AIIMS B.Sc Nursing Physics

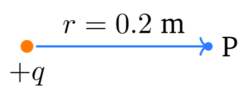
Sample Paper – 2

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. The electric potential at a point 0.2 m from a point charge of 4 nC is (take $k = 9 \times 10^9$ N m^{2}C^{-2}):



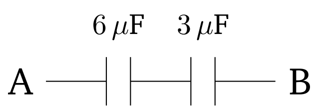
(A) 180 V

(B) 90 V

(C) 360 V

(D) 36 V

Q2. Two capacitors of 6 μF and 3 μF are connected in series, as shown. The equivalent capacitance is:



(A) $9\ \mu$F

(B) $2\ \mu$F

(C) $4.5\ \mu$F

(D) $18\ \mu$F

Q3. A wire of length 2 m and cross-sectional area 4×10^{-7} m^2 is made of a material of resistivity $2 \times 10^{-6}\ \Omega\,$m. The resistance of the wire is:

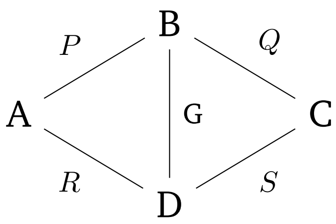
(A) $5\ \Omega$

(B) $20\ \Omega$

(C) $10\ \Omega$

(D) $2.5\ \Omega$

Q4. In the balanced Wheatstone bridge shown, $P = 2\ \Omega$, $Q = 4\ \Omega$ and $R = 3\ \Omega$. The unknown resistance S is:



(A) $1.5\ \Omega$

(B) $2.5\ \Omega$

(C) $8\ \Omega$

(D) $6\ \Omega$

Q5. A capacitor of capacitance $4\ \mu$F is charged to a potential difference of 100 V. The energy stored in it is:

(A) 0.02 J

(B) 0.04 J

(C) 0.2 J

(D) 0.01 J

Q6. The radius of a sphere is measured as 2.1 cm. The number of significant figures in this measurement, and the correctly rounded value of the diameter ($= 2 \times 2.1$ cm), are:

(A) 1 figure, 4.20 cm

(B) 2 figures, 4.2 cm

(C) 3 figures, 4.20 cm

(D) 2 figures, 4.200 cm

Q7. A person walks from home to a shop 300 m away and returns to the starting point along the same road. For the whole round trip, the magnitude of the average velocity is:

(A) equal to the average speed

(B) half the average speed

(C) zero

(D) twice the average speed

Q8. A car starting from rest accelerates uniformly at 2 m/s^2. The distance it travels in 5 s is:

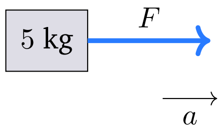
(A) 10 m

(B) 50 m

(C) 20 m

(D) 25 m

Q9. A constant force acts on a body of mass 5 kg, as shown, producing an acceleration of 3 m/s^2. The magnitude of the force is:



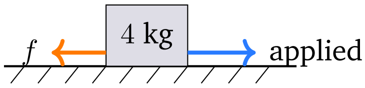
(A) 15 N

(B) 8 N

(C) 1.67 N

(D) 1.5 N

Q10. A block of mass 4 kg rests on a horizontal surface whose coefficient of friction is 0.25. The maximum friction force on the block is (take $g = 10\ \text{m/s}^2$):



(A) 40 N

(B) 10 N

(C) 1 N

(D) 20 N

Q11. A force of 20 N pulls a box through a displacement of 5 m, the force making an angle of 60° with the displacement. The work done is:

(A) 100 J

(B) 86.6 J

(C) 50 J

(D) 25 J

Q12. The escape velocity from a planet of radius R and surface gravity g is $v = \sqrt{2gR}$. For a planet with $g = 8\ \text{m/s}^2$ and $R = 2 \times 10^6$ m, the escape velocity is:

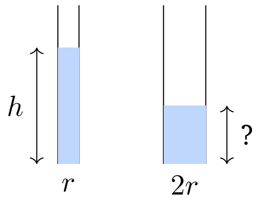
(A) 2×10^3 m/s

(B) 8×10^3 m/s

(C) 1.6×10^4 m/s

(D) 5.66×10^3 m/s

Q13. Water rises to a height h in a capillary tube of radius r. If a second capillary of radius $2r$ is used (same liquid), the new rise is:



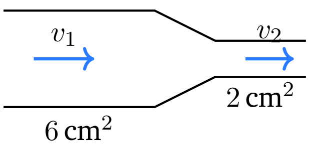
(A) $h/2$

(B) $2h$

(C) h

(D) $4h$

Q14. Water flows steadily through a pipe whose cross-section narrows from $6\ \text{cm}^2$ to $2\ \text{cm}^2$. If the speed in the wide part is 1 m/s, the speed in the narrow part is:



(A) 1.5 m/s

(B) 3 m/s

(C) 0.33 m/s

(D) 12 m/s

Q15. A metal slab of thermal conductivity $k = 200\ \text{W m}^{-1}\text{K}^{-1}$, area $0.5\ \text{m}^2$ and thickness 0.1 m has its faces kept at temperatures differing by 20 K. The rate of heat flow through it is:

(A) 4000 W

(B) 2000 W

(C) 20000 W

(D) 400 W

Q16. The heat required to completely melt 0.5 kg of ice at 0 °C is (latent heat of fusion of ice $= 3.36 \times 10^5$ J kg^{-1}):

(A) 3.36×10^5 J

(B) 6.72×10^5 J

(C) 3.36×10^4 J

(D) 1.68×10^5 J

Q17. A gas absorbs 200 J of heat and does 80 J of work on its surroundings. The change in its internal energy is:

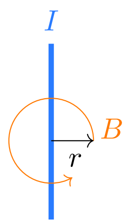
(A) 120 J

(B) 280 J

(C) 80 J

(D) -120 J

Q18. A long straight wire carries a current of 5 A. The magnetic field at a perpendicular distance of 0.1 m from it is (take $\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}):



(A) 2×10^{-5} T

(B) 1×10^{-5} T

(C) 5×10^{-5} T

(D) 1×10^{-6} T

Q19. The current in a coil of self-inductance 0.2 H changes at the rate of 3 A/s. The magnitude of the self-induced emf is:

(A) 0.067 V

(B) 1.5 V

(C) 0.6 V

(D) 15 V

Q20. A capacitor of 50 μF is connected to an AC source of angular frequency 1000 rad/s. Its capacitive reactance is:

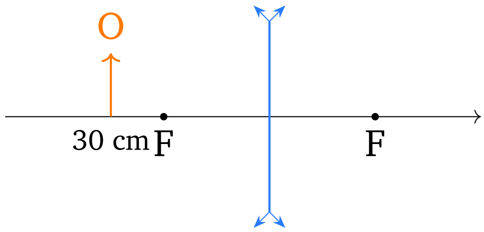
(A) 50 Ω

(B) 5 Ω

(C) 2 Ω

(D) 20 Ω

Q21. An object is placed 30 cm in front of a convex lens of focal length 20 cm, as shown. The distance of the image from the lens is:



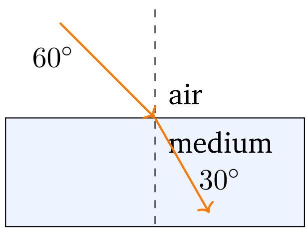
(A) 60 cm

(B) 12 cm

(C) 20 cm

(D) 30 cm

Q22. A ray of light passes from air into a medium. The angle of incidence is 60° and the angle of refraction is 30°, as shown. The refractive index of the medium is:



(A) 1.5

(B) 1.73

(C) 0.58

(D) 2.0

Q23. In a Young's double-slit experiment, the slit separation is 0.5 mm and the screen is 1 m away. Using light of wavelength 600 nm, the fringe width is:

(A) 0.6 mm

(B) 0.3 mm

(C) 1.2 mm

(D) 2.4 mm

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 eV

(C) 10 eV

(D) 3 eV

Q25. A particle of mass 2×10^{-30} kg moves with a speed of 1.1×10^{6} m/s. Its de Broglie wavelength is (take $h = 6.6 \times 10^{-34}$ J s):

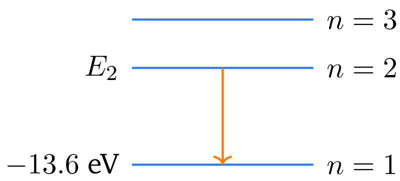
(A) 3×10^{-10} m

(B) 6×10^{-10} m

(C) 1.5×10^{-10} m

(D) 3×10^{-9} m

Q26. In the Bohr model of hydrogen, the energy of the nth level is $E_n = -\dfrac{13.6}{n^2}$ eV. The energy of the second level $(n = 2)$ is:



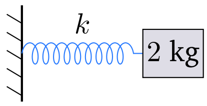
(A) -6.8 eV

(B) -3.4 eV

(C) -13.6 eV

(D) -1.51 eV

Q27. A block of mass 2 kg is attached to a spring of force constant $k = 200$ N/m, as shown. The time period of its oscillation is:



(A) 0.314 s

(B) 0.1 s

(C) 0.628 s

(D) 1.0 s

Q28. A sound wave travels in air at 340 m/s and has a wavelength of 0.85 m. Its frequency is:

(A) 289 Hz

(B) 0.0025 Hz

(C) 200 Hz

(D) 400 Hz

Q29. In an n-type semiconductor, formed by doping silicon with a pentavalent impurity, the majority charge carriers are:

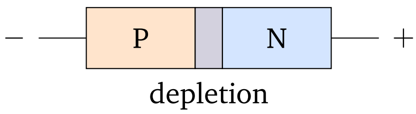
(A) electrons

(B) holes

(C) protons

(D) negative ions

Q30. When the p-n junction shown is reverse biased, the width of its depletion region:



(A) decreases

(B) stays exactly the same

(C) increases

(D) becomes zero

Detailed Solutions

Q1.

Solution

Concept — Potential of a point charge: The electric potential at a distance r from an isolated point charge q is the work done per unit charge in bringing a test charge from infinity to that point. It is a scalar given by $V = \frac{kq}{r}$, where $k = \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9\ \text{N m}^2\text{C}^{-2}$, q is the source charge in coulombs, and r is the radial distance in metres. Unlike field, potential falls off as $1/r$, not $1/r^2$.

Given: $q = 4\ \text{nC} = 4 \times 10^{-9}\ \text{C}$, $r = 0.2\ \text{m}$, $k = 9 \times 10^9\ \text{N m}^2\text{C}^{-2}$.

Step 1 — Write the formula and substitute: $V = \frac{kq}{r} = \frac{(9 \times 10^9\ \text{N m}^2\text{C}^{-2})(4 \times 10^{-9}\ \text{C})}{0.2\ \text{m}}$.

Step 2 — Simplify the numerator: $(9 \times 10^9)(4 \times 10^{-9}) = 36\ \text{V m}$, so $V = \frac{36}{0.2}\ \text{V m / m}$.

Step 3 — Evaluate: $V = 180\ \text{V}$.

Why each other option is wrong:

- (B) 90 V comes from mistakenly using $r = 0.4$ m (a doubled distance) instead of 0.2 m.
- (C) 360 V results from dropping the division by r entirely and instead multiplying 36 by 10.
- (D) 36 V is just the numerator kq without dividing by $r = 0.2$ m.

Key point: Potential is a scalar and varies as $1/r$; always convert nano-coulombs to coulombs before substituting.

Final Answer: $V = 180\ \text{V} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q1

Q2.

Solution

Concept — Capacitors in series: When capacitors are joined in series the same charge sits on each plate, and the applied voltage is shared. The reciprocals of the capacitances add: $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$, where C is the equivalent capacitance and

C_1, C_2 are the individual values. The equivalent is always smaller than the smallest member of the series combination.

Given: $C_1 = 6\ \mu$F, $C_2 = 3\ \mu$F, connected in series between A and B.

Step 1 — Write the formula and substitute: $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} = \frac{1}{6\ \mu\text{F}} + \frac{1}{3\ \mu\text{F}}$.

Step 2 — Add the fractions: Taking the LCD of 6: $\frac{1}{C} = \frac{1+2}{6} = \frac{3}{6} = \frac{1}{2}\ (\mu\text{F})^{-1}$.

Step 3 — Invert to get C: $C = 2\ \mu$F, which is indeed less than the smaller capacitor ($3\ \mu$F), as expected for a series set.

Why each other option is wrong:

- (A) $9\ \mu$F is the *parallel* sum $C_1 + C_2$, which applies only when they are in parallel, not series.
- (C) $4.5\ \mu$F is the simple average $\frac{6+3}{2}$, which has no physical basis here.
- (D) $18\ \mu$F is just the product C_1C_2 without dividing by the sum.

Key point: For two capacitors in series use $C = \frac{C_1C_2}{C_1+C_2} = \frac{18}{9} = 2\ \mu$F; the result must be smaller than either capacitor.

Final Answer: $C = 2\ \mu\text{F} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q2

Q3.

Solution

Concept — Resistance from resistivity: The resistance of a uniform conductor depends on the material and the geometry through $R = \frac{\rho L}{A}$, where ρ is the resistivity (an intrinsic property of the material, in $\Omega\,$m), L is the length along the current direction (m), and A is the cross-sectional area (m^2). Resistance rises with length and falls with area.

Given: $L = 2$ m, $A = 4 \times 10^{-7}$ m^2, $\rho = 2 \times 10^{-6}\ \Omega\,$m.

Step 1 — Write the formula and substitute: $R = \frac{\rho L}{A} = \frac{(2 \times 10^{-6}\ \Omega\,\text{m})(2\ \text{m})}{4 \times 10^{-7}\ \text{m}^2}$.

Step 2 — Simplify the numerator: $(2 \times 10^{-6})(2) = 4 \times 10^{-6}\ \Omega\,\text{m}^2$, so $R = \frac{4 \times 10^{-6}}{4 \times 10^{-7}}\ \Omega$.

Step 3 — Divide the powers of ten: $\frac{4 \times 10^{-6}}{4 \times 10^{-7}} = 10^{-6-(-7)} = 10^1 = 10$, giving

$R = 10\ \Omega$.

Why each other option is wrong:

- (A) $5\ \Omega$ comes from an exponent slip (treating $10^{-6}/10^{-7}$ as 5 rather than 10).
- (B) $20\ \Omega$ multiplies by A instead of dividing, or doubles the correct value.
- (D) $2.5\ \Omega$ inverts part of the ratio, mishandling the power of ten.

Key point: Carefully subtract the exponents when dividing scientific-notation numbers: $10^{-6}/10^{-7} = 10^1$.

Final Answer: $R = 10\ \Omega \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q3

Q4.

Solution

Concept — Wheatstone bridge balance: A Wheatstone bridge has four resistors P, Q, R, S in a diamond with a galvanometer across the middle. At balance no current flows through the galvanometer, and the ratios of resistances in the two arms are equal: $\frac{P}{Q} = \frac{R}{S}$. Rearranging for the unknown gives $S = \frac{QR}{P}$.

Given: $P = 2\ \Omega$, $Q = 4\ \Omega$, $R = 3\ \Omega$; bridge is balanced (galvanometer reads zero).

Step 1 — Write the balance condition: $\frac{P}{Q} = \frac{R}{S} \Rightarrow S = \frac{QR}{P}$.

Step 2 — Substitute with units: $S = \frac{(4\ \Omega)(3\ \Omega)}{2\ \Omega} = \frac{12\ \Omega^2}{2\ \Omega}$.

Step 3 — Evaluate: $S = 6\ \Omega$.

Why each other option is wrong:

- (A) $1.5\ \Omega$ comes from inverting the ratio, i.e. computing $\frac{PR}{Q^2}$ or $\frac{P}{Q} \cdot R$ wrongly.
- (B) $2.5\ \Omega$ does not satisfy $\frac{2}{4} = \frac{3}{S}$; it has no consistent basis.
- (C) $8\ \Omega$ swaps P and Q, computing $\frac{PR}{Q} \times$ wrong factor instead of $\frac{QR}{P}$.

Key point: Check by back-substitution: $\frac{P}{Q} = \frac{2}{4} = 0.5$ and $\frac{R}{S} = \frac{3}{6} = 0.5$, so the bridge is genuinely balanced.

Final Answer: $S = 6\ \Omega \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q4

Q5.

Solution

Concept — Energy stored in a capacitor: A charged capacitor stores electrical potential energy in the field between its plates. The stored energy is $U = \frac{1}{2}CV^2$, where C is the capacitance in farads and V is the potential difference across the plates in volts; the result is in joules. Equivalent forms are $U = \frac{1}{2}QV$ and $U = \dfrac{Q^2}{2C}$.

Given: $C = 4\ \mu\text{F} = 4 \times 10^{-6}$ F, $V = 100$ V.

Step 1 — Write the formula and substitute: $U = \frac{1}{2}CV^2 = \frac{1}{2}(4 \times 10^{-6}\ \text{F})(100\ \text{V})^2$.

Step 2 — Square the voltage: $(100)^2 = 10^4\ \text{V}^2$, so $U = \frac{1}{2}(4 \times 10^{-6})(10^4)$ J.

Step 3 — Evaluate: $(4 \times 10^{-6})(10^4) = 4 \times 10^{-2}$; then $U = \frac{1}{2}(4 \times 10^{-2}) = 2 \times 10^{-2} = 0.02$ J.

Why each other option is wrong:

- (B) 0.04 J omits the factor $\frac{1}{2}$, giving CV^2 instead of $\frac{1}{2}CV^2$.
- (C) 0.2 J results from a power-of-ten slip (treating 4×10^{-6} as 4×10^{-5}).
- (D) 0.01 J halves the answer once too often or uses $V = 70.7$ V.

Key point: Energy scales with the *square* of voltage, so doubling V quadruples the stored energy; never forget the $\frac{1}{2}$.

Final Answer: $U = 0.02$ J $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q5

Q6.

Solution

Concept — Significant figures: Significant figures express how precisely a quantity is known. All non-zero digits are significant, so a measurement like 2.1 carries 2 significant figures. When multiplying, the product must be reported with the same number of significant figures as the least precise factor; exact integers (here the factor 2) carry unlimited precision and do not limit the result.

Given: Measured radius $= 2.1$ cm; required diameter $d = 2 \times 2.1$ cm.

Step 1 — Count significant figures: In 2.1 both digits are non-zero and hence significant, so it has exactly 2 significant figures.

Step 2 — Compute the diameter: $d = 2 \times 2.1$ cm $= 4.2$ cm. The multiplier 2 is an exact (defined) number, so the limiting factor is 2.1 cm with 2 significant figures.

Step 3 — Report with correct precision: The diameter must therefore be written as 4.2 cm (2 significant figures), not with extra trailing zeros.

Why each other option is wrong:

- (A) "1 figure, 4.20 cm" miscounts 2.1 as one significant figure and over-reports the diameter.
- (C) "3 figures, 4.20 cm" adds a trailing zero that falsely implies the radius was known to 0.01 cm.
- (D) "2 figures, 4.200 cm" is internally inconsistent: 4.200 shows 4 significant figures, not 2.

Key point: Do not invent precision; a result is only as precise as the least precise measured input.

Final Answer: 2 figures, 4.2 cm $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q6

Q7.

Solution

Concept — Average velocity vs average speed: Average velocity is a vector defined as $\vec{v}_{avg} = \frac{\text{net displacement}}{\text{total time}}$, while average speed is a scalar equal to $\frac{\text{total distance}}{\text{total time}}$. Displacement is the straight-line vector from start to finish; distance is the entire path length. The two differ whenever the motion is not a single straight uninterrupted leg.

Given: Home to shop $= 300$ m, then shop back to home $= 300$ m along the same road; net trip returns to the start.

Step 1 — Find the displacement: The person ends exactly where they began, so the net displacement is 0 m even though the total distance walked is $300 + 300 = 600$ m.

Step 2 — Compute average velocity: $|\vec{v}_{avg}| = \frac{0 \text{ m}}{t} = 0$, regardless of the time taken.

Step 3 — Compare with average speed: Average speed $= \frac{600 \text{ m}}{t} \neq 0$, so the magnitude of average velocity is strictly less than the average speed here.

Why each other option is wrong:

- (A) "equal to the average speed" holds only for one-way straight-line motion, not a round trip.
- (B) "half the average speed" has no basis; the ratio depends on the path, and here the velocity is exactly zero.
- (D) "twice the average speed" is impossible: average velocity magnitude can never exceed the average speed.

Key point: For any closed path (start point = end point), average velocity is always zero, while average speed is not.

Final Answer: Average velocity $= 0 \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q7

Q8.

Solution

Concept — Equation of motion (uniform acceleration): For constant acceleration the distance covered is $s = ut + \frac{1}{2}at^2$, where u is the initial velocity (m/s), a is the acceleration (m/s^2), and t is the elapsed time (s). For a body starting from rest, $u = 0$, so the expression reduces to $s = \frac{1}{2}at^2$.

Given: $u = 0$ (starts from rest), $a = 2$ m/s^2, $t = 5$ s.

Step 1 — Write the formula and substitute: $s = ut + \frac{1}{2}at^2 = (0)(5) + \frac{1}{2}(2 \text{ m/s}^2)(5 \text{ s})^2$.

Step 2 — Square the time: $(5 \text{ s})^2 = 25 \text{ s}^2$, so $s = \frac{1}{2}(2)(25)$ m.

Step 3 — Evaluate: $\frac{1}{2} \times 2 \times 25 = 25$, giving $s = 25$ m.

Why each other option is wrong:

- (A) 10 m uses $s = at$ (treating time to the first power) instead of the t^2 law.
- (B) 50 m omits the factor $\frac{1}{2}$, computing $at^2 = 2 \times 25$ as the full distance.
- (C) 20 m uses $t = 4$ s ($\frac{1}{2} \times 2 \times 16$) instead of the given 5 s.

Key point: Distance grows with the *square* of time under constant acceleration; never drop the $\frac{1}{2}$.

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

Answer: (D) Go Back to Q8

Q9.

Solution

Concept — Newton's second law: The net force on a body equals the product of its mass and its acceleration, $F = ma$, where F is in newtons (N), m is the mass in kilograms (kg), and a is the acceleration in m/s^2. Force and acceleration point in the same direction, as the figure shows.

Given: $m = 5$ kg, $a = 3$ m/s^2.

Step 1 — Write the formula and substitute: $F = ma = (5 \text{ kg})(3 \text{ m/s}^2)$.

Step 2 — Evaluate: $F = 15 \text{ kg m/s}^2 = 15$ N.

Why each other option is wrong:

- (B) 8 N comes from *adding* mass and acceleration $(5 + 3)$ instead of multiplying.
- (C) 1.67 N divides m by a $(5/3)$, inverting the relationship.
- (D) 1.5 N misplaces a power of ten, treating 15 as 1.5.

Key point: One newton is exactly 1 kg m/s^2; keep the units attached to confirm the answer is a force.

Final Answer: $F = 15 \text{ N} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q9

Q10.

Solution

Concept — Friction on a horizontal surface: The maximum (limiting) static friction is $f = \mu N$, where μ is the coefficient of friction (dimensionless) and N is the normal reaction. On a flat horizontal surface with no vertical applied force, the normal reaction balances the weight, so $N = mg$, with g the acceleration due to gravity.

Given: $m = 4$ kg, $\mu = 0.25$, $g = 10$ m/s^2.

Step 1 — Find the normal force: $N = mg = (4 \text{ kg})(10 \text{ m/s}^2) = 40$ N.

Step 2 — Find the maximum friction: $f = \mu N = (0.25)(40 \text{ N})$.

Step 3 — Evaluate: $f = 10$ N.

Why each other option is wrong:

- (A) 40 N is the normal force N itself, not the friction (it forgets to multiply by μ).
- (C) 1 N drops the factor g, using $f = \mu m = 0.25 \times 4$.
- (D) 20 N uses $\mu = 0.5$ instead of the given 0.25.

Key point: Friction depends on the normal force, not directly on contact area; always compute N first.

Final Answer: $f = 10 \text{ N} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q10

Q11.

Solution

Concept — Work done by a force: Work is the dot product of force and displacement: $W = Fd\cos\theta$, where F is the force magnitude (N), d is the displacement magnitude (m), and θ is the angle between the force and the displacement. Only the component of force along the displacement, $F\cos\theta$, does work; the result is in joules.

Given: $F = 20$ N, $d = 5$ m, $\theta = 60^\circ$.

Step 1 — Write the formula and substitute: $W = Fd\cos\theta = (20 \text{ N})(5 \text{ m})\cos 60^\circ$.

Step 2 — Insert the cosine: $\cos 60^\circ = 0.5$, so $W = (100 \text{ J})(0.5)$.

Step 3 — Evaluate: $W = 50$ J.

Why each other option is wrong:

- (A) 100 J ignores the angle, effectively using $\cos\theta = 1$ ($\theta = 0$).
- (B) 86.6 J mistakenly uses $\cos 30^\circ = 0.866$ instead of $\cos 60^\circ$.
- (D) 25 J applies the factor 0.5 twice (or uses $\cos 60^\circ = 0.25$).

Key point: The angle in $W = Fd\cos\theta$ is between force and displacement; here that angle is 60°, so use $\cos 60^\circ = 0.5$.

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

Answer: (C) Go Back to Q11

Q12.

Solution

Concept — Escape velocity: Escape velocity is the minimum speed a body needs at a planet's surface to break free of its gravity without further propulsion. It is given by $v = \sqrt{2gR}$, where g is the surface gravitational acceleration (m/s^2) and R is the planet's radius (m). The factor 2 and the square root come from equating kinetic energy to gravitational potential energy.

Given: $g = 8$ m/s^2, $R = 2 \times 10^6$ m.

Step 1 — Write the formula and substitute: $v = \sqrt{2gR} = \sqrt{2(8 \text{ m/s}^2)(2 \times 10^6 \text{ m})}$.

Step 2 — Simplify inside the root: $2 \times 8 \times 2 \times 10^6 = 32 \times 10^6 = 3.2 \times 10^7$ m^2/s^2.

Step 3 — Take the square root: $v = \sqrt{32 \times 10^6} = \sqrt{32} \times 10^3 = 5.66 \times 10^3$ m/s (since $\sqrt{32} \approx 5.66$).

Why each other option is wrong:

- (A) 2×10^3 m/s skips most of the product $2gR$ and roots too small a number.
- (B) 8×10^3 m/s uses only $\sqrt{gR}$ with mishandled powers, dropping the factor 2.
- (C) 1.6×10^4 m/s forgets the square root, taking $\frac{1}{2}(3.2 \times 10^4)$ style numbers instead.

Key point: Always evaluate the quantity *inside* the root fully (including the factor 2) before taking the square root; $\sqrt{32} \approx 5.66$.

Final Answer: $v \approx 5.66 \times 10^3$ m/s $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q12

Q13.

Solution

Concept — Capillary rise: Liquid rises in a narrow tube because of surface tension. Jurin's law gives the height as $h = \dfrac{2T\cos\theta}{r\rho g}$, where T is surface tension, θ the contact angle, r the tube radius, ρ the liquid density and g gravity. For the same liquid and tube material, all factors except r are constant, so $h \propto \dfrac{1}{r}$ – the rise is inversely proportional to the radius.

Given: Original rise h in a tube of radius r; second tube has radius $2r$, same liquid.

Step 1 — Apply the proportionality: Since $h \propto \frac{1}{r}$, we can write $h_1 r_1 = h_2 r_2$ (the product hr is constant).

Step 2 — Substitute the radii: $h \cdot r = h_2 \cdot (2r)$, so $h_2 = \frac{hr}{2r}$.

Step 3 — Evaluate: $h_2 = \frac{h}{2}$; doubling the radius halves the rise.

Why each other option is wrong:

- (B) $2h$ wrongly assumes $h \propto r$ (direct proportion), the opposite of Jurin's law.
- (C) h ignores the radius change altogether.
- (D) $4h$ would require $h \propto 1/r^2$, which is not the capillary law.

Key point: In capillarity, height and radius are inversely related; a wider tube gives a lower rise.

Final Answer: $h/2 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q13

Q14.

Solution

Concept — Equation of continuity: For an incompressible fluid in steady flow, the volume flow rate is constant along the pipe: $A_1 v_1 = A_2 v_2$, where A is the cross-sectional area and v is the flow speed at that section. Rearranging for the narrow-section speed gives $v_2 = \frac{A_1 v_1}{A_2}$. Where the pipe narrows, the fluid speeds up.

Given: $A_1 = 6\text{ cm}^2$ (wide), $A_2 = 2\text{ cm}^2$ (narrow), $v_1 = 1\text{ m/s}$.

Step 1 — Write the formula and substitute: $v_2 = \frac{A_1 v_1}{A_2} = \frac{(6\text{ cm}^2)(1\text{ m/s})}{2\text{ cm}^2}$.

Step 2 — Simplify the area ratio: $\frac{6}{2} = 3$ (the cm^2 units cancel), so $v_2 = 3 \times 1\text{ m/s}$.

Step 3 — Evaluate: $v_2 = 3\text{ m/s}$.

Why each other option is wrong:

- (A) 1.5 m/s uses an area ratio of 1.5 (e.g. $3/2$), not $6/2$.
- (C) 0.33 m/s inverts the ratio, computing $\frac{A_2}{A_1} v_1 = \frac{2}{6}$.
- (D) 12 m/s multiplies the two areas (6×2) instead of dividing.

Key point: Smaller area means larger speed; since both areas are in cm^2, the units cancel and no conversion is needed.

Final Answer: $v_2 = 3$ m/s $\Rightarrow$ B

Answer: (B) Go Back to Q14

Q15.

Solution

Concept — Heat conduction (Fourier's law): The steady rate of heat flow through a slab is $H = \frac{kA\,\Delta T}{L}$, where k is the thermal conductivity (W $m^{-1}K^{-1}$), A the face area (m^2), ΔT the temperature difference across the slab (K), and L the thickness in the heat-flow direction (m). The result H is a power, measured in watts.

Given: $k = 200$ W $m^{-1}K^{-1}$, $A = 0.5$ m^2, $\Delta T = 20$ K, $L = 0.1$ m.

Step 1 — Write the formula and substitute: $H = \frac{kA\,\Delta T}{L} = \frac{(200)(0.5)(20)}{0.1}$ W.

Step 2 — Multiply the numerator: $200 \times 0.5 = 100$; $100 \times 20 = 2000$, so $H = \frac{2000}{0.1}$ W.

Step 3 — Divide by the thickness: $\frac{2000}{0.1} = 20000$, giving $H = 20000$ W.

Why each other option is wrong:

- (A) 4000 W mishandles the thickness, e.g. dividing by 0.5 instead of 0.1.
- (B) 2000 W forgets to divide by $L = 0.1$ m (treats L as 1 m).
- (D) 400 W slips a power of ten in the final division.

Key point: Dividing by 0.1 multiplies by 10; a thin slab conducts heat fast, so a small L gives a large H.

Final Answer: $H = 20000$ W $\Rightarrow$ C

Answer: (C) Go Back to Q15

Q16.

Solution

Concept — Latent heat of fusion: During a phase change the temperature stays constant while heat is absorbed to break the bonds of the solid. The heat needed is $Q = mL$, where m is the mass (kg) and L is the specific latent heat of fusion (J kg^{-1}). Here L is the energy required to melt 1 kg of ice at $0\,°$C.

Given: $m = 0.5$ kg, $L = 3.36 \times 10^5$ J kg^{-1}.

Step 1 — Write the formula and substitute: $Q = mL = (0.5\ \text{kg})(3.36 \times 10^5\ \text{J kg}^{-1})$.

Step 2 — Multiply by the mass: $0.5 \times 3.36 = 1.68$, keeping the power of ten, so $Q = 1.68 \times 10^5$ J.

Step 3 — State the result: $Q = 1.68 \times 10^5$ J of heat is required to melt all the ice.

Why each other option is wrong:

- (A) 3.36×10^5 J uses $m = 1$ kg, ignoring that only 0.5 kg is present.
- (B) 6.72×10^5 J doubles the mass instead of halving it ($2\times$ instead of $0.5\times$).
- (C) 3.36×10^4 J slips a power of ten in the multiplication.

Key point: Latent heat involves no temperature change; just multiply mass by L and keep the exponent intact.

Final Answer: $Q = 1.68 \times 10^5$ J $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q16

Q17.

Solution

Concept — First law of thermodynamics: Energy conservation for a gas reads $Q = \Delta U + W$, where Q is the heat *added to* the gas, ΔU is the change in internal energy, and W is the work done *by* the gas on its surroundings. Solving for the internal-energy change gives $\Delta U = Q - W$. All quantities are in joules.

Given: $Q = +200$ J (absorbed), $W = +80$ J (work done by the gas on the surroundings).

Step 1 — Write the formula and substitute: $\Delta U = Q - W = 200$ J $- 80$ J.

Step 2 — Evaluate: $\Delta U = 120$ J.

Step 3 — Interpret the sign: Since $\Delta U > 0$, the internal energy (and hence temperature) of the gas rises.

Why each other option is wrong:

- (B) 280 J *adds* the work ($Q + W$) instead of subtracting it.
- (C) 80 J reports just the work done, not the internal-energy change.
- (D) -120 J flips the sign, as if the gas released heat and had work done on it.

Key point: Heat in is positive, work done *by* the gas is positive; with this sign convention $\Delta U = Q - W$.

Final Answer: $\Delta U = 120$ J $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q17

Q18.

Solution

Concept — Field of a long straight wire: A long straight current-carrying wire produces a circular magnetic field around it. Its magnitude at perpendicular distance r is $B = \dfrac{\mu_0 I}{2\pi r}$, where $\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1} is the permeability of free space, I is the current (A), and r is the distance (m). The field falls off as $1/r$.

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

Step 1 — Write the formula and substitute: $B = \dfrac{\mu_0 I}{2\pi r} = \dfrac{(4\pi \times 10^{-7})(5)}{2\pi(0.1)}$.

Step 2 — Cancel π and simplify: $\dfrac{4\pi}{2\pi} = 2$, so $B = \dfrac{(2 \times 10^{-7})(5)}{0.1} = \dfrac{10 \times 10^{-7}}{0.1}$ T.

Step 3 — Divide: $\dfrac{10 \times 10^{-7}}{0.1} = 10 \times 10^{-6} = 1 \times 10^{-5}$ T.

Why each other option is wrong:

- (A) 2×10^{-5} T drops the factor 2 in the denominator (uses πr instead of $2\pi r$).
- (C) 5×10^{-5} T uses a wrong distance (e.g. $r = 0.04$ m) or mishandles the π cancellation.
- (D) 1×10^{-6} T uses $r = 1$ m instead of 0.1 m, slipping one power of ten.

Key point: The factors of π in μ_0 and the denominator cancel neatly; always keep the 2 in $2\pi r$.

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

Answer: (B) Go Back to Q18

Q19.

Solution

Concept — Self-induced emf: A changing current in a coil induces an emf that opposes the change (Lenz's law). Its value is $\varepsilon = -L\frac{dI}{dt}$, where L is the self-inductance (henry, H) and $\frac{dI}{dt}$ is the rate of change of current (A/s). The magnitude is therefore $|\varepsilon| = L\frac{dI}{dt}$, in volts.

Given: $L = 0.2$ H, $\frac{dI}{dt} = 3$ A/s.

Step 1 — Write the formula and substitute: $|\varepsilon| = L\frac{dI}{dt} = (0.2 \text{ H})(3 \text{ A/s})$.

Step 2 — Evaluate: $|\varepsilon| = 0.6$ V.

Why each other option is wrong:

- (A) 0.067 V divides L by the rate $(0.2/3)$ instead of multiplying.
- (B) 1.5 V uses a wrong inductance (e.g. $L = 0.5$ H) or rate.
- (D) 15 V slips a power of ten, treating 0.6 as 15.

Key point: Self-induced emf is the product of inductance and the rate of current change; the minus sign only indicates opposition, not size.

Final Answer: $|\varepsilon| = 0.6 \text{ V} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q19

Q20.

Solution

Concept — Capacitive reactance: A capacitor opposes alternating current through its reactance $X_C = \frac{1}{\omega C}$, where ω is the angular frequency (rad/s) and C is the capacitance (F). The result is in ohms. Reactance falls as frequency or capacitance rises, since the capacitor charges and discharges more easily.

Given: $C = 50\ \mu\text{F} = 50 \times 10^{-6}$ F, $\omega = 1000$ rad/s.

Step 1 — Write the formula and substitute: $X_C = \frac{1}{\omega C} = \frac{1}{(1000)(50 \times 10^{-6})}$.

Step 2 — Simplify the denominator: $(1000)(50 \times 10^{-6}) = 50 \times 10^{-3} = 0.05$, so

$X_C = \dfrac{1}{0.05}\ \Omega.$

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

Why each other option is wrong:

- (A) $50\ \Omega$ mishandles the power of ten, giving $1/0.02$ style values.
- (B) $5\ \Omega$ slips a factor of 4 in the denominator arithmetic.
- (C) $2\ \Omega$ uses a wrong frequency (e.g. $\omega = 10^4$ rad/s).

Key point: Convert microfarads to farads first; then $\omega C = 0.05$ and $X_C = 1/0.05 = 20\ \Omega$.

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

Answer: (D) Go Back to Q20

Q21.

Solution

Concept — Thin lens formula: For a thin lens, $\dfrac{1}{v} - \dfrac{1}{u} = \dfrac{1}{f}$, where u is the object distance, v the image distance, and f the focal length, all measured with the Cartesian sign convention (distances against the incident light are negative). For a real object in front of a converging lens, u is negative and f is positive.

Given: Object distance $u = -30$ cm, focal length $f = +20$ cm (convex lens).

Step 1 — Rearrange and substitute: $\dfrac{1}{v} = \dfrac{1}{f} + \dfrac{1}{u} = \dfrac{1}{20} + \dfrac{1}{-30} = \dfrac{1}{20} - \dfrac{1}{30}.$

Step 2 — Combine the fractions: With LCD 60: $\dfrac{1}{v} = \dfrac{3-2}{60} = \dfrac{1}{60}\ \text{cm}^{-1}.$

Step 3 — Solve for v: $v = 60$ cm. The positive sign means a real, inverted image forms 60 cm beyond the lens.

Why each other option is wrong:

- (B) 12 cm comes from sign errors, e.g. using $\dfrac{1}{f} + \dfrac{1}{u} = \dfrac{1}{20} + \dfrac{1}{30} = \dfrac{1}{12}.$
- (C) 20 cm is merely the focal length, not the image distance for this object.
- (D) 30 cm just repeats the object distance.

Key point: Apply the sign convention before substituting; an object at $2f$ down to f gives an image beyond $2f$, consistent with $v = 60$ cm.

Final Answer: $v = 60 \text{ cm} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q21

Q22.

Solution

Concept — Snell's law of refraction: When light passes from air into a denser medium, it bends toward the normal. Snell's law relates the angles to the refractive index: $n_1 \sin i = n_2 \sin r$. With air ($n_1 \approx 1$), the refractive index of the medium is $n = \frac{\sin i}{\sin r}$, where i is the angle of incidence and r the angle of refraction, both measured from the normal.

Given: $i = 60°$ (in air), $r = 30°$ (in the medium).

Step 1 — Write the formula and substitute: $n = \frac{\sin i}{\sin r} = \frac{\sin 60°}{\sin 30°}$.

Step 2 — Insert sine values: $\sin 60° = \frac{\sqrt{3}}{2} \approx 0.866$ and $\sin 30° = 0.5$, so $n = \frac{0.866}{0.5}$.

Step 3 — Evaluate: $n = 1.73$, which equals $\sqrt{3}$.

Why each other option is wrong:

- (A) 1.5 would correspond to different angles; it does not match $\sin 60°/\sin 30°$.
- (C) 0.58 inverts the ratio ($\sin r/\sin i$), which would imply the medium is rarer.
- (D) 2.0 over-estimates; $\frac{0.866}{0.5}$ is clearly 1.73, not 2.

Key point: Light bends toward the normal entering a denser medium, so $i > r$ and $n > 1$; the ratio must be incidence over refraction.

Final Answer: $n = 1.73 \Rightarrow \boxed{B}$

Answer: (B) Go Back to Q22

Q23.

Solution

Concept — Fringe width in Young's experiment: In a double-slit interference pattern, the spacing between adjacent bright (or dark) fringes is $\beta = \frac{\lambda D}{d}$, where λ is the wavelength of light, D is the slit-to-screen distance, and d is the slit separation. Wider spacing results from longer wavelength, greater screen distance, or smaller slit separation.

Given: $d = 0.5$ mm $= 0.5 \times 10^{-3}$ m, $D = 1$ m, $\lambda = 600$ nm $= 600 \times 10^{-9}$ m.

Step 1 — Write the formula and substitute: $\beta = \dfrac{\lambda D}{d} = \dfrac{(600 \times 10^{-9}\text{ m})(1\text{ m})}{0.5 \times 10^{-3}\text{ m}}$.

Step 2 — Write in clean powers of ten: $600 \times 10^{-9} = 6 \times 10^{-7}$ and $0.5 \times 10^{-3} = 5 \times 10^{-4}$, so $\beta = \dfrac{6 \times 10^{-7}}{5 \times 10^{-4}}$ m.

Step 3 — Evaluate: $\dfrac{6}{5} = 1.2$ and $10^{-7-(-4)} = 10^{-3}$, giving $\beta = 1.2 \times 10^{-3}$ m $= 1.2$ mm.

Why each other option is wrong:

- (A) 0.6 mm halves the result, e.g. by using $d = 1$ mm.
- (B) 0.3 mm slips a further factor of two or a power of ten.
- (D) 2.4 mm doubles the correct value (uses $\lambda = 1200$ nm or $d = 0.25$ mm).

Key point: Keep wavelength and slit separation in metres; the ratio $6 \times 10^{-7}/5 \times 10^{-4}$ cleanly gives 1.2×10^{-3} m.

Final Answer: $\beta = 1.2\text{ mm} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q23

Q24.

Solution

Concept — Einstein's photoelectric equation: When a photon strikes a metal, part of its energy frees the electron (the work function ϕ) and the rest becomes the electron's kinetic energy. The maximum kinetic energy is $K_{\text{max}} = h\nu - \phi$, where $h\nu$ is the incident photon energy and ϕ is the work function. Emission occurs only when $h\nu > \phi$.

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

Step 1 — Write the formula and substitute: $K_{\text{max}} = h\nu - \phi = 5\text{ eV} - 2\text{ eV}$.

Step 2 — Evaluate: $K_{\text{max}} = 3$ eV.

Why each other option is wrong:

- (A) 7 eV *adds* photon energy and work function instead of subtracting.
- (B) 2 eV simply reports the work function ϕ, not the kinetic energy.

- (C) 10 eV multiplies the two energies, which is dimensionally meaningless here.

Key point: The electron keeps whatever photon energy is left after paying the work-function "toll"; subtract, never add.

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

Answer: (D) Go Back to Q24

Q25.

Solution

Concept — de Broglie wavelength: Every moving particle has an associated matter wave whose wavelength is $\lambda = \dfrac{h}{mv} = \dfrac{h}{p}$, where $h = 6.6 \times 10^{-34}$ J s is Planck's constant, m is the particle mass (kg), v its speed (m/s), and $p = mv$ is the momentum. Heavier or faster particles have shorter wavelengths.

Given: $m = 2 \times 10^{-30}$ kg, $v = 1.1 \times 10^{6}$ m/s, $h = 6.6 \times 10^{-34}$ J s.

Step 1 — Write the formula and substitute: $\lambda = \dfrac{h}{mv} = \dfrac{6.6 \times 10^{-34}}{(2 \times 10^{-30})(1.1 \times 10^{6})}$.

Step 2 — Compute the momentum (denominator): $(2 \times 10^{-30})(1.1 \times 10^{6}) = 2.2 \times 10^{-24}$ kg m/s.

Step 3 — Divide: $\lambda = \dfrac{6.6 \times 10^{-34}}{2.2 \times 10^{-24}} = 3 \times 10^{-10}$ m (since $6.6/2.2 = 3$ and $10^{-34+24} = 10^{-10}$).

Why each other option is wrong:

- (B) 6×10^{-10} m doubles the result, e.g. by halving the momentum.
- (C) 1.5×10^{-10} m halves it, doubling the momentum.
- (D) 3×10^{-9} m slips one power of ten in the exponent subtraction.

Key point: Compute mv first, then divide h by it; carefully subtract exponents: $10^{-34}/10^{-24} = 10^{-10}$.

Final Answer: $\lambda = 3 \times 10^{-10}$ m $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q25

Q26.

Solution

Concept — Bohr energy levels of hydrogen: In the Bohr model, the electron occupies discrete energy levels given by $E_n = -\frac{13.6}{n^2}$ eV, where $n = 1, 2, 3, \ldots$ is the principal quantum number. The energies are negative (bound states), with the ground state $n = 1$ at -13.6 eV; energies rise (become less negative) toward 0 as n increases.

Given: $E_n = -\frac{13.6}{n^2}$ eV; required level $n = 2$.

Step 1 — Substitute $n = 2$**:** $E_2 = -\frac{13.6}{2^2} = -\frac{13.6}{4}$ eV.

Step 2 — Evaluate: $\frac{13.6}{4} = 3.4$, so $E_2 = -3.4$ eV.

Why each other option is wrong:

- (A) -6.8 eV divides by $n^2 = 2$ instead of 4 (forgets to square n).
- (C) -13.6 eV is the $n = 1$ ground-state energy, not $n = 2$.
- (D) -1.51 eV is the $n = 3$ level $(13.6/9)$, not $n = 2$.

Key point: Always *square* the quantum number; for $n = 2$, divide 13.6 by 4, giving -3.4 eV.

Final Answer: $E_2 = -3.4$ eV $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q26

Q27.

Solution

Concept — Spring-mass SHM: A mass on a spring executes simple harmonic motion with time period $T = 2\pi\sqrt{\frac{m}{k}}$, where m is the mass (kg) and k is the spring's force constant (N/m). The period grows with mass and shrinks with stiffness, and is independent of the amplitude.

Given: $m = 2$ kg, $k = 200$ N/m.

Step 1 — Write the formula and substitute: $T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{2}{200}}$.

Step 2 — Simplify the ratio: $\frac{2}{200} = 0.01$ s^2, so $T = 2\pi\sqrt{0.01} = 2\pi(0.1)$.

Step 3 — Evaluate: $2\pi(0.1) = 0.628$ s (using $2\pi \approx 6.283$).

Why each other option is wrong:

- (A) 0.314 s uses π instead of 2π, halving the period.
- (B) 0.1 s drops the factor 2π entirely, reporting only $\sqrt{m/k}$.
- (D) 1.0 s uses a wrong m/k ratio (e.g. treating it as 0.025).

Key point: Take the square root of m/k first, then multiply by 2π; $\sqrt{0.01} = 0.1$, giving $T = 0.628$ s.

Final Answer: $T = 0.628$ s $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q27

Q28.

Solution

Concept — Wave speed relation: For any wave, speed, frequency and wavelength are linked by $v = f\lambda$, where v is the wave speed (m/s), f the frequency (Hz), and λ the wavelength (m). Solving for frequency gives $f = \dfrac{v}{\lambda}$.

Given: $v = 340$ m/s, $\lambda = 0.85$ m.

Step 1 — Write the formula and substitute: $f = \dfrac{v}{\lambda} = \dfrac{340 \text{ m/s}}{0.85 \text{ m}}$.

Step 2 — Evaluate: $\dfrac{340}{0.85} = 400$, so $f = 400$ Hz (the metres cancel, leaving $\text{s}^{-1} =$ Hz).

Why each other option is wrong:

- (A) 289 Hz multiplies v by λ (340×0.85) instead of dividing.
- (B) 0.0025 Hz inverts the formula, computing λ/v.
- (C) 200 Hz uses $\lambda = 1.7$ m, double the given wavelength.

Key point: Frequency is speed divided by wavelength; dividing by 0.85 is the same as multiplying by about 1.18.

Final Answer: $f = 400$ Hz $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q28

Q29.

Solution

Concept — n-type semiconductor doping: Silicon is tetravalent, so each atom forms four covalent bonds. Doping with a pentavalent impurity (such as phosphorus or arsenic) introduces atoms with five valence electrons; four form bonds and the fifth is loosely bound and easily freed. These donor atoms supply free electrons, making electrons the dominant carriers – hence "n-type" for negative charge carriers.

Step 1 — Count the contributed carriers: Each pentavalent donor gives one extra conduction electron, so the free-electron population greatly exceeds the thermally generated holes.

Step 2 — Identify majority vs minority: Electrons are the majority carriers; the few holes present are the minority carriers.

Step 3 — Conclusion: In an n-type semiconductor the majority charge carriers are electrons.

Why each other option is wrong:

- (B) holes are the *minority* carriers in n-type material, not the majority.
- (C) protons are bound in the nuclei and never act as mobile charge carriers in a solid.
- (D) negative ions are not the conduction mechanism; conduction is by free electrons, not migrating ions.

Key point: Pentavalent (donor) doping gives n-type with electron majority; trivalent (acceptor) doping would give p-type with hole majority.

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

Answer: (A) Go Back to Q29

Q30.

Solution

Concept — Reverse-biased p-n junction: A p-n junction has a built-in depletion region: a thin layer at the junction emptied of mobile carriers, with an internal field opposing further diffusion. In reverse bias the external supply connects $+$ to the n-side and $-$ to the p-side (as the figure shows), so the applied field *adds* to the built-in field, pulling electrons and holes further away from the junction.

Step 1 — Effect of the applied field: The reverse voltage drives majority carriers away from the junction on both sides, exposing more fixed ionic charge.

Step 2 — Effect on the depletion layer: With mobile carriers swept back, the charge-free region grows, so the depletion width *increases*; only a tiny reverse leakage current flows.

Step 3 — Conclusion: Reverse biasing widens the depletion region (and raises the junction's potential barrier).

Why each other option is wrong:

- (A) "decreases" describes *forward* bias, where the applied field opposes the built-in field and narrows the layer.
- (B) "stays exactly the same" is wrong because the applied voltage clearly changes the carrier distribution.
- (D) "becomes zero" would require very heavy forward bias, not reverse bias.

Key point: Reverse bias widens the depletion region and blocks current; forward bias narrows it and allows current.

Final Answer: The depletion region increases $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q30

Answer Key

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