AIIMS Paramedical Physics

Sample Paper – 1

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

Instructions

- This paper contains **30** Multiple Choice Questions (Single Correct Answer), modelled on the Physics portion of **AIIMS Paramedical** entrance.
- Each correct answer carries **+1 mark**. A penalty of $-\frac{1}{3}$ **mark** is deducted for each incorrect answer. Unattempted questions carry **0** marks (no negative marking).
- Only **one** option is correct. Choose carefully.
- Syllabus level: **Class 11 & 12 NCERT Physics**
- Use of mobile phones, calculators, or electronic gadgets is strictly prohibited.

Q1. The coefficient of viscosity η appears in the force law $F = \eta A \frac{dv}{dx}$, where A is area, v is velocity and x is distance. The dimensional formula of η is:

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

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

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

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

Q2. A ball is projected with speed 20 m s^{-1} at 30° above the horizontal. Taking $g = 10$ m s^{-2}, its maximum height H and horizontal range R are respectively:

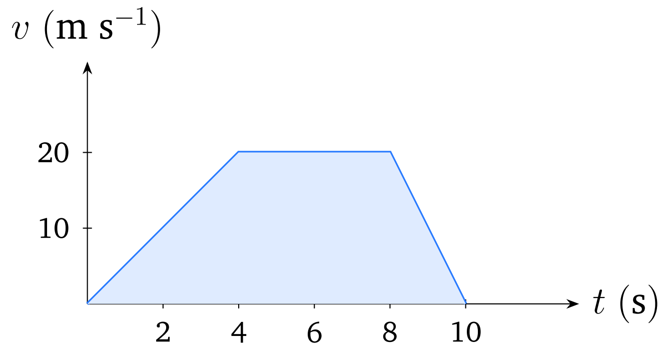
(A) $H = 5$ m, $R = 20\sqrt{3}$ m

(B) $H = 10$ m, $R = 20\sqrt{3}$ m

(C) $H = 5$ m, $R = 40$ m

(D) $H = 10$ m, $R = 40$ m

Q3. The velocity–time graph of a particle moving in a straight line is shown. The total displacement in the 10 s interval is:



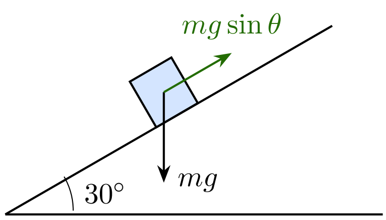
(A) 40 m

(B) 50 m

(C) 60 m

(D) 70 m

Q4. A block of mass 2 kg is released on a rough incline of angle $30°$ with coefficient of kinetic friction $\mu = \dfrac{1}{2\sqrt{3}}$. Taking $g = 10$ m s^{-2}, its acceleration down the incline is:



(A) 2.0 m s^{-2}

(B) 2.5 m s^{-2}

(C) 5.0 m s^{-2}

(D) 7.5 m s^{-2}

Q5. Two masses 3 kg and 2 kg hang from the two ends of a light inextensible string passing over a frictionless pulley. Taking $g = 10$ m s^{-2}, the acceleration of the system and the string tension are:

(A) $a = 2$ m s^{-2}, $T = 24$ N

(B) $a = 2$ m s^{-2}, $T = 30$ N

(C) $a = 4$ m s^{-2}, $T = 24$ N

(D) $a = 5$ m s^{-2}, $T = 20$ N

Q6. A block moving with kinetic energy 18 J strikes a horizontal spring of force constant $k = 400$ N m^{-1} and is brought momentarily to rest. The maximum compression of the spring is:

(A) 0.15 m

(B) 0.20 m

(C) 0.30 m

(D) 0.45 m

Q7. A pump raises 600 kg of water per minute from a well and delivers it at the top with negligible speed through a height of 20 m. Taking $g = 10$ m s^{-2}, the minimum power of the pump is:

(A) 1000 W

(B) 2000 W

(C) 3000 W

(D) 6000 W

Q8. A uniform circular disc of mass 4 kg and radius 0.5 m rotates about an axis through its centre and perpendicular to its plane. Its moment of inertia is:

(A) 0.125 kg m^2

(B) 0.25 kg m^2

(C) 1.0 kg m^2

(D) 0.5 kg m^2

Q9. A satellite orbits the Earth (radius $R = 6400$ km, surface gravity $g = 10$ m s^{-2}) at a height $h = R$ above the surface. Its orbital speed is approximately:

(A) 8.0 km s^{-1}

(B) 6.4 km s^{-1}

(C) 5.7 km s^{-1}

(D) 11.2 km s^{-1}

Q10. A steel wire of length 2 m and cross-sectional area 1 mm^2 is stretched by a load of 100 N. If Young's modulus of steel is 2×10^{11} N m^{-2}, the elongation of the wire is:

(A) 1.0 mm

(B) 0.5 mm

(C) 2.0 mm

(D) 0.25 mm

Q11. The amount of heat required to convert 10 g of ice at $0°$C completely into steam at $100°$C is (take $L_f = 80$ cal g^{-1}, $L_v = 540$ cal g^{-1}, specific heat of water $= 1$ cal g^{-1} °C^{-1}):

(A) 6200 cal

(B) 7200 cal

(C) 5400 cal

(D) 8000 cal

Q12. One mole of an ideal gas expands isothermally and reversibly at temperature $T = 300$ K from volume V to $2V$. Taking $R = 8.3$ J mol^{-1}K^{-1} and $\ln 2 = 0.693$, the work done by the gas is approximately:

(A) 830 J

(B) 1245 J

(C) 1725 J

(D) 2490 J

Q13. A mass of 0.4 kg attached to a spring executes simple harmonic motion with a force constant $k = 100$ N m^{-1}. The time period of oscillation is approximately:

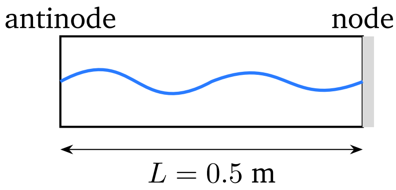
(A) 0.1 s

(B) 0.2 s

(C) 0.6 s

(D) 0.4 s

Q14. A closed organ pipe (closed at one end) of length 0.5 m resonates with air in which the speed of sound is 340 m s^{-1}. The fundamental frequency of the pipe is:



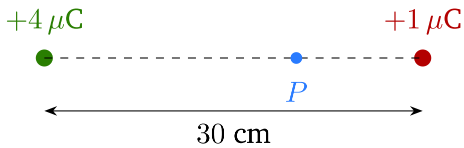
(A) 170 Hz

(B) 340 Hz

(C) 255 Hz

(D) 510 Hz

Q15. Two point charges $+4\ \mu$C and $+1\ \mu$C are fixed 30 cm apart as shown. At what distance from the $+4\ \mu$C charge (along the line joining them) is the net electric field zero?



(A) 10 cm

(B) 20 cm

(C) 15 cm

(D) 25 cm

Q16. Two point charges $+2\ \mu$C and $-2\ \mu$C are placed 0.2 m apart. The electric potential at the midpoint of the line joining them is (take $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ SI units):

(A) 1.8×10^5 V

(B) 3.6×10^5 V

(C) 0 V

(D) 9.0×10^4 V

Q17. Three capacitors of $6\ \mu$F, $6\ \mu$F and $3\ \mu$F are connected so that the two $6\ \mu$F capacitors are in series, and this combination is in parallel with the $3\ \mu$F capacitor. The equivalent capacitance is:

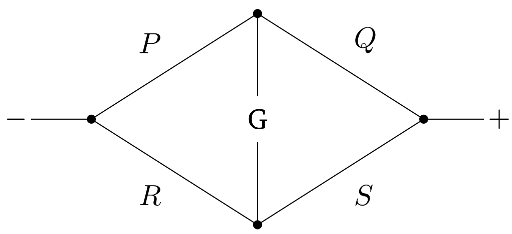
(A) $15\ \mu$F

(B) $9\ \mu$F

(C) $4.5\ \mu$F

(D) $6\ \mu$F

Q18. In the balanced Wheatstone bridge shown, the galvanometer reads zero. Given $P = 10\ \Omega$, $Q = 20\ \Omega$ and $R = 15\ \Omega$, the unknown resistance S is:



(A) $30\ \Omega$

(B) $7.5\ \Omega$

(C) $20\ \Omega$

(D) $45\ \Omega$

Q19. A cell of EMF 2.0 V and internal resistance $0.5\ \Omega$ is connected to an external resistance of $1.5\ \Omega$. The terminal voltage across the cell is:

(A) 2.0 V

(B) 1.5 V

(C) 1.0 V

(D) 0.5 V

Q20. A copper wire carries a current of 1.6 A. If the free-electron density is $n = 8 \times 10^{28}$ m^{-3} and the cross-sectional area is 1×10^{-6} m^2 (take $e = 1.6 \times 10^{-19}$ C), the drift velocity of the electrons is:

(A) 1.25×10^{-3} m s^{-1}

(B) 1.25×10^{-2} m s^{-1}

(C) 1.25×10^{-4} m s^{-1}

(D) 1.25×10^{-5} m s^{-1}

Q21. A proton (charge 1.6×10^{-19} C, mass 1.6×10^{-27} kg) moves with speed 2×10^5 m s^{-1} perpendicular to a uniform magnetic field of 0.4 T. The radius of its circular path is:

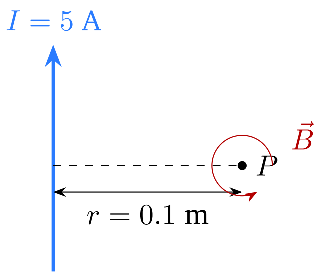
(A) 1.25×10^{-2} m

(B) 2.5×10^{-2} m

(C) 1.0×10^{-2} m

(D) 5.0×10^{-3} m

Q22. A long straight wire carries a current of 5 A. The magnitude of the magnetic field at a perpendicular distance of 0.1 m from the wire is (take $\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}):



(A) 1.0×10^{-5} T

(B) 2.0×10^{-5} T

(C) 0.5×10^{-5} T

(D) 4.0×10^{-5} T

Q23. A conducting rod of length 0.5 m moves with a velocity of 4 m s^{-1} perpendicular to its length in a uniform magnetic field of 0.2 T directed perpendicular to both the rod and its velocity. The EMF induced across the rod is:

(A) 0.2 V

(B) 0.4 V

(C) 0.8 V

(D) 1.6 V

Q24. An ideal step-down transformer has 1000 turns in its primary and 100 turns in its secondary. If the primary is connected to 220 V AC, the secondary output voltage is:

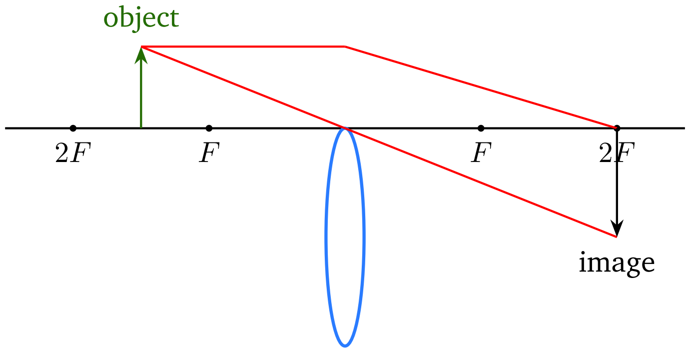
(A) 2200 V

(B) 110 V

(C) 22 V

(D) 44 V

Q25. An object is placed 30 cm in front of a convex lens of focal length 20 cm. The position of the image and its magnification are:



(A) $v = 60$ cm, $m = +2$

(B) $v = -60$ cm, $m = +2$

(C) $v = 60$ cm, $m = +1$

(D) $v = 60$ cm, $m = -2$

Q26. A medium has refractive index $\sqrt{2}$ relative to air. The critical angle for total internal reflection at the medium–air boundary is:

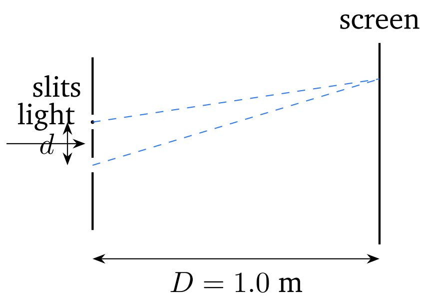
(A) $45°$

(B) $30°$

(C) $60°$

(D) $90°$

Q27. In a Young's double-slit experiment, the slit separation is 0.5 mm and the screen is 1.0 m away. Light of wavelength 600 nm is used. The fringe width on the screen is:



(A) 0.6 mm

(B) 1.2 mm

(C) 2.4 mm

(D) 0.3 mm

Q28. Light of energy 5 eV falls on a metal surface whose work function is 2 eV. The stopping potential required to halt the most energetic photoelectrons is:

(A) 5 V

(B) 2 V

(C) 3 V

(D) 7 V

Q29. In the Bohr model of the hydrogen atom, the energy of the electron in the ground state is -13.6 eV. The energy of the electron in the second excited state ($n = 3$) is:

(A) -3.4 eV

(B) -6.8 eV

(C) -13.6 eV

(D) -1.51 eV

Q30. A single pn-junction diode is used as a half-wave rectifier with a sinusoidal AC input of frequency 50 Hz. The frequency of the rectified output (ripple) is:

(A) 50 Hz

(B) 100 Hz

(C) 25 Hz

(D) 0 Hz (DC)

Detailed Solutions

Q1.

Solution

Concept — Dimensional analysis: Each physical quantity has a dimensional formula in terms of mass $[M]$, length $[L]$ and time $[T]$. We isolate η from the given force law and substitute dimensions.

Step 1 — Rearrange the law: From $F = \eta A \dfrac{dv}{dx}$ we get

$$\eta = \frac{F}{A\,(dv/dx)}.$$

Step 2 — Substitute dimensions: Force $[F] = [MLT^{-2}]$, area $[A] = [L^2]$, and velocity gradient $\dfrac{dv}{dx}$ has dimensions $\dfrac{[LT^{-1}]}{[L]} = [T^{-1}]$.

Step 3 — Combine:

$$[\eta] = \frac{[MLT^{-2}]}{[L^2]\,[T^{-1}]} = [ML^{-1}T^{-1}].$$

Why other options are wrong:

- (A) $[ML^{-1}T^{-2}]$ is the dimension of pressure or stress, not viscosity.
- (B) $[MLT^{-1}]$ is the dimension of linear momentum.
- (D) $[ML^{-2}T^{-1}]$ has the wrong power of length.

Final Answer: $[\eta] = [ML^{-1}T^{-1}] \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 1

Q2.

Solution

Concept — Projectile motion: For a projectile launched with speed u at angle θ, the maximum height is $H = \dfrac{u^2 \sin^2\theta}{2g}$ and the range is $R = \dfrac{u^2 \sin 2\theta}{g}$.

Step 1 — List the data: $u = 20$ m s^{-1}, $\theta = 30°$, $g = 10$ m s^{-2}. So $\sin 30° = \frac{1}{2}$ and $\sin 60° = \frac{\sqrt{3}}{2}$.

Step 2 — Maximum height:

$$H = \frac{u^2 \sin^2\theta}{2g} = \frac{(20)^2(\frac{1}{2})^2}{2 \times 10} = \frac{400 \times \frac{1}{4}}{20} = \frac{100}{20} = 5 \text{ m}.$$

Step 3 — Range:

$$R = \frac{u^2 \sin 2\theta}{g} = \frac{400 \times \sin 60^\circ}{10} = \frac{400 \times \frac{\sqrt{3}}{2}}{10} = \frac{200\sqrt{3}}{10} = 20\sqrt{3} \text{ m}.$$

Why other options are wrong:

- (B) doubles the height by dropping the $\sin^2\theta$ factor.
- (C) and (D) use $R = 40$ m, which would need $\theta = 45^\circ$.

Final Answer: $H = 5 \text{ m}, \ R = 20\sqrt{3} \text{ m} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 2

Q3.

Solution

Concept — Area under a v–t graph: The displacement of a particle in a time interval equals the area enclosed between the velocity–time curve and the time axis.

Step 1 — Identify the shape: The graph rises from $(0, 0)$ to $(2, 20)$, stays flat at 20 m s^{-1} until $t = 4$ s, then falls to $(5, 0)$. This is a trapezium with parallel sides on the velocity axis.

Step 2 — Use the trapezium area: The parallel sides are the top edge (from $t = 2$ to $t = 4$, length 2 s) and the base on the time axis (from $t = 0$ to $t = 5$, length 5 s); the height is the peak velocity 20 m s^{-1}.

$$\text{Area} = \frac{1}{2}(\text{sum of parallel sides}) \times \text{height}.$$

Step 3 — Compute:

$$\text{Displacement} = \frac{1}{2}(5 + 2) \times 20 = \frac{1}{2} \times 7 \times 20 = 70 \text{ m}.$$

Why other options are wrong:

- (A) 40 m counts only the flat part incorrectly.
- (B) and (C) miss part of the rising or falling triangle.

Final Answer: Displacement $= 70 \text{ m} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 3

Q4.

Solution

Concept — Block on a rough incline: The component of gravity along the incline ($mg\sin\theta$) drives the block down, while kinetic friction ($\mu mg\cos\theta$) opposes the motion. Net force gives the acceleration.

Step 1 — Write the equation of motion:

$$ma = mg\sin\theta - \mu mg\cos\theta, \qquad a = g(\sin\theta - \mu\cos\theta).$$

Step 2 — Substitute values: $\theta = 30°$, so $\sin 30° = \frac{1}{2}$, $\cos 30° = \frac{\sqrt{3}}{2}$, and $\mu = \dfrac{1}{2\sqrt{3}}$.

$$\mu\cos\theta = \frac{1}{2\sqrt{3}} \times \frac{\sqrt{3}}{2} = \frac{1}{4}.$$

Step 3 — Compute the acceleration:

$$a = 10\left(\frac{1}{2} - \frac{1}{4}\right) = 10 \times \frac{1}{4} = 2.5 \text{ m s}^{-2}.$$

Why other options are wrong:

- (A) 2.0 m s^{-2} uses a wrong friction term.
- (C) 5.0 m s^{-2} ignores friction entirely ($g\sin\theta$).
- (D) 7.5 m s^{-2} exceeds even the frictionless value.

Final Answer: $a = 2.5$ m s^{-2} $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q 4

Q5.

Solution

Concept — Atwood machine: For two masses $m_1 > m_2$ over a frictionless pulley, the acceleration is $a = \dfrac{(m_1 - m_2)g}{m_1 + m_2}$ and the string tension is $T = \dfrac{2m_1 m_2 g}{m_1 + m_2}$.

Step 1 — Identify masses: $m_1 = 3$ kg (heavier), $m_2 = 2$ kg, $g = 10$ m s^{-2}.

Step 2 — Acceleration:

$$a = \frac{(3-2)\times 10}{3+2} = \frac{10}{5} = 2 \text{ m s}^{-2}.$$

Step 3 — Tension:

$$T = \frac{2 \times 3 \times 2 \times 10}{5} = \frac{120}{5} = 24 \text{ N}.$$

Why other options are wrong:

- (B) keeps a correct but uses $T = 30$ N (the static weight of 3 kg).
- (C) and (D) use wrong accelerations.

Final Answer: $a = 2 \text{ m s}^{-2}$, $T = 24 \text{ N} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 5

Q6.

Solution

Concept — Work-energy theorem with a spring: The kinetic energy of the block is fully converted into the elastic potential energy stored in the spring at maximum compression x, where $U = \frac{1}{2}kx^2$.

Step 1 — Equate energies:

$$\frac{1}{2}kx^2 = KE.$$

Step 2 — Solve for x:

$$x = \sqrt{\frac{2\,KE}{k}} = \sqrt{\frac{2 \times 18}{400}} = \sqrt{\frac{36}{400}}.$$

Step 3 — Evaluate:

$$x = \frac{6}{20} = 0.30 \text{ m}.$$

Why other options are wrong:

- (A) and (B) come from arithmetic errors in the square root.
- (D) 0.45 m uses $k = 200$ instead of 400.

Final Answer: $x = 0.30 \text{ m} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 6

Q7.

Solution

Concept — Power of a pump: Power is the rate of doing work. To lift water of mass m through height h in time t, the work done is mgh and the power is $P = \dfrac{mgh}{t}$.

Step 1 — Convert the rate: 600 kg is lifted per minute, so per second $\dfrac{m}{t} = \dfrac{600}{60} = 10\ \text{kg s}^{-1}$.

Step 2 — Apply the power formula:

$$P = \frac{m}{t}\,g\,h = 10 \times 10 \times 20.$$

Step 3 — Evaluate:

$$P = 2000\ \text{W}.$$

Why other options are wrong:

- (A) 1000 W forgets a factor of 2 in the height or rate.
- (C) and (D) overcount by using 600 kg per second or wrong g.

Final Answer: $P = 2000\ \text{W} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 7

Q8.

Solution

Concept — Moment of inertia of a disc: For a uniform circular disc of mass M and radius R, rotating about an axis through its centre perpendicular to its plane, $I = \frac{1}{2}MR^2$.

Step 1 — List the data: $M = 4$ kg, $R = 0.5$ m.

Step 2 — Apply the formula:

$$I = \frac{1}{2}MR^2 = \frac{1}{2} \times 4 \times (0.5)^2.$$

Step 3 — Evaluate:

$$I = \frac{1}{2} \times 4 \times 0.25 = 0.5\ \text{kg m}^2.$$

Why other options are wrong:

- (A) 0.125 kg m^2 uses $\frac{1}{4}MR^2$ (diameter axis).
- (B) and (C) come from dropping the $\frac{1}{2}$ factor or squaring R wrongly.

Final Answer: $I = 0.5$ kg m^2 $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q 8

Q9.

Solution

Concept — Orbital velocity: A satellite at height h above a planet of radius R orbits with speed $v = \sqrt{\dfrac{gR^2}{R+h}}$, where g is the surface gravity.

Step 1 — Set the orbit radius: With $h = R$, the orbit radius is $R + h = 2R$.

Step 2 — Substitute:

$$v = \sqrt{\frac{gR^2}{2R}} = \sqrt{\frac{gR}{2}}.$$

Step 3 — Plug in numbers: $g = 10$ m s^{-2}, $R = 6.4 \times 10^6$ m.

$$v = \sqrt{\frac{10 \times 6.4 \times 10^6}{2}} = \sqrt{3.2 \times 10^7} \approx 5.66 \times 10^3 \text{ m s}^{-1} \approx 5.7 \text{ km s}^{-1}.$$

Why other options are wrong:

- (A) 8.0 km s^{-1} is the low-orbit speed at $h = 0$.
- (D) 11.2 km s^{-1} is the escape velocity, not orbital.

Final Answer: $v \approx 5.7$ km s^{-1} $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q 9

Q10.

Solution

Concept — Young's modulus: For a wire of length L, area A under load F, Young's modulus $Y = \frac{FL}{A\,\Delta L}$, so the elongation is $\Delta L = \frac{FL}{AY}$.

Step 1 — Convert the area: $A = 1\ \text{mm}^2 = 1 \times 10^{-6}\ \text{m}^2$.

Step 2 — Substitute the data: $F = 100$ N, $L = 2$ m, $Y = 2 \times 10^{11}$ N m^{-2}.

$$\Delta L = \frac{100 \times 2}{(1 \times 10^{-6})(2 \times 10^{11})}.$$

Step 3 — Evaluate:

$$\Delta L = \frac{200}{2 \times 10^5} = 1 \times 10^{-3}\ \text{m} = 1.0\ \text{mm}.$$

Why other options are wrong:

- (B) 0.5 mm drops a factor of two in the length.
- (C) and (D) use the wrong power of ten for the area.

Final Answer: $\Delta L = 1.0$ mm $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q 10

Q11.

Solution

Concept — Calorimetry: Heat is needed in three stages: melt the ice (latent heat of fusion), warm the water from 0°C to 100°C, then boil it (latent heat of vaporisation).

Step 1 — Melting the ice:

$$Q_1 = mL_f = 10 \times 80 = 800\ \text{cal}.$$

Step 2 — Heating the water:

$$Q_2 = mc\,\Delta T = 10 \times 1 \times 100 = 1000\ \text{cal}.$$

Step 3 — Boiling the water:

$$Q_3 = mL_v = 10 \times 540 = 5400 \text{ cal}.$$

Step 4 — Total heat:

$$Q = Q_1 + Q_2 + Q_3 = 800 + 1000 + 5400 = 7200 \text{ cal}.$$

Why other options are wrong:

- (C) 5400 cal counts only the vaporisation stage.
- (A) and (D) omit one of the three stages.

Final Answer: $Q = 7200$ cal $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 11

Q12.

Solution

Concept — Isothermal work: For an ideal gas expanding isothermally and reversibly, the work done by the gas is $W = nRT \ln \frac{V_2}{V_1}$.

Step 1 — List the data: $n = 1$, $R = 8.3$ J mol^{-1}K^{-1}, $T = 300$ K, $\frac{V_2}{V_1} = 2$.

Step 2 — Substitute:

$$W = 1 \times 8.3 \times 300 \times \ln 2.$$

Step 3 — Evaluate:

$$W = 2490 \times 0.693 \approx 1725 \text{ J}.$$

Why other options are wrong:

- (D) 2490 J forgets the $\ln 2$ factor.
- (A) and (B) use wrong arithmetic for $nRT \ln 2$.

Final Answer: $W \approx 1725$ J $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 12

Q13.

Solution

Concept — Spring-mass SHM: A mass m on a spring of force constant k oscillates with time period $T = 2\pi\sqrt{\frac{m}{k}}$.

Step 1 — Form the ratio:

$$\frac{m}{k} = \frac{0.4}{100} = 4 \times 10^{-3}\ \text{s}^2.$$

Step 2 — Take the square root:

$$\sqrt{\frac{m}{k}} = \sqrt{4 \times 10^{-3}} = 0.0632\ \text{s}.$$

Step 3 — Multiply by 2π:

$$T = 2\pi \times 0.0632 \approx 0.397 \approx 0.4\ \text{s}.$$

Why other options are wrong:

- (A) and (B) drop the 2π factor.
- (C) 0.6 s uses a wrong mass-to-stiffness ratio.

Final Answer: $T \approx 0.4$ s $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q 13

Q14.

Solution

Concept — Closed organ pipe: A pipe closed at one end has a displacement node at the closed end and an antinode at the open end. Its fundamental wavelength is $\lambda = 4L$, so $f = \frac{v}{4L}$.

Step 1 — List the data: $L = 0.5$ m, $v = 340$ m s^{-1}.

Step 2 — Apply the formula:

$$f = \frac{v}{4L} = \frac{340}{4 \times 0.5}.$$

Step 3 — Evaluate:

$$f = \frac{340}{2} = 170 \text{ Hz}.$$

Why other options are wrong:

- (B) 340 Hz uses $f = \frac{v}{2L}$ (open pipe).
- (D) 510 Hz is the third harmonic ($3f$), not the fundamental.

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

Answer: (A) Go Back to Q 14

Q15.

Solution

Concept — Null point of electric field: Between two like charges there is a point where the fields cancel. Setting the field magnitudes equal locates it.

Step 1 — Set up the balance: Let P be at distance x from the $+4\,\mu$C charge, so it is $(30 - x)$ cm from the $+1\,\mu$C charge. The fields are equal at the null point:

$$\frac{k(4\mu)}{x^2} = \frac{k(1\mu)}{(30 - x)^2}.$$

Step 2 — Simplify:

$$\frac{4}{x^2} = \frac{1}{(30 - x)^2} \Rightarrow \frac{(30 - x)^2}{x^2} = \frac{1}{4}.$$

Step 3 — Take the square root:

$$\frac{30 - x}{x} = \frac{1}{2} \Rightarrow 2(30 - x) = x \Rightarrow 60 = 3x \Rightarrow x = 20 \text{ cm}.$$

Why other options are wrong:

- (A) 10 cm places the point closer to the larger charge, where its field dominates.
- (C) and (D) do not satisfy the inverse-square balance.

Final Answer: $x = 20$ cm from the $+4\,\mu$C charge $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q 15

Q16.

Solution

Concept — Electric potential (a scalar sum): The potential due to several point charges is the algebraic sum $V = \sum \frac{kq_i}{r_i}$, where signs of the charges are included.

Step 1 — Locate the midpoint: Each charge is 0.1 m from the midpoint.

Step 2 — Add the two contributions:

$$V = \frac{k(+2\mu)}{0.1} + \frac{k(-2\mu)}{0.1}.$$

Step 3 — Cancel: The two terms are equal in magnitude and opposite in sign, so

$$V = 0\text{ V}.$$

Why other options are wrong:

- (A), (B), (D) ignore the sign of the negative charge; potential is a scalar that must be added with sign.
- Note: the electric *field* at the midpoint is non-zero, but the *potential* cancels.

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

Answer: (C) **Go Back to Q 16**

Q17.

Solution

Concept — Series and parallel capacitors: Capacitors in series add reciprocally ($\frac{1}{C_s} = \frac{1}{C_1} + \frac{1}{C_2}$); capacitors in parallel add directly ($C_p = C_a + C_b$).

Step 1 — Series combination of the two $6\,\mu$F capacitors:

$$\frac{1}{C_s} = \frac{1}{6} + \frac{1}{6} = \frac{2}{6} = \frac{1}{3} \Rightarrow C_s = 3\ \mu\text{F}.$$

Step 2 — Parallel with the $3\,\mu$F capacitor:

$$C_{eq} = C_s + 3 = 3 + 3 = 6\ \mu\text{F}.$$

Why other options are wrong:

- (A) $15\,\mu$F adds all three in parallel.
- (B) $9\,\mu$F forgets the series reduction of the $6\,\mu$F pair.
- (C) $4.5\,\mu$F mishandles the parallel step.

Final Answer: $C_{eq} = 6\ \mu\text{F} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 17

Q18.

Solution

Concept — Balanced Wheatstone bridge: When the galvanometer reads zero, the bridge is balanced and $\dfrac{P}{Q} = \dfrac{R}{S}$.

Step 1 — Write the balance condition:

$$\frac{P}{Q} = \frac{R}{S} \Rightarrow S = \frac{QR}{P}.$$

Step 2 — Substitute: $P = 10\ \Omega$, $Q = 20\ \Omega$, $R = 15\ \Omega$.

$$S = \frac{20 \times 15}{10}.$$

Step 3 — Evaluate:

$$S = \frac{300}{10} = 30\ \Omega.$$

Why other options are wrong:

- (B) $7.5\ \Omega$ inverts the ratio.
- (C) and (D) use the wrong arm pairing.

Final Answer: $S = 30\ \Omega \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 18

Q19.

Solution

Concept — Terminal voltage: For a cell of EMF E and internal resistance r driving current I through external resistance R, the current is $I = \frac{E}{R+r}$ and the terminal voltage is $V = IR = E - Ir$.

Step 1 — Find the current:

$$I = \frac{E}{R+r} = \frac{2.0}{1.5+0.5} = \frac{2.0}{2.0} = 1.0 \text{ A}.$$

Step 2 — Terminal voltage:

$$V = IR = 1.0 \times 1.5 = 1.5 \text{ V}.$$

Step 3 — Check: $V = E - Ir = 2.0 - 1.0 \times 0.5 = 1.5$ V. Consistent.

Why other options are wrong:

- (A) 2.0 V ignores the internal-resistance drop.
- (C) and (D) use wrong current or resistance values.

Final Answer: $V = 1.5 \text{ V} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 19

Q20.

Solution

Concept — Drift velocity: The current in a conductor is $I = nAe\,v_d$, where n is electron density, A the area, e the electron charge and v_d the drift velocity. Hence $v_d = \frac{I}{nAe}$.

Step 1 — Form the denominator:

$$nAe = (8 \times 10^{28})(1 \times 10^{-6})(1.6 \times 10^{-19}).$$

Step 2 — Evaluate the denominator:

$$nAe = 8 \times 1.6 \times 10^{28-6-19} = 12.8 \times 10^{3} = 1.28 \times 10^{4}.$$

Step 3 — Divide:

$$v_d = \frac{1.6}{1.28 \times 10^4} = 1.25 \times 10^{-4}\ \text{m s}^{-1}.$$

Why other options are wrong:

- (A), (B), (D) carry the wrong power of ten from the exponent arithmetic.

Final Answer: $v_d = 1.25 \times 10^{-4}$ m s^{-1} $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q 20

Q21.

Solution

Concept — Circular motion in a magnetic field: A charge q of mass m moving with speed v perpendicular to a field B follows a circle of radius $r = \dfrac{mv}{qB}$.

Step 1 — Form the numerator:

$$mv = (1.6 \times 10^{-27})(2 \times 10^5) = 3.2 \times 10^{-22}.$$

Step 2 — Form the denominator:

$$qB = (1.6 \times 10^{-19})(0.4) = 6.4 \times 10^{-20}.$$

Step 3 — Divide:

$$r = \frac{3.2 \times 10^{-22}}{6.4 \times 10^{-20}} = 0.5 \times 10^{-2} = 5.0 \times 10^{-3}\ \text{m}.$$

Why other options are wrong:

- (A), (B), (C) result from misplacing the power of ten in the division.

Final Answer: $r = 5.0 \times 10^{-3}$ m $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q 21

Q22.

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 — Substitute the data: $I = 5$ A, $r = 0.1$ m, $\mu_0 = 4\pi \times 10^{-7}$.

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

Step 2 — Cancel π:

$$B = \frac{4 \times 10^{-7} \times 5}{2 \times 0.1} = \frac{2 \times 10^{-6}}{0.2}.$$

Step 3 — Evaluate:

$$B = 1.0 \times 10^{-5}\ \text{T}.$$

Why other options are wrong:

- (B) 2.0×10^{-5} T drops the factor of two in the denominator.
- (C) and (D) misplace the power of ten.

Final Answer: $B = 1.0 \times 10^{-5}$ T $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 22

Q23.

Solution

Concept — Motional EMF: A rod of length ℓ moving with speed v perpendicular to a magnetic field B (with all three mutually perpendicular) develops an EMF $\varepsilon = B\ell v$.

Step 1 — List the data: $B = 0.2$ T, $\ell = 0.5$ m, $v = 4$ m s^{-1}.

Step 2 — Apply the formula:

$$\varepsilon = B\ell v = 0.2 \times 0.5 \times 4.$$

Step 3 — Evaluate:

$$\varepsilon = 0.4\ \text{V}.$$

Why other options are wrong:

- (A) 0.2 V omits a factor in the product.
- (C) and (D) double or quadruple the correct result.

Final Answer: $\varepsilon = 0.4 \text{ V} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 23

Q24.

Solution

Concept — Ideal transformer: For an ideal transformer the voltage ratio equals the turns ratio: $\dfrac{V_s}{V_p} = \dfrac{N_s}{N_p}$.

Step 1 — Form the turns ratio:

$$\frac{N_s}{N_p} = \frac{100}{1000} = \frac{1}{10}.$$

Step 2 — Find the secondary voltage:

$$V_s = V_p \times \frac{N_s}{N_p} = 220 \times \frac{1}{10}.$$

Step 3 — Evaluate:

$$V_s = 22 \text{ V}.$$

Why other options are wrong:

- (A) 2200 V inverts the ratio (step-up).
- (B) and (D) use wrong turns ratios.

Final Answer: $V_s = 22 \text{ V} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 24

Q25.

Solution

Concept — Lens formula: The thin-lens formula is $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$, and the magnification is $m = \frac{v}{u}$, using the sign convention (object distance u negative for a real object).

Step 1 — Assign signs: $u = -30$ cm, $f = +20$ cm (convex lens).

Step 2 — Apply the lens formula:

$$\frac{1}{v} = \frac{1}{f} + \frac{1}{u} = \frac{1}{20} + \frac{1}{-30} = \frac{3-2}{60} = \frac{1}{60}.$$

So $v = +60$ cm (real image on the far side).

Step 3 — Magnification:

$$m = \frac{v}{u} = \frac{60}{-30} = -2.$$

The image is real, inverted and twice the object size.

Why other options are wrong:

- (A), (B), (C) give a positive (erect) magnification, which a real image cannot have.
- (B) also reports a virtual image position with the wrong sign.

Final Answer: $v = 60$ cm, $m = -2 \Rightarrow$ D

Answer: (D) Go Back to Q 25

Q26.

Solution

Concept — Critical angle: At the boundary from a denser to a rarer medium, total internal reflection begins at the critical angle θ_c, where $\sin\theta_c = \frac{1}{\mu}$.

Step 1 — Apply the relation:

$$\sin\theta_c = \frac{1}{\mu} = \frac{1}{\sqrt{2}}.$$

Step 2 — Solve for the angle:

$$\theta_c = \sin^{-1}\left(\frac{1}{\sqrt{2}}\right) = 45^\circ.$$

Why other options are wrong:

- (B) 30° corresponds to $\sin\theta_c = \frac{1}{2}$, i.e. $\mu = 2$.
- (C) 60° corresponds to $\mu = \frac{2}{\sqrt{3}}$.
- (D) 90° would mean no total internal reflection ($\mu = 1$).

Final Answer: $\theta_c = 45^\circ \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 26

Q27.

Solution

Concept — Fringe width in YDSE: The spacing between consecutive bright (or dark) fringes is $\beta = \dfrac{\lambda D}{d}$, where λ is the wavelength, D the slit-to-screen distance and d the slit separation.

Step 1 — Convert to SI: $\lambda = 600$ nm $= 6 \times 10^{-7}$ m, $d = 0.5$ mm $= 5 \times 10^{-4}$ m, $D = 1.0$ m.

Step 2 — Substitute:

$$\beta = \frac{(6 \times 10^{-7})(1.0)}{5 \times 10^{-4}}.$$

Step 3 — Evaluate:

$$\beta = 1.2 \times 10^{-3} \text{ m} = 1.2 \text{ mm}.$$

Why other options are wrong:

- (A) 0.6 mm uses $d = 1$ mm.
- (C) and (D) misplace a factor of two in the wavelength or separation.

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

Answer: (B) Go Back to Q 27

Q28.

Solution

Concept — Photoelectric effect: Einstein's equation gives the maximum kinetic energy of photoelectrons as $KE_{\max} = E_{\text{photon}} - \phi$, and the stopping potential satisfies $eV_0 = KE_{\max}$.

Step 1 — Find the maximum kinetic energy:

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

Step 2 — Relate to stopping potential: Since $eV_0 = KE_{\max}$ and energies are in electron-volts,

$$V_0 = \frac{KE_{\max}}{e} = 3 \text{ V}.$$

Why other options are wrong:

- (A) 5 V ignores the work function.
- (B) 2 V uses the work function alone.
- (D) 7 V adds instead of subtracting.

Final Answer: $V_0 = 3 \text{ V} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 28

Q29.

Solution

Concept — Bohr energy levels: The energy of the nth orbit in hydrogen is $E_n = \frac{-13.6}{n^2}$ eV. The second excited state corresponds to $n = 3$.

Step 1 — Identify the level: Ground state is $n = 1$, first excited $n = 2$, second excited $n = 3$.

Step 2 — Substitute $n = 3$:

$$E_3 = \frac{-13.6}{3^2} = \frac{-13.6}{9}.$$

Step 3 — Evaluate:

$$E_3 = -1.51 \text{ eV}.$$

Why other options are wrong:

- (A) -3.4 eV is the $n = 2$ level (first excited state).
- (C) -13.6 eV is the ground state.
- (B) -6.8 eV does not correspond to any hydrogen level.

Final Answer: $E_3 = -1.51$ eV $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 29

Q30.

Solution

Concept — Half-wave rectifier: A single diode conducts during only one half of each AC cycle, so the output contains one pulse per input cycle. The ripple (output) frequency therefore equals the input frequency.

Step 1 — Recall the conduction pattern: During the half-cycle that forward-biases the diode, current flows; during the other half it is blocked. Thus one output pulse appears per full input cycle.

Step 2 — Relate the frequencies: Since there is one pulse per input cycle, the output frequency equals the input frequency:

$$f_{\text{out}} = f_{\text{in}} = 50 \text{ Hz}.$$

Why other options are wrong:

- (B) 100 Hz is the output of a *full-wave* rectifier (two pulses per cycle).
- (C) and (D) do not match the half-wave conduction pattern.

Final Answer: $f_{\text{out}} = 50$ Hz $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 30

Answer Key

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