AIIMS B.Sc Nursing Physics

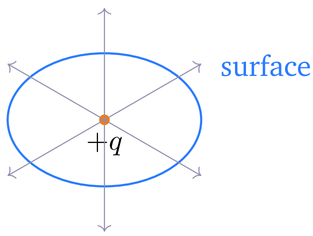
Sample Paper – 6

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

Instructions

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

Q1. A point charge of $q = 4.0\ \mu$C is enclosed by a closed surface, as shown. The net electric flux through the surface is (take $\varepsilon_0 = 8.85\times10^{-12}$ C^{2}N^{-1}m^{-2}):



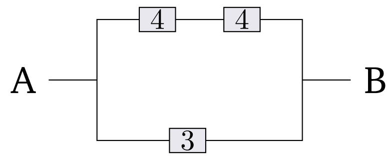
(A) 4.5×10^5 N m^{2}C^{-1}

(B) 9.0×10^5 N m^{2}C^{-1}

(C) 2.3×10^5 N m^{2}C^{-1}

(D) zero

Q2. In the network shown, two capacitors of $4\ \mu$F each are in series, and this series pair is connected in parallel with a $3\ \mu$F capacitor. The equivalent capacitance between A and B is:



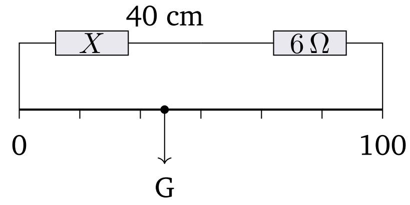
(A) 11 μF

(B) 7 μF

(C) 5 μF

(D) 2 μF

Q3. In a meter bridge, the balance point is obtained at 40 cm from the left end when the unknown resistance X is in the left gap and a known resistance of $6\ \Omega$ is in the right gap. The value of X is:



(A) $9\ \Omega$

(B) $4\ \Omega$

(C) $6\ \Omega$

(D) $3\ \Omega$

Q4. The resistivity of a conducting material is $2 \times 10^{-2}\ \Omega\,\text{m}$. Its electrical conductivity is:

(A) $50\ \Omega^{-1}\text{m}^{-1}$

(B) $2 \times 10^{2}\ \Omega^{-1}\text{m}^{-1}$

(C) $0.02\ \Omega^{-1}\text{m}^{-1}$

(D) $5\ \Omega^{-1}\text{m}^{-1}$

Q5. Three identical cells, each of emf 1.5 V and internal resistance $0.3\ \Omega$, are connected in parallel across an external resistance of $0.4\ \Omega$. The current drawn from the combination is:

(A) 1.5 A

(B) 3.0 A

(C) 0.5 A

(D) 4.5 A

Q6. Using dimensional analysis, which of the following equations is dimensionally correct? (v = speed, a = acceleration, t = time, s = distance)

(A) $v = at^2$

(B) $s = vt^2$

(C) $v^2 = 2as$

(D) $s = at$

Q7. A particle moves in a circle of radius 0.5 m, completing one revolution every π seconds. Its speed is:

(A) 0.5 m/s

(B) 2 m/s

(C) 0.25 m/s

(D) 1 m/s

Q8. A car moving at 20 m/s is brought to rest by a uniform deceleration of 5 m/s^2. The distance it travels before stopping is:

(A) 20 m

(B) 80 m

(C) 40 m

(D) 10 m

Q9. A constant force of 25 N acts on a body for 0.2 s. The change in momentum (impulse) of the body is:

(A) 5 kg m/s

(B) 125 kg m/s

(C) 50 kg m/s

(D) 0.5 kg m/s

Q10. A person of mass 60 kg stands in a lift that accelerates upward at 2 m/s^2 (take $g = 10$ m/s^2). The apparent weight (reading of the scale) is:

(A) 600 N

(B) 720 N

(C) 480 N

(D) 120 N

Q11. A pump lifts 200 kg of water to a height of 9 m in 30 s. The power of the pump is (take $g = 10$ m/s^2):

(A) 1800 W

(B) 18000 W

(C) 300 W

(D) 600 W

Q12. The gravitational field intensity at a point due to a mass $M = 6 \times 10^{10}$ kg, at a distance of 2 m from it, is (take $G = 6.67 \times 10^{-11}$ N m^2kg^{-2}):

(A) 2.0 N kg^{-1}

(B) 1.0 N kg^{-1}

(C) 4.0 N kg^{-1}

(D) 0.5 N kg^{-1}

Q13. A liquid drop of radius R is split into 8 identical smaller drops. If the surface tension of the liquid is T, the work done in the process is:

(A) $4\pi R^2 T$

(B) $8\pi R^2 T$

(C) $2\pi R^2 T$

(D) $16\pi R^2 T$

Q14. Water flows steadily through a horizontal capillary tube. According to Poiseuille's law, the volume flow rate Q depends on the tube radius r as:

(A) $Q \propto r$

(B) $Q \propto r^2$

(C) $Q \propto r^4$

(D) $Q \propto r^3$

Q15. A black body at temperature 3000 K emits radiation with peak wavelength λ_m. If the temperature is raised to 6000 K, the new peak wavelength is:

(A) $2\lambda_m$

(B) $4\lambda_m$

(C) λ_m

(D) $\lambda_m/2$

Q16. For an ideal gas, the molar specific heat at constant volume is $C_v = 20.8$ J mol^{-1}K^{-1}. Its molar specific heat at constant pressure is (take $R = 8.3$ J mol^{-1}K^{-1}):

(A) 29.1 J mol^{-1}K^{-1}

(B) 12.5 J mol^{-1}K^{-1}

(C) 20.8 J mol^{-1}K^{-1}

(D) 8.3 J mol^{-1}K^{-1}

Q17. In an isochoric (constant volume) process, 300 J of heat is supplied to a gas. The increase in the internal energy of the gas is:

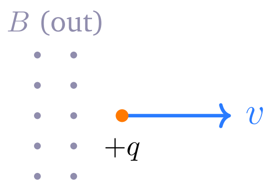
(A) zero

(B) 150 J

(C) 600 J

(D) 300 J

Q18. A charge of $2\ \mu$C moves with a speed of 3×10^5 m/s perpendicular to a uniform magnetic field of 0.4 T, as shown. The magnetic force on the charge is:



(A) 0.12 N

(B) 0.24 N

(C) 0.48 N

(D) 2.4 N

Q19. The energy stored in an inductor of inductance 0.5 H carrying a steady current of 4 A is:

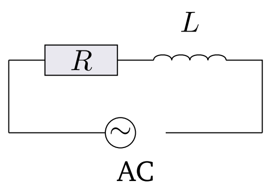
(A) 1 J

(B) 2 J

(C) 4 J

(D) 8 J

Q20. In the series RL circuit shown, the resistance is $30\ \Omega$ and the inductive reactance is $40\ \Omega$. The impedance of the circuit is:



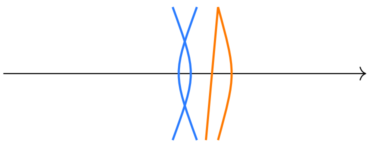
(A) $50\ \Omega$

(B) 70 Ω

(C) 10 Ω

(D) 35 Ω

Q21. Two thin lenses, a converging lens of focal length 20 cm and a diverging lens of focal length 30 cm, are placed in contact, as shown. The focal length of the combination is:



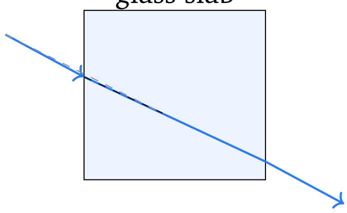
(A) 12 cm

(B) 60 cm

(C) 50 cm

(D) -60 cm

Q22. A ray of light passes through a parallel-sided glass slab of thickness 6 cm and refractive index 1.5, with an angle of refraction of 30° inside the slab and an angle of incidence of 60°, as shown. After refraction the emergent ray is:



parallel to the incident ray but laterally shifted. The lateral shift is approximately:

(A) 6.0 cm

(B) 3.0 cm

(C) 1.2 cm

(D) 2.0 cm

Q23. In a two-source interference experiment using light of wavelength 600 nm, a bright fringe (constructive interference) is formed at a point where the path difference is:

(A) 300 nm

(B) 900 nm

(C) 1200 nm

(D) 1500 nm

Q24. The work function of a metal is $\phi = 2.48$ eV. The threshold wavelength for photoemission is (take $hc = 1240$ eV nm):

(A) 250 nm

(B) 500 nm

(C) 620 nm

(D) 1000 nm

Q25. A radioactive sample contains 5×10^{18} undecayed nuclei, and its decay constant is $\lambda = 2 \times 10^{-6}$ s^{-1}. The activity of the sample is:

(A) 1×10^{13} decays/s

(B) 2.5×10^{24} decays/s

(C) 1×10^{12} decays/s

(D) 1×10^{6} decays/s

Q26. The radius of a nucleus is given by $R = R_0 A^{1/3}$. The ratio of the radius of a nucleus with mass number $A = 216$ to that of a nucleus with $A = 8$ is:

(A) 27

(B) 9

(C) 3

(D) 6

Q27. A particle in SHM is described by $x = 0.1\sin(\omega t)$ metres. At the instant when the phase $\omega t = 30°$, the displacement of the particle is:

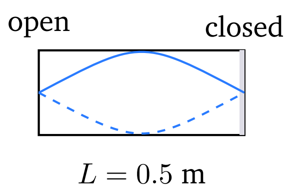
(A) 0.1 m

(B) 0.0866 m

(C) 0 m

(D) 0.05 m

Q28. A closed organ pipe (closed at one end) of length 0.5 m vibrates in its fundamental mode, as shown. The fundamental frequency is (speed of sound = 340 m/s):



(A) 340 Hz

(B) 170 Hz

(C) 85 Hz

(D) 680 Hz

Q29. Which of the following correctly gives the approximate forbidden energy gap (band gap) of silicon and germanium at room temperature?

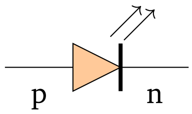
(A) Si ≈ 1.1 eV, Ge ≈ 0.7 eV

(B) Si ≈ 0.7 eV, Ge ≈ 1.1 eV

(C) Si ≈ 5.0 eV, Ge ≈ 3.0 eV

(D) Si ≈ 0.0 eV, Ge ≈ 0.0 eV

Q30. A light-emitting diode (LED) in the circuit shown glows only when it is forward biased. The energy of the emitted photon is approximately equal to:



(A) the reverse breakdown voltage

(B) zero, since no energy is involved

(C) twice the band gap of the material

(D) the band gap energy of the semiconductor

Detailed Solutions

Q1.

Solution

Concept — Gauss's law: Gauss's law states that the net electric flux through any closed surface (a Gaussian surface) equals the total charge enclosed divided by the permittivity of free space, $\Phi = \frac{q_{enc}}{\varepsilon_0}$. Here Φ is the flux in N m^{2}C^{-1}, q_{enc} is the net charge enclosed by the surface in coulombs, and $\varepsilon_0 = 8.85 \times 10^{-12}$ C^{2}N^{-1}m^{-2} is the permittivity of free space. Notice that the flux depends only on the enclosed charge, not on the shape or size of the surface, nor on where the charge sits inside it.

Given: Enclosed charge $q = 4.0\ \mu$C $= 4.0 \times 10^{-6}$ C; permittivity $\varepsilon_0 = 8.85 \times 10^{-12}$ C^{2}N^{-1}m^{-2}.

Step 1 — Write the formula and substitute: The flux is $\Phi = \frac{q}{\varepsilon_0} = \frac{4.0 \times 10^{-6}\ \text{C}}{8.85 \times 10^{-12}\ \text{C}^2\text{N}^{-1}\text{m}^{-2}}$.

Step 2 — Handle the numbers and powers of ten: The numerical part is $\frac{4.0}{8.85} = 0.452$, and the powers of ten give $\frac{10^{-6}}{10^{-12}} = 10^6$. Multiplying, $0.452 \times 10^6 = 4.52 \times 10^5$.

Step 3 — State the result with units: $\Phi = 4.5 \times 10^5$ N m^{2}C^{-1}. The unit follows from C/(C^{2}N^{-1}m^{-2}) = N m^{2}C^{-1}.

Why each other option is wrong:

- (B) 9.0×10^5 is exactly double the correct value; it results from mistakenly using $q = 8\ \mu$C or forgetting that only the single $4\ \mu$C charge is enclosed.
- (C) 2.3×10^5 is roughly half the answer; this comes from dividing the charge by $2\varepsilon_0$, as if an extra factor were present.
- (D) zero would be correct only if no net charge were enclosed; here a $+4\ \mu$C charge sits inside, so the flux cannot vanish.

Key point: Flux through a closed surface depends only on the enclosed charge; the position of the charge and the surface geometry do not matter.

Final Answer: $\Phi = 4.5 \times 10^5$ N m^{2}C^{-1} $\Rightarrow$ $\boxed{A}$

Answer: (A) Go Back to Q1

Q2.

Solution

Concept — Combining capacitors: Capacitors in series add as reciprocals, $\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2}$, so the series capacitance is always smaller than either member. Capacitors in parallel simply add, $C_p = C_1 + C_2$. Here we first reduce the two $4\ \mu$F capacitors in series, then combine that result in parallel with the $3\ \mu$F capacitor. The symbols C_s and C_{eq} denote the series capacitance and the final equivalent capacitance between A and B.

Given: Two capacitors of $4\ \mu$F in series; this series pair in parallel with a $3\ \mu$F capacitor.

Step 1 — Reduce the series pair: $\frac{1}{C_s} = \frac{1}{4} + \frac{1}{4} = \frac{2}{4} = \frac{1}{2}\ \mu\text{F}^{-1}$, so $C_s = 2\ \mu$F. For two equal capacitors in series the result is just half of one of them, which checks out.

Step 2 — Add the parallel branch: The $2\ \mu$F series block is in parallel with the $3\ \mu$F capacitor, so $C_{eq} = C_s + 3 = 2 + 3 = 5\ \mu$F.

Step 3 — State the result: The equivalent capacitance between A and B is $C_{eq} = 5\ \mu$F.

Why each other option is wrong:

- (A) $11\ \mu$F treats all three capacitors as parallel $(4+4+3)$, ignoring the series connection of the two $4\ \mu$F units.
- (B) $7\ \mu$F adds only one $4\ \mu$F to the $3\ \mu$F $(4+3)$, forgetting the second series capacitor entirely.
- (D) $2\ \mu$F stops after the series pair and never adds the parallel $3\ \mu$F capacitor.

Key point: Always collapse the innermost series or parallel group first, then work outward step by step; do not mix the two rules in one expression.

Final Answer: $C_{eq} = 5\ \mu\text{F} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q2

Q3.

Solution

Concept — Meter bridge (Wheatstone principle): A meter bridge is a practical form of the Wheatstone bridge. At balance the galvanometer reads zero and the ratio of the two gap resistances equals the ratio of the two segment lengths of the wire: $\frac{X}{R} = \frac{l}{100-l}$. Here X is the unknown resistance in the left gap, R is the known resistance in the right gap, and l is the balancing length measured from the left end (in cm).

Given: Balancing length $l = 40$ cm; known resistance $R = 6\ \Omega$; unknown X in the left gap.

Step 1 — Write the balance condition and substitute: $\frac{X}{R} = \frac{l}{100-l}$ becomes $\frac{X}{6} = \frac{40}{100-40} = \frac{40}{60} = \frac{2}{3}$.

Step 2 — Solve for X: $X = 6 \times \frac{2}{3} = \frac{12}{3} = 4\ \Omega$.

Step 3 — Sanity check: Since the balance point (40 cm) lies on the left of centre, the left resistance X should be smaller than the right resistance $R = 6\ \Omega$, and indeed $4\ \Omega < 6\ \Omega$.

Why each other option is wrong:

- (A) $9\ \Omega$ comes from inverting the ratio as $\frac{60}{40} = \frac{3}{2}$ and writing $X = 6 \times \frac{3}{2}$, i.e. swapping the segments.
- (C) $6\ \Omega$ ignores the length ratio altogether and just copies the known resistance.
- (D) $3\ \Omega$ uses an incorrect fraction such as $\frac{1}{2}$ instead of $\frac{2}{3}$.

Key point: The unknown sits in the same ratio as its own segment length; a balance point left of centre means the left-gap resistance is the smaller one.

Final Answer: $X = 4\ \Omega \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q3

Q4.

Solution

Concept — Conductivity and resistivity: Electrical conductivity σ measures how readily a material carries current, while resistivity ρ measures how strongly it opposes current. They are exact reciprocals: $\sigma = \frac{1}{\rho}$. The SI unit of resistivity is $\Omega\,\text{m}$, so the unit of conductivity is its inverse, $\Omega^{-1}\text{m}^{-1}$ (also written S m^{-1}, siemens per metre).

Given: Resistivity $\rho = 2 \times 10^{-2}\ \Omega\,\text{m}$.

Step 1 — Write the formula and substitute: $\sigma = \frac{1}{\rho} = \frac{1}{2 \times 10^{-2}\ \Omega\,\text{m}}$.

Step 2 — Evaluate the powers of ten: $\frac{1}{2 \times 10^{-2}} = \frac{1}{2} \times 10^{2} = 0.5 \times 10^{2} = 50$. Hence $\sigma = 50\ \Omega^{-1}\text{m}^{-1}$.

Step 3 — Confirm the unit: The inverse of $\Omega\,\text{m}$ is $\Omega^{-1}\text{m}^{-1}$, matching the result.

Why each other option is wrong:

- (B) $2 \times 10^{2} = 200$ would follow from $\frac{1}{0.5 \times 10^{-2}}$, i.e. using $\rho = 0.5 \times 10^{-2}$ instead of the given value.
- (C) 0.02 simply repeats the numerical value of ρ without inverting it.
- (D) 5 drops a power of ten in the reciprocal, treating 10^{-2} as 10^{-1}.

Key point: Conductivity and resistivity are reciprocals; inverting a small resistivity (10^{-2}) gives a large conductivity, so watch the sign of the exponent.

Final Answer: $\sigma = 50\ \Omega^{-1}\text{m}^{-1} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q4

Q5.

Solution

Concept — Identical cells in parallel: When n identical cells of emf E and internal resistance r are joined in parallel, the combined emf stays equal to a single cell's emf E (the parallel cells share the load, they do not add their voltages), while the combined internal resistance drops to r/n because the resistances are in parallel. The current through an external resistance R is then $I = \frac{E}{R + r/n}$, from Ohm's law applied to the whole loop.

Given: Number of cells $n = 3$; emf $E = 1.5$ V each; internal resistance $r = 0.3\ \Omega$

each; external resistance $R = 0.4\ \Omega$.

Step 1 — Effective internal resistance: $\frac{r}{n} = \frac{0.3\ \Omega}{3} = 0.1\ \Omega$.

Step 2 — Total circuit resistance: $R_{total} = R + \frac{r}{n} = 0.4 + 0.1 = 0.5\ \Omega$.

Step 3 — Current from Ohm's law: $I = \frac{E}{R_{total}} = \frac{1.5\ \text{V}}{0.5\ \Omega} = 3.0$ A.

Why each other option is wrong:

- (A) 1.5 A uses the full single-cell resistance $r = 0.3\ \Omega$ ($I = 1.5/(0.4 + 0.3) \approx 2.14$, often mis-rounded), failing to divide r by n.
- (C) 0.5 A inverts the calculation or uses far too large a total resistance.
- (D) 4.5 A wrongly treats the cells as series, tripling the emf to 4.5 V over the same resistance.

Key point: Parallel identical cells keep the emf the same but cut the internal resistance to r/n; series cells instead add emfs and resistances.

Final Answer: $I = 3.0$ A $\Rightarrow$ B

Answer: (B) Go Back to Q5

Q6.

Solution

Concept — Principle of dimensional homogeneity: Any physically valid equation must be dimensionally homogeneous, meaning the dimensions on the left-hand side equal those on the right-hand side. Using the base dimensions length $[L]$ and time $[T]$: speed v has $[LT^{-1}]$, acceleration a has $[LT^{-2}]$, time t has $[T]$, and distance s has $[L]$. Pure numbers such as the 2 in $v^2 = 2as$ are dimensionless and do not affect the check.

Step 1 — Test the candidate $v^2 = 2as$: LHS $= [LT^{-1}]^2 = [L^2T^{-2}]$. RHS $= [a][s] = [LT^{-2}][L] = [L^2T^{-2}]$. The two sides match, so this equation is dimensionally correct.

Step 2 — Test $v = at^2$ (option A): RHS $= [LT^{-2}][T^2] = [L]$, which is a length, not a speed $[LT^{-1}]$. Fails.

Step 3 — Test $s = vt^2$ (option B) and $s = at$ (option D): For B, RHS $= [LT^{-1}][T^2] = [LT]$, not $[L]$. For D, RHS $= [LT^{-2}][T] = [LT^{-1}]$, a speed, not $[L]$. Both fail.

Why each other option is wrong:

- (A) $v = at^2$ has dimensions of length on the right, not speed.
- (B) $s = vt^2$ gives $[LT]$ on the right, which is neither length nor any standard quantity.
- (D) $s = at$ gives a speed $[LT^{-1}]$ on the right, not the length on the left.

Key point: Dimensional analysis can flag a wrong equation, but it cannot verify dimensionless constants; an equation passing the check (like $v^2 = 2as$) is the kinematic relation with $u = 0$.

Final Answer: $v^2 = 2as \Rightarrow \boxed{C}$

Answer: (C) Go Back to Q6

Q7.

Solution

Concept — Speed in uniform circular motion: A particle moving in a circle of radius r covers the circumference $2\pi r$ in one period T. Its (constant) linear speed is therefore $v = \dfrac{\text{distance per revolution}}{\text{time per revolution}} = \dfrac{2\pi r}{T}$. Equivalently $v = \omega r$ with angular velocity $\omega = 2\pi/T$. Here r is the radius in metres and T is the time for one revolution in seconds.

Given: Radius $r = 0.5$ m; period $T = \pi$ s (one revolution every π seconds).

Step 1 — Write the formula and substitute: $v = \dfrac{2\pi r}{T} = \dfrac{2\pi(0.5\text{ m})}{\pi\text{ s}}$.

Step 2 — Simplify: The numerator is $2\pi \times 0.5 = \pi$ (in m), so $v = \dfrac{\pi\text{ m}}{\pi\text{ s}}$.

Step 3 — Cancel π: $v = 1$ m/s.

Why each other option is wrong:

- (A) 0.5 m/s drops the factor of 2π in the circumference, using just r/T.
- (B) 2 m/s keeps an extra factor of 2, perhaps from $4\pi r/T$ or a doubled radius.
- (C) 0.25 m/s halves the radius and the factor, mishandling the π cancellation.

Key point: The π in the period cancels the π from the circumference, leaving a clean 1 m/s; always carry the 2π factor for circular distance.

Final Answer: $v = 1\text{ m/s} \Rightarrow \boxed{D}$

Answer: (D) Go Back to Q7

Q8.

Solution

Concept — Stopping distance under uniform deceleration: For uniformly decelerated motion the kinematic equation $v^2 = u^2 - 2as$ relates final speed v, initial speed u, deceleration a and distance s. When the body comes to rest, $v = 0$, which rearranges to $s = \frac{u^2}{2a}$. Here u is in m/s, a in m/s^2, and s in metres.

Given: Initial speed $u = 20$ m/s; deceleration $a = 5$ m/s^2; final speed $v = 0$.

Step 1 — Write the formula and substitute: $s = \frac{u^2}{2a} = \frac{(20 \text{ m/s})^2}{2 \times 5 \text{ m/s}^2}$.

Step 2 — Compute the numerator and denominator: Numerator $= 400$ m^{2}s^{-2}; denominator $= 10$ m/s^2.

Step 3 — Divide and check units: $s = \frac{400}{10} = 40$ m. The units reduce as $\frac{\text{m}^2\text{s}^{-2}}{\text{m s}^{-2}} =$ m, confirming a length.

Why each other option is wrong:

- (A) 20 m halves the correct result, e.g. by using $u^2/(4a)$.
- (B) 80 m drops the factor of 2 in the denominator, using $s = u^2/a$.
- (D) 10 m mistakenly uses u (not u^2), giving $20/(2 \times 5) \cdot \ldots$, i.e. a linear instead of quadratic dependence on speed.

Key point: Stopping distance grows with the *square* of the speed, so doubling the speed quadruples the distance needed to stop.

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

Answer: (C) Go Back to Q8

Q9.

Solution

Concept — Impulse–momentum theorem: The impulse delivered by a force equals the change in momentum it produces. For a constant force F acting for a time interval Δt, the impulse is $J = F\,\Delta t = \Delta p$. Here F is in newtons, Δt in seconds, and the impulse J has units N s = kg m/s (since 1 N = 1 kg m s^{-2}).

Given: Force $F = 25$ N; time of action $\Delta t = 0.2$ s.

Step 1 — Write the formula and substitute: $J = F\,\Delta t = (25 \text{ N})(0.2 \text{ s})$.

Step 2 — Evaluate: $J = 5$ N s $= 5$ kg m/s.

Step 3 — Interpret: This is the change in the body's momentum, regardless of its mass; a lighter body simply ends up faster for the same impulse.

Why each other option is wrong:

- (B) 125 kg m/s uses $\Delta t = 5$ s instead of 0.2 s.
- (C) 50 kg m/s doubles the correct value, e.g. taking $\Delta t = 0.4$ s or $F = 50$ N.
- (D) 0.5 kg m/s misplaces the decimal, treating 0.2 as 0.02.

Key point: Impulse $= F\,\Delta t$ equals the momentum change directly; the units N s and kg m/s are identical.

Final Answer: $J = 5$ kg m/s $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q9

Q10.

Solution

Concept — Apparent weight in an accelerating lift: The scale reads the normal force N it exerts on the person. Applying Newton's second law to the person in a lift accelerating upward with acceleration a: $N - mg = ma$, so $N = m(g + a)$. When the lift accelerates upward the floor must push harder, so the apparent weight exceeds the true weight mg. Here m is mass in kg, g the gravitational acceleration, and a the lift's acceleration.

Given: Mass $m = 60$ kg; upward acceleration $a = 2$ m/s^2; $g = 10$ m/s^2.

Step 1 — Write the formula and substitute: $N = m(g+a) = 60$ kg $(10+2)$ m/s^2.

Step 2 — Add inside the bracket: $g + a = 12$ m/s^2.

Step 3 — Multiply: $N = 60 \times 12 = 720$ N (since kg $\cdot$ m/s^2 = N).

Why each other option is wrong:

- (A) 600 N is the true weight mg, valid only if the lift is at rest or moving at constant velocity ($a = 0$).
- (C) 480 N uses $m(g - a)$, which applies to a lift accelerating *downward*, not upward.
- (D) 120 N keeps only the ma term and forgets to add the weight mg.

Key point: Upward acceleration adds to g ($g + a$); downward acceleration subtracts ($g - a$); free fall ($a = g$) gives apparent weightlessness.

Final Answer: $N = 720 \text{ N} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q10

Q11.

Solution

Concept — Power of a pump: Power is the rate of doing work, $P = \frac{W}{t}$. To raise a mass m through a height h against gravity the work done equals the gain in gravitational potential energy, $W = mgh$. Hence the pump's power is $P = \frac{mgh}{t}$, where m is in kg, g in m/s^2, h in m, t in s, and P in watts (1 W $=$ 1 J/s).

Given: Mass $m = 200$ kg; height $h = 9$ m; time $t = 30$ s; $g = 10$ m/s^2.

Step 1 — Work done (energy lifted): $W = mgh = (200)(10)(9) = 18000$ J.

Step 2 — Substitute into the power formula: $P = \frac{W}{t} = \frac{18000 \text{ J}}{30 \text{ s}}$.

Step 3 — Evaluate: $P = 600$ W.

Why each other option is wrong:

- (A) 1800 W divides by $t = 10$ s instead of 30 s.
- (B) 18000 W is the work done in joules, not the power; it forgets to divide by the time.
- (C) 300 W uses half the mass (100 kg) or doubles the time.

Key point: Compute the energy (mgh) first, then divide by the time; do not confuse the work in joules with the power in watts.

Final Answer: $P = 600 \text{ W} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q11

Q12.

Solution

Concept — Gravitational field intensity: The gravitational field intensity at a point is the gravitational force per unit mass that a test mass would feel there. For a point mass M at distance r, $E_g = \frac{GM}{r^2}$, where $G = 6.67 \times 10^{-11}$ N m^{2}kg^{-2} is the universal gravitational constant, M is the source mass in kg, r is the distance in m, and E_g has units N kg^{-1}. Note the inverse-square dependence on r.

Given: Source mass $M = 6\times10^{10}$ kg; distance $r = 2$ m; $G = 6.67\times10^{-11}$ N m^{2}kg^{-2}.

Step 1 — Write the formula and substitute: $E_g = \dfrac{GM}{r^2} = \dfrac{(6.67\times10^{-11})(6\times10^{10})}{(2)^2}$.

Step 2 — Evaluate the numerator: $6.67\times6 = 40.02$ and $10^{-11}\times10^{10} = 10^{-1}$, so the numerator is $40.02\times10^{-1} = 4.0$ (in N m^2 kg^{-1}).

Step 3 — Divide by r^2: $r^2 = 2^2 = 4$ m^2, so $E_g = \dfrac{4.0}{4} = 1.0$ N kg^{-1}.

Why each other option is wrong:

- (A) 2.0 N kg^{-1} uses r instead of r^2 in the denominator (dividing by 2, not 4).
- (C) 4.0 N kg^{-1} drops the r^2 term altogether, leaving just GM.
- (D) 0.5 N kg^{-1} uses too large a distance (about $r = 2.8$ m, i.e. $r^2 = 8$).

Key point: Gravitational field falls off as $1/r^2$; always square the distance before dividing.

Final Answer: $E_g = 1.0$ N kg^{-1} $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q12

Q13.

Solution

Concept — Work done in splitting a drop: Surface tension T is the energy stored per unit area of a liquid surface, so creating new surface area requires work $W = T\,\Delta A$, where ΔA is the increase in total surface area. When a large drop splits into smaller drops the total surface area increases (smaller drops have more area per unit volume), so external work must be supplied. Volume is conserved throughout the splitting.

Given: One drop of radius R splits into 8 identical drops of radius r; surface tension T.

Step 1 — Find the small-drop radius from volume conservation: $\frac{4}{3}\pi R^3 = 8\left(\frac{4}{3}\pi r^3\right) \Rightarrow R^3 = 8r^3 \Rightarrow r = \dfrac{R}{2}$.

Step 2 — Compute the final total area: Each small drop has area $4\pi r^2 = 4\pi(R/2)^2 = \pi R^2$. For 8 drops the total is $8\times\pi R^2 = 8\pi R^2$.

Step 3 — Find the area increase: Initial area $= 4\pi R^2$, so $\Delta A = 8\pi R^2 - 4\pi R^2 = 4\pi R^2$.

Step 4 — Work done: $W = T\,\Delta A = T(4\pi R^2) = 4\pi R^2 T$.

Why each other option is wrong:

- (B) $8\pi R^2 T$ uses the total *final* area rather than the *increase* in area.
- (C) $2\pi R^2 T$ undercounts the area change, halving the correct ΔA.
- (D) $16\pi R^2 T$ overcounts, e.g. by squaring or doubling the area change incorrectly.

Key point: Work equals surface tension times the *change* in area, not the final area; splitting into n drops increases area by a factor $n^{1/3}$ relative to the original.

Final Answer: $W = 4\pi R^2 T \Rightarrow \boxed{A}$

Answer: (A) Go Back to Q13

Q14.

Solution

Concept — Poiseuille's law of laminar flow: For steady, laminar (streamline) flow of a viscous fluid through a horizontal capillary tube, the volume flow rate is $Q = \dfrac{\pi P r^4}{8\eta L}$. Here P is the pressure difference across the tube, r is the tube radius, η is the coefficient of viscosity, and L is the tube length. The striking feature is the *fourth-power* dependence on radius: r appears as r^4, not r or r^2.

Step 1 — Isolate the radius dependence: Holding P, η and L constant, every other factor is a constant, so $Q \propto r^4$.

Step 2 — Why the fourth power: The cross-sectional area contributes r^2, and the velocity profile of laminar flow contributes a further r^2 (the average speed itself scales with r^2), giving $r^2 \times r^2 = r^4$.

Step 3 — Illustrate the sensitivity: If the radius doubles ($r \to 2r$), the flow rate rises by $2^4 = 16$ times; even small changes in radius dramatically alter the flow.

Why each other option is wrong:

- (A) $Q \propto r$ matches neither the area nor the velocity scaling; far too weak.
- (B) $Q \propto r^2$ accounts only for the cross-sectional area, ignoring how the mean speed grows with r^2.
- (D) $Q \propto r^3$ is an intermediate guess with no physical basis in Poiseuille's law.

Key point: Poiseuille's law makes flow rate extremely sensitive to radius ($Q \propto r^4$); this is why narrowing a blood vessel slightly cuts flow sharply.

Final Answer: $Q \propto r^4 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q14

Q15.

Solution

Concept — Wien's displacement law: The wavelength at which a black body emits the most radiation shifts with temperature according to $\lambda_m T = b$, where $b = 2.898 \times 10^{-3}$ m K is Wien's constant. Since the product is constant, the peak wavelength is inversely proportional to the absolute temperature: $\lambda_m \propto \dfrac{1}{T}$. As a body gets hotter its emission peak moves toward shorter (bluer) wavelengths.

Given: Initial temperature $T_1 = 3000$ K with peak wavelength λ_m; final temperature $T_2 = 6000$ K.

Step 1 — Apply the constancy of λT: $\lambda_1 T_1 = \lambda_2 T_2$, so $\lambda_2 = \lambda_1 \dfrac{T_1}{T_2}$.

Step 2 — Substitute the temperatures: $\dfrac{T_1}{T_2} = \dfrac{3000}{6000} = \dfrac{1}{2}$.

Step 3 — New peak wavelength: $\lambda_2 = \lambda_m \times \dfrac{1}{2} = \dfrac{\lambda_m}{2}$.

Why each other option is wrong:

- (A) $2\lambda_m$ wrongly makes the wavelength grow with temperature, the opposite of Wien's law.
- (B) $4\lambda_m$ treats the dependence as $\lambda \propto T^2$ and in the wrong direction.
- (C) λ_m ignores the temperature change entirely.

Key point: Hotter bodies peak at shorter wavelengths; doubling T halves λ_m (a blue shift).

Final Answer: $\lambda_m/2 \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q15

Q16.

Solution

Concept — Mayer's relation: For one mole of an ideal gas, the molar heat capacities at constant pressure and constant volume differ by the universal gas constant: $C_p - C_v = R$, hence $C_p = C_v + R$. Physically, at constant pressure the gas must do work expanding as it is heated, so more heat is needed to raise its temperature than at constant volume; that extra heat per mole per kelvin is exactly R. All quantities are in J $\text{mol}^{-1}\text{K}^{-1}$.

Given: $C_v = 20.8$ J $\text{mol}^{-1}\text{K}^{-1}$; $R = 8.3$ J $\text{mol}^{-1}\text{K}^{-1}$.

Step 1 — Write the relation and substitute: $C_p = C_v + R = 20.8 + 8.3$.

Step 2 — Add: $C_p = 29.1$ J $\text{mol}^{-1}\text{K}^{-1}$.

Step 3 — Sanity check: C_p must always exceed C_v for a gas, and $29.1 > 20.8$, as expected.

Why each other option is wrong:

- (B) 12.5 subtracts R ($C_v - R$) instead of adding it.
- (C) 20.8 simply repeats C_v, ignoring the $+R$ term.
- (D) 8.3 is just the gas constant R on its own.

Key point: C_p is always larger than C_v by exactly R because of the work the gas does while expanding at constant pressure.

Final Answer: $C_p = 29.1$ J $\text{mol}^{-1}\text{K}^{-1} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q16

Q17.

Solution

Concept — Isochoric process and the first law: The first law of thermodynamics states $Q = \Delta U + W$, where Q is the heat supplied, ΔU the change in internal energy, and W the work done *by* the gas. In an isochoric (constant-volume) process the gas neither expands nor contracts, so the work $W = \int P\,dV = 0$ because $dV = 0$ throughout. With no work done, every joule of heat supplied goes directly into internal energy.

Given: Heat supplied $Q = 300$ J at constant volume; work $W = 0$.

Step 1 — Set the work term to zero: Since volume is constant, $W = 0$.

Step 2 — Apply the first law: $Q = \Delta U + W \Rightarrow \Delta U = Q - W = 300 - 0$.

Step 3 — Result: $\Delta U = 300$ J. All the supplied heat raises the internal energy.

Why each other option is wrong:

- (A) zero would require all the heat to go into work, but at constant volume no work is done.
- (B) 150 J halves the supplied heat with no physical justification.
- (C) 600 J doubles the supplied heat, violating energy conservation.

Key point: At constant volume $W = 0$, so $\Delta U = Q$; this is also why $Q = nC_v\Delta T$ for an isochoric change.

Final Answer: $\Delta U = 300$ J $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q17

Q18.

Solution

Concept — Magnetic (Lorentz) force on a moving charge: A charge q moving with speed v in a magnetic field B experiences a force $F = qvB\sin\theta$, where θ is the angle between the velocity and the field. When the motion is perpendicular to the field, $\theta = 90^\circ$ and $\sin\theta = 1$, giving the maximum force $F = qvB$. Here q is in coulombs, v in m/s, B in tesla, and F in newtons.

Given: Charge $q = 2\ \mu\text{C} = 2 \times 10^{-6}$ C; speed $v = 3 \times 10^5$ m/s; field $B = 0.4$ T; motion perpendicular to B ($\theta = 90^\circ$).

Step 1 — Write the formula and substitute: $F = qvB = (2 \times 10^{-6}\ \text{C})(3 \times 10^5\ \text{m/s})(0.4\ \text{T})$.

Step 2 — Multiply v and B first: $vB = (3 \times 10^5)(0.4) = 1.2 \times 10^5$.

Step 3 — Multiply by q: $F = (2 \times 10^{-6})(1.2 \times 10^5) = 2.4 \times 10^{-1} = 0.24$ N.

Why each other option is wrong:

- (A) 0.12 N drops a factor of 2, e.g. using $q = 1\ \mu$C.
- (C) 0.48 N doubles the correct value, using $q = 4\ \mu$C or $B = 0.8$ T.
- (D) 2.4 N misplaces the power of ten, treating 10^{-6} as 10^{-5}.

Key point: The force is greatest when velocity is perpendicular to the field ($\sin 90^\circ = 1$) and zero when parallel; this magnetic force does no work since it is always perpendicular to v.

Final Answer: $F = 0.24$ N $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q18

Q19.

Solution

Concept — Energy stored in an inductor: An inductor carrying a steady current stores energy in its magnetic field. The stored energy is $U = \frac{1}{2}LI^2$, where L is the inductance in henries (H), I is the current in amperes (A), and U is the energy in joules (J). Note the factor of $\frac{1}{2}$ and the square on the current, exactly analogous to the kinetic energy $\frac{1}{2}mv^2$.

Given: Inductance $L = 0.5$ H; steady current $I = 4$ A.

Step 1 — Write the formula and substitute: $U = \frac{1}{2}LI^2 = \frac{1}{2}(0.5\text{ H})(4\text{ A})^2$.

Step 2 — Square the current: $I^2 = 4^2 = 16\text{ A}^2$.

Step 3 — Multiply through: $U = \frac{1}{2} \times 0.5 \times 16 = 0.25 \times 16 = 4$ J.

Why each other option is wrong:

- (A) 1 J forgets to square the current, using I instead of I^2.
- (B) 2 J drops a factor (e.g. omits the $\frac{1}{2}$ but also miscomputes), undershooting the result.
- (D) 8 J omits the $\frac{1}{2}$ factor, computing LI^2 instead of $\frac{1}{2}LI^2$.

Key point: Inductor energy scales with the *square* of the current; keep both the $\frac{1}{2}$ factor and the square to avoid the common errors.

Final Answer: $U = 4$ J $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q19

Q20.

Solution

Concept — Impedance of a series RL circuit: In an AC series circuit, the resistance R and the inductive reactance X_L are at 90° to each other in the phasor diagram (the voltage across L leads the current by 90°). They therefore combine like perpendicular vectors, and the total opposition to current, the impedance, is $Z = \sqrt{R^2 + X_L^2}$, measured in ohms. You cannot simply add R and X_L arithmetically because they are out of phase.

Given: Resistance $R = 30\ \Omega$; inductive reactance $X_L = 40\ \Omega$.

Step 1 — Write the formula and substitute: $Z = \sqrt{R^2 + X_L^2} = \sqrt{(30)^2 + (40)^2}$.

Step 2 — Square and add: $30^2 = 900$, $40^2 = 1600$, so $Z = \sqrt{900 + 1600} = \sqrt{2500}$.

Step 3 — Take the square root: $Z = 50\ \Omega$ (a 3-4-5 right triangle).

Why each other option is wrong:

- (B) $70\ \Omega$ adds R and X_L arithmetically $(30 + 40)$, ignoring the $90°$ phase difference.
- (C) $10\ \Omega$ subtracts them $(40 - 30)$, which is not how perpendicular phasors combine.
- (D) $35\ \Omega$ takes the simple average of R and X_L, which has no physical basis.

Key point: Resistance and reactance add in quadrature (as a right triangle), so the impedance is the hypotenuse, never the plain sum.

Final Answer: $Z = 50\ \Omega \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q20

Q21.

Solution

Concept — Thin lenses in contact: When two thin lenses are placed in contact, their powers add, and since power $P = 1/f$, the combined focal length obeys $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$. The Cartesian sign convention gives a converging (convex) lens a positive focal length and a diverging (concave) lens a negative one. So here $f_1 = +20$ cm and $f_2 = -30$ cm.

Given: Converging lens $f_1 = +20$ cm; diverging lens $f_2 = -30$ cm; lenses in contact.

Step 1 — Write the formula and substitute with signs: $\frac{1}{f} = \frac{1}{20} + \frac{1}{-30} = \frac{1}{20} - \frac{1}{30}$.

Step 2 — Take a common denominator: The LCM of 20 and 30 is 60, so $\frac{1}{f} = \frac{3}{60} - \frac{2}{60} = \frac{1}{60}\ \text{cm}^{-1}$.

Step 3 — Invert to find f: $f = 60$ cm. The positive sign means the combination is net converging.

Why each other option is wrong:

- (A) 12 cm comes from adding $\frac{1}{20}+\frac{1}{30}$ as if both lenses converged (wrong sign on f_2).
- (C) 50 cm results from incorrect arithmetic with the fractions.
- (D) -60 cm has the right magnitude but the wrong sign, implying a diverging combination.

Key point: Always insert the sign of each focal length before combining; the stronger converging lens here wins, giving a net converging system.

Final Answer: $f = 60$ cm $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q21

Q22.

Solution

Concept — Lateral shift through a parallel-sided slab: When light passes through a glass slab with parallel faces, the emergent ray is parallel to the incident ray but displaced sideways. This perpendicular displacement (lateral shift) is $d = \dfrac{t\,\sin(i-r)}{\cos r}$, where t is the slab thickness, i the angle of incidence, and r the angle of refraction inside the slab. The shift grows with thickness and with the difference $(i-r)$.

Given: Thickness $t = 6$ cm; angle of incidence $i = 60°$; angle of refraction $r = 30°$; refractive index 1.5.

Step 1 — Write the formula and substitute: $d = \dfrac{t\,\sin(i-r)}{\cos r} = \dfrac{6\,\sin(60°-30°)}{\cos 30°} = \dfrac{6\,\sin 30°}{\cos 30°}$.

Step 2 — Insert trig values: $\sin 30° = 0.5$ and $\cos 30° = 0.866$, so $d = \dfrac{6\times 0.5}{0.866} = \dfrac{3}{0.866}$.

Step 3 — Evaluate and compare with the options: $d \approx 3.46$ cm. Among the four choices, this is closest to 3.0 cm, so $d \approx 3.0$ cm.

Why each other option is wrong:

- (A) 6.0 cm is just the slab thickness t, not the lateral shift.
- (C) 1.2 cm uses a much smaller angle difference, badly underestimating the shift.
- (D) 2.0 cm comes from dropping the $\cos r$ denominator or using a wrong angle.

Key point: The lateral shift depends on thickness and the angle pair through $\sin(i-r)/\cos r$; the emergent ray stays parallel to the incident ray.

Final Answer: $d \approx 3.0$ cm $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q22

Q23.

Solution

Concept — Condition for constructive interference: In two-source interference, a bright fringe (constructive interference) occurs where the two waves arrive in phase, which happens when the path difference is a whole-number multiple of the wavelength: $\Delta = m\lambda$ with $m = 0, 1, 2, \ldots$. A dark fringe (destructive interference) occurs at half-integer multiples, $\Delta = (m+\frac{1}{2})\lambda$. Here $\lambda = 600$ nm is the wavelength of the light used.

Given: Wavelength $\lambda = 600$ nm; need the path difference that gives a bright fringe.

Step 1 — Express each option as a multiple of λ: $\frac{300}{600} = 0.5\lambda$; $\frac{900}{600} = 1.5\lambda$; $\frac{1200}{600} = 2.0\lambda$; $\frac{1500}{600} = 2.5\lambda$.

Step 2 — Apply the bright-fringe condition: Only 1200 nm $= 2\lambda$ is an integer multiple ($m = 2$), so it alone gives constructive interference.

Step 3 — Classify the rest: 0.5λ, 1.5λ and 2.5λ are all half-integer multiples and therefore produce dark fringes.

Why each other option is wrong:

- (A) 300 nm $= \frac{1}{2}\lambda$ gives destructive interference (a dark fringe).
- (B) 900 nm $= 1.5\lambda$ is also a half-integer multiple, hence dark.
- (D) 1500 nm $= 2.5\lambda$ is again half-integer, hence dark.

Key point: Bright fringes need a path difference equal to a whole number of wavelengths; half-wavelength offsets always give darkness.

Final Answer: $\Delta = 1200$ nm $= 2\lambda \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q23

Q24.

Solution

Concept — Threshold wavelength in the photoelectric effect: The work function ϕ is the minimum energy needed to free an electron from a metal surface. The threshold wavelength λ_0 is the longest wavelength (lowest photon energy) that can just eject an electron, so the photon energy exactly equals the work function: $\frac{hc}{\lambda_0} = \phi$, giving $\lambda_0 = \frac{hc}{\phi}$. Using $hc = 1240$ eV nm lets us work directly in eV and nm.

Given: Work function $\phi = 2.48$ eV; $hc = 1240$ eV nm.

Step 1 — Write the formula and substitute: $\lambda_0 = \frac{hc}{\phi} = \frac{1240 \text{ eV nm}}{2.48 \text{ eV}}$.

Step 2 — Cancel the eV and divide: The eV units cancel, leaving nm: $\frac{1240}{2.48} = 500$.

Step 3 — State the result: $\lambda_0 = 500$ nm, which lies in the visible (green) region.

Why each other option is wrong:

- (A) 250 nm corresponds to $\phi = 4.96$ eV, i.e. twice the given work function.
- (C) 620 nm corresponds to $\phi = 2.0$ eV, a different work function.
- (D) 1000 nm corresponds to $\phi = 1.24$ eV, again the wrong work function.

Key point: A larger work function means a shorter threshold wavelength; the convenient constant $hc = 1240$ eV nm avoids juggling joules and metres.

Final Answer: $\lambda_0 = 500 \text{ nm} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q24

Q25.

Solution

Concept — Activity of a radioactive sample: The activity A is the number of nuclei decaying per second. It is the product of the decay constant λ and the number of undecayed nuclei present, $A = \lambda N$. Here λ is in s^{-1} and N is the number of nuclei, so A comes out in decays per second (becquerel). The activity falls over time as N decreases.

Given: Number of undecayed nuclei $N = 5 \times 10^{18}$; decay constant $\lambda = 2 \times 10^{-6}\ s^{-1}$.

Step 1 — Write the formula and substitute: $A = \lambda N = (2 \times 10^{-6}\ s^{-1})(5 \times 10^{18})$.

Step 2 — Multiply the coefficients and powers separately: $2 \times 5 = 10$ and

$10^{-6} \times 10^{18} = 10^{12}$, so $A = 10 \times 10^{12}$.

Step 3 — Express in standard form: $A = 1 \times 10^{13}$ decays/s.

Why each other option is wrong:

- (B) 2.5×10^{24} multiplies or adds the exponents incorrectly (and divides the coefficients).
- (C) 1×10^{12} loses one power of ten when combining 10^{-6} and 10^{18}.
- (D) 1×10^{6} is off by seven orders of magnitude, mishandling the exponents.

Key point: Activity $A = \lambda N$; combine coefficients and powers of ten separately, then normalise to one digit before the decimal.

Final Answer: $A = 1 \times 10^{13}$ decays/s $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q25

Q26.

Solution

Concept — Nuclear radius and mass number: Experimentally the radius of a nucleus depends on its mass number A as $R = R_0 A^{1/3}$, where $R_0 \approx 1.2$ fm is a constant. This cube-root law follows because nuclear density is roughly constant, so volume ($\propto R^3$) is proportional to the number of nucleons A. For two nuclei the constant R_0 cancels in a ratio: $\frac{R_1}{R_2} = \left(\frac{A_1}{A_2}\right)^{1/3}$.

Given: $A_1 = 216$ and $A_2 = 8$.

Step 1 — Write the ratio and substitute: $\frac{R_1}{R_2} = \left(\frac{A_1}{A_2}\right)^{1/3} = \left(\frac{216}{8}\right)^{1/3}$.

Step 2 — Simplify inside the bracket: $\frac{216}{8} = 27$, so $\frac{R_1}{R_2} = (27)^{1/3}$.

Step 3 — Take the cube root: Since $3^3 = 27$, $(27)^{1/3} = 3$.

Why each other option is wrong:

- (A) 27 is the raw mass-number ratio A_1/A_2 without taking the cube root.
- (B) 9 would be $(27)^{2/3}$, applying the wrong exponent.
- (D) 6 has no consistent derivation; it neither cubes nor cube-roots correctly.

Key point: Nuclear radius scales as $A^{1/3}$, so a 27-fold change in mass number gives only a 3-fold change in radius.

Final Answer: ratio $= 3 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q26

Q27.

Solution

Concept — Displacement in simple harmonic motion: For SHM written as $x = A\sin(\omega t)$, the displacement x at any instant equals the amplitude A times the sine of the phase angle ωt. Here A is the maximum displacement (amplitude) and ωt is the instantaneous phase. The displacement ranges between $+A$ and $-A$ as the phase sweeps through a cycle.

Given: $x = 0.1\sin(\omega t)$ m, so amplitude $A = 0.1$ m; phase $\omega t = 30°$.

Step 1 — Write the formula and substitute the phase: $x = A\sin(\omega t) = 0.1\sin 30°$.

Step 2 — Insert $\sin 30°$: $\sin 30° = 0.5$, so $x = 0.1 \times 0.5$.

Step 3 — Multiply: $x = 0.05$ m.

Why each other option is wrong:

- (A) 0.1 m is the amplitude, reached only at phase $90°$ where $\sin = 1$.
- (B) 0.0866 m uses $\sin 60° = 0.866$ instead of $\sin 30°$.
- (C) 0 m uses phase $0°$ where $\sin 0° = 0$.

Key point: At phase $30°$ the particle is exactly halfway to its amplitude in displacement, since $\sin 30° = 0.5$.

Final Answer: $x = 0.05$ m $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q27

Q28.

Solution

Concept — Closed organ pipe (fundamental mode): A pipe closed at one end has a displacement node at the closed end and an antinode at the open end. In the fundamental (lowest) mode the pipe length holds exactly one quarter of a wavelength, $L = \dfrac{\lambda}{4}$, so $\lambda = 4L$. Using $v = f\lambda$, the fundamental frequency is $f = \dfrac{v}{\lambda} = \dfrac{v}{4L}$, where v is the speed of sound and L the pipe length.

Given: Pipe length $L = 0.5$ m; speed of sound $v = 340$ m/s; closed at one end.

Step 1 — Write the formula and substitute: $f = \dfrac{v}{4L} = \dfrac{340 \text{ m/s}}{4 \times 0.5 \text{ m}}$.

Step 2 — Simplify the denominator: $4 \times 0.5 = 2$ m, so $f = \dfrac{340}{2}$.

Step 3 — Evaluate: $f = 170$ Hz.

Why each other option is wrong:

- (A) 340 Hz uses $f = v/L$, ignoring the factor of 4 for a closed pipe.
- (C) 85 Hz uses $8L$ in the denominator (the second-overtone spacing, not the fundamental).
- (D) 680 Hz uses an open-pipe relation, doubling instead of quartering.

Key point: A closed pipe's fundamental is $v/4L$ (only odd harmonics exist); an open pipe's is $v/2L$. Mixing the two formulas is the usual error.

Final Answer: $f = 170$ Hz $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q28

Q29.

Solution

Concept — Forbidden energy gap of semiconductors: In a solid, the forbidden energy gap (band gap) E_g is the energy separation between the top of the valence band and the bottom of the conduction band. Conductors have effectively zero gap, insulators have large gaps (several eV), and semiconductors have small gaps of around 1 eV. The standard room-temperature values are $E_g \approx 1.1$ eV for silicon and $E_g \approx 0.7$ eV for germanium.

Step 1 — Recall the standard values: Silicon ≈ 1.1 eV; germanium ≈ 0.7 eV.

Step 2 — Cross-check with conduction behaviour: Germanium's smaller gap means more electrons are thermally excited across it at room temperature, so germanium is the more conducting (and more temperature-sensitive) of the two, consistent with $E_g(\text{Ge}) < E_g(\text{Si})$.

Step 3 — Select the matching option: Si ≈ 1.1 eV, Ge ≈ 0.7 eV.

Why each other option is wrong:

- (B) Si ≈ 0.7 eV, Ge ≈ 1.1 eV swaps the two values; silicon actually has the larger gap.

- (C) 5 eV / 3 eV are insulator-like gaps (e.g. diamond), far too large for these semiconductors.
- (D) 0 eV / 0 eV would describe conductors, not semiconductors.

Key point: Remember Si ≈ 1.1 eV $>$ Ge ≈ 0.7 eV; the smaller-gap material (Ge) conducts more easily at room temperature.

Final Answer: Si ≈ 1.1 eV, Ge ≈ 0.7 eV $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q29

Q30.

Solution

Concept — Light emission from an LED: A light-emitting diode is a heavily doped p-n junction. When it is forward biased, electrons are pushed from the n-side and holes from the p-side into the junction region, where they recombine. Each electron-hole recombination drops an electron from the conduction band into the valence band, releasing the energy difference as a photon. That energy difference is essentially the band gap, so the emitted photon energy is $E_{photon} = h\nu \approx E_g$, where E_g is the band gap of the semiconductor.

Step 1 — Forward bias enables recombination: Under forward bias the junction barrier is lowered, the diode conducts, and electrons and holes meet and recombine at the junction.

Step 2 — Energy released per recombination: An electron falling across the gap releases energy $\approx E_g$, emitted as a single photon of energy $h\nu \approx E_g$ (this also sets the colour of the LED).

Step 3 — Identify the option: The emitted photon energy equals the band gap energy of the semiconductor.

Why each other option is wrong:

- (A) the reverse breakdown voltage relates to reverse bias, not to light emission under forward bias.
- (B) zero is wrong because real photons of definite energy are emitted when carriers recombine.
- (C) twice the band gap overstates the energy; a single recombination releases about one band gap, not two.

Key point: An LED's photon energy (and hence its colour) is fixed by the semiconductor's band gap, $h\nu \approx E_g$; choosing materials with different E_g gives different colours.

Final Answer: band gap energy $\Rightarrow$ $\boxed{D}$

Answer: (D) Go Back to Q30

Answer Key

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