PGIMER BSc Nursing Physics

Sample Paper – 4

Duration: 23 Minutes **Maximum Marks: 25**

Instructions

- This paper contains **25** Multiple Choice Questions (Single Correct Answer), modelled on the Physics portion of the **PGIMER BSc Nursing** entrance exam.
- Each correct answer carries **+1 mark**. **0.25 mark** is deducted for every incorrect answer. Unattempted questions carry **0 marks**.
- Only **one** option is correct. Choose carefully.
- Syllabus level: **Class 11 and 12 (NCERT) Physics**.
- The exam is conducted as a computer-based test. Personal calculators, mobile phones, log tables, and other electronic gadgets are strictly prohibited.

Q1. Planck's constant h appears in the relation $E = h\nu$, where E is energy and ν is frequency. The dimensional formula of Planck's constant is:

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

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

(C) $[MLT^{-1}]$

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

Q2. Two cars move toward each other along the same straight road. One travels at 15 m s^{-1} and the other at 25 m s^{-1}. The magnitude of the velocity of approach (relative velocity) of one car with respect to the other is:

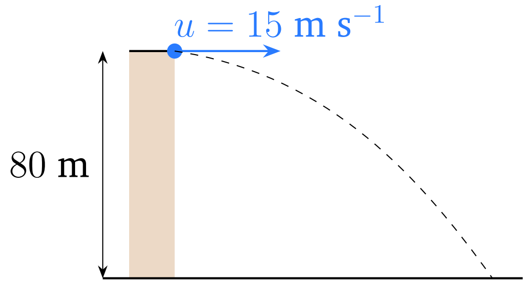
(A) 10 m s^{-1}

(B) 25 m s^{-1}

(C) 15 m s^{-1}

(D) 40 m s^{-1}

Q3. A ball is projected horizontally with a speed of 15 m s^{-1} from the top of a tower of height 80 m, as shown. Taking $g = 10 \text{ m s}^{-2}$, the time taken by the ball to reach the ground is:



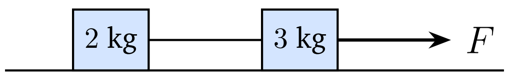
(A) 2 s

(B) 4 s

(C) 8 s

(D) 16 s

Q4. Two blocks of masses 2 kg and 3 kg are connected by a light string and rest on a smooth horizontal table. A horizontal force $F = 10$ N is applied to the 3 kg block, as shown. The tension in the connecting string is:



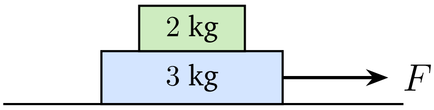
(A) 4 N

(B) 6 N

(C) 10 N

(D) 2 N

Q5. A block of mass 2 kg rests on top of a block of mass 3 kg, which lies on a frictionless floor. A horizontal force $F = 15$ N applied to the lower block makes both blocks move together (without slipping) with the same acceleration. The frictional force acting on the upper 2 kg block is:



(A) 2 N

(B) 4 N

(C) 6 N

(D) 10 N

Q6. A spring of force constant $k = 200$ N m^{-1} is compressed by 0.1 m from its natural length. The elastic potential energy stored in the spring is:

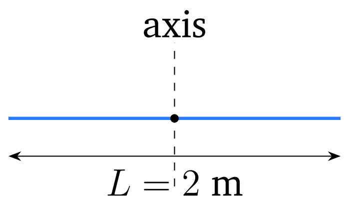
(A) 0.5 J

(B) 2 J

(C) 4 J

(D) 1 J

Q7. A uniform thin rod of mass 3 kg and length 2 m rotates about an axis passing through its centre and perpendicular to its length, as shown $\left(I = \dfrac{ML^2}{12}\right)$. Its moment of inertia about this axis is:



(A) 4 kg m^2

(B) 2 kg m^2

(C) 1 kg m^2

(D) 0.5 kg m^2

Q8. The acceleration due to gravity at the Earth's surface is $g = 9.8$ m s^{-2}. Assuming the Earth to be a uniform sphere, the value of acceleration due to gravity at a depth equal to half the Earth's radius below the surface is:

(A) 9.8 m s^{-2}

(B) 4.9 m s^{-2}

(C) 2.45 m s^{-2}

(D) 0 m s^{-2}

Q9. Water rises in a capillary tube of radius 0.5 mm. Taking surface tension of water $T = 0.075$ N m^{-1}, angle of contact $\theta = 0°$, density $\rho = 1000$ kg m^{-3} and $g = 10$ m s^{-2}, the height to which water rises is approximately:

(A) 3 cm

(B) 1.5 cm

(C) 6 cm

(D) 0.3 cm

Q10. A gas at constant pressure 2×10^5 Pa expands from a volume of 2 litre to 5 litre. The work done by the gas during this isobaric process is:

(A) 300 J

(B) 600 J

(C) 1200 J

(D) 200 J

Q11. The root-mean-square speed of oxygen molecules (molar mass $M =$ 32 g mol^{-1}) at a temperature of 300 K is $\left(v_{\text{rms}} = \sqrt{\dfrac{3RT}{M}},\ R = 8.3 \text{ J mol}^{-1}\text{K}^{-1} \right)$ approximately:

(A) 483 m s^{-1}

(B) 966 m s^{-1}

(C) 242 m s^{-1}

(D) 380 m s^{-1}

Q12. A particle executes simple harmonic motion with angular frequency $\omega = 10$ rad s^{-1} and amplitude 5 cm. Its speed when the displacement from the mean position is 3 cm $\left(v = \omega\sqrt{A^2 - x^2}\right)$ is:

(A) 0.5 m s^{-1}

(B) 0.3 m s^{-1}

(C) 0.4 m s^{-1}

(D) 0.8 m s^{-1}

Q13. Two point charges exert an electrostatic force F on each other. If the distance of separation between them is halved while the charges are kept unchanged, the new force between them becomes:

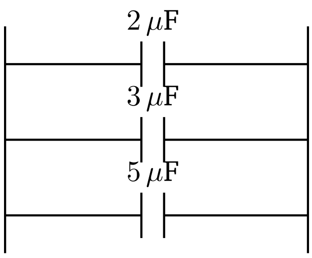
(A) $4F$

(B) $2F$

(C) $F/2$

(D) $F/4$

Q14. Three capacitors of capacitances 2 μF, 3 μF and 5 μF are connected in parallel, as shown. The equivalent capacitance of the combination is:



(A) 1 μF

(B) 10 μF

(C) 0.97 μF

(D) 30 μF

Q15. A cell of emf 12 V and internal resistance 0.5 Ω delivers a current of 2 A to an external circuit. The terminal voltage across the cell is:

(A) 11 V

(B) 13 V

(C) 12 V

(D) 10 V

Q16. A cylindrical wire has resistance $12\ \Omega$. If the wire is replaced by another wire of the same material and same length but with its radius doubled, the resistance of the new wire is:

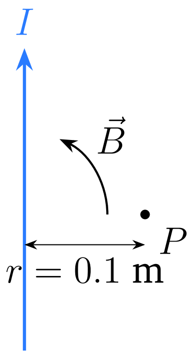
(A) $12\ \Omega$

(B) $6\ \Omega$

(C) $3\ \Omega$

(D) $48\ \Omega$

Q17. A long straight wire carries a steady current of 5 A. The magnitude of the magnetic field at a point P located 0.1 m from the wire $\left(B = \frac{\mu_0 I}{2\pi r},\ \mu_0 = 4\pi \times 10^{-7}\right.$ is:



(A) 5×10^{-5} T

(B) 2×10^{-5} T

(C) 1×10^{-6} T

(D) 1×10^{-5} T

Q18. A short bar magnet of magnetic moment $2\ \text{A m}^2$ produces a magnetic field at a point on its axial line 0.2 m from its centre $\left(B = \frac{\mu_0}{4\pi} \cdot \frac{2M}{d^3},\ \frac{\mu_0}{4\pi} = 10^{-7}\right)$ of magnitude:

(A) 1×10^{-5} T

(B) 2.5×10^{-5} T

(C) 5×10^{-5} T

(D) 1×10^{-4} T

Q19. An ideal transformer has 100 turns in its primary coil and 500 turns in its secondary coil. If the primary is connected to a 220 V AC supply, the secondary output voltage is:

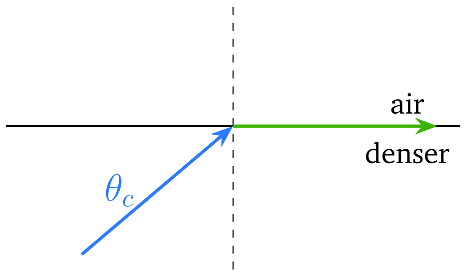
(A) 44 V

(B) 1100 V

(C) 220 V

(D) 550 V

Q20. Light travels from a denser medium of refractive index 2 into air (refractive index 1). The critical angle for total internal reflection at this interface $\left(\sin\theta_c = \frac{1}{n}\right)$ is:



(A) 60°

(B) 45°

(C) 90°

(D) 30°

Q21. In a two-source interference experiment with monochromatic light of wavelength λ, constructive interference (a bright fringe) is observed at a point when the path difference between the two waves reaching that point equals:

(A) an integral multiple of λ (i.e. $n\lambda$)

(B) an odd multiple of $\frac{\lambda}{2}$

(C) an odd multiple of $\frac{\lambda}{4}$

(D) a half-integral multiple of λ

Q22. Light of photon energy 5 eV is incident on a metal surface whose work function is 3 eV. The stopping potential required to just stop the most energetic photoelectrons is:

(A) 5 V

(B) 3 V

(C) 8 V

(D) 2 V

Q23. In the Bohr model, the energy of the electron in the ground state $(n = 1)$ of the hydrogen atom is -13.6 eV. The ionization energy of a hydrogen atom (the energy needed to remove the electron from the ground state) is:

(A) 3.4 eV

(B) 13.6 eV

(C) 27.2 eV

(D) 1.51 eV

Q24. A radioactive sample initially contains 8×10^{20} nuclei and has a half-life of 5 days. The number of undecayed nuclei remaining after 15 days is:

(A) 1×10^{20}

(B) 2×10^{20}

(C) 4×10^{20}

(D) 0.5×10^{20}

Q25. Consider the depletion region of a p-n junction diode under external bias. Which of the following statements is correct?

(A) Forward bias increases the depletion width while reverse bias decreases it.

(B) Both forward and reverse bias increase the depletion width.

(C) Forward bias decreases the depletion width while reverse bias increases it.

(D) The depletion width is unaffected by the biasing.

Detailed Solutions

Q1.

Solution

Concept — Dimensions from a defining equation: Isolate the quantity in its defining relation and substitute the dimensions of the known quantities.

Step 1 — Rearrange the relation: From $E = h\nu$, solve for h:

$$h = \frac{E}{\nu}.$$

Step 2 — Write the dimensions of each quantity: Energy: $[E] = [ML^2T^{-2}]$.

Frequency: ν is the number of cycles per second, so $[\nu] = [T^{-1}]$.

Step 3 — Substitute and simplify:

$$[h] = \frac{[ML^2T^{-2}]}{[T^{-1}]} = [ML^2T^{-2}] \times [T^1].$$

$$[h] = [ML^2T^{-2+1}] = [ML^2T^{-1}].$$

Why other options are wrong:

- Option A $[MLT^{-2}]$: this is the dimension of force.
- Option B $[ML^2T^{-2}]$: this is the dimension of energy itself, not h.
- Option C $[MLT^{-1}]$: this is the dimension of linear momentum.

Final Answer: The dimensional formula of Planck's constant is $[ML^2T^{-1}] \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q1

Q2.

Solution

Concept — Relative velocity of approach: When two bodies move toward each other along the same line, the magnitude of their relative velocity is the sum of their individual speeds.

Step 1 — Assign directions: Take one car's velocity as $+15$ m s^{-1}.

The other car moves in the opposite direction, so its velocity is -25 m s^{-1}.

Step 2 — Relative velocity of the first car with respect to the second:

$$v_{rel} = v_1 - v_2 = (+15) - (-25).$$

Step 3 — Simplify:

$$v_{rel} = 15 + 25 = 40 \text{ m s}^{-1}.$$

Why other options are wrong:

- Option A (10 m s^{-1}): this is the speed of separation if the cars moved in the same direction.
- Option B (25 m s^{-1}): uses only one car's speed.
- Option C (15 m s^{-1}): uses only the other car's speed.

Final Answer: Velocity of approach $= 40 \text{ m s}^{-1} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q2

Q3.

Solution

Concept — Horizontal projectile: For a body launched horizontally, the vertical motion is free fall and is independent of the horizontal speed. The time of flight depends only on the height.

Step 1 — Write the vertical motion equation: The initial vertical velocity is zero, so

$$h = \frac{1}{2}gt^2.$$

Step 2 — Solve for the time t:

$$t = \sqrt{\frac{2h}{g}}.$$

Step 3 — Substitute the numbers:

$$t = \sqrt{\frac{2 \times 80}{10}} = \sqrt{\frac{160}{10}} = \sqrt{16}.$$

$$t = 4 \text{ s}.$$

Step 4 — Note about the horizontal speed: The horizontal speed of 15 m s^{-1}

does not affect the time to land; it only sets the horizontal distance.

Why other options are wrong:

- Option A (2 s): forgets the factor of 2 inside the root.
- Option C (8 s): doubles the correct time.
- Option D (16 s): mistakes t^2 for t.

Final Answer: Time to reach the ground $= 4$ s $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q3

Q4.

Solution

Concept — Connected blocks on a smooth surface: The two blocks share a common acceleration. First find the acceleration of the system, then apply Newton's second law to the block that is pulled only by the string.

Step 1 — Acceleration of the whole system: The applied force accelerates the total mass:

$$a = \frac{F}{m_1 + m_2} = \frac{10}{2+3} = \frac{10}{5} = 2 \text{ m s}^{-2}.$$

Step 2 — Apply Newton's law to the 2 kg block: The only horizontal force on the 2 kg block is the string tension T:

$$T = m_1 a.$$

Step 3 — Substitute the values:

$$T = 2 \times 2 = 4 \text{ N}.$$

Why other options are wrong:

- Option B (6 N): uses the 3 kg mass instead of 2 kg.
- Option C (10 N): equals the full applied force.
- Option D (2 N): uses the acceleration value as the tension.

Final Answer: Tension in the string $= 4$ N $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q4

Q5.

Solution

Concept — Friction as the driving force on a stacked block: When two stacked blocks move together, the upper block is accelerated only by the friction from the lower block. First find the common acceleration, then the friction equals the upper mass times that acceleration.

Step 1 — Common acceleration of the two blocks: The floor is frictionless, so the applied force accelerates the combined mass:

$$a = \frac{F}{m_{\text{top}} + m_{\text{bottom}}} = \frac{15}{2+3} = \frac{15}{5} = 3 \text{ m s}^{-2}.$$

Step 2 — Force needed to accelerate the upper block: The upper block (2 kg) is pushed forward only by friction f from the lower block:

$$f = m_{\text{top}}\, a.$$

Step 3 — Substitute the values:

$$f = 2 \times 3 = 6 \text{ N}.$$

Why other options are wrong:

- Option A (2 N): equals the mass alone, not mass times acceleration.
- Option B (4 N): uses the wrong acceleration.
- Option D (10 N): uses the lower block's share of the force.

Final Answer: Friction on the upper block $= 6$ N $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q5

Q6.

Solution

Concept — Elastic potential energy of a spring: A spring compressed or stretched by x from its natural length stores energy $U = \frac{1}{2}kx^2$.

Step 1 — List the values: Force constant $k = 200$ N m^{-1}.

Compression $x = 0.1$ m, so $x^2 = 0.01$ m^2.

Step 2 — Substitute into the energy formula:

$$U = \frac{1}{2}kx^2 = \frac{1}{2} \times 200 \times 0.01.$$

Step 3 — Simplify:

$$U = \frac{1}{2} \times 2 = 1 \text{ J}.$$

Why other options are wrong:

- Option A (0.5 J): halves the correct value.
- Option B (2 J): forgets the factor $\frac{1}{2}$.
- Option C (4 J): uses $x = 0.2$ or doubles incorrectly.

Final Answer: Energy stored in the spring $= 1$ J $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q6

Q7.

Solution

Concept — Moment of inertia of a uniform rod: For a thin rod of mass M and length L about an axis through its centre and perpendicular to its length, $I = \frac{ML^2}{12}$.

Step 1 — List the values: Mass $M = 3$ kg.

Length $L = 2$ m, so $L^2 = 4$ m^2.

Step 2 — Substitute into the formula:

$$I = \frac{ML^2}{12} = \frac{3 \times 4}{12}.$$

Step 3 — Simplify:

$$I = \frac{12}{12} = 1 \text{ kg m}^2.$$

Why other options are wrong:

- Option A (4 kg m^2): uses ML^2 about the centre without the factor $\frac{1}{12}$ wrongly.
- Option B (2 kg m^2): uses $\frac{1}{6}$ instead of $\frac{1}{12}$.
- Option D (0.5 kg m^2): halves the correct value.

Final Answer: Moment of inertia $= 1$ kg m^2 $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q7

Q8.

Solution

Concept — Variation of g with depth: At a depth d below the surface of a uniform Earth of radius R, $g' = g\left(1 - \frac{d}{R}\right)$.

Step 1 — Substitute $d = \frac{R}{2}$:

$$g' = g\left(1 - \frac{R/2}{R}\right) = g\left(1 - \frac{1}{2}\right).$$

Step 2 — Simplify the bracket:

$$g' = g \times \frac{1}{2} = \frac{g}{2}.$$

Step 3 — Put in the numerical value:

$$g' = \frac{9.8}{2} = 4.9 \text{ m s}^{-2}.$$

Why other options are wrong:

- Option A (9.8): assumes no change with depth.
- Option C (2.45): uses the formula for height $h = R$, not depth.
- Option D (0): is the value only at the Earth's centre $(d = R)$.

Final Answer: $g' = 4.9 \text{ m s}^{-2} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q8

Q9.

Solution

Concept — Capillary rise: A liquid rises in a fine tube to a height $h = \frac{2T\cos\theta}{\rho g r}$, where T is surface tension, θ the angle of contact and r the tube radius.

Step 1 — List the values in SI units: Surface tension $T = 0.075 \text{ N m}^{-1}$.

Angle of contact $\theta = 0^\circ$, so $\cos\theta = 1$.

Radius $r = 0.5$ mm $= 0.5 \times 10^{-3} = 5 \times 10^{-4}$ m.

Density $\rho = 1000$ kg m^{-3}, $g = 10$ m s^{-2}.

Step 2 — Substitute into the formula:

$$h = \frac{2 \times 0.075 \times 1}{1000 \times 10 \times (5 \times 10^{-4})}.$$

Step 3 — Simplify the denominator:

$$1000 \times 10 \times 5 \times 10^{-4} = 10^{4} \times 5 \times 10^{-4} = 5.$$

Step 4 — Complete the calculation:

$$h = \frac{0.15}{5} = 0.03 \text{ m} = 3 \text{ cm}.$$

Why other options are wrong:

- Option B (1.5 cm): forgets the factor of 2 in the numerator.
- Option C (6 cm): uses half the radius.
- Option D (0.3 cm): a power-of-ten slip.

Final Answer: Capillary rise $= 3$ cm $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q9

Q10.

Solution

Concept — Work done in an isobaric process: At constant pressure, the work done by a gas is $W = P\,\Delta V$, where ΔV is the change in volume.

Step 1 — Find the change in volume in SI units:

$$\Delta V = 5 \text{ L} - 2 \text{ L} = 3 \text{ L} = 3 \times 10^{-3} \text{ m}^3.$$

Step 2 — List the pressure:

$$P = 2 \times 10^{5} \text{ Pa}.$$

Step 3 — Substitute into $W = P\,\Delta V$:

$$W = (2 \times 10^5) \times (3 \times 10^{-3}).$$

Step 4 — Simplify:

$$W = 6 \times 10^{5-3} = 6 \times 10^2 = 600 \text{ J}.$$

Why other options are wrong:

- Option A (300 J): halves the volume change.
- Option C (1200 J): doubles the result.
- Option D (200 J): uses $\Delta V = 1$ L.

Final Answer: Work done by the gas $= 600$ J $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) **Go Back to Q10**

Q11.

Solution

Concept — Root-mean-square speed: The rms speed of gas molecules is $v_{\text{rms}} = \sqrt{\dfrac{3RT}{M}}$, where M is the molar mass in kg/mol.

Step 1 — List the values in SI units: $R = 8.3$ J mol^{-1}K^{-1}, $T = 300$ K.

Molar mass $M = 32$ g mol^{-1} $= 32 \times 10^{-3} = 0.032$ kg mol^{-1}.

Step 2 — Compute the numerator $3RT$:

$$3RT = 3 \times 8.3 \times 300 = 7470.$$

Step 3 — Divide by the molar mass:

$$\frac{3RT}{M} = \frac{7470}{0.032} = 233437.5 \text{ m}^2\text{s}^{-2}.$$

Step 4 — Take the square root:

$$v_{\text{rms}} = \sqrt{233437.5} \approx 483 \text{ m s}^{-1}.$$

Why other options are wrong:

- Option B (966 m s^{-1}): doubles the correct value.
- Option C (242 m s^{-1}): halves the correct value.
- Option D (380 m s^{-1}): uses the wrong constant or temperature.

Final Answer: rms speed ≈ 483 m $s^{-1} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q11

Q12.

Solution

Concept — Speed in simple harmonic motion: At a displacement x from the mean position, the speed of a particle in SHM is $v = \omega\sqrt{A^2 - x^2}$.

Step 1 — List the values in SI units: $\omega = 10$ rad s^{-1}.

Amplitude $A = 5$ cm $= 0.05$ m.

Displacement $x = 3$ cm $= 0.03$ m.

Step 2 — Evaluate $A^2 - x^2$:

$$A^2 = 0.0025, \qquad x^2 = 0.0009.$$

$$A^2 - x^2 = 0.0025 - 0.0009 = 0.0016 \text{ m}^2.$$

Step 3 — Take the square root:

$$\sqrt{A^2 - x^2} = \sqrt{0.0016} = 0.04 \text{ m}.$$

Step 4 — Multiply by ω:

$$v = 10 \times 0.04 = 0.4 \text{ m s}^{-1}.$$

Why other options are wrong:

- Option A (0.5 m s^{-1}): is the maximum speed ωA, valid only at the mean position.
- Option B (0.3 m s^{-1}): uses x instead of $\sqrt{A^2 - x^2}$.
- Option D (0.8 m s^{-1}): doubles the correct value.

Final Answer: Speed at $x = 3$ cm is 0.4 m $s^{-1} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q12

Q13.

Solution

Concept — Coulomb's inverse-square law: The electrostatic force between two fixed charges varies as $F \propto \frac{1}{r^2}$, so changing the separation changes the force by the square of the inverse ratio.

Step 1 — Write the proportionality:

$$\frac{F'}{F} = \left(\frac{r}{r'}\right)^2.$$

Step 2 — Substitute the new separation $r' = \frac{r}{2}$:

$$\frac{F'}{F} = \left(\frac{r}{r/2}\right)^2 = (2)^2.$$

Step 3 — Simplify:

$$\frac{F'}{F} = 4 \quad \Rightarrow \quad F' = 4F.$$

Why other options are wrong:

- Option B ($2F$): treats the force as $\propto 1/r$ instead of $1/r^2$.
- Option C ($F/2$): wrong direction of change.
- Option D ($F/4$): is the result when the distance is doubled, not halved.

Final Answer: The force becomes $4F \Rightarrow \boxed{A}$

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

Q14.

Solution

Concept — Capacitors in parallel: When capacitors are connected in parallel, they share the same potential difference, and the equivalent capacitance is the simple sum of the individual capacitances.

Step 1 — Write the rule:

$$C_{eq} = C_1 + C_2 + C_3.$$

Step 2 — Substitute the values:

$$C_{eq} = 2 + 3 + 5.$$

Step 3 — Add the terms:

$$C_{\text{eq}} = 10\ \mu\text{F}.$$

Why other options are wrong:

- Option A ($1\ \mu$F): mistakenly uses the smallest single capacitor.
- Option C ($0.97\ \mu$F): is the result for a series combination.
- Option D ($30\ \mu$F): multiplies the capacitances instead of adding.

Final Answer: Equivalent capacitance $= 10\ \mu\text{F} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q14

Q15.

Solution

Concept — Terminal voltage of a cell: When a cell of emf ε and internal resistance r supplies a current I, the terminal voltage is $V = \varepsilon - Ir$ because part of the emf is dropped across the internal resistance.

Step 1 — List the values: emf $\varepsilon = 12$ V, current $I = 2$ A, internal resistance $r = 0.5\ \Omega$.

Step 2 — Find the internal voltage drop:

$$Ir = 2 \times 0.5 = 1\text{ V}.$$

Step 3 — Subtract from the emf:

$$V = \varepsilon - Ir = 12 - 1 = 11\text{ V}.$$

Why other options are wrong:

- Option B (13 V): adds the drop instead of subtracting.
- Option C (12 V): ignores the internal resistance.
- Option D (10 V): uses an incorrect drop of 2 V.

Final Answer: Terminal voltage $= 11\text{ V} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q15

Q16.

Solution

Concept — Resistance and cross-sectional area: For a wire of fixed material and length, $R = \rho\frac{L}{A}$, so $R \propto \frac{1}{A}$. Since the area $A = \pi r^2$, the resistance varies as $\frac{1}{r^2}$.

Step 1 — Effect of doubling the radius on the area: If r becomes $2r$, the new area is

$$A' = \pi(2r)^2 = 4\pi r^2 = 4A.$$

Step 2 — New resistance:

$$R' = \rho\frac{L}{A'} = \rho\frac{L}{4A} = \frac{R}{4}.$$

Step 3 — Put in the value:

$$R' = \frac{12}{4} = 3\ \Omega.$$

Why other options are wrong:

- Option A ($12\ \Omega$): assumes no change.
- Option B ($6\ \Omega$): assumes $R \propto 1/r$ instead of $1/r^2$.
- Option D ($48\ \Omega$): multiplies by 4 instead of dividing.

Final Answer: New resistance $= 3\ \Omega \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q16

Q17.

Solution

Concept — Field of a long straight wire: The magnetic field at perpendicular distance r from a long straight wire carrying current I is $B = \frac{\mu_0 I}{2\pi r}$.

Step 1 — List the values: $\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}, $I = 5$ A, $r = 0.1$ m.

Step 2 — Substitute into the formula:

$$B = \frac{(4\pi \times 10^{-7}) \times 5}{2\pi \times 0.1}.$$

Step 3 — Cancel π and simplify:

$$B = \frac{4 \times 10^{-7} \times 5}{2 \times 0.1} = \frac{20 \times 10^{-7}}{0.2}.$$

Step 4 — Complete the division:

$$B = 100 \times 10^{-7} = 1 \times 10^{-5}\ \text{T}.$$

Why other options are wrong:

- Option A (5×10^{-5} T): drops the factor of 2 in the denominator and mishandles powers.
- Option B (2×10^{-5} T): doubles the correct value.
- Option C (1×10^{-6} T): a power-of-ten slip.

Final Answer: Magnetic field $= 1 \times 10^{-5}$ T $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q17

Q18.

Solution

Concept — Axial field of a short bar magnet: On the axis of a short bar magnet at distance d, the field is $B = \frac{\mu_0}{4\pi} \cdot \frac{2M}{d^3}$.

Step 1 — List the values: $\frac{\mu_0}{4\pi} = 10^{-7}$, magnetic moment $M = 2$ A m^2, $d = 0.2$ m.

Step 2 — Evaluate d^3:

$$d^3 = (0.2)^3 = 0.008\ \text{m}^3.$$

Step 3 — Substitute into the formula:

$$B = 10^{-7} \times \frac{2 \times 2}{0.008} = 10^{-7} \times \frac{4}{0.008}.$$

Step 4 — Simplify:

$$\frac{4}{0.008} = 500, \qquad B = 10^{-7} \times 500 = 5 \times 10^{-5}\ \text{T}.$$

Why other options are wrong:

- Option A (1×10^{-5} T): drops the factor of $2M$.

- Option B (2.5×10^{-5} T): uses the equatorial formula (factor M not $2M$).
- Option D (1×10^{-4} T): doubles the correct value.

Final Answer: Axial field $= 5 \times 10^{-5}$ T $\Rightarrow$ C

Answer: (C) Go Back to Q18

Q19.

Solution

Concept — Transformer turns ratio: For an ideal transformer, the voltage ratio equals the turns ratio: $\frac{V_s}{V_p} = \frac{N_s}{N_p}$. More turns in the secondary make it a step-up transformer.

Step 1 — List the values: $N_p = 100$, $N_s = 500$, $V_p = 220$ V.

Step 2 — Find the turns ratio:

$$\frac{N_s}{N_p} = \frac{500}{100} = 5.$$

Step 3 — Compute the secondary voltage:

$$V_s = V_p \times \frac{N_s}{N_p} = 220 \times 5 = 1100 \text{ V}.$$

Why other options are wrong:

- Option A (44 V): divides instead of multiplies (a step-down result).
- Option C (220 V): assumes equal turns.
- Option D (550 V): uses a turns ratio of 2.5.

Final Answer: Secondary voltage $= 1100$ V $\Rightarrow$ B

Answer: (B) Go Back to Q19

Q20.

Solution

Concept — Critical angle for total internal reflection: When light passes from a denser medium (refractive index n) to a rarer one (air), the critical angle satisfies $\sin\theta_c = \frac{1}{n}$.

Step 1 — Substitute the refractive index:

$$\sin\theta_c = \frac{1}{n} = \frac{1}{2}.$$

Step 2 — Find the angle whose sine is $\frac{1}{2}$:

$$\theta_c = \sin^{-1}\left(\frac{1}{2}\right) = 30^\circ.$$

Step 3 — Interpretation: For angles of incidence greater than 30°, the light is totally internally reflected back into the denser medium.

Why other options are wrong:

- Option A (60°): would require $\sin\theta_c = \frac{\sqrt{3}}{2}$, i.e. $n = 1.15$.
- Option B (45°): corresponds to $n = \sqrt{2} \approx 1.41$.
- Option C (90°): would mean no total internal reflection occurs.

Final Answer: Critical angle $= 30^\circ \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q20

Q21.

Solution

Concept — Condition for constructive interference: Two waves reinforce each other (bright fringe) when they arrive in phase. This happens when the path difference is a whole number of wavelengths.

Step 1 — Phase relation for reinforcement: For the crests of the two waves to coincide, the path difference Δx must correspond to a whole-number phase shift of 2π.

Step 2 — Write the path-difference condition:

$$\Delta x = n\lambda, \qquad n = 0, 1, 2, 3, \ldots$$

That is, the path difference must be an integral multiple of the wavelength.

Step 3 — Contrast with destructive interference: A dark fringe (destructive interference) instead occurs when $\Delta x = \left(n + \frac{1}{2}\right)\lambda$, an odd multiple of $\frac{\lambda}{2}$.

Why other options are wrong:

- Option B (odd multiple of $\frac{\lambda}{2}$): this is the condition for destructive interference.
- Option C (odd multiple of $\frac{\lambda}{4}$): does not correspond to either maxima or minima.
- Option D (half-integral multiple of λ): this also gives destructive, not constructive, interference.

Final Answer: Constructive interference requires $\Delta x = n\lambda \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q21

Q22.

Solution

Concept — Stopping potential: The stopping potential V_0 is the voltage needed to stop the fastest photoelectrons, so $eV_0 = K_{\max} = E_{\text{photon}} - \phi$. Numerically, V_0 in volts equals $K_{\max}$ in electron-volts.

Step 1 — List the values: Photon energy $E_{\text{photon}} = 5$ eV, work function $\phi = 3$ eV.

Step 2 — Maximum kinetic energy:

$$K_{\max} = E_{\text{photon}} - \phi = 5 - 3 = 2 \text{ eV}.$$

Step 3 — Relate to the stopping potential:

$$eV_0 = K_{\max} = 2 \text{ eV} \quad \Rightarrow \quad V_0 = 2 \text{ V}.$$

Why other options are wrong:

- Option A (5 V): equals the photon energy, ignoring the work function.
- Option B (3 V): equals the work function, not the kinetic energy.
- Option C (8 V): adds instead of subtracting.

Final Answer: Stopping potential $= 2$ V $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q22

Q23.

Solution

Concept — Ionization energy: The ionization energy is the energy required to take the electron from the ground state ($n = 1$) completely out of the atom (to $n = \infty$, where $E = 0$).

Step 1 — Write the ground-state energy:

$$E_1 = -13.6 \text{ eV}.$$

Step 2 — Energy of the free electron:

$$E_\infty = 0 \text{ eV}.$$

Step 3 — Ionization energy as the difference:

$$E_{\text{ion}} = E_\infty - E_1 = 0 - (-13.6) = 13.6 \text{ eV}.$$

Why other options are wrong:

- Option A (3.4 eV): is the magnitude of the $n = 2$ energy, not the ground-state ionization energy.
- Option C (27.2 eV): doubles the correct value.
- Option D (1.51 eV): corresponds to the $n = 3$ level.

Final Answer: Ionization energy of hydrogen $= 13.6$ eV $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q23

Q24.

Solution

Concept — Radioactive decay over half-lives: After n half-lives, the number of undecayed nuclei is $N = N_0 \left(\frac{1}{2}\right)^n$.

Step 1 — Find the number of half-lives elapsed:

$$n = \frac{\text{total time}}{\text{half-life}} = \frac{15}{5} = 3.$$

Step 2 — Apply the decay law:

$$N = N_0 \left(\frac{1}{2}\right)^3 = N_0 \times \frac{1}{8}.$$

Step 3 — Substitute $N_0 = 8 \times 10^{20}$:

$$N = \frac{8 \times 10^{20}}{8} = 1 \times 10^{20}.$$

Why other options are wrong:

- Option B (2×10^{20}): corresponds to 2 half-lives ($\frac{1}{4}$).
- Option C (4×10^{20}): corresponds to 1 half-life ($\frac{1}{2}$).
- Option D (0.5×10^{20}): corresponds to 4 half-lives ($\frac{1}{16}$).

Final Answer: Number of nuclei remaining $= 1 \times 10^{20} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q24

Q25.

Solution

Concept — Depletion region under bias: The depletion region is the charge-free zone around a p-n junction. An external bias either adds to or opposes the built-in potential, changing the width of this zone.

Step 1 — Forward bias: In forward bias, the external voltage opposes the built-in potential. This pushes majority carriers toward the junction, which neutralises some of the immobile charges, so the depletion region becomes *narrower*.

Step 2 — Reverse bias: In reverse bias, the external voltage aids the built-in potential. Majority carriers are pulled away from the junction, exposing more immobile ions, so the depletion region becomes *wider*.

Step 3 — Combine the two results: Forward bias decreases the depletion width; reverse bias increases it. This matches option C.

Why other options are wrong:

- Option A: reverses the two effects.
- Option B: forward bias does not increase the width.
- Option D: bias certainly changes the width, which is why a diode conducts more easily in forward bias.

Final Answer: Forward bias decreases and reverse bias increases the depletion width $\Rightarrow \boxed{C}$

Answer: (C) **Go Back to Q25**

Answer Key

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