AIIMS B.Sc Nursing Physics

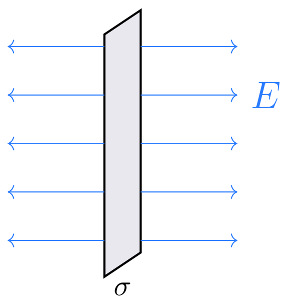
Sample Paper – 7

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. An infinite plane sheet carries a uniform surface charge density $\sigma = 4.0 \times 10^{-7}$ C/m^2. The electric field at a point just outside the sheet is (take $\varepsilon_0 = 8.85 \times 10^{-12}$ C^{2}N^{-1}m^{-2}):



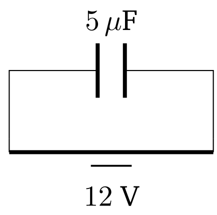
(A) 4.5×10^3 N/C

(B) 2.26×10^4 N/C

(C) 9.0×10^4 N/C

(D) 1.13×10^4 N/C

Q2. A capacitor of capacitance $5\ \mu$F is connected across a 12 V battery as shown. The charge stored on the capacitor is:



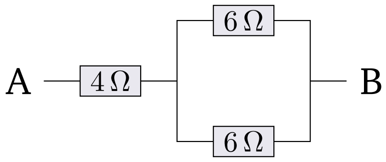
(A) $60\ \mu$C

(B) $17\ \mu$C

(C) $2.4\ \mu$C

(D) $0.42\ \mu$C

Q3. In the network shown, a $4\,\Omega$ resistor is in series with a parallel combination of two $6\,\Omega$ resistors. The equivalent resistance between A and B is:



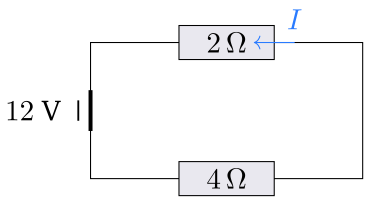
(A) $16\,\Omega$

(B) $10\,\Omega$

(C) $7\,\Omega$

(D) $3\,\Omega$

Q4. In the single-loop circuit shown, a 12 V battery drives current through resistors of $2\,\Omega$ and $4\,\Omega$ in series. Applying Kirchhoff's voltage law, the current in the loop is:



(A) 6 A

(B) 3 A

(C) 1 A

(D) 2 A

Q5. A current of 2 A flows through a 5 Ω resistor for 3 minutes. The heat produced in the resistor is:

(A) 3600 J

(B) 60 J

(C) 1200 J

(D) 600 J

Q6. The dimensional formula of power is:

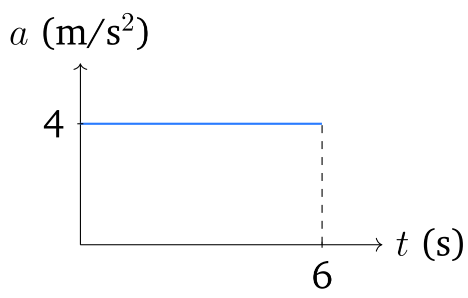
(A) $[ML^2T^{-2}]$

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

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

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

Q7. The acceleration–time graph of a body starting from rest is shown. The velocity gained by the body in the 6 s is equal to the area under the graph, which is:



(A) 24 m/s

(B) 12 m/s

(C) 10 m/s

(D) 6 m/s

Q8. A car starts with an initial velocity of 4 m/s and accelerates uniformly at 3 m/s^2. Its velocity at the end of 5 s is:

(A) 15 m/s

(B) 12 m/s

(C) 23 m/s

(D) 19 m/s

Q9. A ball of mass 0.2 kg strikes a wall horizontally at 10 m/s and rebounds with the same speed. The magnitude of the change in its momentum is:

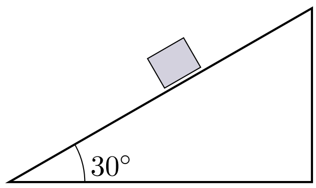
(A) 2 kg m/s

(B) 4 kg m/s

(C) 0 kg m/s

(D) 1 kg m/s

Q10. A block placed on an inclined plane is on the verge of sliding when the incline makes an angle of 30° with the horizontal, as shown. The coefficient of static friction between the block and the surface is:



(A) 0.5

(B) 0.58

(C) 0.87

(D) 1.0

Q11. A machine does 6000 J of work in 2 minutes. The power of the machine is:

(A) 3000 W

(B) 120 W

(C) 50 W

(D) 100 W

Q12. A planet has twice the mass of the Earth and twice its radius. If g on the Earth's surface is 10 m/s^2, the acceleration due to gravity on the surface of this planet is:

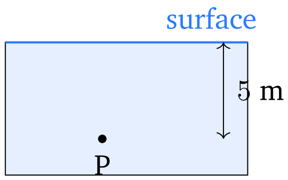
(A) 10 m/s^2

(B) 20 m/s^2

(C) 2.5 m/s^2

(D) 5 m/s^2

Q13. The gauge pressure at a depth of 5 m below the surface of a lake is (take $\rho = 1000$ kg/m^3 and $g = 10$ m/s^2):



(A) 5.0×10^4 Pa

(B) 5.0×10^3 Pa

(C) 5.0×10^5 Pa

(D) 2.5×10^4 Pa

Q14. Within the elastic limit, Hooke's law states that for a stretched wire:

(A) stress is inversely proportional to strain

(B) stress is directly proportional to strain

(C) stress is independent of strain

(D) strain is proportional to the square of stress

Q15. A gas occupies a volume of 4 L at a pressure of 1 atm. Keeping the temperature constant, the pressure is increased to 2 atm. The new volume of the gas is:

(A) 8 L

(B) 4 L

(C) 2 L

(D) 1 L

Q16. A body absorbs 500 J of heat and its temperature rises by 10 °C. The heat capacity of the body is:

(A) 5000 J/°C

(B) 0.02 J/°C

(C) 100 J/°C

(D) 50 J/°C

Q17. A heat engine absorbs 800 J of heat from the source and rejects 600 J to the sink in each cycle. Its efficiency is:

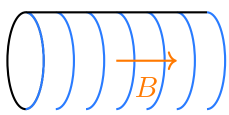
(A) 75%

(B) 25%

(C) 33%

(D) 60%

Q18. A long solenoid has 500 turns per metre and carries a current of 4 A, as shown. The magnetic field inside it is (take $\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}):



$n = 500$/m, $I = 4$ A

(A) 2.51×10^{-3} T

(B) 1.26×10^{-3} T

(C) 6.28×10^{-4} T

(D) 5.0×10^{-3} T

Q19. When the north pole of a magnet is pushed towards a closed coil, the induced current in the coil flows in such a direction that:

(A) it aids the motion of the magnet

(B) it has no relation to the motion

(C) the near face of the coil becomes a north pole and opposes the magnet

(D) the near face of the coil becomes a south pole and attracts the magnet

Q20. The rms value of an alternating voltage is 220 V. Its peak value is approximately:

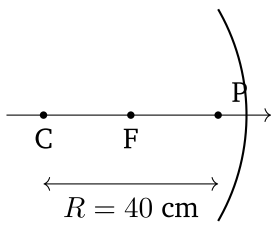
(A) 220 V

(B) 156 V

(C) 440 V

(D) 311 V

Q21. A concave mirror has a radius of curvature of 40 cm, as shown. Its focal length is:



(A) 20 cm

(B) 40 cm

(C) 80 cm

(D) 10 cm

Q22. A concave (diverging) lens has a focal length of magnitude 25 cm. Its power is:

(A) $+4$ D

(B) -4 D

(C) $+0.25$ D

(D) -0.25 D

Q23. An astronomical telescope has an objective of focal length 60 cm and an eyepiece of focal length 5 cm. Its magnifying power in normal adjustment is:

(A) 300

(B) 65

(C) 12

(D) 55

Q24. Light of energy 5 eV falls on a metal whose work function is 2 eV. The maximum kinetic energy of the emitted photoelectrons is:

(A) 7 eV

(B) 2.5 eV

(C) 2 eV

(D) 3 eV

Q25. The energy of the electron in the ground state of the hydrogen atom is -13.6 eV. The energy required to ionize a hydrogen atom from its ground state is:

(A) 13.6 eV

(B) 3.4 eV

(C) 27.2 eV

(D) 6.8 eV

Q26. Two nuclei that have the same number of protons but different numbers of neutrons are called:

(A) isobars

(B) isotopes

(C) isotones

(D) isomers

Q27. A particle executing simple harmonic motion has an amplitude of 0.05 m and an angular frequency of 20 rad/s. Its maximum speed is:

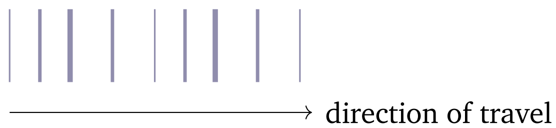
(A) 1.0 m/s

(B) 0.0025 m/s

(C) 4.0 m/s

(D) 400 m/s

Q28. The diagram shows the compressions and rarefactions of a sound wave travelling in air. Sound waves in air are:



(A) transverse, needing no medium

(B) transverse, needing a medium

(C) longitudinal, needing a medium

(D) electromagnetic in nature

Q29. As the temperature of a pure semiconductor is raised, its electrical conductivity:

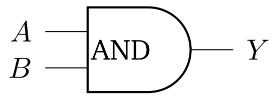
(A) decreases, as in a metal

(B) remains unchanged

(C) first increases then decreases

(D) increases, because more charge carriers are produced

Q30. For the AND gate shown, the output Y is 1 only when:



(A) either A or B is 1

(B) both A and B are 1

(C) both A and B are 0

(D) exactly one input is 1

Detailed Solutions

Q1.

Solution

Concept — Field of an infinite charged sheet: An infinite plane sheet with uniform surface charge density σ sets up a uniform electric field on both sides, directed perpendicularly away from (or toward) the sheet. From Gauss's law applied to a pillbox straddling the sheet, the magnitude is $E = \dfrac{\sigma}{2\varepsilon_0}$, where σ is the charge per unit area (C/m^2) and ε_0 is the permittivity of free space (C^{2}N^{-1}m^{-2}). The field does not depend on distance from the sheet, so "just outside" uses the same formula.

Given: $\sigma = 4.0 \times 10^{-7}$ C/m^2; $\varepsilon_0 = 8.85 \times 10^{-12}$ C^{2}N^{-1}m^{-2}.

Step 1 — Write the formula: $E = \dfrac{\sigma}{2\varepsilon_0}$.

Step 2 — Substitute with units: $E = \dfrac{4.0 \times 10^{-7}\ \text{C/m}^2}{2 \times (8.85 \times 10^{-12}\ \text{C}^2\text{N}^{-1}\text{m}^{-2})} = \dfrac{4.0 \times 10^{-7}}{1.77 \times 10^{-11}}$ N/C.

Step 3 — Evaluate: $E = 2.259 \times 10^4$ N/C $\approx 2.26 \times 10^4$ N/C.

Why each other option is wrong:

- (A) 4.5×10^3 N/C comes from using a wrong power of ten in ε_0 or in σ, shifting the exponent.
- (C) 9.0×10^4 N/C uses $E = \sigma/\varepsilon_0$ (dropping the factor of 2 that arises because the flux leaves from both faces of the sheet); that formula is for the field at a conductor's surface, not a thin sheet.
- (D) 1.13×10^4 N/C halves the correct value, e.g. by writing $E = \sigma/(4\varepsilon_0)$.

Key point: For a thin charged sheet use $E = \sigma/2\varepsilon_0$; the $1/2$ disappears only for a charged conductor's surface where the field exists on one side only.

Final Answer: $E \approx 2.26 \times 10^4$ N/C $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q1

Q2.

Solution

Concept — Charge on a capacitor: A capacitor stores charge in proportion to the voltage across it. The defining relation is $Q = CV$, where Q is the charge (coulombs), C is the capacitance (farads), and V is the potential difference applied across the plates (volts). When connected to an ideal battery, the steady-state voltage across the capacitor equals the battery emf, so we simply multiply C by V.

Given: $C = 5\ \mu\text{F} = 5 \times 10^{-6}$ F; $V = 12$ V.

Step 1 — Write the formula: $Q = CV$.

Step 2 — Substitute with units: $Q = (5 \times 10^{-6}\text{ F})(12\text{ V})$.

Step 3 — Evaluate: $Q = 60 \times 10^{-6}$ C $= 60\ \mu$C (since $1\text{ F} \cdot \text{V} = 1$ C).

Why each other option is wrong:

- (B) $17\ \mu$C wrongly adds C and V $(5 + 12)$ instead of multiplying them.
- (C) $2.4\ \mu$C divides C by V $(5/12)$, which is dimensionally meaningless for charge.
- (D) $0.42\ \mu$C divides V by C in microunits $(12/5 \times 10^{-1})$, again the wrong operation.

Key point: Charge on a capacitor scales linearly with applied voltage; always multiply C (in farads) by V (in volts) to get the charge in coulombs.

Final Answer: $Q = 60\ \mu\text{C} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q2

Q3.

Solution

Concept — Series and parallel combinations: For resistors in parallel the reciprocals add, $\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$, giving an equivalent smaller than either branch. For resistors in series the resistances add directly, $R = R_1 + R_2$. Here the two $6\,\Omega$ resistors form the parallel block, and that block sits in series with the lone $4\,\Omega$ resistor between A and B.

Given: Series resistor $= 4\,\Omega$; two parallel resistors each $= 6\,\Omega$.

Step 1 — Reduce the parallel pair: $\frac{1}{R_p} = \frac{1}{6\,\Omega} + \frac{1}{6\,\Omega} = \frac{2}{6\,\Omega} = \frac{1}{3\,\Omega}$, so $R_p = 3\,\Omega$ (two equal resistors in parallel give half of one).

Step 2 — Add the series resistor: $R_{AB} = 4\,\Omega + R_p = 4\,\Omega + 3\,\Omega$.

Step 3 — Evaluate: $R_{AB} = 7\,\Omega$.

Why each other option is wrong:

- (A) $16\,\Omega$ treats all three resistors as a simple series chain $(4+6+6)$, ignoring the parallel branching.
- (B) $10\,\Omega$ adds $4+6$, counting only one of the two parallel resistors.
- (D) $3\,\Omega$ reports just the parallel block and forgets the series $4\,\Omega$.

Key point: Always collapse parallel blocks first, then add the remaining series resistors; two equal resistors in parallel always halve to one branch's value.

Final Answer: $R = 7\,\Omega \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q3

Q4.

Solution

Concept — Kirchhoff's voltage law (KVL): The algebraic sum of potential differences around any closed loop is zero. For a single loop with one source this means the emf equals the total of the IR drops: $\mathcal{E} = I(R_1 + R_2)$, where $\mathcal{E}$ is the battery emf (V), I is the loop current (A), and R_1, R_2 are the series resistances (Ω). Solving gives $I = \mathcal{E}/R_{\text{total}}$.

Given: $\mathcal{E} = 12$ V; $R_1 = 2\,\Omega$; $R_2 = 4\,\Omega$ (in series).

Step 1 — Add the series resistances: $R_{\text{total}} = R_1 + R_2 = 2\,\Omega + 4\,\Omega = 6\,\Omega$.

Step 2 — Apply KVL / Ohm's law: $I = \dfrac{\mathcal{E}}{R_{\text{total}}} = \dfrac{12\text{ V}}{6\,\Omega}$.

Step 3 — Evaluate: $I = 2$ A (since $1\text{ V}/\Omega = 1$ A).

Why each other option is wrong:

- (A) 6 A divides 12 V by $2\,\Omega$ only, ignoring the $4\,\Omega$ resistor in series.
- (B) 3 A divides 12 V by $4\,\Omega$ only, ignoring the $2\,\Omega$ resistor.
- (C) 1 A uses $R = 12\,\Omega$, e.g. by mistakenly doubling the total resistance.

Key point: In a single series loop, add all resistances first, then divide the emf by that total; series elements carry the same current.

Final Answer: $I = 2\text{ A} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q4

Q5.

Solution

Concept — Joule heating: When a current I flows through a resistance R for time t, electrical energy is dissipated as heat. The heat produced is $H = I^2Rt$, where I is in amperes, R in ohms, and t in seconds, giving H in joules. The current must be squared, and time must be in SI units (seconds).

Given: $I = 2$ A; $R = 5\,\Omega$; $t = 3$ min.

Step 1 — Convert time to seconds: $t = 3 \text{ min} \times 60 \text{ s/min} = 180$ s.

Step 2 — Write the formula: $H = I^2Rt$.

Step 3 — Substitute and evaluate: $H = (2\text{ A})^2(5\,\Omega)(180\text{ s}) = 4 \times 5 \times 180 \text{ J} = 3600$ J.

Why each other option is wrong:

- (B) 60 J forgets to convert minutes to seconds, using $t = 3$ s.
- (C) 1200 J drops the square on the current, using I instead of I^2 ($2 \times 5 \times 120$ type error).
- (D) 600 J uses $t = 30$ s, an incorrect time conversion.

Key point: Square the current and convert time to seconds before applying $H = I^2Rt$; these are the two most common slips.

Final Answer: $H = 3600 \text{ J} \Rightarrow \boxed{A}$

Answer: (A) Go Back to Q5

Q6.

Solution

Concept — Dimensional formula of power: Power is the rate of doing work, $P = W/t$. To find its dimensions we build up work from force and distance: force = mass $\times$ acceleration, with dimensions $[MLT^{-2}]$, and work = force $\times$ displacement. Dividing the resulting energy dimension by time gives the dimension of power. The symbols are M (mass), L (length), T (time).

Step 1 — Dimensions of force: $[F] = [M][LT^{-2}] = MLT^{-2}$.

Step 2 — Dimensions of work (energy): $[W] = [F][L] = (MLT^{-2})(L) =$

ML^2T^{-2}.

Step 3 — Divide by time for power: $[P] = \dfrac{[W]}{[T]} = \dfrac{ML^2T^{-2}}{T} = ML^2T^{-3}$.

Why each other option is wrong:

- (A) $[ML^2T^{-2}]$ is the dimension of work or energy, not power; it lacks the extra T^{-1} from dividing by time.
- (B) $[MLT^{-2}]$ is the dimension of force.
- (D) $[ML^2T^{-1}]$ is the dimension of angular momentum (or Planck's constant), not power.

Key point: Power carries one more inverse power of time than energy: energy is ML^2T^{-2}, power is ML^2T^{-3}.

Final Answer: $[ML^2T^{-3}] \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q6

Q7.

Solution

Concept — Area under an a–t graph: Since acceleration is the rate of change of velocity, $a = \dfrac{dv}{dt}$, integrating gives $\Delta v = \int a\,dt$, which is geometrically the area enclosed between the acceleration–time curve and the time axis. For a constant acceleration the graph is a horizontal line, so the area is simply a rectangle: $\Delta v = a \times t$.

Given: From the graph, $a = 4$ m/s^2 (constant height) over $t = 6$ s (width); the body starts from rest.

Step 1 — Identify the area shape: The acceleration stays at 4 m/s^2 for the full 6 s, so the enclosed region is a rectangle of height 4 and width 6.

Step 2 — Compute the area: $\Delta v = a \times t = (4\text{ m/s}^2)(6\text{ s})$.

Step 3 — Evaluate: $\Delta v = 24$ m/s; since the body started from rest, the final velocity is also 24 m/s.

Why each other option is wrong:

- (B) 12 m/s wrongly uses the triangle formula $\frac{1}{2}at$, but the graph is a rectangle, not a triangle.
- (C) 10 m/s misreads the constant height as some value other than 4 m/s^2.

- (D) 6 m/s confuses the area with the width (time) alone.

Key point: Area under an a–t graph gives change in velocity; use a rectangle for constant acceleration, a triangle only when a rises linearly from zero.

Final Answer: $\Delta v = 24$ m/s $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q7

Q8.

Solution

Concept — First equation of motion: For uniformly accelerated motion in a straight line, the velocity after time t is $v = u + at$, where u is the initial velocity (m/s), a is the constant acceleration (m/s^2), and t is the elapsed time (s). The term at is the velocity gained during the interval, which is added to the starting velocity u.

Given: $u = 4$ m/s; $a = 3$ m/s^2; $t = 5$ s.

Step 1 — Write the formula: $v = u + at$.

Step 2 — Substitute with units: $v = 4\ \text{m/s} + (3\ \text{m/s}^2)(5\ \text{s})$.

Step 3 — Evaluate: $v = 4\ \text{m/s} + 15\ \text{m/s} = 19\ \text{m/s}$.

Why each other option is wrong:

- (A) 15 m/s computes only the gained velocity at and forgets to add the initial velocity u.
- (B) 12 m/s uses $t = 4$ s (or otherwise mishandles the numbers), giving $4 + 3 \times (\text{wrong } t)$.
- (C) 23 m/s adds an extra increment, e.g. using $t = 6$ s, $4 + 19$.

Key point: Always add the initial velocity u to the term at; dropping u is the most frequent error.

Final Answer: $v = 19$ m/s $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q8

Q9.

Solution

Concept — Change in momentum on rebound: Momentum is a vector, $p = mv$. When a ball strikes a wall and rebounds with the same speed, its velocity reverses direction. Taking the initial direction as positive, $p_i = +mv$ and $p_f = -mv$, so the change is $\Delta p = p_f - p_i = -mv - (+mv) = -2mv$, and its magnitude is $|\Delta p| = 2mv$, where m is the mass (kg) and v is the speed (m/s).

Given: $m = 0.2$ kg; $v = 10$ m/s (same before and after).

Step 1 — Write the formula: $|\Delta p| = 2mv$.

Step 2 — Substitute with units: $|\Delta p| = 2(0.2\text{ kg})(10\text{ m/s})$.

Step 3 — Evaluate: $|\Delta p| = 4$ kg m/s.

Why each other option is wrong:

- (A) 2 kg m/s uses mv only, treating the collision as if the ball stopped rather than reversed.
- (C) 0 kg m/s wrongly assumes momentum is unchanged because the speed is unchanged, ignoring the reversal of direction.
- (D) 1 kg m/s uses an incorrect mass or drops the factor of 2 as well.

Key point: On a same-speed rebound, momentum change is $2mv$, not mv, because the direction flips; momentum is a vector.

Final Answer: $\Delta p = 4$ kg m/s $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q9

Q10.

Solution

Concept — Angle of repose: A block on an incline is on the verge of sliding when the gravity component along the slope, $mg\sin\theta$, just balances the maximum static friction, $\mu_s mg\cos\theta$. Setting them equal, $mg\sin\theta = \mu_s mg\cos\theta$, the mass and g cancel, leaving $\mu_s = \tan\theta$. This critical angle is called the angle of repose; μ_s is the coefficient of static friction (dimensionless).

Given: Critical angle $\theta = 30^\circ$ (block just begins to slide).

Step 1 — Write the condition: $\mu_s = \tan\theta$.

Step 2 — Substitute: $\mu_s = \tan 30^\circ = \dfrac{1}{\sqrt{3}}$.

Step 3 — Evaluate: $\mu_s = \dfrac{1}{1.732} \approx 0.58$.

Why each other option is wrong:

- (A) 0.5 is $\sin 30^\circ$, not $\tan 30^\circ$; friction depends on the tangent at the verge of sliding.
- (C) 0.87 is $\cos 30^\circ$, again the wrong trig ratio.
- (D) 1.0 would be $\tan 45^\circ$, corresponding to a 45° incline, not 30°.

Key point: At the angle of repose, $\mu_s = \tan\theta$; mixing this up with $\sin$ or $\cos$ is the classic trap.

Final Answer: $\mu \approx 0.58 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q10

Q11.

Solution

Concept — Power: Power is the rate at which work is done, $P = \dfrac{W}{t}$, where W is the work done (joules) and t is the time taken (seconds), giving P in watts (1 W = 1 J/s). Time must be expressed in seconds before dividing.

Given: $W = 6000$ J; $t = 2$ min.

Step 1 — Convert time to seconds: $t = 2 \text{ min} \times 60 \text{ s/min} = 120$ s.

Step 2 — Write the formula: $P = \dfrac{W}{t}$.

Step 3 — Substitute and evaluate: $P = \dfrac{6000 \text{ J}}{120 \text{ s}} = 50$ W.

Why each other option is wrong:

- (A) 3000 W uses $t = 2$ s, forgetting to convert minutes to seconds.
- (B) 120 W simply reuses the time value 120 and is not a correct division of work by time.
- (D) 100 W uses $t = 60$ s, an incomplete time conversion.

Key point: Always convert the time interval to seconds before computing power in watts.

Final Answer: $P = 50 \text{ W} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q11

Q12.

Solution

Concept — Acceleration due to gravity at a planet's surface: The surface gravity is $g = \frac{GM}{R^2}$, where G is the gravitational constant, M is the planet's mass, and R its radius. Since G is fixed, $g \propto \frac{M}{R^2}$. Comparing two bodies, ratios of M and R determine the ratio of g, so absolute values of G are not needed.

Given: $M_p = 2M_E$; $R_p = 2R_E$; $g_E = 10 \text{ m/s}^2$.

Step 1 — Form the ratio: $\frac{g_p}{g_E} = \frac{M_p}{M_E}\left(\frac{R_E}{R_p}\right)^2 = (2)\left(\frac{1}{2}\right)^2$.

Step 2 — Simplify: $\frac{g_p}{g_E} = 2 \times \frac{1}{4} = \frac{1}{2}$.

Step 3 — Evaluate: $g_p = \frac{1}{2} \times g_E = \frac{10}{2} = 5 \text{ m/s}^2$.

Why each other option is wrong:

- (A) 10 m/s^2 ignores the radius change, accounting only for the doubled mass.
- (B) 20 m/s^2 multiplies by the mass factor but forgets to divide by R^2.
- (C) 2.5 m/s^2 uses R^4 or otherwise over-counts the radius dependence.

Key point: Radius enters as R^2 in the denominator, so doubling R cuts g to a quarter; the net effect here is a halving.

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

Answer: (D) Go Back to Q12

Q13.

Solution

Concept — Gauge pressure at a depth: In a static fluid, the pressure due to the column of liquid above a point increases linearly with depth. This gauge pressure (pressure above atmospheric) is $P = h\rho g$, where h is the depth (m), ρ is the fluid density (kg/m^3), and g is the acceleration due to gravity (m/s^2). The result is in pascals (Pa $=$ N/m^2).

Given: $h = 5$ m; $\rho = 1000 \text{ kg/m}^3$; $g = 10 \text{ m/s}^2$.

Step 1 — Write the formula: $P = h\rho g$.

Step 2 — Substitute with units: $P = (5\text{ m})(1000\text{ kg/m}^3)(10\text{ m/s}^2)$.

Step 3 — Evaluate: $P = 50000\text{ Pa} = 5.0 \times 10^4\text{ Pa}$.

Why each other option is wrong:

- (B) 5.0×10^3 Pa drops a factor of ten, e.g. using $g = 1$ or $h = 0.5$.
- (C) 5.0×10^5 Pa overshoots by a factor of ten, an incorrect power of ten.
- (D) 2.5×10^4 Pa halves the answer, e.g. by using $h = 2.5$ m.

Key point: Gauge pressure grows linearly with depth as $h\rho g$; this is pressure above atmospheric, so atmospheric pressure is not added here.

Final Answer: $P = 5.0 \times 10^4\text{ Pa} \Rightarrow \boxed{\text{A}}$

Answer: (A) **Go Back to Q13**

Q14.

Solution

Concept — Hooke's law: Within the elastic limit of a material, the deforming stress is directly proportional to the strain produced. Mathematically, stress $=$ $Y \times$ strain, where the constant of proportionality Y is Young's modulus. Stress is force per unit area (F/A) and strain is the fractional change in length ($\Delta L/L$), a dimensionless ratio. This linear relation holds only up to the elastic limit; beyond it the material no longer returns to its original shape.

Step 1 — Write the relation: $\dfrac{F}{A} = Y\dfrac{\Delta L}{L}$, i.e. stress $= Y \times$ strain.

Step 2 — Interpret: Because Y is a constant for a given material, stress $\propto$ strain — doubling the strain doubles the stress.

Why each other option is wrong:

- (A) "Stress inversely proportional to strain" would mean stress falls as strain rises, contradicting the straight-line stress–strain graph.
- (C) "Stress independent of strain" is false; a stretched wire clearly develops more stress as it strains more.
- (D) "Strain proportional to the square of stress" implies a curved (non-linear) law, which violates Hooke's linear elastic behaviour.

Key point: Hooke's law is a linear (first-power) proportionality between stress and strain, valid only within the elastic limit.

Final Answer: Stress is directly proportional to strain $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q14

Q15.

Solution

Concept — Boyle's law: For a fixed mass of gas held at constant temperature, the pressure is inversely proportional to the volume, so the product PV stays constant: $P_1V_1 = P_2V_2$. Here P is the pressure and V the volume, with subscripts 1 and 2 denoting the initial and final states. Doubling the pressure therefore halves the volume.

Given: $P_1 = 1$ atm; $V_1 = 4$ L; $P_2 = 2$ atm; temperature constant.

Step 1 — Write the law: $P_1V_1 = P_2V_2$.

Step 2 — Substitute with units: $(1\text{ atm})(4\text{ L}) = (2\text{ atm})(V_2)$.

Step 3 — Solve for V_2: $V_2 = \dfrac{(1)(4)}{2}\text{ L} = 2\text{ L}$.

Why each other option is wrong:

- (A) 8 L doubles the volume, as if pressure and volume were directly (not inversely) related.
- (B) 4 L ignores the pressure change entirely.
- (D) 1 L quarters the volume, over-applying the pressure ratio.

Key point: At constant temperature PV is constant, so pressure and volume change in opposite directions; doubling P halves V.

Final Answer: $V_2 = 2\text{ L} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q15

Q16.

Solution

Concept — Heat capacity: The heat capacity of a body is the amount of heat needed to raise its temperature by one degree. It is defined as $C = \dfrac{Q}{\Delta T}$, where Q is the heat absorbed (joules) and ΔT is the resulting temperature rise (°C or K), giving C in J/°C. Note this is the heat capacity of the whole body (it includes the mass), not the specific heat per kilogram.

Given: $Q = 500$ J; $\Delta T = 10$ °C.

Step 1 — Write the formula: $C = \dfrac{Q}{\Delta T}$.

Step 2 — Substitute with units: $C = \dfrac{500 \text{ J}}{10 \text{ °C}}$.

Step 3 — Evaluate: $C = 50$ J/°C.

Why each other option is wrong:

- (A) 5000 J/°C multiplies Q by ΔT instead of dividing.
- (B) 0.02 J/°C inverts the ratio, computing $\Delta T/Q$.
- (C) 100 J/°C uses $\Delta T = 5$ instead of 10.

Key point: Heat capacity is heat divided by temperature change; do not confuse it with specific heat, which further divides by mass.

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

Answer: (D) Go Back to Q16

Q17.

Solution

Concept — Efficiency of a heat engine: A heat engine absorbs heat Q_1 from a hot source, converts part of it to useful work W, and rejects the rest Q_2 to a cold sink. By energy conservation $W = Q_1 - Q_2$, and the efficiency is the fraction of input heat turned into work: $\eta = \dfrac{W}{Q_1} = 1 - \dfrac{Q_2}{Q_1}$. Efficiency is dimensionless and is usually quoted as a percentage.

Given: $Q_1 = 800$ J (absorbed); $Q_2 = 600$ J (rejected).

Step 1 — Work done per cycle: $W = Q_1 - Q_2 = 800 \text{ J} - 600 \text{ J} = 200$ J.

Step 2 — Compute efficiency: $\eta = \dfrac{W}{Q_1} = \dfrac{200 \text{ J}}{800 \text{ J}} = 0.25$.

Step 3 — Express as a percentage: $\eta = 0.25 \times 100\% = 25\%$.

Why each other option is wrong:

- (A) 75% uses $Q_2/Q_1 = 600/800$ directly, which is the rejected fraction, not the efficiency.
- (C) 33% comes from a wrong ratio such as $W/Q_2 = 200/600$.
- (D) 60% mismatches the numbers entirely (e.g. Q_2/Q_1 read as 0.6 from wrong values).

Key point: Efficiency is work output divided by heat input (W/Q_1), equivalently $1 - Q_2/Q_1$; never divide by the rejected heat.

Final Answer: $\eta = 25\% \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q17

Q18.

Solution

Concept — Magnetic field inside a long solenoid: A long solenoid produces a nearly uniform axial field given by $B = \mu_0 n I$, where μ_0 is the permeability of free space (T m A^{-1}), n is the number of turns per metre (m^{-1}), and I is the current (A). The field depends on turns per unit length, not the total number of turns.

Given: $n = 500$ turns/m; $I = 4$ A; $\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}.

Step 1 — Write the formula: $B = \mu_0 n I$.

Step 2 — Substitute with units: $B = (4\pi \times 10^{-7}\ \text{T m A}^{-1})(500\ \text{m}^{-1})(4\ \text{A})$.

Step 3 — Evaluate: $B = (4\pi \times 10^{-7})(2000) = 8\pi \times 10^{-4}\ \text{T} = 2.513 \times 10^{-3} \approx 2.51 \times 10^{-3}$ T.

Why each other option is wrong:

- (B) 1.26×10^{-3} T halves the correct value, e.g. using $n = 250$ or $I = 2$.
- (C) 6.28×10^{-4} T is one quarter of the answer, e.g. from $\mu_0 n I$ with nI reduced fourfold.
- (D) 5.0×10^{-3} T drops the factor π, treating 4π as 4 and rounding $8 \times 10^{-4} \times \ldots$ wrongly.

Key point: Use turns per metre (n) in $B = \mu_0 n I$, and keep the 4π in μ_0 throughout.

Final Answer: $B \approx 2.51 \times 10^{-3}\ \text{T} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q18

Q19.

Solution

Concept — Lenz's law: The direction of an induced current is always such that it opposes the change in magnetic flux that produces it. This is a consequence of conservation of energy: the induced current must resist the motion causing it, otherwise energy would be created from nothing. The induced effect therefore acts to maintain the existing flux.

Step 1 — Identify the change: As the north pole of the magnet is pushed toward the coil, the magnetic flux through the coil (directed into the near face) is increasing.

Step 2 — Apply Lenz's law: To oppose this increase, the induced current must make the near face of the coil a north pole, since two north poles repel and push back against the incoming magnet.

Step 3 — Consequence: The coil resists the approach, so external work must be done to push the magnet in, and that work appears as the electrical energy of the induced current.

Why each other option is wrong:

- (A) "It aids the motion" would mean the coil pulls the magnet in, releasing energy for free, violating conservation of energy.
- (B) "No relation to the motion" is false; the induced current is created precisely by the changing flux of the moving magnet.
- (D) "Near face becomes a south pole and attracts" would again aid the motion rather than oppose it, contradicting Lenz's law.

Key point: An approaching pole is always repelled (near face same polarity), and a receding pole is attracted; the induced current always opposes the change.

Final Answer: Near face becomes a north pole and opposes the magnet $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q19

Q20.

Solution

Concept — Peak and rms values of an AC voltage: For a sinusoidal alternating voltage, the root-mean-square (rms) value is related to the peak (maximum) value by $V_{rms} = \frac{V_0}{\sqrt{2}}$, so the peak value is $V_0 = \sqrt{2}\,V_{rms}$. The rms value is what AC voltmeters read and what determines power; the peak is the maximum instantaneous value.

Given: $V_{rms} = 220$ V; $\sqrt{2} = 1.414$.

Step 1 — Write the formula: $V_0 = \sqrt{2}\,V_{rms}$.

Step 2 — Substitute with units: $V_0 = 1.414 \times 220$ V.

Step 3 — Evaluate: $V_0 = 311.1 \approx 311$ V.

Why each other option is wrong:

- (A) 220 V simply repeats the rms value, ignoring the $\sqrt{2}$ factor.
- (B) 156 V divides by $\sqrt{2}$ ($220/1.414$) instead of multiplying.
- (C) 440 V doubles the rms value, as if $V_0 = 2V_{rms}$, which is wrong.

Key point: Peak is $\sqrt{2}$ times rms (about $1.41\times$); the standard 220 V mains has a peak of roughly 311 V.

Final Answer: $V_0 \approx 311 \text{ V} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q20

Q21.

Solution

Concept — Focal length of a spherical mirror: For a spherical mirror, the focal length is half the radius of curvature, $f = \dfrac{R}{2}$, where R is the radius of the sphere of which the mirror is a part. Parallel rays converge to (or appear to diverge from) the focus, which lies midway between the pole and the centre of curvature. The magnitudes are used here for a concave mirror.

Given: Radius of curvature $R = 40$ cm.

Step 1 — Write the formula: $f = \dfrac{R}{2}$.

Step 2 — Substitute with units: $f = \dfrac{40 \text{ cm}}{2}$.

Step 3 — Evaluate: $f = 20$ cm.

Why each other option is wrong:

- (B) 40 cm equals R itself, forgetting the factor of $\frac{1}{2}$.
- (C) 80 cm uses $f = 2R$, doubling instead of halving.
- (D) 10 cm uses $f = R/4$, dividing by the wrong factor.

Key point: The focus of a spherical mirror sits halfway between pole and centre of curvature, so $f = R/2$ always.

Final Answer: $f = 20 \text{ cm} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q21

Q22.

Solution

Concept — Power of a lens: The power of a lens measures its converging or diverging ability and is the reciprocal of its focal length in metres: $P = \dfrac{1}{f\ (\text{m})}$, with unit dioptre (D). By sign convention, a converging (convex) lens has positive f and positive power, while a diverging (concave) lens has negative f and hence negative power.

Given: Concave lens of focal-length magnitude 25 cm, so $f = -25$ cm.

Step 1 — Convert to metres: $f = -25\ \text{cm} = -0.25$ m.

Step 2 — Write the formula: $P = \dfrac{1}{f}$.

Step 3 — Substitute and evaluate: $P = \dfrac{1}{-0.25\ \text{m}} = -4$ D.

Why each other option is wrong:

- (A) $+4$ D drops the negative sign; a diverging lens must have negative power.
- (C) $+0.25$ D forgets to convert cm to m (and the sign), using $f = 25$ directly.
- (D) -0.25 D keeps the sign but again fails to convert cm to m before taking the reciprocal.

Key point: Convert focal length to metres and apply the sign convention — concave lenses always give negative power.

Final Answer: $P = -4\ \text{D} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q22

Q23.

Solution

Concept — Magnifying power of an astronomical telescope: In normal adjustment (final image at infinity), the magnifying power is the ratio of the objective's focal length to the eyepiece's focal length, $M = \dfrac{f_o}{f_e}$, where f_o is the objective focal length and f_e the eyepiece focal length (same units). A large objective focal length and a small eyepiece focal length give high magnification.

Given: $f_o = 60$ cm; $f_e = 5$ cm.

Step 1 — Write the formula: $M = \dfrac{f_o}{f_e}$.

Step 2 — Substitute with units: $M = \dfrac{60 \text{ cm}}{5 \text{ cm}}$.

Step 3 — Evaluate: $M = 12$ (dimensionless).

Why each other option is wrong:

- (A) 300 multiplies the two focal lengths (60×5) instead of dividing.
- (B) 65 adds the focal lengths ($60 + 5$), which gives the tube length, not magnification.
- (D) 55 subtracts the focal lengths ($60 - 5$), again unrelated to magnifying power.

Key point: Telescope magnification in normal adjustment is f_o/f_e; the sum $f_o + f_e$ gives the tube length, not the magnification.

Final Answer: $M = 12 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q23

Q24.

Solution

Concept — Einstein's photoelectric equation: When light of photon energy $h\nu$ strikes a metal, part of the energy (ϕ, the work function) is used to free an electron from the surface and the rest becomes the electron's kinetic energy. The maximum kinetic energy of the emitted photoelectrons is $K_{\max} = h\nu - \phi$, where $h\nu$ is the incident photon energy and ϕ is the work function (both in the same units, here eV).

Given: Photon energy $h\nu = 5$ eV; work function $\phi = 2$ eV.

Step 1 — Write the formula: $K_{\max} = h\nu - \phi$.

Step 2 — Substitute with units: $K_{\max} = 5 \text{ eV} - 2 \text{ eV}$.

Step 3 — Evaluate: $K_{\max} = 3$ eV.

Why each other option is wrong:

- (A) 7 eV adds the photon energy and work function instead of subtracting.
- (B) 2.5 eV halves the photon energy, ignoring the work function entirely.
- (C) 2 eV merely reports the work function ϕ, not the kinetic energy.

Key point: Subtract the work function from the photon energy; the remainder is the maximum kinetic energy of the ejected electrons.

Final Answer: $K_{\text{max}} = 3$ eV $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q24

Q25.

Solution

Concept — Ionization energy of hydrogen: The ionization energy is the energy needed to completely remove the electron from the atom, i.e. to raise it from its bound ground-state energy to zero energy (free electron at rest, infinitely far away). For the ground state of hydrogen, $E_1 = -13.6$ eV, so the ionization energy equals the magnitude of this binding energy.

Given: Ground-state energy $E_1 = -13.6$ eV; final (free) energy $E_\infty = 0$.

Step 1 — Write the relation: $E_{\text{ion}} = E_\infty - E_1$.

Step 2 — Substitute: $E_{\text{ion}} = 0 - (-13.6 \text{ eV})$.

Step 3 — Evaluate: $E_{\text{ion}} = 13.6$ eV.

Why each other option is wrong:

- (B) 3.4 eV is the magnitude of the $n = 2$ level energy, not the ground-state ionization energy.
- (C) 27.2 eV doubles the correct value (this is the magnitude of the potential energy, $2E_1$).
- (D) 6.8 eV halves the correct value.

Key point: Ionization energy from the ground state equals the magnitude of the ground-state energy, 13.6 eV for hydrogen.

Final Answer: $E_{\text{ion}} = 13.6$ eV $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q25

Q26.

Solution

Concept — Nuclear classification: Nuclei are classified by their proton number Z, neutron number N, and mass number $A = Z + N$. Isotopes are nuclei of the same element: they have the same number of protons (Z) but different numbers of neutrons (N), and hence different mass numbers. For example, ^{12}C and ^{14}C both have $Z = 6$ but $N = 6$ and $N = 8$ respectively.

Step 1 — Match the given condition: The problem states "same number of protons, different number of neutrons," which is exactly the definition of isotopes.

Step 2 — Conclusion: The two nuclei are isotopes of the same element.

Why each other option is wrong:

- (A) Isobars have the same mass number A but different Z (different elements), e.g. ^{40}Ar and ^{40}Ca.
- (C) Isotones have the same neutron number N but different Z.
- (D) Isomers are nuclei with the same Z and same A that differ only in their internal energy state (excited vs ground).

Key point: Same protons, different neutrons $\Rightarrow$ isotopes ("iso-top" $=$ same place/element in the periodic table).

Final Answer: Isotopes $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q26

Q27.

Solution

Concept — Maximum speed in SHM: In simple harmonic motion $x = A\sin(\omega t)$, the velocity is $v = A\omega\cos(\omega t)$, which is largest when $\cos = 1$, i.e. as the particle passes through the equilibrium position. The maximum speed is therefore $v_{\text{max}} = A\omega$, where A is the amplitude (m) and ω is the angular frequency (rad/s), giving v_{max} in m/s.

Given: $A = 0.05$ m; $\omega = 20$ rad/s.

Step 1 — Write the formula: $v_{\text{max}} = A\omega$.

Step 2 — Substitute with units: $v_{\text{max}} = (0.05\text{ m})(20\text{ rad/s})$.

Step 3 — Evaluate: $v_{\text{max}} = 1.0$ m/s.

Why each other option is wrong:

- (B) 0.0025 m/s comes from $A \times A$ or a similar wrong product, not $A\omega$.
- (C) 4.0 m/s uses $A\omega^2$ (0.05×400), which is the maximum acceleration's form, not speed.
- (D) 400 m/s misplaces the decimal/forgets the amplitude factor.

Key point: Maximum speed is $A\omega$ (occurs at the mean position); maximum acceleration is $A\omega^2$ (occurs at the extremes) — do not interchange them.

Final Answer: $v_{\max} = 1.0$ m/s $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q27

Q28.

Solution

Concept — Nature of sound waves: Sound travels through air as a series of compressions (regions of high pressure/density) and rarefactions (regions of low pressure/density). In such a wave the air particles vibrate back and forth along the same line as the wave propagates. A wave in which the particle oscillation is parallel to the direction of travel is called longitudinal, and because it relies on particle collisions to pass the disturbance along, it requires a material medium.

Step 1 — Particle motion: The diagram shows alternating dense and sparse regions; air molecules oscillate parallel to the direction of travel (not perpendicular to it).

Step 2 — Need for a medium: In a vacuum there are no particles to compress and rarefy, so no compressions/rarefactions can form and sound cannot propagate.

Why each other option is wrong:

- (A) "Transverse, needing no medium" is doubly wrong: sound is not transverse, and it cannot travel through vacuum.
- (B) "Transverse, needing a medium" gets the medium right but the wave type wrong; transverse waves have particle motion perpendicular to travel.
- (D) "Electromagnetic in nature" is false; sound is a mechanical wave needing matter, unlike EM waves which travel through vacuum.

Key point: Sound is a mechanical, longitudinal wave that always requires a medium; it cannot travel through a vacuum.

Final Answer: Longitudinal, needing a medium $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q28

Q29.

Solution

Concept — Conductivity of a semiconductor vs temperature: In a pure (intrinsic) semiconductor at low temperature, almost all electrons are bound in the valence band and there are very few free charge carriers. Raising the temperature supplies thermal energy that lets electrons jump across the small band gap into the conduction band, each leaving behind a hole. This generation of extra electron–hole pairs greatly increases the number of mobile charge carriers, so conductivity rises (resistivity falls) with temperature.

Step 1 — Carrier generation: The number density of free carriers increases roughly exponentially with temperature because more electrons gain enough energy to cross the band gap.

Step 2 — Net effect on conductivity: Since conductivity is proportional to the number of charge carriers, it increases sharply as temperature rises — the opposite trend to a metal, whose conductivity falls with temperature due to increased lattice scattering.

Why each other option is wrong:

- (A) "Decreases, as in a metal" is wrong because in a semiconductor the surge in carrier number outweighs scattering, raising conductivity.
- (B) "Remains unchanged" contradicts the strong temperature dependence of intrinsic carrier concentration.
- (C) "First increases then decreases" is not the behaviour of a pure semiconductor; its conductivity keeps rising with temperature.

Key point: Heating a semiconductor creates more electron–hole pairs, so its conductivity increases with temperature — the reverse of a metal.

Final Answer: Increases, because more charge carriers are produced $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q29

Q30.

Solution

Concept — AND logic gate: An AND gate implements logical multiplication, $Y = A \cdot B$. Its output Y is HIGH (logic 1) only when every input is HIGH; if any input is LOW (logic 0), the output is LOW. This mirrors the idea that "A and B" is true only when both conditions hold.

Step 1 — Build the truth table: $A{=}0, B{=}0 \Rightarrow Y = 0 \cdot 0 = 0$; $A{=}1, B{=}0 \Rightarrow Y = 1 \cdot 0 = 0$; $A{=}0, B{=}1 \Rightarrow Y = 0 \cdot 1 = 0$; $A{=}1, B{=}1 \Rightarrow Y = 1 \cdot 1 = 1$.

Step 2 — Read off the condition: Only the last row gives $Y = 1$, i.e. when both inputs are 1.

Why each other option is wrong:

- (A) "Either A or B is 1" describes an OR gate ($Y = A + B$), not AND.
- (C) "Both A and B are 0" gives $Y = 0$ for an AND gate, the opposite of a HIGH output.
- (D) "Exactly one input is 1" describes an XOR (exclusive-OR) gate, where $Y = 1$ only when the inputs differ.

Key point: AND output is 1 only when all inputs are 1; remember $Y = A \cdot B$ behaves like multiplication of 0s and 1s.

Final Answer: Both A and B are $1 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q30

Answer Key

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