AIIMS B.Sc Nursing Physics

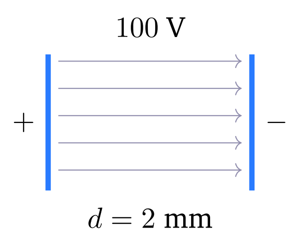
Sample Paper – 3

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 parallel metal plates are separated by 2 mm and connected to a 100 V battery, as shown. The magnitude of the uniform electric field between the plates is:



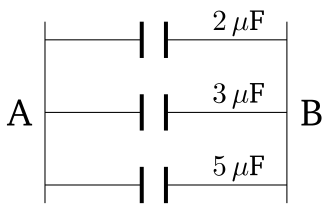
(A) 5×10^4 V/m

(B) 2×10^4 V/m

(C) 200 V/m

(D) 5×10^2 V/m

Q2. Three capacitors of $2\ \mu$F, $3\ \mu$F and $5\ \mu$F are connected in parallel, as shown. The equivalent capacitance of the combination is:



(A) $0.97\ \mu$F

(B) $10\ \mu$F

(C) $30\ \mu$F

(D) $1.03\ \mu$F

Q3. A current of 1.6 A flows through a wire of cross-sectional area 1×10^{-6} m^2. If the free electron density is 1×10^{28} m^{-3} and the electronic charge is 1.6×10^{-19} C, the drift velocity of the electrons is:

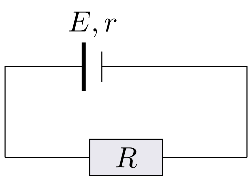
(A) 1×10^{-2} m/s

(B) 1×10^{-4} m/s

(C) 1×10^{-3} m/s

(D) 1 m/s

Q4. A cell of emf 2 V and internal resistance $0.5\ \Omega$ drives a current of 2 A through an external resistor, as shown. The terminal voltage of the cell is:



(A) 2 V

(B) 0.5 V

(C) 3 V

(D) 1 V

Q5. A resistor of $4\ \Omega$ is connected across a 12 V supply. The power dissipated in the resistor is:

(A) 36 W

(B) 3 W

(C) 48 W

(D) 9 W

Q6. The dimensional formula of work (or energy) is:

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

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

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

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

Q7. Two cars A and B move along the same straight road in the same direction with speeds 20 m/s and 12 m/s respectively. The velocity of car A relative to car B is:

(A) 32 m/s

(B) 12 m/s

(C) 8 m/s

(D) 20 m/s

Q8. A body is dropped from rest. Taking $g = 10$ m/s^2, the distance it covers during the 3rd second of its fall is:

(A) 45 m

(B) 30 m

(C) 20 m

(D) 25 m

Q9. A body of mass 2 kg moving at 6 m/s collides head-on with a stationary body of mass 4 kg and the two stick together. The common velocity after collision is:

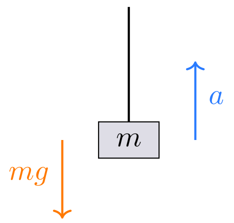
(A) 2 m/s

(B) 3 m/s

(C) 4 m/s

(D) 1 m/s

Q10. A mass of 5 kg hangs from a string and is pulled vertically upward with an acceleration of 2 m/s^2, as shown. Taking $g = 10$ m/s^2, the tension in the string is:



(A) 50 N

(B) 60 N

(C) 40 N

(D) 10 N

Q11. A constant force of 50 N pushes a trolley so that it moves with a steady speed of 4 m/s. The power delivered by the force is:

(A) 12.5 W

(B) 54 W

(C) 200 W

(D) 100 W

Q12. A satellite revolves in a circular orbit just above the surface of a planet of radius R where the acceleration due to gravity is g. Its orbital speed is given by:

(A) gR

(B) $\sqrt{2gR}$

(C) $\frac{g}{R}$

(D) $\sqrt{gR}$

Q13. The excess pressure inside a soap bubble of radius r and surface tension T is:

(A) $\frac{4T}{r}$

(B) $\frac{2T}{r}$

(C) $\frac{T}{r}$

(D) $\frac{8T}{r}$

Q14. A small spherical ball falling through a viscous liquid attains a terminal velocity. According to Stokes' law, this terminal velocity is directly proportional to:

(A) the radius of the ball

(B) the square of the radius of the ball

(C) the coefficient of viscosity

(D) the cube of the radius of the ball

Q15. The absolute temperature of a black body is doubled. By Stefan's law, the power radiated per unit area of its surface becomes:

(A) 2 times

(B) 8 times

(C) 16 times

(D) 4 times

Q16. Equal masses of water at 20 °C and 60 °C are mixed in an insulated container. Assuming no heat loss to the surroundings, the final temperature of the mixture is:

(A) 30 °C

(B) 50 °C

(C) 80 °C

(D) 40 °C

Q17. For an ideal gas undergoing a reversible adiabatic process, which of the following quantities remains constant?

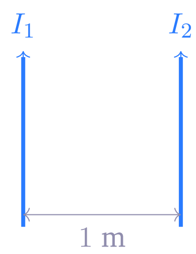
(A) PV^γ

(B) PV

(C) P/V

(D) V/T

Q18. Two long parallel wires placed 1 m apart in vacuum each carry a current of 5 A in the same direction, as shown. The force per unit length between them is (take $\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}):



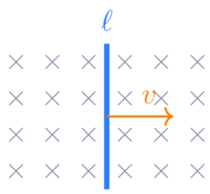
(A) 1×10^{-6} N/m

(B) 5×10^{-6} N/m

(C) 2.5×10^{-6} N/m

(D) 5×10^{-7} N/m

Q19. A conducting rod of length 0.4 m moves at 5 m/s perpendicular to a uniform magnetic field of 0.5 T, as shown. The emf induced across its ends is:



(A) 0.2 V

(B) 2.5 V

(C) 1 V

(D) 4 V

Q20. An inductor of inductance 0.2 H is connected to an AC source of angular frequency 100 rad/s. The inductive reactance is:

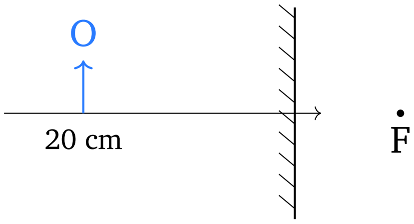
(A) 0.002 Ω

(B) 500 Ω

(C) 2 Ω

(D) 20 Ω

Q21. An object is placed 20 cm in front of a convex mirror of focal length 20 cm, as shown. The magnification of the image formed is:



(A) 0.5

(B) 1

(C) 2

(D) 0.25

Q22. The refractive index of a glass is 2. The critical angle for total internal reflection at a glass–air interface is:

(A) 45°

(B) 30°

(C) 60°

(D) 90°

Q23. A simple microscope (magnifying glass) has a lens of focal length 5 cm. Taking the least distance of distinct vision as $D = 25$ cm, its magnifying power for the image at D is:

(A) 5

(B) 4

(C) 6

(D) 25

Q24. In a photoelectric experiment, monochromatic light of frequency greater than the threshold frequency falls on a metal. If the frequency of the incident light is increased while its intensity is kept constant, the stopping potential will:

(A) remain unchanged

(B) decrease

(C) become zero

(D) increase

Q25. According to Einstein's mass–energy relation, the energy equivalent of a mass of 2 kg is (take $c = 3 \times 10^8$ m/s):

(A) 1.8×10^{17} J

(B) 6×10^8 J

(C) 9×10^{16} J

(D) 1.8×10^8 J

Q26. The mass defect when a certain nucleus is formed from its constituent nucleons is 0.05 u. Taking 1 u of mass to be equivalent to 931 MeV of energy, the binding energy of the nucleus is approximately:

(A) 9.31 MeV

(B) 46.6 MeV

(C) 931 MeV

(D) 93.1 MeV

Q27. A particle executing simple harmonic motion passes through its mean (equilibrium) position. At this instant, its energy is:

(A) entirely potential

(B) half kinetic and half potential

(C) entirely kinetic

(D) zero

Q28. Two tuning forks of frequencies 256 Hz and 260 Hz are sounded together. The number of beats heard per second is:

(A) 516

(B) 258

(C) 2

(D) 4

Q29. Which of the following statements correctly distinguishes an extrinsic semiconductor from an intrinsic one?

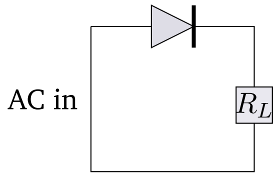
(A) An extrinsic semiconductor is doped with a suitable impurity, while an intrinsic one is pure

(B) An intrinsic semiconductor is doped, while an extrinsic one is pure

(C) Both are pure but differ in temperature

(D) An extrinsic semiconductor has no charge carriers

Q30. In the half-wave rectifier circuit shown, the diode conducts during:



(A) the full input cycle

(B) only one half of each input cycle

(C) neither half of the cycle

(D) both halves but with reversed polarity

Detailed Solutions

Q1.

Solution

Concept — Uniform field between parallel plates: When two large parallel conducting plates are held at a constant potential difference V and separated by a small distance d, the electric field in the gap is uniform and points from the positive to the negative plate. Its magnitude is the potential gradient $E = \frac{V}{d}$, where E is the field in V/m (or N/C), V is the potential difference in volts, and d is the plate separation in metres. The field is uniform because the equipotential surfaces between the plates are evenly spaced parallel planes.

Given: potential difference $V = 100$ V; plate separation $d = 2$ mm.

Step 1 — Convert the separation to SI units: The distance must be in metres before substituting, so $d = 2$ mm $= 2 \times 10^{-3}$ m. This single conversion is where most errors creep in.

Step 2 — Apply the field formula: $E = \frac{V}{d} = \frac{100 \text{ V}}{2 \times 10^{-3} \text{ m}}$.

Step 3 — Evaluate: $E = \frac{100}{2 \times 10^{-3}} = 50 \times 10^{3} = 5 \times 10^{4}$ V/m. The units V/m confirm we have an electric field.

Why each other option is wrong:

- (B) 2×10^{4} V/m comes from dividing 100 by 5×10^{-3} or otherwise mishandling the power of ten in d; it is not consistent with $d = 2 \times 10^{-3}$ m.
- (C) 200 V/m results from forgetting to convert millimetres to metres and dividing 100 V by 2 (treating d as just the number 2); the missing factor of 10^{3} makes it far too small.
- (D) 5×10^{2} V/m keeps the correct leading digit 5 but drops two powers of ten, again a units-conversion slip.

Key point: Always convert the plate separation to metres before using $E = V/d$; a millimetre-to-metre slip changes the answer by a factor of 1000.

Final Answer: $E = 5 \times 10^{4}$ V/m $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q1

Q2.

Solution

Concept — Capacitors in parallel: When capacitors are connected in parallel, each plate pair experiences the same potential difference V across it, but the total stored charge is the sum of the individual charges. Since $Q = CV$, the charges add as $Q = (C_1 + C_2 + C_3)V$, so the equivalent capacitance is simply the sum $C_{eq} = C_1 + C_2 + C_3$. Here C_{eq} is the combined capacitance and C_1, C_2, C_3 are the individual capacitances, all in the same unit (μF). Parallel combination always gives a capacitance larger than the largest single capacitor.

Given: $C_1 = 2\ \mu$F, $C_2 = 3\ \mu$F, $C_3 = 5\ \mu$F, all connected in parallel between the same two nodes A and B.

Step 1 — Write the parallel rule: $C_{eq} = C_1 + C_2 + C_3$.

Step 2 — Substitute the values: $C_{eq} = (2 + 3 + 5)\ \mu$F.

Step 3 — Evaluate: $C_{eq} = 10\ \mu$F, which is indeed larger than the biggest single capacitor ($5\ \mu$F), as expected for a parallel set.

Why each other option is wrong:

- (A) $0.97\ \mu$F is the result of the *series* formula $\frac{1}{C} = \frac{1}{2} + \frac{1}{3} + \frac{1}{5}$, which gives roughly $0.97\ \mu$F; series is the wrong rule here.
- (C) $30\ \mu$F comes from *multiplying* the three values $(2 \times 3 \times 5)$, which has no physical basis for capacitors.
- (D) $1.03\ \mu$F is another series-style mis-computation; like (A) it is smaller than every capacitor, so it cannot be a parallel result.

Key point: Parallel capacitances add directly (largest grows larger); only series capacitances combine reciprocally and give a result smaller than the smallest member.

Final Answer: $C_{eq} = 10\ \mu\text{F} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q2

Q3.

Solution

Concept — Drift velocity of electrons: In a current-carrying conductor the free electrons drift slowly opposite to the field with an average speed v_d. The current is related to this drift speed by $I = nAe\,v_d$, where I is the current (A), n is the number of free electrons per unit volume (m^{-3}), A is the cross-sectional area (m^2), e is the electronic charge (C), and v_d is the drift velocity (m/s). Rearranging gives $v_d = \frac{I}{nAe}$. The drift speed is typically tiny because n is enormous.

Given: $I = 1.6$ A; $A = 1 \times 10^{-6}$ m^2; $n = 1 \times 10^{28}$ m^{-3}; $e = 1.6 \times 10^{-19}$ C.

Step 1 — Write the formula: $v_d = \frac{I}{nAe}$.

Step 2 — Evaluate the denominator: $nAe = (1 \times 10^{28})(1 \times 10^{-6})(1.6 \times 10^{-19})$. Multiplying the powers of ten: $10^{28} \times 10^{-6} \times 10^{-19} = 10^3$, and the coefficient is $1 \times 1 \times 1.6 = 1.6$, so $nAe = 1.6 \times 10^3$ A · s/m.

Step 3 — Divide: $v_d = \frac{1.6 \text{ A}}{1.6 \times 10^3} = 1 \times 10^{-3}$ m/s.

Why each other option is wrong:

- (A) 1×10^{-2} m/s overestimates by a factor of 10, from miscounting one power of ten in the denominator.
- (B) 1×10^{-4} m/s underestimates by a factor of 10, the opposite power-of-ten slip.
- (D) 1 m/s ignores the huge electron density $n = 10^{28}$; such a large drift speed is physically impossible in a metal.

Key point: Drift velocities in metals are on the order of 10^{-3} to 10^{-4} m/s; the current still travels near light speed because n is colossal, not because the electrons move fast.

Final Answer: $v_d = 1 \times 10^{-3}$ m/s $\Rightarrow \boxed{C}$

Answer: (C) Go Back to Q3

Q4.

Solution

Concept — Terminal voltage of a cell: A real cell of emf E has an internal resistance r. When it drives a current I, some voltage is lost internally across r, so the voltage actually available at the terminals is $V = E - Ir$, where V is the terminal voltage (V), E is the emf (V), I is the current (A), and r is the internal resistance (Ω). The product Ir is the internal voltage drop. When the cell delivers current, the terminal voltage is always less than the emf.

Given: emf $E = 2$ V; internal resistance $r = 0.5\ \Omega$; current $I = 2$ A.

Step 1 — Compute the internal drop: $Ir = (2\text{ A})(0.5\ \Omega) = 1$ V. This is the voltage consumed inside the cell.

Step 2 — Apply the terminal-voltage relation: $V = E - Ir = 2\text{ V} - 1\text{ V}$.

Step 3 — Evaluate: $V = 1$ V, which is correctly less than the emf of 2 V.

Why each other option is wrong:

- (A) 2 V is the emf itself; it ignores the internal drop Ir and would only equal the terminal voltage if no current flowed ($I = 0$).
- (B) 0.5 V mistakenly quotes the internal resistance r as if it were a voltage.
- (C) 3 V comes from *adding* the drop ($E + Ir$) instead of subtracting; terminal voltage can never exceed the emf when the cell is discharging.

Key point: While a cell delivers current, $V < E$; the difference $E - V = Ir$ is the internal loss. Only on open circuit does the terminal voltage equal the emf.

Final Answer: $V = 1\text{ V} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q4

Q5.

Solution

Concept — Power dissipated in a resistor: The electrical power converted to heat in a resistor can be written three equivalent ways: $P = VI = I^2R = \frac{V^2}{R}$. When the voltage V across the resistor and its resistance R are known, the most direct form is $P = \frac{V^2}{R}$, where P is power (W), V is the voltage (V), and R is the resistance (Ω). The power grows with the square of the voltage.

Given: resistance $R = 4\ \Omega$; supply voltage $V = 12$ V.

Step 1 — Choose and write the formula: $P = \frac{V^2}{R}$.

Step 2 — Substitute the values: $P = \frac{(12\text{ V})^2}{4\ \Omega} = \frac{144}{4}$ W.

Step 3 — Evaluate: $P = 36$ W.

Why each other option is wrong:

- (B) 3 W comes from computing $V/R = 12/4$ (which is actually the current $I = 3$ A), not the power.
- (C) 48 W uses $V^2/3$ (wrong denominator) or VI with a wrong current; it does not match V^2/R.
- (D) 9 W squares the current incorrectly as $(V/R)^2 = 3^2$ without multiplying by R; the correct $I^2R = 3^2 \times 4 = 36$ W.

Key point: Check your form: I^2R and V^2/R must give the same answer. Here $I = V/R = 3$ A, so $I^2R = 9 \times 4 = 36$ W, confirming the result.

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

Answer: (A) Go Back to Q5

Q6.

Solution

Concept — Dimensional formula of work/energy: Work done by a force is the product of the force and the displacement along its direction: $W = F\,s$. To find its dimensions we replace each physical quantity by its dimensional formula. Force has dimensions $[MLT^{-2}]$ (from $F = ma$, i.e. mass $\times$ acceleration), and displacement has dimensions $[L]$. Energy, being measured in the same unit (joule) as work, shares the same dimensional formula.

Step 1 — Write the dimensions of each factor: $[F] = [MLT^{-2}]$ and $[s] = [L]$.

Step 2 — Multiply them: $[W] = [MLT^{-2}]\,[L] = [M\,L^{1+1}\,T^{-2}]$.

Step 3 — Combine the powers of L: $[W] = [ML^2T^{-2}]$, which is also the dimensional formula of kinetic energy $\frac{1}{2}mv^2$ (check: $[M][LT^{-1}]^2 = ML^2T^{-2}$).

Why each other option is wrong:

- (A) $[MLT^{-2}]$ is the dimension of *force*, not work; it has only one power of L.
- (C) $[ML^2T^{-1}]$ is the dimension of *angular momentum* (or Planck's constant); the time exponent is -1, not -2.
- (D) $[ML^{-1}T^{-2}]$ is the dimension of *pressure* or stress (force per unit area); the length exponent is negative.

Key point: Work and every form of energy share $[ML^2T^{-2}]$; cross-check using kinetic energy $\frac{1}{2}mv^2$ whenever you are unsure.

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

Answer: (B) Go Back to Q6

Q7.

Solution

Concept — Relative velocity: The velocity of one body A as seen from another body B is $\vec{v}_{AB} = \vec{v}_A - \vec{v}_B$. When both bodies move along the same straight line in the *same* direction, the vectors are collinear and we subtract their magnitudes: $v_{AB} = v_A - v_B$. Here v_A and v_B are the ground speeds of A and B (m/s) and v_{AB} is how fast A appears to move relative to B. A positive result means A is gaining on B.

Given: $v_A = 20$ m/s, $v_B = 12$ m/s, both in the same direction along the road.

Step 1 — Write the relation for same-direction motion: $v_{AB} = v_A - v_B$.

Step 2 — Substitute: $v_{AB} = 20$ m/s $-$ 12 m/s.

Step 3 — Evaluate: $v_{AB} = 8$ m/s, directed the same way as both cars; A creeps ahead of B at 8 m/s.

Why each other option is wrong:

- (A) 32 m/s is $v_A + v_B$, which would be correct only if the cars moved in *opposite* directions (approaching or receding).
- (B) 12 m/s is simply v_B, the ground speed of car B, not a relative speed.
- (D) 20 m/s is simply v_A, the ground speed of car A, again not relative.

Key point: Same direction $\Rightarrow$ subtract speeds; opposite directions $\Rightarrow$ add speeds. Always check the directions before deciding the sign.

Final Answer: $v_{AB} = 8$ m/s $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q7

Q8.

Solution

Concept — Distance covered in the nth second: The distance travelled during the nth second of motion (not the total up to n seconds) under uniform acceleration is $s_n = u + \frac{a}{2}(2n - 1)$, where u is the initial velocity, a is the acceleration, and n is the number of the second in question. For a body dropped from rest in free fall, $u = 0$ and $a = g$, so $s_n = \frac{g}{2}(2n - 1)$. This is a distance for a one-second interval, hence its unit is metres.

Given: initial velocity $u = 0$ (dropped from rest); $g = 10$ m/s^2; the $n = 3$rd second of fall.

Step 1 — Write the formula with $u = 0$: $s_n = \frac{g}{2}(2n-1)$.

Step 2 — Substitute $n = 3$: $s_3 = \frac{10}{2}(2 \times 3 - 1) = 5\,(6-1) = 5 \times 5$.

Step 3 — Evaluate: $s_3 = 25$ m.

Why each other option is wrong:

- (A) 45 m is the *total* distance fallen in 3 full seconds, $\frac{1}{2}gt^2 = \frac{1}{2}(10)(3)^2 = 45$ m, not the distance in the third second alone.
- (B) 30 m mis-applies the formula (e.g. using $2n$ instead of $2n-1$, giving 5×6); it does not match the standard expression.
- (C) 20 m uses $(2n-3)$ instead of $(2n-1)$, i.e. it is actually the distance in the 2nd second, $5 \times (4-1)$ mis-shifted.

Key point: "Distance in the nth second" means a one-second slice and uses $(2n-1)$; do not confuse it with total distance $\frac{1}{2}gt^2$. Check: total in 3 s (45 m) minus total in 2 s (20 m) $= 25$ m, confirming the answer.

Final Answer: $s_3 = 25$ m $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q8

Q9.

Solution

Concept — Conservation of linear momentum (perfectly inelastic collision): In the absence of external forces, the total momentum of a system is conserved during a collision. When a moving body of mass m_1 with velocity u_1 strikes a stationary body of mass m_2 and the two stick together, they move off with a common velocity v. Momentum conservation gives $m_1u_1 + m_2(0) = (m_1 + m_2)v$, i.e. $v = \dfrac{m_1u_1}{m_1 + m_2}$. Kinetic energy is *not* conserved (some is lost as heat/deformation), but momentum is.

Given: $m_1 = 2$ kg moving at $u_1 = 6$ m/s; $m_2 = 4$ kg at rest; the bodies coalesce.

Step 1 — Write momentum conservation: $m_1u_1 = (m_1 + m_2)v$.

Step 2 — Substitute: $(2\text{ kg})(6\text{ m/s}) = (2+4)\text{ kg} \times v \Rightarrow 12\text{ kg m/s} = 6\text{ kg} \times v$.

Step 3 — Solve for v: $v = \frac{12}{6} = 2$ m/s, directed the same way as the original 6 m/s.

Why each other option is wrong:

- (B) 3 m/s divides the momentum 12 by the wrong total mass (e.g. using only m_1-related figures), not by the combined 6 kg.
- (C) 4 m/s would require a combined mass of 3 kg (12/3), which is not the case here.
- (D) 1 m/s would need a combined mass of 12 kg; it over-divides the momentum.

Key point: For "stick-together" (perfectly inelastic) collisions, use the single combined mass in the denominator. Momentum is conserved; kinetic energy is not.

Final Answer: $v = 2$ m/s $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q9

Q10.

Solution

Concept — Tension in a string accelerating a mass upward: Two forces act on the hanging mass: the upward tension T and the downward weight mg. By Newton's second law, the net upward force equals mass times the upward acceleration: $T - mg = ma$, which rearranges to $T = m(g + a)$. Here T is the tension (N), m is the mass (kg), g is gravitational acceleration (m/s^2), and a is the upward acceleration (m/s^2). The tension exceeds the weight whenever the body accelerates upward.

Given: mass $m = 5$ kg; upward acceleration $a = 2$ m/s^2; $g = 10$ m/s^2.

Step 1 — Apply Newton's second law: $T - mg = ma \Rightarrow T = m(g + a)$.

Step 2 — Substitute: $T = 5$ kg $\times$ $(10 + 2)$ m/s^2.

Step 3 — Evaluate: $T = 5 \times 12 = 60$ N, which is greater than the weight $mg = 50$ N, as expected for upward acceleration.

Why each other option is wrong:

- (A) 50 N is just the weight mg; it would be the tension only if $a = 0$ (constant velocity or rest).
- (C) 40 N uses $m(g - a)$, the formula for downward acceleration; here the body accelerates upward, so we add.
- (D) 10 N keeps only the extra term $ma = 5 \times 2$ and forgets the weight altogether.

Key point: Accelerating up $\Rightarrow T = m(g + a) > mg$; accelerating down $\Rightarrow T = m(g - a) < mg$. The sign of a relative to gravity decides which.

Final Answer: $T = 60\text{ N} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q10

Q11.

Solution

Concept — Power delivered by a force: Power is the rate of doing work. For a constant force F moving a body at velocity v in the direction of the force, the instantaneous power is $P = Fv$ (more generally $P = \vec{F} \cdot \vec{v} = Fv\cos\theta$, but here $\theta = 0$). Here P is power (W), F is force (N), and v is speed (m/s). One watt equals one newton-metre per second.

Given: force $F = 50$ N; steady speed $v = 4$ m/s, with F along the direction of motion.

Step 1 — Write the formula: $P = Fv$ (force and velocity collinear, so $\cos\theta = 1$).

Step 2 — Substitute: $P = (50\text{ N})(4\text{ m/s})$.

Step 3 — Evaluate: $P = 200$ W.

Why each other option is wrong:

- (A) 12.5 W comes from dividing F by v $(50/4)$, which is not a valid expression for power.
- (B) 54 W comes from *adding* F and v $(50+4)$; power is a product, not a sum, and the units would not even be watts.
- (D) 100 W halves the correct product (perhaps using $\frac{1}{2}Fv$ by confusing this with a kinetic-energy expression); steady-speed power has no factor of $\frac{1}{2}$.

Key point: At constant speed the applied force balances resistance, and the delivered power is simply Fv with no $\frac{1}{2}$ factor; that half-factor belongs to kinetic energy, not power.

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

Answer: (C) Go Back to Q11

Q12.

Solution

Concept — Orbital speed just above a planet's surface: A satellite in a circular orbit needs a centripetal force directed toward the planet's centre, and this is supplied entirely by gravity. For an orbit just above the surface, the orbital radius is essentially the planet's radius R, and the gravitational acceleration there is g. Setting the gravitational force equal to the required centripetal force, $\frac{mv^2}{R} = mg$, where m is the satellite mass, v its orbital speed, R the radius, and g the surface gravity. The mass m cancels, so the orbital speed is independent of the satellite's mass.

Step 1 — Balance gravity and centripetal requirement: $\frac{mv^2}{R} = mg$.

Step 2 — Cancel m and isolate v^2: $v^2 = gR$.

Step 3 — Take the square root: $v = \sqrt{gR}$. A quick units check: $[g][R] = (\text{m/s}^2)(\text{m}) = \text{m}^2/\text{s}^2$, whose root is m/s, a valid speed.

Why each other option is wrong:

- (A) gR omits the square root; its units are m^2/s^2 (an energy-per-mass), not a speed.
- (B) $\sqrt{2gR}$ is the *escape* speed, which is $\sqrt{2}$ times the orbital speed, not the orbital speed itself.
- (C) $\frac{g}{R}$ has units of $1/\text{s}^2$, which is dimensionally not a velocity at all.

Key point: Surface orbital speed is $\sqrt{gR}$, and escape speed is $\sqrt{2gR} = \sqrt{2}\times$ orbital speed; remember the factor $\sqrt{2}$ that separates them.

Final Answer: $v = \sqrt{gR} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q12

Q13.

Solution

Concept — Excess pressure inside a soap bubble: Surface tension causes the pressure inside a curved liquid surface to exceed the pressure outside. For a single curved surface of radius r and surface tension T, the excess pressure is $\frac{2T}{r}$. A soap bubble, however, has *two* liquid–air surfaces (an inner and an outer film surface), each contributing $\frac{2T}{r}$, so the total excess pressure is $\Delta P = 2 \times \frac{2T}{r} = \frac{4T}{r}$. Here T is surface tension (N/m) and r is the bubble radius (m).

Step 1 — Pressure across one surface: A single surface (as in a liquid drop) gives $\frac{2T}{r}$.

Step 2 — Count the surfaces of a soap bubble: A soap bubble is a thin shell with two surfaces in contact with air, so the contributions add.

Step 3 — Total excess pressure: $\Delta P = \frac{2T}{r} + \frac{2T}{r} = \frac{4T}{r}$.

Why each other option is wrong:

- (B) $\frac{2T}{r}$ is the excess pressure for a *liquid drop* or a single surface, not for a two-surface soap bubble.
- (C) $\frac{T}{r}$ misses the factor of 2 from the basic Laplace relation altogether.
- (D) $\frac{8T}{r}$ wrongly doubles the bubble result again, as if there were four surfaces.

Key point: Remember the surface count: drop $\Rightarrow \frac{2T}{r}$ (one surface); soap bubble $\Rightarrow \frac{4T}{r}$ (two surfaces).

Final Answer: $\Delta P = \frac{4T}{r} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q13

Q14.

Solution

Concept — Stokes' law and terminal velocity: A small sphere falling through a viscous fluid quickly reaches a steady "terminal" velocity at which the net force is zero: its weight is balanced by the upward buoyant force plus the viscous drag $F = 6\pi\eta r v$. Setting the forces in balance gives the terminal velocity $v_t = \frac{2r^2(\rho - \sigma)g}{9\eta}$, where r is the radius, ρ the density of the sphere, σ the density of the liquid, g gravity, and η the coefficient of viscosity. The only length in the expression appears as r^2.

Step 1 — Inspect the radius dependence: In $v_t = \frac{2r^2(\rho - \sigma)g}{9\eta}$, every other quantity is fixed for a given ball and liquid, so $v_t \propto r^2$.

Step 2 — State the proportionality: Doubling the radius would quadruple the terminal velocity ($2^2 = 4$).

Step 3 — Note the viscosity dependence: v_t is *inversely* proportional to η, i.e.

thicker liquids give slower fall.

Why each other option is wrong:

- (A) "the radius" ($v_t \propto r$) understates the dependence; the formula clearly has r^2.
- (C) "the coefficient of viscosity" is wrong because $v_t \propto 1/\eta$ (inverse), not directly proportional.
- (D) "the cube of the radius" (r^3) overstates the dependence; r^3 describes the *volume* (and hence mass), not the terminal velocity.

Key point: Terminal velocity scales as r^2 and as $1/\eta$. The drag force $6\pi\eta rv$ grows only linearly with r, but the weight grows as r^3, and the balance leaves $v_t \propto r^2$.

Final Answer: Square of the radius $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q14

Q15.

Solution

Concept — Stefan–Boltzmann law: A black body radiates energy from its surface at a rate per unit area that depends on the fourth power of its absolute (Kelvin) temperature: $E = \sigma T^4$, where E is the emissive power (W/m^2), σ is the Stefan constant (5.67×10^{-8} W m^{-2}K^{-4}), and T is the absolute temperature (K). Because of the fourth power, even a modest rise in temperature produces a large jump in radiated power.

Given: the absolute temperature is doubled, i.e. $T \to 2T$.

Step 1 — Write the law before and after: initially $E = \sigma T^4$; after doubling, $E' = \sigma(2T)^4$.

Step 2 — Expand the fourth power: $(2T)^4 = 2^4 T^4 = 16\,T^4$, so $E' = 16\,\sigma T^4$.

Step 3 — Take the ratio: $\dfrac{E'}{E} = \dfrac{16\,\sigma T^4}{\sigma T^4} = 16$. The radiated power per unit area becomes 16 times larger.

Why each other option is wrong:

- (A) 2 times assumes $E \propto T$ (first power), ignoring the exponent 4.
- (B) 8 times assumes $E \propto T^3$ (so $2^3 = 8$), which would be the case for the wrong power.
- (D) 4 times assumes $E \propto T^2$ (so $2^2 = 4$); again the exponent is wrong.

Key point: Stefan's law uses the *fourth* power of the *absolute* temperature; doubling T multiplies the radiated power per unit area by $2^4 = 16$. Always use Kelvin, never Celsius.

Final Answer: 16 times $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q15

Q16.

Solution

Concept — Method of mixtures (calorimetry): In an insulated container with no heat lost to the surroundings, the principle of calorimetry says heat lost by the hotter body equals heat gained by the colder body. Using $Q = mc\,\Delta T$, where m is mass, c is specific heat, and ΔT is the temperature change, we write $m_1c_1(T_{hot} - T) = m_2c_2(T - T_{cold})$. When the masses are equal and the substance (water) is the same, m and c cancel, and the final temperature is simply the average of the two starting temperatures.

Given: equal masses of water at $T_{cold} = 20$ °C and $T_{hot} = 60$ °C; insulated, so no heat loss.

Step 1 — Apply heat lost = heat gained: $mc(60 - T) = mc(T - 20)$.

Step 2 — Cancel mc and expand: $60 - T = T - 20$.

Step 3 — Solve for T: $60 + 20 = 2T \Rightarrow 2T = 80 \Rightarrow T = 40$ °C, which is exactly midway between 20 and 60.

Why each other option is wrong:

- (A) 30 °C is below the true midpoint; it would require unequal masses weighted toward the cold water.
- (B) 50 °C is above the midpoint; it would require more hot water than cold.
- (C) 80 °C simply adds the two temperatures, which violates energy conservation (the mixture cannot be hotter than the hottest part).

Key point: Equal masses of the same liquid mix to the simple average temperature. The final temperature must lie strictly between the two initial values.

Final Answer: $T = 40$ °C $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q16

Q17.

Solution

Concept — Reversible adiabatic process: An adiabatic process is one in which no heat is exchanged with the surroundings ($Q = 0$). For an ideal gas undergoing a reversible adiabatic change, the pressure and volume are related by $PV^\gamma =$ constant, where P is pressure, V is volume, and $\gamma = C_p/C_V$ is the ratio of the molar specific heats at constant pressure and constant volume. Since $\gamma > 1$, the adiabatic curve on a P–V diagram is steeper than the corresponding isotherm.

Step 1 — Recall the adiabatic condition: For $Q = 0$ in an ideal gas, the first law combined with $PV = nRT$ leads to $PV^\gamma =$ constant (equivalently $TV^{\gamma-1} =$ const and $T^\gamma P^{1-\gamma} =$ const).

Step 2 — Note the value of γ: $\gamma = C_p/C_V$ is always greater than 1 (e.g. 1.4 for a diatomic gas), which is why the adiabat falls more steeply than the isotherm.

Step 3 — Identify the invariant: Among the listed quantities, the one held constant in a reversible adiabatic process is PV^γ.

Why each other option is wrong:

- (B) PV is constant only in an *isothermal* process (Boyle's law at fixed temperature), not adiabatic.
- (C) P/V constant describes a specific straight-line process through the origin on the P–V diagram, not an adiabatic one.
- (D) V/T constant is Charles's law, valid for an *isobaric* (constant-pressure) process, not adiabatic.

Key point: $PV^\gamma =$ const is the signature of a reversible adiabatic; $PV =$ const is isothermal. The exponent γ is what distinguishes them.

Final Answer: $PV^\gamma = \text{const} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q17

Q18.

Solution

Concept — Force per unit length between parallel current-carrying wires: Each wire produces a magnetic field that exerts a force on the other. For two long straight parallel wires separated by a distance d carrying currents I_1 and I_2, the force per unit length is $\frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi d}$, where μ_0 is the permeability of free space (T m A^{-1}), and d is in metres. Currents in the *same* direction attract; opposite directions repel.

Given: $I_1 = I_2 = 5$ A (same direction); $d = 1$ m; $\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}.

Step 1 — Write the formula: $\dfrac{F}{L} = \dfrac{\mu_0 I_1 I_2}{2\pi d}$.

Step 2 — Substitute the values: $\dfrac{F}{L} = \dfrac{(4\pi \times 10^{-7})(5)(5)}{2\pi(1)}$.

Step 3 — Simplify: cancel π and reduce $\frac{4}{2} = 2$: $\dfrac{F}{L} = \dfrac{4\pi \times 25 \times 10^{-7}}{2\pi} = 2 \times 25 \times 10^{-7} = 50 \times 10^{-7} = 5 \times 10^{-6}$ N/m, an attractive force.

Why each other option is wrong:

- (A) 1×10^{-6} N/m drops a factor of 5 (using one current of 1 A instead of 5 A, or otherwise mis-multiplying).
- (C) 2.5×10^{-6} N/m halves the correct value, e.g. by keeping the $\frac{4}{2}$ as 1 rather than 2.
- (D) 5×10^{-7} N/m keeps the right digit 5 but is off by a power of ten in handling 10^{-7} vs 10^{-6}.

Key point: A handy shortcut is $\dfrac{F}{L} = \dfrac{2 \times 10^{-7}\, I_1 I_2}{d}$, since $\dfrac{\mu_0}{2\pi} = 2 \times 10^{-7}$. Here that gives $2 \times 10^{-7} \times 25 = 5 \times 10^{-6}$ N/m directly.

Final Answer: 5×10^{-6} N/m $\Rightarrow$ B

Answer: (B) Go Back to Q18

Q19.

Solution

Concept — Motional emf: When a conducting rod of length ℓ moves with velocity v perpendicular to a uniform magnetic field B, the free charges in the rod experience a magnetic force that separates them, setting up a potential difference across the ends. The induced emf is $\varepsilon = B\ell v$, where ε is in volts, B in tesla, ℓ in metres, and v in m/s, provided B, ℓ and v are mutually perpendicular. This is a direct consequence of Faraday's law applied to the changing area swept by the rod.

Given: length $\ell = 0.4$ m; speed $v = 5$ m/s; field $B = 0.5$ T, with the motion perpendicular to the field.

Step 1 — Write the formula: $\varepsilon = B\ell v$.

Step 2 — Substitute: $\varepsilon = (0.5 \text{ T})(0.4 \text{ m})(5 \text{ m/s})$.

Step 3 — Evaluate: $\varepsilon = 0.5 \times 0.4 \times 5 = 1$ V.

Why each other option is wrong:

- (A) 0.2 V drops the velocity factor (computes only $B\ell = 0.5 \times 0.4$), giving 0.2 instead of 1.
- (B) 2.5 V drops the length factor (computes $Bv = 0.5 \times 5$), giving 2.5 instead of 1.
- (D) 4 V comes from mis-multiplying the three numbers (e.g. $0.4 \times 5 \times 2$); it does not match $B\ell v$.

Key point: All three quantities B, ℓ, v must appear in the product, and they must be mutually perpendicular; if the rod moved parallel to the field, the emf would be zero.

Final Answer: $\varepsilon = 1 \text{ V} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q19

Q20.

Solution

Concept — Inductive reactance: An inductor opposes changes in current, and in an AC circuit this opposition is measured by the inductive reactance $X_L = \omega L = 2\pi f L$, where X_L is in ohms, ω is the angular frequency (rad/s), L is the inductance (H), and f is the frequency (Hz). Reactance grows in proportion to both the frequency and the inductance, so an inductor passes low frequencies more easily than high ones.

Given: inductance $L = 0.2$ H; angular frequency $\omega = 100$ rad/s.

Step 1 — Write the formula: $X_L = \omega L$ (angular frequency is given directly, so no 2π conversion is needed).

Step 2 — Substitute: $X_L = (100 \text{ rad/s})(0.2 \text{ H})$.

Step 3 — Evaluate: $X_L = 20\ \Omega$.

Why each other option is wrong:

- (A) $0.002\ \Omega$ comes from dividing L by ω $(0.2/100)$ instead of multiplying.
- (B) $500\ \Omega$ comes from dividing ω by L $(100/0.2)$, again the wrong operation.
- (C) $2\ \Omega$ misplaces a factor of ten (e.g. using $L = 0.02$ H), giving 100×0.02.

Key point: Reactance is a *product* ωL, not a ratio. If frequency were given in Hz instead of rad/s, you would first compute $\omega = 2\pi f$.

Final Answer: $X_L = 20\ \Omega \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q20

Q21.

Solution

Concept — Image in a convex mirror: The mirror equation $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$ relates the image distance v, object distance u, and focal length f. Using the standard sign convention (distances measured from the pole, with the incident-light direction positive): the object is real so $u = -20$ cm, and a convex mirror has a virtual focus so $f = +20$ cm. The linear magnification is $m = -\frac{v}{u}$; a positive m less than 1 means an erect, diminished image, which is exactly what a convex mirror always produces.

Given: object distance $u = -20$ cm; focal length $f = +20$ cm (convex).

Step 1 — Solve the mirror equation for v: $\frac{1}{v} = \frac{1}{f} - \frac{1}{u} = \frac{1}{20} - \frac{1}{-20} = \frac{1}{20} + \frac{1}{20} = \frac{2}{20} = \frac{1}{10}$, hence $v = +10$ cm (positive $\Rightarrow$ virtual image behind the mirror).

Step 2 — Compute the magnification: $m = -\frac{v}{u} = -\frac{(+10)}{(-20)} = +\frac{10}{20} = +0.5$.

Step 3 — Interpret: $m = +0.5$ means the image is erect and half the object's height, consistent with a convex mirror.

Why each other option is wrong:

- (B) 1 would mean the image is the same size as the object, which a convex mirror never gives for a finite object distance.
- (C) 2 would be a magnified image; convex mirrors always diminish, so $m < 1$.
- (D) 0.25 does not follow from the mirror equation with $u = -20$, $f = +20$; it would need a different geometry.

Key point: A convex mirror always forms a virtual, erect, diminished image ($0 < m < 1$); careful sign handling ($u < 0$, $f > 0$) gives $v = +10$ cm and $m = +0.5$.

Final Answer: $m = 0.5 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q21

Q22.

Solution

Concept — Critical angle and total internal reflection: When light travels from a denser medium (refractive index n) to a rarer one (air, index 1), there is a particular angle of incidence, the critical angle θ_c, at which the refracted ray grazes the interface (90°). Beyond θ_c the light is totally internally reflected. Applying Snell's law $n \sin\theta_c = 1 \cdot \sin 90^\circ$ gives $\sin\theta_c = \frac{1}{n}$, where n is the refractive index of the denser medium.

Given: refractive index of glass $n = 2$; the second medium is air.

Step 1 — Write the relation: $\sin\theta_c = \frac{1}{n}$.

Step 2 — Substitute: $\sin\theta_c = \frac{1}{2}$.

Step 3 — Solve: $\theta_c = \sin^{-1}\left(\frac{1}{2}\right) = 30^\circ$.

Why each other option is wrong:

- (A) 45° would require $\sin\theta_c = \frac{1}{\sqrt{2}}$, i.e. $n = \sqrt{2} \approx 1.41$, not 2.
- (C) 60° would require $\sin\theta_c = \frac{\sqrt{3}}{2}$, i.e. $n = \frac{2}{\sqrt{3}} \approx 1.15$.
- (D) 90° would require $\sin\theta_c = 1$, i.e. $n = 1$, meaning no denser medium at all.

Key point: A larger refractive index gives a smaller critical angle ($\sin\theta_c = 1/n$). Total internal reflection occurs only for angles greater than θ_c and only when light goes from denser to rarer.

Final Answer: $\theta_c = 30^\circ \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q22

Q23.

Solution

Concept — Magnifying power of a simple microscope: A simple microscope (magnifying glass) is a single convex lens. When the final image is formed at the least distance of distinct vision D (the near point, normally 25 cm), the eye is maximally strained and the magnifying power is largest: $M = 1 + \frac{D}{f}$, where f is the focal length of the lens and D is the near-point distance, both in the same length unit. If instead the image is at infinity (relaxed eye), the magnifying power is the smaller value $M = D/f$.

Given: focal length $f = 5$ cm; least distance of distinct vision $D = 25$ cm; image at D.

Step 1 — Choose the near-point formula: $M = 1 + \frac{D}{f}$.

Step 2 — Substitute: $M = 1 + \frac{25 \text{ cm}}{5 \text{ cm}}$.

Step 3 — Evaluate: $M = 1 + 5 = 6$.

Why each other option is wrong:

- (A) 5 uses only D/f, which is the magnifying power for the image at *infinity* (relaxed eye), not at the near point.
- (B) 4 wrongly subtracts the 1 ($D/f - 1$) instead of adding it.
- (D) 25 ignores the focal length entirely and just quotes D; it is not a magnification.

Key point: Image at the near point $\Rightarrow M = 1 + D/f$ (maximum); image at infinity $\Rightarrow M = D/f$. The two differ by exactly 1.

Final Answer: $M = 6 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q23

Q24.

Solution

Concept — Photoelectric effect and stopping potential: Einstein's photoelectric equation states that a photon of energy $h\nu$ ejects an electron and gives it a maximum kinetic energy $K_{max} = h\nu - \phi$, where ϕ is the work function of the metal. The stopping potential V_0 is the reverse voltage that just halts the most energetic electrons, so $eV_0 = K_{max} = h\nu - \phi$, giving $V_0 = \frac{h\nu - \phi}{e}$. Here h is Planck's constant, ν the light frequency, e the electronic charge, and ϕ the (fixed) work function.

Step 1 — Effect of increasing frequency: As ν increases, $h\nu$ increases while ϕ stays constant for the given metal, so $V_0 = \frac{h\nu - \phi}{e}$ increases. The graph of V_0 versus ν is a straight line of positive slope h/e.

Step 2 — Effect of intensity: Keeping intensity constant (or changing it) only affects the *number* of photoelectrons (the current), not their maximum energy, so intensity does not change V_0. Hence the answer depends solely on the frequency.

Step 3 — Conclusion: Raising the frequency above the threshold raises the maximum kinetic energy of the electrons, so the stopping potential *increases*.

Why each other option is wrong:

- (A) "remain unchanged" would be true if *intensity* were varied, but here it is the frequency that changes, so V_0 must change.
- (B) "decrease" is the opposite of what Einstein's equation predicts; higher ν means more energetic electrons, not fewer.
- (C) "become zero" happens only when $h\nu = \phi$, i.e. at the threshold frequency, not when ν is increased above it.

Key point: Stopping potential depends on *frequency*, not intensity; intensity controls the number of electrons (photocurrent), while frequency controls their maximum energy.

Final Answer: The stopping potential increases $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q24

Q25.

Solution

Concept — Mass–energy equivalence: Einstein's relation $E = mc^2$ states that mass and energy are interchangeable: a mass m is equivalent to an energy E, where c is the speed of light in vacuum. With m in kg and c in m/s, E comes out in joules. Because $c^2 \approx 9 \times 10^{16}$ m^2/s^2 is enormous, even a small mass corresponds to a huge energy.

Given: mass $m = 2$ kg; speed of light $c = 3 \times 10^8$ m/s.

Step 1 — Write the formula: $E = mc^2$.

Step 2 — Substitute: $E = (2)\,(3\times10^8)^2 = 2\times(9\times10^{16})$, using $(3\times10^8)^2 = 9\times10^{16}$.

Step 3 — Evaluate: $E = 18 \times 10^{16} = 1.8 \times 10^{17}$ J.

Why each other option is wrong:

- (B) 6×10^8 J uses $E = mc$ (multiplying by c once, not c^2); it ignores the square entirely.
- (C) 9×10^{16} J forgets the factor of mass $m = 2$ kg, quoting just c^2 for 1 kg.
- (D) 1.8×10^8 J again uses c instead of c^2 (with the mass), losing many powers of ten.

Key point: The speed of light must be *squared* in $E = mc^2$; the most common slip is using c instead of c^2, which is wrong by a factor of 3×10^8.

Final Answer: $E = 1.8 \times 10^{17}$ J $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q25

Q26.

Solution

Concept — Mass defect and binding energy: When a nucleus forms from its separate protons and neutrons, the mass of the nucleus is slightly less than the sum of the masses of the free nucleons. This missing mass, the mass defect Δm, is converted into the binding energy that holds the nucleus together. Using $E = mc^2$ with the convenient conversion 1 u $\equiv 931$ MeV, the binding energy is $E_b = \Delta m\,(\text{in u}) \times 931$ MeV.

Given: mass defect $\Delta m = 0.05$ u; conversion 1 u $= 931$ MeV.

Step 1 — Write the relation: $E_b = \Delta m \times 931$ MeV.

Step 2 — Substitute: $E_b = 0.05 \times 931$ MeV.

Step 3 — Evaluate: $E_b = 46.55 \approx 46.6$ MeV.

Why each other option is wrong:

- (A) 9.31 MeV corresponds to $\Delta m = 0.01$ u (0.01×931), a factor of 5 too small.
- (C) 931 MeV corresponds to a full $\Delta m = 1$ u, twenty times the given defect.
- (D) 93.1 MeV corresponds to $\Delta m = 0.1$ u (0.1×931), exactly double the given defect.

Key point: Multiply the mass defect (in u) by 931 MeV/u to get the binding energy directly; keep careful track of the decimal place in Δm.

Final Answer: $E_b \approx 46.6$ MeV $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q26

Q27.

Solution

Concept — Energy in simple harmonic motion: In SHM the total mechanical energy $E = \frac{1}{2}m\omega^2 A^2$ stays constant, continually converting between kinetic energy $KE = \frac{1}{2}m\omega^2(A^2 - x^2)$ and potential energy $PE = \frac{1}{2}m\omega^2 x^2$, where x is the displacement from the mean position and A is the amplitude. At any instant $KE+PE = E$. The distribution between the two forms depends entirely on where the particle is.

Step 1 — Locate the mean position: At the mean (equilibrium) position the displacement is $x = 0$, so the potential energy $PE = \frac{1}{2}m\omega^2(0)^2 = 0$.

Step 2 — Find the kinetic energy there: With $PE = 0$ and total energy conserved, $KE = E - PE = E$, which is also the *maximum* kinetic energy because the speed is greatest ($v_{max} = \omega A$) at the mean position.

Step 3 — Conclusion: At the mean position all of the energy is kinetic.

Why each other option is wrong:

- (A) "entirely potential" is true at the *extreme* positions ($x = \pm A$), where the particle is momentarily at rest, not at the mean position.
- (B) "half kinetic and half potential" occurs only at the intermediate point $x = A/\sqrt{2}$, not at the centre.
- (D) "zero" is impossible at the mean position; the particle is moving fastest there, so its energy is certainly non-zero.

Key point: Mean position $\Rightarrow$ maximum speed $\Rightarrow$ all kinetic; extreme position $\Rightarrow$ momentarily at rest $\Rightarrow$ all potential. The total energy is the same everywhere.

Final Answer: Entirely kinetic $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q27

Q28.

Solution

Concept — Beats: When two sound waves of slightly different frequencies are sounded together, they alternately reinforce and cancel, producing a periodic rise and fall in loudness called beats. The number of beats heard per second (the beat frequency) equals the magnitude of the difference of the two frequencies: $f_b = |f_1 - f_2|$, where f_1 and f_2 are the two source frequencies in Hz. Beats are clearly perceptible only when this difference is small (typically below about 10

Hz).

Given: $f_1 = 256$ Hz and $f_2 = 260$ Hz, sounded together.

Step 1 — Write the relation: $f_b = |f_1 - f_2|$.

Step 2 — Substitute: $f_b = |260 - 256|$ Hz.

Step 3 — Evaluate: $f_b = 4$ beats per second.

Why each other option is wrong:

- (A) 516 *adds* the two frequencies $(256+260)$; the sum has no acoustic meaning as a beat rate.
- (B) 258 is the *average* of the two $(\frac{256+260}{2})$; that is roughly the pitch you hear, not the beat frequency.
- (C) 2 halves the correct difference; the beat frequency is the full difference, not half of it.

Key point: Beat frequency is the simple *difference* of the two frequencies, never the sum, average, or half-difference.

Final Answer: $f_b = 4 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q28

Q29.

Solution

Concept — Intrinsic versus extrinsic semiconductors: A pure semiconductor such as silicon or germanium, with no added impurity, is called *intrinsic*; its few charge carriers come only from thermally broken bonds, so its conductivity is low. When a controlled amount of a suitable impurity is added (a process called doping), the material becomes *extrinsic*; doping with a pentavalent donor gives an n-type semiconductor (extra electrons) and doping with a trivalent acceptor gives a p-type (extra holes). Doping dramatically raises the carrier concentration and hence the conductivity.

Step 1 — State the distinguishing feature: The key difference is purity: intrinsic $=$ pure, extrinsic $=$ doped with a deliberate impurity.

Step 2 — Effect of doping: Adding even a tiny fraction of impurity introduces many additional charge carriers, increasing conductivity by orders of magnitude over the intrinsic value.

Step 3 — Match to the options: The statement that "an extrinsic semiconductor is doped, while an intrinsic one is pure" correctly captures this distinction.

Why each other option is wrong:

- (B) reverses the roles (claims the intrinsic one is doped and the extrinsic is pure), which is exactly backwards.
- (C) "both are pure but differ in temperature" is false; an extrinsic semiconductor is by definition impure (doped).
- (D) "an extrinsic semiconductor has no charge carriers" is false; doping actually *adds* carriers, giving extrinsic material more carriers than intrinsic.

Key point: Intrinsic means chemically pure; extrinsic means intentionally doped. Doping is what raises conductivity and creates n-type or p-type material.

Final Answer: Extrinsic is doped, intrinsic is pure $\Rightarrow \boxed{A}$

Answer: (A) Go Back to Q29

Q30.

Solution

Concept — Half-wave rectifier: A rectifier converts alternating current (AC) into direct current (DC). A half-wave rectifier uses a single p–n junction diode in series with the load R_L. A diode conducts only when it is *forward biased* (anode positive with respect to cathode) and blocks current when *reverse biased*. Because an AC input reverses polarity every half-cycle, the single diode lets current through during only one of the two halves of each input cycle.

Step 1 — During the favourable half-cycle: The input makes the diode forward biased, so it conducts and current flows through R_L, producing an output voltage.

Step 2 — During the opposite half-cycle: The input reverses, the diode becomes reverse biased and blocks the current, so no output appears during that half.

Step 3 — Net result: Output is present for only one half of each full input cycle, which is why it is called *half-wave* rectification.

Why each other option is wrong:

- (A) "the full input cycle" describes a *full-wave* rectifier, which needs two or four diodes (or a centre-tapped transformer), not a single diode.
- (C) "neither half of the cycle" is wrong; the diode does conduct during the forward-biased half, so there is an output.

- (D) "both halves but with reversed polarity" is not how a single-diode circuit behaves; it simply blocks the reverse half rather than inverting it.

Key point: One diode = half-wave (output on one half-cycle only); a bridge or two-diode arrangement is needed for full-wave rectification.

Final Answer: Only one half of each cycle $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q30

Answer Key

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