \omega^2 = \frac{1}{LC} \Rightarrow \omega = \frac{1}{\sqrt{LC}}$.

Step 2 — Convert angular frequency to frequency: $f = \frac{\omega}{2\pi} = \frac{1}{2\pi} \cdot \frac{1}{\sqrt{LC}} = \frac{1}{2\pi\sqrt{LC}}$.

Why each other option is wrong:

- (A) $2\pi\sqrt{LC}$ is the *time period* $T = 1/f$, the reciprocal of the answer.
- (B) $\frac{1}{\sqrt{LC}}$ is the *angular* frequency ω, which still needs dividing by 2π to give f.
- (C) $\frac{\sqrt{LC}}{2\pi}$ inverts the dependence on LC, so frequency would wrongly increase with larger L or C.

Key point: $f = \dfrac{1}{2\pi\sqrt{LC}}$; larger L or C lowers the resonant frequency. Do not confuse ω (no 2π) with f.

Final Answer: $f = \dfrac{1}{2\pi\sqrt{LC}} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q20

Q21.

Solution

Concept — Magnification of a spherical mirror: The linear magnification of a mirror is $m = -\dfrac{v}{u}$, where u is the object distance and v the image distance, both measured with the Cartesian sign convention (distances measured against the incident light, i.e. in front of the mirror, are negative). A negative m means the image is inverted, and $|m| > 1$ means it is magnified (enlarged).

Given: concave mirror; object distance $u = -20$ cm (in front); real image distance $v = -40$ cm (real images in a concave mirror form on the same, front side, so v is negative).

Step 1 — Write the formula and substitute: $m = -\dfrac{v}{u} = -\dfrac{(-40)}{(-20)}$.

Step 2 — Simplify the fraction: $\dfrac{-40}{-20} = +2$, so $m = -(+2)$.

Step 3 — Final value: $m = -2$, indicating a real, inverted image twice the object's size.

Why each other option is wrong:

- (B) $+2$ has the wrong sign; a real image in a concave mirror is inverted, so m must be negative.
- (C) -0.5 inverts the ratio (uses u/v instead of v/u), giving a diminished image instead of magnified.
- (D) $+0.5$ has both the ratio inverted and the wrong sign.

Key point: $m = -v/u$; a real, magnified image gives m negative with magnitude greater than 1.

Final Answer: $m = -2 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q21

Q22.

Solution

Concept — Deviation produced by a thin prism: For a thin prism (small refracting angle), the angle of deviation of a ray is $\delta = (\mu - 1)A$, where μ is the refractive index of the prism material and A is the refracting (apex) angle of the prism. This formula is independent of the angle of incidence for small angles, which is why thin prisms give a fixed deviation.

Given: refracting angle $A = 6°$; refractive index $\mu = 1.5$.

Step 1 — Write the formula and find $(\mu - 1)$: $\mu - 1 = 1.5 - 1 = 0.5$.

Step 2 — Substitute: $\delta = (\mu - 1)A = 0.5 \times 6°$.

Step 3 — Evaluate: $\delta = 3°$.

Why each other option is wrong:

- (A) $6°$ omits the factor $(\mu - 1)$ and just repeats the prism angle.
- (B) $1.5°$ wrongly multiplies A by something like 0.25, or divides instead of using $(\mu - 1)$.
- (C) $9°$ uses $(\mu + 1) = 1.5 + 1 = 1.5 \times 6$, an incorrect sign in the bracket.

Key point: For a thin prism, deviation $= (\mu - 1)\times$ apex angle; always subtract 1 from the refractive index.

Final Answer: $\delta = 3° \Rightarrow \boxed{\text{D}}$

Answer: (D) **Go Back to Q22**

Q23.

Solution

Concept — Single-slit diffraction minima: When light of wavelength λ passes through a slit of width a, the secondary wavelets from across the slit interfere on the screen. A dark fringe (minimum) forms in the direction θ for which the wavelets cancel in pairs; this happens when the path difference between the slit edges, $a\sin\theta$, equals a whole number of wavelengths, $a\sin\theta = n\lambda$ with $n = 1, 2, 3, \ldots$ (note $n = 0$ is excluded, as that direction is the central bright maximum).

Step 1 — Apply the minimum condition for the first dark fringe: The first minimum corresponds to $n = 1$.

Step 2 — Substitute $n = 1$: $a \sin\theta = (1)\lambda = \lambda$.

Step 3 — Interpret: This gives the angular position of the first dark band on each side of the bright central maximum.

Why each other option is wrong:

- (A) $a \sin\theta = \lambda/2$ is a half-wavelength path difference; for a single slit this lies within the central bright region, not a minimum.
- (C) $a \sin\theta = 2\lambda$ is the *second* minimum ($n = 2$), not the first.
- (D) $a \cos\theta = \lambda$ uses the wrong trigonometric function; the path difference across the slit involves $\sin\theta$, not $\cos\theta$.

Key point: For single-slit *minima*, $a \sin\theta = n\lambda$ ($n \geq 1$); the first dark fringe is at $a \sin\theta = \lambda$. (This is the opposite of the double-slit bright-fringe condition.)

Final Answer: $a \sin\theta = \lambda \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q23

Q24.

Solution

Concept — Stopping potential in the photoelectric effect: Einstein's photoelectric equation gives the maximum kinetic energy of the ejected electrons as $K_{\max} = h\nu - \phi$, where h is Planck's constant, ν the frequency of the incident light and ϕ the work function of the metal. The stopping potential V_0 is the reverse voltage that just halts the most energetic electrons, so $eV_0 = K_{\max} = h\nu - \phi$. Crucially, V_0 depends only on ν and ϕ, not on the light's intensity.

Step 1 — Hold the frequency fixed: With ν constant, $K_{\max} = h\nu - \phi$ is fixed, so $eV_0 = h\nu - \phi$ is fixed too.

Step 2 — Consider raising the intensity: Greater intensity means more photons per second, which eject more electrons per second (a larger photocurrent), but each photon still carries the same energy $h\nu$, so the maximum energy per electron is unchanged.

Step 3 — Conclude about V_0: Since $K_{\max}$ does not change, the stopping potential V_0 remains unchanged.

Why each other option is wrong:

- (A) "Increase" would require more energy per electron, but intensity adds more electrons, not more energy each.

- (B) "Decrease" has no physical basis; nothing reduces the electrons' maximum energy when only intensity rises.
- (D) "Become zero" would mean no electrons are stopped, contradicting $eV_0 = h\nu - \phi > 0$ for above-threshold light.

Key point: Stopping potential depends on *frequency* (and work function), never on intensity; intensity controls only the photocurrent (number of electrons).

Final Answer: Remains unchanged $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q24

Q25.

Solution

Concept — Radioactive decay and half-life: The half-life $T_{1/2}$ is the time in which half of a radioactive sample decays. After each half-life the undecayed amount halves, so after n half-lives the remaining fraction is $\frac{N}{N_0} = \left(\frac{1}{2}\right)^n = \frac{1}{2^n}$, where N_0 is the initial number of nuclei and N the number remaining. The number of half-lives is $n = \frac{t}{T_{1/2}}$.

Given: half-life $T_{1/2} = 5$ years; elapsed time $t = 15$ years.

Step 1 — Find the number of half-lives: $n = \frac{t}{T_{1/2}} = \frac{15}{5} = 3$.

Step 2 — Apply the decay fraction: Fraction remaining $= \frac{1}{2^n} = \frac{1}{2^3}$.

Step 3 — Evaluate: $\frac{1}{2^3} = \frac{1}{8}$.

Why each other option is wrong:

- (A) $\frac{1}{2}$ corresponds to just one half-life ($t = 5$ years).
- (B) $\frac{1}{4}$ corresponds to two half-lives ($t = 10$ years).
- (C) $\frac{1}{16}$ corresponds to four half-lives ($t = 20$ years), one too many.

Key point: Count $n = t/T_{1/2}$ first, then the surviving fraction is $1/2^n$; here three half-lives give $1/8$.

Final Answer: $\frac{1}{8} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q25

Q26.

Solution

Concept — Spectral series of hydrogen: In the hydrogen atom, the spectral lines are grouped into series according to the lower energy level n_f at which the electron's transition ends. Each series falls in a characteristic part of the electromagnetic spectrum: transitions ending at $n = 1$ form the Lyman series, those ending at $n = 2$ form the Balmer series, $n = 3$ the Paschen series and $n = 4$ the Brackett series. The wavelengths follow the Rydberg formula $\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$.

Step 1 — Identify the lower level in the question: The transitions end at $n = 2$, which defines the Balmer series.

Step 2 — Check the spectral region: The Balmer series lies in the visible region (e.g. the red Hα line at 656 nm), matching the "visible region" stated in the question.

Why each other option is wrong:

- (B) Lyman series ends at $n = 1$ and lies in the *ultraviolet*, not the visible.
- (C) Paschen series ends at $n = 3$ and lies in the *infrared*.
- (D) Brackett series ends at $n = 4$ and lies further into the *infrared*.

Key point: Only the Balmer series (transitions to $n = 2$) produces visible hydrogen lines; remember Lyman = UV, Balmer = visible, Paschen/Brackett = IR.

Final Answer: Balmer series $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q26

Q27.

Solution

Concept — Acceleration in simple harmonic motion: In SHM the acceleration is directed towards the mean position and is proportional to the displacement, $a = -\omega^2 x$, where ω is the angular frequency and x the displacement from the centre. Its magnitude is greatest at the extreme positions where $x = A$ (the amplitude), giving the maximum acceleration $a_{\text{max}} = \omega^2 A$.

Given: amplitude $A = 0.05$ m; angular frequency $\omega = 10$ rad/s.

Step 1 — Write the formula and find ω^2: $a_{\text{max}} = \omega^2 A$, with $\omega^2 = (10)^2 = 100$ rad^2/s^2.

Step 2 — Substitute: $a_{\max} = 100 \times 0.05$.

Step 3 — Evaluate: $a_{\max} = 5\ \text{m/s}^2$.

Why each other option is wrong:

- (A) $0.5\ \text{m/s}^2$ drops the square on ω (uses $\omega A = 10 \times 0.05$).
- (C) $50\ \text{m/s}^2$ uses a wrong amplitude (e.g. $A = 0.5$ m) or an extra factor of 10.
- (D) $2.5\ \text{m/s}^2$ is half the correct value, e.g. from $\frac{1}{2}\omega^2 A$.

Key point: Maximum acceleration in SHM is $\omega^2 A$ (ω squared); it occurs at the extreme positions, while velocity is maximum at the centre.

Final Answer: $a_{\max} = 5\ \text{m/s}^2 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q27

Q28.

Solution

Concept — Fundamental frequency of a stretched string: A string fixed at both ends vibrates in its fundamental mode with a single antinode, and the wavelength equals twice the length. The fundamental frequency is $f = \frac{1}{2L}\sqrt{\frac{T}{\mu}}$, where L is the length of the string, T the tension and μ the linear mass density (mass per unit length). The factor $\sqrt{T/\mu}$ is the speed of transverse waves on the string.

Given: $L = 0.5$ m; $\mu = 0.01$ kg/m; $T = 100$ N.

Step 1 — Find the wave speed: $v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{100}{0.01}} = \sqrt{10000} = 100$ m/s.

Step 2 — Substitute into the frequency formula: $f = \frac{v}{2L} = \frac{100}{2(0.5)} = \frac{100}{1}$.

Step 3 — Evaluate: $f = 100$ Hz.

Why each other option is wrong:

- (A) 50 Hz uses $L = 1$ m instead of 0.5 m, doubling $2L$ in the denominator.
- (B) 200 Hz drops a factor of 2 in $2L$ (uses $1/L$ instead of $1/2L$).
- (D) 400 Hz makes both the L and tension/density errors, doubling twice over.

Key point: First compute $v = \sqrt{T/\mu}$, then $f = v/(2L)$; with $2L = 1$ m here the numbers fall out neatly to 100 Hz.

Final Answer: $f = 100$ Hz $\Rightarrow$ C

Answer: (C) Go Back to Q28

Q29.

Solution

Concept — Energy band gap in solids: In a solid the electron energy levels broaden into a filled valence band and a higher conduction band, separated by a forbidden energy gap E_g. The size of E_g determines how easily electrons reach the conduction band and hence how well the material conducts: a small or zero gap means easy conduction, while a large gap blocks it. This single quantity classifies solids into conductors, semiconductors and insulators.

Step 1 — Compare the three classes: In a conductor (metal) the valence and conduction bands overlap, so $E_g \approx 0$ and electrons conduct freely. In a semiconductor E_g is small (roughly 1 eV, e.g. ~ 1.1 eV for silicon), so some electrons cross at room temperature. In an insulator E_g is large (several eV), so almost no electrons reach the conduction band.

Step 2 — Match to the correct statement: The ordering is therefore: gap zero/overlapping for a conductor, small for a semiconductor, and large for an insulator, which is exactly option (D).

Why each other option is wrong:

- (A) "E_g largest for a conductor" is backwards; a conductor has essentially no gap.
- (B) "Same for all three" contradicts the very basis of the conductor/semiconductor/insulator classification.
- (C) "Semiconductor has a larger gap than an insulator" reverses the truth; the insulator has the larger gap.

Key point: Band gap increases in the order conductor (≈ 0) $<$ semiconductor (small) $<$ insulator (large); this ordering is the heart of the classification.

Final Answer: Conductor ≈ 0, semiconductor small, insulator large $\Rightarrow$ D

Answer: (D) Go Back to Q29

Q30.

Solution

Concept — Ripple frequency of a full-wave rectifier: A full-wave rectifier conducts during *both* halves of each a.c. input cycle, inverting the negative half so that the output always has the same polarity. Because each input cycle now yields *two* output humps, the fundamental ripple frequency of the output is twice the input frequency, $f_{\text{ripple}} = 2f_{\text{input}}$. (A half-wave rectifier, by contrast, gives only one hump per cycle, so its ripple equals the input frequency.)

Given: a.c. input frequency $f_{\text{input}} = 50$ Hz; full-wave rectification.

Step 1 — Apply the full-wave relation: $f_{\text{ripple}} = 2 \times f_{\text{input}} = 2 \times 50$ Hz.

Step 2 — Evaluate: $f_{\text{ripple}} = 100$ Hz.

Why each other option is wrong:

- (B) 50 Hz is the input frequency and the ripple of a *half*-wave rectifier, not a full-wave one.
- (C) 25 Hz halves the input frequency, which no rectifier does.
- (D) 200 Hz multiplies by four instead of two, double the correct factor.

Key point: Full-wave ripple $= 2\times$ input frequency; half-wave ripple $= 1\times$ input frequency. With 50 Hz input the full-wave output ripples at 100 Hz.

Final Answer: 100 Hz $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q30

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	A	2	D	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
21	A	22	D	23	B	24	C	25	D
26	A	27	B	28	C	29	D	30	A