AIIMS B.Sc Nursing Physics

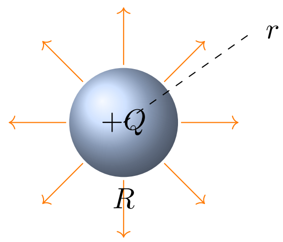
Sample Paper – 10

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. A solid conducting sphere of radius R carries a total charge Q. The electric field at a point at distance r ($r > R$) outside the sphere is the same as that of:



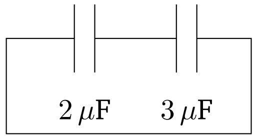
(A) a point charge Q placed at the centre, $E = \dfrac{kQ}{r^2}$

(B) a point charge Q placed on the surface

(C) zero everywhere outside

(D) $E = \dfrac{kQ}{R^2}$, independent of r

Q2. A capacitor of $2\ \mu$F charged to 100 V is connected in parallel to an uncharged $3\ \mu$F capacitor. The common potential after connection is:



(A) 60 V

(B) 50 V

(C) 40 V

(D) 100 V

Q3. When the temperature of a metallic conductor is raised, its electrical resistance:

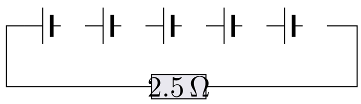
(A) increases, because more frequent collisions of electrons reduce their drift

(B) decreases, because the number of free electrons increases

(C) remains exactly constant

(D) first increases and then becomes zero

Q4. Five identical cells, each of emf 1.5 V and internal resistance $0.5\ \Omega$, are joined in series and connected across an external resistance of $2.5\ \Omega$. The current in the circuit is:



(A) 1.0 A

(B) 1.5 A

(C) 0.75 A

(D) 3.0 A

Q5. A 40 W bulb and a 100 W bulb (both rated for the same voltage) are first connected in series and then in parallel across the same supply. Which statement is correct?

(A) The 100 W bulb is brighter in both cases

(B) Both glow equally in both cases

(C) The 40 W bulb is brighter in parallel

(D) In series the 40 W bulb is brighter, in parallel the 100 W bulb is brighter

Q6. From Newton's law of gravitation $F = \frac{Gm_1m_2}{r^2}$, the dimensional formula of the gravitational constant G is:

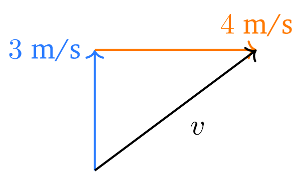
(A) $[ML^3T^{-2}]$

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

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

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

Q7. A boat can move at 3 m/s in still water. It heads straight across a river that flows at 4 m/s. The resultant speed of the boat relative to the ground is:



(A) 1 m/s

(B) 7 m/s

(C) 5 m/s

(D) 3.5 m/s

Q8. A body is released from rest and falls freely through a height of 45 m. The speed with which it strikes the ground is (take $g = 10$ m/s^2):

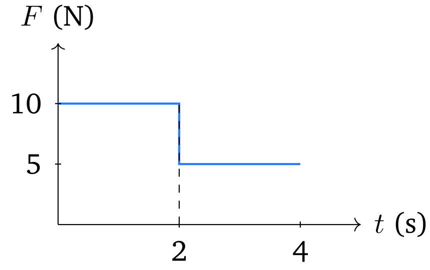
(A) 15 m/s

(B) 45 m/s

(C) 90 m/s

(D) 30 m/s

Q9. The force on a body varies with time as shown. The impulse delivered to the body in the 4 s interval (area under the graph) is:



(A) 30 N·s

(B) 20 N·s

(C) 40 N·s

(D) 15 N·s

Q10. A block of mass 5 kg is dragged 4 m along a rough horizontal floor at constant speed. If the coefficient of kinetic friction is 0.2 (take $g = 10$ m/s^2), the work done against friction is:

(A) 100 J

(B) 200 J

(C) 20 J

(D) 40 J

Q11. A vehicle engine develops a power of 60 kW while the vehicle moves at a constant speed of 20 m/s. The driving force exerted by the engine is:

(A) 1200 N

(B) 3000 N

(C) 300 N

(D) 1.2×10^6 N

Q12. A body weighs 60 N on the surface of the Earth. Taking the acceleration due to gravity on the Moon as one-sixth of that on the Earth, the weight of the body on the Moon is:

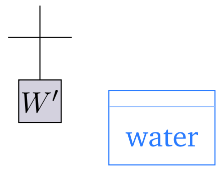
(A) 60 N

(B) 360 N

(C) 10 N

(D) 6 N

Q13. A solid weighs 50 N in air and 40 N when fully immersed in water. The relative density (specific gravity) of the solid is:



(A) 5

(B) 1.25

(C) 0.8

(D) 4

Q14. A tangential force produces a shear strain of 0.002 rad in a block whose modulus of rigidity is 5×10^{10} Pa. The shearing stress on the block is:

(A) 2.5×10^{13} Pa

(B) 1×10^{6} Pa

(C) 2.5×10^{7} Pa

(D) 1×10^{8} Pa

Q15. The average translational kinetic energy of a single gas molecule at absolute temperature T is (with k the Boltzmann constant):

(A) kT

(B) $\frac{1}{2}kT$

(C) $\frac{3}{2}kT$

(D) $\frac{5}{2}kT$

Q16. The heat required to convert 10 g of ice at 0 °C completely into steam at 100 °C is (latent heat of fusion $= 80$ cal/g, specific heat of water $= 1$ cal g^{-1} °C^{-1}, latent heat of vaporisation $= 540$ cal/g):

(A) 6200 cal

(B) 7200 cal

(C) 5400 cal

(D) 800 cal

Q17. A fixed mass of an ideal gas is taken through a complete cyclic process and returns to its initial state. The change in its internal energy over the full cycle is:

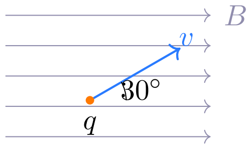
(A) zero

(B) equal to the net work done

(C) equal to the heat absorbed

(D) always positive

Q18. A charge of 2×10^{-3} C moves with a speed of 5×10^{4} m/s at 30° to a uniform magnetic field of 0.4 T. The magnetic force on the charge is:



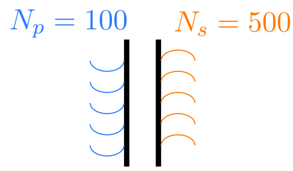
(A) 40 N

(B) 20 N

(C) 34.6 N

(D) 10 N

Q19. An ideal step-up transformer has 100 turns in the primary and 500 turns in the secondary. If the primary current is 10 A, the secondary current is:



(A) 50 A

(B) 10 A

(C) 2 A

(D) 5 A

Q20. An alternating supply is described by $v = 311\sin(100\pi t)$ volt, with t in seconds. The frequency of this supply is:

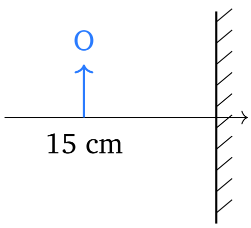
(A) 100 Hz

(B) 314 Hz

(C) 25 Hz

(D) 50 Hz

Q21. A concave mirror forms a real image of magnification -2 (twice the object size) of an object placed 15 cm in front of it. The focal length of the mirror is:



(A) 10 cm

(B) 30 cm

(C) 7.5 cm

(D) 5 cm

Q22. A convex lens forms an image at 30 cm of an object of height 4 cm placed 10 cm from the lens (object and image distances measured as magnitudes). The size of the image is:

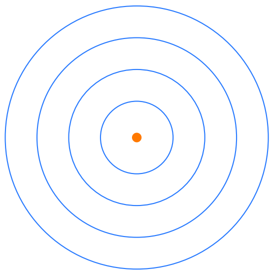
(A) 4 cm

(B) 12 cm

(C) 1.33 cm

(D) 40 cm

Q23. According to Huygens' principle, the wavefront produced by a point source of light in an isotropic medium is:



point source

(A) spherical

(B) plane

(C) cylindrical

(D) parabolic

Q24. A monochromatic source emits light of photon energy 4×10^{-19} J at a power of 8 W. The number of photons emitted per second is:

(A) 2×10^{19}

(B) 3.2×10^{-18}

(C) 2×10^{19} (per second)

(D) 0.5×10^{19}

Q25. In Bohr's model of the hydrogen atom, the radius of the first (ground state) orbit is 0.53 Å. The radius of the third orbit ($n = 3$) is:

(A) 1.59 Å

(B) 0.53 Å

(C) 2.12 Å

(D) 4.77 Å

Q26. The nuclear radius is given by $R = R_0 A^{1/3}$, where A is the mass number. The density of a nucleus therefore:

(A) increases with A

(B) is the same for all nuclei, independent of A

(C) decreases as $1/A$

(D) is proportional to $A^{1/3}$

Q27. Two simple pendulums of the same length are set oscillating with different amplitudes (both small). Which statement about their time periods is correct?

(A) The one with larger amplitude has a longer period

(B) The one with larger amplitude has a shorter period

(C) Both have the same period, since it is independent of amplitude

(D) The period depends on the mass of the bob

Q28. A stretched string of linear mass density 0.01 kg/m is held at a tension of 4 N. The speed of a transverse wave on the string is:

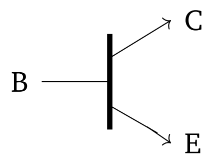
(A) 20 m/s

(B) 400 m/s

(C) 2 m/s

(D) 0.05 m/s

Q29. In the NPN transistor shown, the three terminals E, B and C are the:



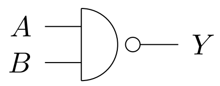
(A) base, collector, emitter respectively

(B) emitter, base, collector respectively

(C) collector, emitter, base respectively

(D) all three are emitters

Q30. For the two-input NAND gate shown, the output Y is LOW (0) only when:



(A) $A = 0$ and $B = 0$

(B) $A = 1$ and $B = 0$

(C) $A = 0$ and $B = 1$

(D) $A = 1$ and $B = 1$

Detailed Solutions

Q1.

Solution

Concept — Field outside a charged conductor: On any isolated charged conductor in static equilibrium, the entire excess charge Q migrates to the outer surface, because mutual repulsion drives the charges as far apart as possible and the interior field must be zero. For a spherically symmetric distribution, Gauss's law tells us the field at an external point depends only on the total enclosed charge and the distance r, not on how the charge is spread. The governing relation is $E = \frac{kQ}{r^2}$, where E is the field magnitude, $k = \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ \mathrm{N\,m^2C^{-2}}$, Q is the total charge, and r is the distance from the centre.

Step 1 — Choose a Gaussian surface: Take a concentric spherical Gaussian surface of radius $r > R$. By symmetry $\vec{E}$ is radial and constant in magnitude over this surface, so the flux is $\Phi_E = E\,(4\pi r^2)$.

Step 2 — Apply Gauss's law: The charge enclosed is the whole charge Q (all of it lies inside the surface), so $E\,(4\pi r^2) = \frac{Q}{\varepsilon_0}$. Solving for E gives $E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2} = \frac{kQ}{r^2}$.

Step 3 — Interpret the result: This is exactly the field a single point charge Q would produce if it sat at the centre of the sphere. The external field falls off as $1/r^2$ and carries no memory of the sphere's radius R once you are outside it.

Why each other option is wrong:

- (B) A point charge on the surface would break the spherical symmetry and give a field that depends on direction, contradicting the uniform radial field actually observed.
- (C) "Zero everywhere outside" is false; the field is zero only *inside* the conducting material, not outside it.
- (D) $E = \frac{kQ}{R^2}$ uses the fixed radius R, making E independent of r; but the external field clearly weakens with distance as $1/r^2$.

Key point: Outside any spherically symmetric charge, only the total charge and the distance to the centre matter; the body behaves like a point charge at its centre.

Final Answer: $E = \frac{kQ}{r^2} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q1

Q2.

Solution

Concept — Common potential of connected capacitors: When a charged capacitor is connected in parallel to another capacitor, charge flows between them until both plates reach the same potential. No charge can escape the isolated combination, so the total charge is conserved. The shared final potential is the total charge divided by the total capacitance, $V = \frac{Q_{\text{total}}}{C_{\text{total}}}$, where Q_{total} is the sum of the initial charges and $C_{\text{total}} = C_1 + C_2$ for a parallel connection.

Given: $C_1 = 2\ \mu\text{F}$ charged to $V_1 = 100$ V; $C_2 = 3\ \mu\text{F}$ initially uncharged ($V_2 = 0$).

Step 1 — Find the initial charge: $Q_1 = C_1V_1 = (2\ \mu\text{F})(100\ \text{V}) = 200\ \mu\text{C}$. The second capacitor carries $Q_2 = 0$, so the total charge available is $Q_{\text{total}} = 200 + 0 = 200\ \mu\text{C}$.

Step 2 — Add the capacitances: In parallel the plates connect directly, so $C_{\text{total}} = C_1 + C_2 = 2 + 3 = 5\ \mu\text{F}$.

Step 3 — Compute the common potential: $V = \frac{Q_{\text{total}}}{C_{\text{total}}} = \frac{200\ \mu\text{C}}{5\ \mu\text{F}} = 40$ V.

Why each other option is wrong:

- (A) 60 V would need a total capacitance of about $3.3\ \mu\text{F}$, not the correct $5\ \mu\text{F}$.
- (B) 50 V comes from dividing $200\ \mu\text{C}$ by $4\ \mu\text{F}$, an incorrect capacitance sum.
- (D) 100 V ignores the uncharged $3\ \mu\text{F}$ capacitor; once it shares the charge, the potential must drop below 100 V.

Key point: Charge is conserved, but energy is not; some stored energy is always lost as heat in the connecting wires during the redistribution.

Final Answer: $V = 40\ \text{V} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q2

Q3.

Solution

Concept — Resistance of a metal versus temperature: In a metallic conductor the density of free (conduction) electrons is essentially fixed and does not increase with heating. What changes is the lattice: raising the temperature makes the positive ion cores vibrate with larger amplitude, so the drifting electrons collide with them far more frequently. Resistance therefore rises with temperature, captured by $R_T = R_0(1 + \alpha\,\Delta T)$, where R_0 is the resistance at the reference temperature,

$\alpha > 0$ is the temperature coefficient of resistance for a metal, and ΔT is the temperature rise.

Step 1 — Effect on the relaxation time: More frequent electron–ion collisions shorten the average time τ between collisions (the relaxation time). Since $\sigma = \frac{ne^2\tau}{m}$, a smaller τ means smaller conductivity.

Step 2 — Effect on drift velocity: For a fixed applied field E, the drift speed $v_d = \frac{eE\tau}{m}$ falls when τ falls, so the same field drives a smaller current.

Step 3 — Net result: Lower conductivity means higher resistivity $\rho = \frac{1}{\sigma}$, hence higher resistance. For a metal α is positive, so R climbs roughly linearly over moderate temperature ranges.

Why each other option is wrong:

- (B) The free-electron count barely changes in a metal; the rise in carrier number with temperature is a semiconductor effect, where resistance *falls*.
- (C) The resistance is not constant; experiments clearly show metal wires heat up and resist more as current flows.
- (D) Resistance never spontaneously drops to zero on heating; superconductivity occurs on *cooling* certain materials, the opposite trend.

Key point: For metals, heat increases resistance (positive α); for semiconductors the opposite holds because new charge carriers are freed.

Final Answer: Resistance increases $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q3

Q4.

Solution

Concept — Identical cells in series: When n identical cells are joined in series, their emfs add directly (head to tail) and their internal resistances also add in series. The circuit current obeys $I = \frac{nE}{R + nr}$, where E is the emf of one cell, r is the internal resistance of one cell, R is the external resistance, and n is the number of cells.

Given: $n = 5$ cells, $E = 1.5$ V each, $r = 0.5\ \Omega$ each, external resistance $R = 2.5\ \Omega$.

Step 1 — Total emf: $nE = 5 \times 1.5\ \text{V} = 7.5\ \text{V}$.

Step 2 — Total internal resistance: $nr = 5 \times 0.5\ \Omega = 2.5\ \Omega$, so the full circuit resistance is $R + nr = 2.5 + 2.5 = 5\ \Omega$.

Step 3 — Current: $I = \dfrac{nE}{R + nr} = \dfrac{7.5\ \text{V}}{5\ \Omega} = 1.5$ A.

Why each other option is wrong:

- (A) 1.0 A results from using a single cell's emf 1.5 V instead of the combined 7.5 V.
- (C) 0.75 A comes from doubling the resistance to $10\ \Omega$, an error in adding R and nr.
- (D) 3.0 A ignores the internal resistance entirely, dividing 7.5 V by only $2.5\ \Omega$.

Key point: Series cells boost the driving emf but also stack up internal resistance; always include nr in the denominator.

Final Answer: $I = 1.5$ A $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q4

Q5.

Solution

Concept — Bulb resistance and brightness: A bulb's filament resistance is fixed by its rating through $R = \dfrac{V^2}{P}$, where V is the rated voltage and P the rated power. For the same rated voltage, the *lower*-power bulb has the *higher* resistance, so the 40 W bulb is the more resistive one. Brightness depends on the power actually dissipated, which is $P = I^2R$ when the current I is shared (series) and $P = \dfrac{V^2}{R}$ when the voltage V is shared (parallel).

Step 1 — Compare resistances: $R_{40} = \dfrac{V^2}{40}$ and $R_{100} = \dfrac{V^2}{100}$, so $R_{40} > R_{100}$. The 40 W bulb has the larger resistance by a factor of $\dfrac{100}{40} = 2.5$.

Step 2 — Series connection: Here the same current I flows through both bulbs, so $P = I^2R$ grows with R. The higher-resistance 40 W bulb dissipates more power and therefore glows brighter in series.

Step 3 — Parallel connection: Here the same supply voltage V sits across each bulb, so $P = \dfrac{V^2}{R}$ grows as R shrinks. The lower-resistance 100 W bulb now dissipates more power and glows brighter (each bulb runs at its rated power).

Why each other option is wrong:

- (A) The 100 W bulb is brighter only in parallel, not in series, so it is not brighter in both cases.

- (B) The two bulbs have different resistances, so they cannot glow equally in either arrangement.
- (C) In parallel the 100 W bulb (lower R) is brighter, not the 40 W bulb.

Key point: In series, "higher resistance wins" ($P = I^2R$); in parallel, "lower resistance wins" ($P = V^2/R$). The brighter bulb swaps between the two connections.

Final Answer: 40 W brighter in series, 100 W brighter in parallel $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q5

Q6.

Solution

Concept — Dimensions of the gravitational constant G: The dimensional formula of any physical constant is found by isolating it in its defining equation and substituting the known dimensions of every other quantity. Starting from Newton's law $F = \dfrac{Gm_1m_2}{r^2}$ and solving for G gives $G = \dfrac{Fr^2}{m_1m_2}$, where F is force, r a distance, and m_1, m_2 are masses.

Given: $[F] = [MLT^{-2}]$, $[r^2] = [L^2]$, $[m_1m_2] = [M^2]$.

Step 1 — Substitute the dimensions: $[G] = \dfrac{[F][r^2]}{[m_1m_2]} = \dfrac{[MLT^{-2}][L^2]}{[M][M]}$.

Step 2 — Combine numerator: The numerator is $[MLT^{-2}][L^2] = [ML^3T^{-2}]$, and the denominator is $[M^2]$, so $[G] = \dfrac{[ML^3T^{-2}]}{[M^2]}$.

Step 3 — Simplify the powers: Subtracting the mass exponents, $M^{1-2} = M^{-1}$, gives $[G] = [M^{-1}L^3T^{-2}]$.

Why each other option is wrong:

- (A) $[ML^3T^{-2}]$ forgets to divide by the two masses, leaving the wrong $+1$ power of M.
- (C) $[M^{-1}L^2T^{-2}]$ uses L^2 instead of L^3, dropping one power of length from r^2 times the L in force.
- (D) $[ML^{-3}T^2]$ inverts the length and time dimensions and keeps the wrong mass power.

Key point: G carries the SI units $\text{N m}^2\text{kg}^{-2}$, which match $[M^{-1}L^3T^{-2}]$ exactly.

Final Answer: $[M^{-1}L^3T^{-2}] \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q6

Q7.

Solution

Concept — Resultant of two perpendicular velocities: Velocities add as vectors. When the boat points straight across the river, its velocity (across) and the river current (along the bank) are at right angles, so the ground velocity is the vector sum of two perpendicular vectors. Their magnitudes combine by the Pythagorean rule $v = \sqrt{v_b^2 + v_r^2}$, where v_b is the boat's speed in still water and v_r is the river's speed.

Given: $v_b = 3$ m/s (across the river), $v_r = 4$ m/s (along the river), and the angle between them is $90°$.

Step 1 — Write the resultant: $v = \sqrt{v_b^2 + v_r^2} = \sqrt{3^2 + 4^2}$.

Step 2 — Evaluate the squares: $v = \sqrt{9 + 16} = \sqrt{25}$ (units of m^2/s^2 under the root).

Step 3 — Take the root: $v = 5$ m/s, directed at an angle $\theta = \tan^{-1}\left(\frac{4}{3}\right) \approx 53°$ to the boat's heading.

Why each other option is wrong:

- (A) 1 m/s is $v_r - v_b$, the result only for two *antiparallel* velocities, not perpendicular ones.
- (B) 7 m/s is $v_b + v_r$, valid only if the two velocities pointed the same way.
- (D) 3.5 m/s is the plain average of 3 and 4, which has no basis in vector addition.

Key point: Perpendicular vectors combine through the hypotenuse, giving the familiar 3–4–5 right triangle here.

Final Answer: $v = 5$ m/s $\Rightarrow$ C

Answer: (C) Go Back to Q7

Q8.

Solution

Concept — Free fall under gravity: A body released from rest falls with constant acceleration g. Using the kinematic relation $v^2 = u^2 + 2gh$ with initial speed $u = 0$ gives $v = \sqrt{2gh}$, where v is the speed on striking the ground, g is the acceleration due to gravity, and h is the height fallen. The mass of the body does not appear, so all bodies (ignoring air resistance) reach the same speed from the same height.

Given: $u = 0$ (released from rest), $h = 45$ m, $g = 10$ m/s^2.

Step 1 — Write the formula: $v = \sqrt{2gh}$.

Step 2 — Substitute the data: $v = \sqrt{2 \times 10 \text{ m/s}^2 \times 45 \text{ m}} = \sqrt{900 \text{ m}^2/\text{s}^2}$.

Step 3 — Take the root: $v = 30$ m/s.

Why each other option is wrong:

- (A) 15 m/s drops the factor of 2 inside the root, giving $\sqrt{450}$ instead of $\sqrt{900}$.
- (B) 45 m/s wrongly equates the speed with the numerical value of the height.
- (C) 90 m/s forgets the square root, reporting $2gh = 900$ directly as a speed.

Key point: Free-fall speed scales as $\sqrt{h}$, not h; quadrupling the height only doubles the impact speed.

Final Answer: $v = 30 \text{ m/s} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q8

Q9.

Solution

Concept — Impulse as the area under an F–t graph: Impulse is defined as $J = \int F\,dt$, the time integral of force, which equals the change in momentum of the body. Graphically this integral is simply the area enclosed between the force–time curve and the time axis, so a step graph is handled by summing the areas of the separate rectangular blocks.

Given: From the graph, $F = 10$ N for $0 \le t \le 2$ s, then $F = 5$ N for $2 \le t \le 4$ s.

Step 1 — First rectangle (0 to 2 s): Area $= F \times \Delta t = 10 \text{ N} \times 2 \text{ s} = 20 \text{ N} \cdot \text{s}$.

Step 2 — Second rectangle (2 to 4 s): Area $= 5 \text{ N} \times 2 \text{ s} = 10 \text{ N} \cdot \text{s}$.

Step 3 — Total impulse: $J = 20 + 10 = 30 \text{ N} \cdot \text{s}$.

Why each other option is wrong:

- (B) 20 N·s counts only the first block and ignores the 5 N segment.
- (C) 40 N·s double-counts, treating both segments as if they were 10 N tall.
- (D) 15 N·s wrongly treats a flat step as a sloping triangle, halving an area.

Key point: For a piecewise-constant force, just add "height $\times$ width" for each block; impulse equals the total momentum change.

Final Answer: $J = 30$ N·s $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q9

Q10.

Solution

Concept — Work done against kinetic friction: On a horizontal surface the normal reaction equals the weight, $N = mg$, so the kinetic friction force is $f = \mu N = \mu mg$. The work done against this constant force over a straight distance d is $W = f\,d = \mu mg\,d$, where μ is the coefficient of kinetic friction, m the mass, g the gravitational acceleration, and d the displacement. Because the block moves at constant speed, all this work is converted into heat.

Given: $m = 5$ kg, $d = 4$ m, $\mu = 0.2$, $g = 10$ m/s^2.

Step 1 — Friction force: $f = \mu mg = 0.2 \times 5$ kg $\times 10$ m/s$^2 = 10$ N.

Step 2 — Work against friction: $W = f\,d = 10$ N $\times 4$ m $= 40$ J.

Step 3 — Interpret: Since speed is constant, the kinetic energy does not change; the 40 J supplied by the dragging force is entirely dissipated as heat at the contact surface.

Why each other option is wrong:

- (A) 100 J omits the coefficient $\mu = 0.2$, using $mg\,d$ alone.
- (B) 200 J both omits μ and uses an inflated force, far above the actual 10 N.
- (C) 20 J uses half the distance (or half the force), giving 10×2 instead of 10×4.

Key point: On a level floor, friction work is just μmg times distance; at constant speed this equals the heat generated.

Final Answer: $W = 40$ J $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q10

Q11.

Solution

Concept — Power, force and speed: The mechanical power delivered by a force acting along the direction of motion is $P = Fv$, the product of force and speed. For a vehicle moving at constant speed the driving force balances the resistive forces, and rearranging gives $F = \frac{P}{v}$, where P is the engine power, F the driving force, and v the steady speed.

Given: $P = 60 \text{ kW} = 60\,000 \text{ W} = 6 \times 10^4 \text{ W}$; $v = 20 \text{ m/s}$.

Step 1 — Write the formula: $F = \frac{P}{v}$.

Step 2 — Substitute the data: $F = \frac{6 \times 10^4 \text{ W}}{20 \text{ m/s}}$.

Step 3 — Evaluate: $F = 3000 \text{ N}$ (units: $\text{W}/(\text{m/s}) = \text{N}$).

Why each other option is wrong:

- (A) 1200 N comes from a wrong arithmetic split of $60\,000$ by 50, not by the given 20.
- (C) 300 N drops a factor of ten, dividing 6000 rather than $60\,000$ by 20.
- (D) 1.2×10^6 N multiplies P by v instead of dividing, inverting the relation.

Key point: At constant speed, $F = P/v$; the larger the speed, the smaller the force a fixed-power engine can supply.

Final Answer: $F = 3000 \text{ N} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q11

Q12.

Solution

Concept — Weight on the Moon: Weight is the gravitational force on a body, $W = mg$, where m is the (invariant) mass and g is the local gravitational acceleration. Moving to the Moon does not change the mass, but the Moon's surface gravity is about one-sixth of Earth's, $g_{\text{moon}} = \frac{g}{6}$. Hence the weight is simply scaled by the same factor, $W_{\text{moon}} = \frac{W_{\text{earth}}}{6}$.

Given: $W_{\text{earth}} = 60 \text{ N}$; $g_{\text{moon}} = \frac{g_{\text{earth}}}{6}$.

Step 1 — Note the mass is unchanged: The same body keeps the same mass

$m = \dfrac{W_{\text{earth}}}{g_{\text{earth}}}$; only g changes.

Step 2 — Apply the gravity ratio: $W_{\text{moon}} = m\,g_{\text{moon}} = m\,\dfrac{g_{\text{earth}}}{6} = \dfrac{W_{\text{earth}}}{6} = \dfrac{60\text{ N}}{6}$.

Step 3 — Evaluate: $W_{\text{moon}} = 10$ N.

Why each other option is wrong:

- (A) 60 N assumes weight is unchanged, ignoring the smaller lunar gravity.
- (B) 360 N multiplies by 6 instead of dividing, as if the Moon's gravity were stronger.
- (D) 6 N divides by 10 rather than by the correct factor of 6.

Key point: Mass is the same everywhere; only weight changes with g, so lunar weight is one-sixth of Earth weight.

Final Answer: $W_{\text{moon}} = 10\text{ N} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q12

Q13.

Solution

Concept — Archimedes' principle and relative density: A fully immersed solid loses apparent weight equal to the upthrust, which by Archimedes' principle is the weight of the water it displaces. The relative density (specific gravity) of the solid is the ratio of its weight to the weight of an equal volume of water, which conveniently equals $\text{R.D.} = \dfrac{\text{weight in air}}{\text{loss of weight in water}}$, since the displaced water has the same volume as the solid.

Given: Weight in air $W_a = 50$ N; weight fully immersed in water $W_w = 40$ N.

Step 1 — Loss of weight (upthrust): $W_a - W_w = 50 - 40 = 10$ N. This 10 N equals the weight of the displaced water.

Step 2 — Apply the relative-density formula: $\text{R.D.} = \dfrac{W_a}{W_a - W_w} = \dfrac{50\text{ N}}{10\text{ N}}$.

Step 3 — Evaluate: $\text{R.D.} = 5$ (a pure number, since it is a ratio of two weights).

Why each other option is wrong:

- (B) 1.25 comes from dividing 50 by 40, using the immersed weight rather than the weight loss.
- (C) 0.8 is the reciprocal $40/50$, inverting the correct ratio.

- (D) 4 uses the immersed weight 40 in the numerator over the loss 10, mixing up the quantities.

Key point: $\text{R.D.} = \dfrac{\text{weight in air}}{\text{apparent loss in water}}$; the denominator is the upthrust, not the immersed weight.

Final Answer: $\text{R.D.} = 5 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q13

Q14.

Solution

Concept — Modulus of rigidity (shear modulus): The modulus of rigidity relates the shearing stress applied to a body to the shear strain it produces: $\eta = \dfrac{\text{shearing stress}}{\text{shear strain}}$. Here η is the shear modulus (in pascals), the shear strain is the angle ϕ (in radians) through which the block is sheared, and the shearing stress is the tangential force per unit area. Rearranging gives stress $= \eta \times$ strain.

Given: shear strain $\phi = 0.002$ rad $= 2 \times 10^{-3}$ rad; modulus of rigidity $\eta = 5 \times 10^{10}$ Pa.

Step 1 — Write the formula: stress $= \eta\,\phi$.

Step 2 — Substitute the data: stress $= (5 \times 10^{10}\text{ Pa})(2 \times 10^{-3})$.

Step 3 — Evaluate: Multiply the mantissas $5 \times 2 = 10$ and add the exponents $10 + (-3) = 7$, giving $10 \times 10^{7} = 1 \times 10^{8}$ Pa.

Why each other option is wrong:

- (A) 2.5×10^{13} Pa comes from dividing η by the strain instead of multiplying.
- (B) 1×10^{6} Pa uses the wrong power of ten, off by a factor of 100.
- (C) 2.5×10^{7} Pa both halves the mantissa and uses an incorrect exponent.

Key point: Shear strain is dimensionless (an angle in radians), so stress and modulus share the same units of pascals.

Final Answer: stress $= 1 \times 10^{8}$ Pa $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q14

Q15.

Solution

Concept — Kinetic theory and the equipartition of energy: The equipartition theorem assigns an average energy of $\frac{1}{2}kT$ to each independent quadratic degree of freedom, where k is the Boltzmann constant and T the absolute temperature. Translational motion has three independent directions (x, y, z), so the average translational kinetic energy of a single molecule is $\overline{KE} = \dfrac{3}{2}kT$. This depends only on temperature, not on the gas's identity or pressure.

Step 1 — Count the translational degrees of freedom: A point molecule can move along three perpendicular axes, giving three translational degrees of freedom.

Step 2 — Assign energy to each: Each direction contributes $\frac{1}{2}kT$ on average, so the per-molecule translational energy is the sum over the three axes.

Step 3 — Add them: $\overline{KE} = 3 \times \dfrac{1}{2}kT = \dfrac{3}{2}kT$.

Why each other option is wrong:

- (A) kT counts only two translational directions, undercounting the degrees of freedom.
- (B) $\frac{1}{2}kT$ counts a single direction, the energy of just one translational mode.
- (D) $\frac{5}{2}kT$ adds rotational modes; that is the *total* energy of a diatomic molecule, not the purely translational part.

Key point: Translational kinetic energy is always $\frac{3}{2}kT$ per molecule, regardless of whether the gas is monatomic or polyatomic.

Final Answer: $\overline{KE} = \dfrac{3}{2}kT \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q15

Q16.

Solution

Concept — Multi-stage calorimetry: Converting ice at $0\,°\text{C}$ into steam at $100\,°\text{C}$ happens in three distinct stages, each with its own heat term. Latent-heat stages use $Q = mL$ (no temperature change while phases change) and the warming stage uses $Q = mc\,\Delta T$. Here m is the mass, L_f the latent heat of fusion, c the specific heat of water, ΔT the temperature rise, and L_v the latent heat of vaporisation. The total heat is the sum of all three.

Given: $m = 10$ g, $L_f = 80$ cal/g, $c = 1$ cal g^{-1} °C^{-1}, $\Delta T = 100$ °C, $L_v = 540$ cal/g.

Step 1 — Melt the ice (0 °C): $Q_1 = mL_f = 10 \times 80 = 800$ cal.

Step 2 — Warm the water (0 → 100 °C): $Q_2 = mc\Delta T = 10 \times 1 \times 100 = 1000$ cal.

Step 3 — Boil the water to steam (100 °C): $Q_3 = mL_v = 10 \times 540 = 5400$ cal. The total is $Q = Q_1 + Q_2 + Q_3 = 800 + 1000 + 5400 = 7200$ cal.

Why each other option is wrong:

- (A) 6200 cal drops the 1000 cal warming stage, adding only $800 + 5400$.
- (C) 5400 cal counts only the vaporisation term, ignoring melting and warming.
- (D) 800 cal counts only the melting term, the smallest of the three.

Key point: Never skip the warming stage between two phase changes; latent heat covers the transition, but raising the temperature still needs $mc\Delta T$.

Final Answer: $Q = 7200$ cal $\Rightarrow$ B

Answer: (B) Go Back to Q16

Q17.

Solution

Concept — Internal energy as a state function: The internal energy U of an ideal gas depends only on its current thermodynamic state (for an ideal gas, on its temperature), and not on the path by which that state was reached. Such a quantity is called a state function, and its change between two states depends only on the endpoints. The first law of thermodynamics reads $\Delta U = Q - W$, where Q is heat added and W is work done by the gas.

Step 1 — Recognise the cyclic process: In a complete cycle the gas is brought back to its exact initial state, so the initial and final temperatures (and hence U) are identical: $U_{\text{final}} = U_{\text{initial}}$.

Step 2 — Compute the change: Therefore $\Delta U = U_{\text{final}} - U_{\text{initial}} = 0$ over the full cycle, no matter how complicated the intermediate path.

Step 3 — Consistency with the first law: With $\Delta U = 0$, the first law gives $Q_{\text{net}} = W_{\text{net}}$; all the heat absorbed in a cycle is converted into net work, but that does not make ΔU nonzero.

Why each other option is wrong:

- (B) The net work is generally nonzero, but it equals Q_{net}, not ΔU (which is zero).
- (C) The heat absorbed over the cycle is nonzero, yet it is not the internal-energy change.
- (D) ΔU is not "always positive"; for a closed cycle it is exactly zero.

Key point: Over any closed cycle, $\Delta U = 0$ because U is a state function; work and heat (path functions) need not vanish.

Final Answer: $\Delta U = 0 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q17

Q18.

Solution

Concept — Magnetic force on a moving charge: A charge moving through a magnetic field feels the Lorentz magnetic force $F = qvB\sin\theta$, where q is the charge, v its speed, B the magnetic flux density, and θ the angle between the velocity and the field. The force is largest when motion is perpendicular to B ($\theta = 90^\circ$) and zero when motion is parallel ($\theta = 0^\circ$).

Given: $q = 2 \times 10^{-3}$ C, $v = 5 \times 10^4$ m/s, $B = 0.4$ T, $\theta = 30^\circ$ so $\sin 30^\circ = 0.5$.

Step 1 — Write the formula: $F = qvB\sin\theta$.

Step 2 — Compute the product qvB: $qvB = (2 \times 10^{-3})(5 \times 10^4)(0.4)$. First $2 \times 5 = 10$ with exponent $-3 + 4 = 1$, giving $10 \times 10^1 = 100$; then $\times 0.4 = 40$ N.

Step 3 — Apply the angle factor: $F = qvB\sin\theta = 40 \times 0.5 = 20$ N.

Why each other option is wrong:

- (A) 40 N forgets the $\sin 30^\circ$ factor, treating the motion as perpendicular to B.
- (C) 34.6 N uses $\sin 60^\circ \approx 0.866$ instead of $\sin 30^\circ$, mistaking the angle.
- (D) 10 N applies the sine factor twice (or halves 40 once too often).

Key point: Always include $\sin\theta$; only the velocity component perpendicular to B produces a magnetic force.

Final Answer: $F = 20 \text{ N} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q18

Q19.

Solution

Concept — Ideal transformer: In an ideal (loss-free) transformer all the input power appears at the output, so $V_pI_p = V_sI_s$. Combined with the voltage rule $\frac{V_s}{V_p} = \frac{N_s}{N_p}$, this gives the current relation $\frac{I_s}{I_p} = \frac{N_p}{N_s}$, where N_p, N_s are the primary and secondary turns and I_p, I_s the corresponding currents. A step-up transformer (more secondary turns) raises voltage but lowers current.

Given: $N_p = 100$ turns, $N_s = 500$ turns, primary current $I_p = 10$ A.

Step 1 — Form the turns ratio: $\frac{N_p}{N_s} = \frac{100}{500} = \frac{1}{5}$.

Step 2 — Apply the current relation: $I_s = I_p \times \frac{N_p}{N_s} = 10\text{ A} \times \frac{1}{5}$.

Step 3 — Evaluate: $I_s = 2$ A. (As a check, voltage is stepped up by $5\times$, so current must fall by $5\times$, keeping power constant.)

Why each other option is wrong:

- (A) 50 A multiplies the current by the turns ratio the wrong way, raising current in a step-up unit.
- (B) 10 A leaves the current unchanged, ignoring the transformation entirely.
- (D) 5 A uses an incorrect ratio (such as $\sqrt{N_s/N_p}$) rather than N_p/N_s.

Key point: In a step-up transformer voltage and current trade off inversely; higher secondary voltage always means lower secondary current.

Final Answer: $I_s = 2\text{ A} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q19

Q20.

Solution

Concept — Frequency from a sinusoidal supply: Any alternating quantity written as $v = v_0 \sin(\omega t)$ has angular frequency ω (in rad/s) sitting beside t inside the sine. The ordinary frequency is related by $\omega = 2\pi f$, so $f = \frac{\omega}{2\pi}$, where v_0 is the peak voltage, ω the angular frequency, and f the frequency in hertz.

Given: $v = 311 \sin(100\pi t)$ V, so the peak voltage is $v_0 = 311$ V and the angular frequency is $\omega = 100\pi$ rad/s.

Step 1 — Identify ω: Comparing with $v = v_0 \sin(\omega t)$, the coefficient of t is $\omega =$

100π rad/s.

Step 2 — Apply the frequency relation: $f = \dfrac{\omega}{2\pi} = \dfrac{100\pi}{2\pi}$.

Step 3 — Evaluate: The π cancels, leaving $f = \dfrac{100}{2} = 50$ Hz, the standard Indian mains frequency.

Why each other option is wrong:

- (A) 100 Hz keeps the bare number 100 from ω without dividing by 2π.
- (B) 314 Hz mistakes the numerical value of $\omega = 100\pi \approx 314$ rad/s for the frequency.
- (C) 25 Hz divides by an extra factor of 2, using 4π in the denominator.

Key point: The number multiplying t is ω, not f; always divide by 2π to get the frequency in hertz.

Final Answer: $f = 50$ Hz $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q20

Q21.

Solution

Concept — Magnification and the mirror formula: The linear magnification of a mirror is $m = -\dfrac{v}{u}$, where u is the object distance and v the image distance. A real, inverted, magnified image has $m = -2$, which means $|v| = 2|u|$. The focal length then follows from the mirror formula, here written in magnitudes for a concave mirror as $\dfrac{1}{f} = \dfrac{1}{v} + \dfrac{1}{u}$.

Given: object distance $|u| = 15$ cm, magnification $m = -2$ (real image, twice the object size).

Step 1 — Find the image distance: From $|m| = \dfrac{|v|}{|u|} = 2$, we get $|v| = 2 \times 15 = 30$ cm.

Step 2 — Apply the mirror formula: $\dfrac{1}{f} = \dfrac{1}{|v|} + \dfrac{1}{|u|} = \dfrac{1}{30} + \dfrac{1}{15} = \dfrac{1}{30} + \dfrac{2}{30} = \dfrac{3}{30} = \dfrac{1}{10}$.

Step 3 — Solve for f: Inverting gives $f = 10$ cm (and the radius of curvature would be $R = 2f = 20$ cm).

Why each other option is wrong:

- (B) 30 cm is the image distance $|v|$, not the focal length.
- (C) 7.5 cm comes from mishandling the magnification, e.g. taking $|v| = |u|/2$.
- (D) 5 cm results from adding the reciprocals incorrectly or halving the correct focal length.

Key point: First convert the magnification into the image distance, then feed both distances into the mirror formula.

Final Answer: $f = 10 \text{ cm} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q21

Q22.

Solution

Concept — Linear magnification of a lens: The linear magnification of a thin lens is $m = \frac{v}{u} = \frac{h_i}{h_o}$, the ratio of image distance to object distance, which also equals the ratio of image height to object height. Working with magnitudes for the image size, $h_i = h_o \times \frac{v}{u}$, where h_o is the object height, h_i the image height, u the object distance, and v the image distance.

Given: object height $h_o = 4$ cm, object distance $|u| = 10$ cm, image distance $|v| = 30$ cm.

Step 1 — Compute the magnification magnitude: $\frac{|v|}{|u|} = \frac{30}{10} = 3$, so the image is three times the object's height.

Step 2 — Find the image size: $h_i = h_o \times \frac{|v|}{|u|} = 4 \text{ cm} \times 3 = 12 \text{ cm}$.

Why each other option is wrong:

- (A) 4 cm assumes a magnification of 1, ignoring that the image is three times farther than the object.
- (C) 1.33 cm divides the height by 3, using $\frac{u}{v}$ instead of $\frac{v}{u}$.
- (D) 40 cm multiplies the object distance by the height, mixing unrelated quantities.

Key point: Image size scales with $\frac{v}{u}$; when the image distance exceeds the object distance, the image is enlarged.

Final Answer: $h_i = 12 \text{ cm} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q22

Q23.

Solution

Concept — Huygens' principle and wavefronts: A wavefront is the locus of all points oscillating in the same phase. According to Huygens' principle, every point on a wavefront acts as a secondary source emitting wavelets. A point source in an isotropic (direction-independent) medium radiates equally in all directions, so the disturbance reaches every point at the same distance at the same instant, putting them all in phase.

Step 1 — Identify the locus of equal phase: The set of points equidistant from a single point is, by definition, the surface of a sphere centred on that point.

Step 2 — Name the wavefront: Hence the wavefront from a point source is spherical, expanding outward like concentric shells as time passes.

Step 3 — Large-distance limit: Very far from the source, a tiny patch of the huge sphere looks almost flat, which is why distant starlight reaches us as an approximately plane wavefront; but the fundamental shape from a point source is spherical.

Why each other option is wrong:

- (B) A plane wavefront requires a source at infinity (or a collimated beam), not a nearby point source.
- (C) A cylindrical wavefront is produced by a line source, such as an illuminated slit, not a point.
- (D) Parabolic is not a free-space wavefront shape; parabolas appear in reflector geometry, not in the wavefront from a point source.

Key point: Point source $\rightarrow$ spherical wavefront; line source $\rightarrow$ cylindrical; source at infinity $\rightarrow$ plane.

Final Answer: Spherical $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q23

Q24.

Solution

Concept — Photon emission rate: A monochromatic source delivers its power in discrete photons, each carrying energy E. The radiated power equals the energy per photon times the number of photons emitted per second, $P = nE$, so the emission rate is $n = \frac{P}{E}$, where P is the source power (watts), E the energy of one photon (joules), and n the number of photons per second.

Given: photon energy $E = 4 \times 10^{-19}$ J; source power $P = 8$ W $= 8$ J/s.

Step 1 — Write the formula: $n = \dfrac{P}{E}$.

Step 2 — Substitute the data: $n = \dfrac{8}{4 \times 10^{-19}}$ (units: $\dfrac{\text{J/s}}{\text{J}} = \text{s}^{-1}$).

Step 3 — Evaluate: $\dfrac{8}{4} = 2$ and dividing by 10^{-19} multiplies by 10^{19}, so $n = 2 \times 10^{19}$ photons per second.

Why each other option is wrong:

- (A) This lists the same numerical value but without the explicit "per second" rate unit the question asks for, whereas option (C) states it correctly.
- (B) 3.2×10^{-18} multiplies P by E instead of dividing, giving a meaningless tiny number.
- (D) 0.5×10^{19} inverts the ratio, computing $\dfrac{E}{P}$ scaled wrongly.

Key point: Emission rate is power divided by photon energy; a larger photon energy means fewer photons for the same wattage.

Final Answer: $n = 2 \times 10^{19}$ per second $\Rightarrow$ C

Answer: (C) Go Back to Q24

Q25.

Solution

Concept — Bohr orbit radius: In Bohr's model of hydrogen the allowed (stationary) orbit radii grow as the square of the principal quantum number: $r_n = n^2 r_1$, where $r_1 = 0.53$ Å is the ground-state (Bohr) radius and $n = 1, 2, 3, \ldots$ labels the orbit. The n^2 dependence arises from quantising the angular momentum in units of $\dfrac{h}{2\pi}$.

Given: first-orbit radius $r_1 = 0.53$ Å; required orbit $n = 3$.

Step 1 — Write the formula: $r_n = n^2 r_1$, so $r_3 = 3^2\, r_1$.

Step 2 — Insert $n = 3$: $r_3 = 9 \times 0.53$ Å.

Step 3 — Evaluate: $r_3 = 4.77$ Å.

Why each other option is wrong:

- (A) 1.59 Å uses $n = 3$ linearly (3×0.53) instead of $n^2 = 9$.
- (B) 0.53 Å is simply the first-orbit radius, with no scaling applied.
- (C) 2.12 Å corresponds to $n = 2$ (4×0.53), the wrong orbit.

Key point: Bohr radii scale as n^2; the third orbit is nine times the first, not three times.

Final Answer: $r_3 = 4.77$ Å $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q25

Q26.

Solution

Concept — Nuclear density: Density is mass divided by volume, $\rho = \dfrac{M}{V}$. A nucleus of mass number A has mass $M \approx A\,m_p$ (with m_p the nucleon mass) and, from $R = R_0 A^{1/3}$, a volume $V = \frac{4}{3}\pi R^3$. The key point is that $R^3 \propto (A^{1/3})^3 = A$, so both mass and volume are proportional to A, and the density turns out to be independent of A.

Step 1 — Express the volume: $V = \frac{4}{3}\pi R^3 = \frac{4}{3}\pi\,(R_0 A^{1/3})^3 = \frac{4}{3}\pi R_0^3 A$.

Step 2 — Form the density ratio: $\rho = \dfrac{M}{V} = \dfrac{A\,m_p}{\frac{4}{3}\pi R_0^3 A}$.

Step 3 — Cancel the mass number: The factor A appears in both numerator and denominator and cancels exactly, leaving $\rho = \dfrac{m_p}{\frac{4}{3}\pi R_0^3}$, a constant ($\sim 2.3 \times 10^{17}$ kg/m^3) that does not depend on A.

Why each other option is wrong:

- (A) The density cannot increase with A because the A factors cancel; adding nucleons also adds proportional volume.
- (C) It does not decrease as $1/A$; that would require a volume independent of A, contradicting $V \propto A$.
- (D) It is not proportional to $A^{1/3}$; that is how the *radius* scales, not the density.

Key point: Because $R \propto A^{1/3}$, nuclear volume grows in step with mass, making nuclear density essentially constant across all nuclei.

Final Answer: Same for all nuclei $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q26

Q27.

Solution

Concept — Time period of a simple pendulum: For small oscillations a simple pendulum executes simple harmonic motion with period $T = 2\pi\sqrt{\frac{L}{g}}$, where L is the length and g the gravitational acceleration. Crucially, this expression contains neither the amplitude nor the mass of the bob; the period depends only on L and g. This amplitude-independence is called isochronism (Galileo's observation).

Step 1 — Compare the two pendulums: Both pendulums share the same length L and sit in the same gravitational field g, even though their amplitudes differ.

Step 2 — Apply the formula: Since T depends only on L and g, and both are identical, the two pendulums have exactly the same period.

Step 3 — Note the conditions: This holds for small amplitudes where $\sin\theta \approx \theta$; at large angles the period does creep up slightly, but the question specifies both amplitudes are small.

Why each other option is wrong:

- (A) A larger small amplitude does not lengthen the period; the formula has no amplitude term.
- (B) Likewise it does not shorten the period; period is independent of amplitude for small swings.
- (D) The bob's mass cancels out of the pendulum equation, so the period does not depend on mass.

Key point: For small swings, a pendulum's period depends only on its length and local gravity, not on amplitude or mass.

Final Answer: Both have the same period $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q27

Q28.

Solution

Concept — Speed of a transverse wave on a string: A transverse wave travels along a stretched string at $v = \sqrt{\frac{T}{\mu}}$, where T is the tension (the restoring force) and μ is the linear mass density (the inertia per unit length). Higher tension speeds the wave up, while a heavier string slows it down.

Given: linear mass density $\mu = 0.01$ kg/m; tension $T = 4$ N.

Step 1 — Write the formula: $v = \sqrt{\frac{T}{\mu}}$.

Step 2 — Substitute the data: $v = \sqrt{\frac{4\ \text{N}}{0.01\ \text{kg/m}}} = \sqrt{400\ \text{m}^2/\text{s}^2}$.

Step 3 — Take the root: $v = 20$ m/s.

Why each other option is wrong:

- (B) 400 m/s reports the value T/μ without taking the square root.
- (C) 2 m/s comes from taking the root of 4 alone, ignoring the division by μ.
- (D) 0.05 m/s inverts the ratio, computing μ/T instead of T/μ.

Key point: Wave speed depends on the square root of tension over mass density; doubling tension increases speed only by $\sqrt{2}$.

Final Answer: $v = 20$ m/s $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q28

Q29.

Solution

Concept — Bipolar junction transistor terminals: A bipolar junction transistor (BJT) is a three-terminal device with an emitter (E), a base (B) and a collector (C). The base is the thin central region; the emitter heavily injects charge carriers and the collector gathers them. In the circuit symbol, the lead drawn with an arrowhead is always the emitter, and for an NPN transistor that arrow points outward, away from the base (a useful memory aid: "Not Pointing iN").

Step 1 — Identify each lead from the figure: The horizontal lead labelled B connects to the central vertical bar (the base region). The upper slanted lead is the collector C, and the lower lead carrying the arrowhead is the emitter E.

Step 2 — Read the terminals in order: Taking the three terminals as drawn, the labels B, C and E correspond to base, collector and emitter respectively.

Step 3 — Note the switching action: In a transistor switch, a small base current controls the much larger collector–emitter current, turning the C–E path ON when the base is suitably biased.

Why each other option is wrong:

- (B) "Emitter, base, collector" reorders the leads incorrectly; B in the figure is clearly the base, not the emitter.

- (C) "Collector, emitter, base" again swaps the identified roles of the three labelled leads.
- (D) The three leads are functionally distinct (emitter, base, collector); they are not all emitters.

Key point: The arrowed lead is the emitter; in an NPN device the arrow points outward, fixing E, and the labelled B is the base.

Final Answer: Base, collector, emitter $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q29

Q30.

Solution

Concept — Two-input NAND gate: A NAND (NOT-AND) gate performs an AND operation and then inverts the result, so its output is $Y = \overline{A \cdot B}$. Equivalently, the output is HIGH (1) in every case *except* when both inputs are HIGH, in which case it is LOW (0). Here A and B are the inputs and Y is the output.

Step 1 — Build the truth table: The AND term $A \cdot B$ equals 1 only when both $A = 1$ and $B = 1$; for all other input combinations $A \cdot B = 0$.

Step 2 — Invert to get Y: Applying the NOT, $Y = \overline{A \cdot B}$. So when $A \cdot B = 1$ (both inputs HIGH), $Y = \overline{1} = 0$; otherwise $Y = \overline{0} = 1$.

Step 3 — Read off the LOW condition: The output is LOW only for the single input combination $A = 1$ and $B = 1$. (Since any logic function can be built from NAND gates alone, NAND is called a universal gate.)

Why each other option is wrong:

- (A) For $A = 0,\ B = 0$ the AND output is 0, so $Y = \overline{0} = 1$ (HIGH), not LOW.
- (B) For $A = 1,\ B = 0$ the AND output is 0, giving $Y = 1$ (HIGH).
- (C) For $A = 0,\ B = 1$ the AND output is again 0, so $Y = 1$ (HIGH).

Key point: A NAND output is LOW for exactly one input pattern, both inputs HIGH; it is the complement of the AND gate.

Final Answer: $A = 1$ and $B = 1 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q30

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	A	2	C	3	A	4	B	5	D
6	B	7	C	8	D	9	A	10	D
11	B	12	C	13	A	14	D	15	C
16	B	17	A	18	B	19	C	20	D
21	A	22	B	23	A	24	C	25	D
26	B	27	C	28	A	29	A	30	D