AIIMS Paramedical Physics

Sample Paper – 10

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.
- 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. A force of 20 N acts at an angle of 60° above the horizontal. To keep a particle in equilibrium under this force together with one horizontal force and one vertical force, the magnitudes of the required horizontal and vertical balancing components are respectively

(A) 20 N and 20 N

(B) 10 N and $10\sqrt{3}$ N

(C) $10\sqrt{3}$ N and 10 N

(D) $20\sqrt{3}$ N and 20 N

Q2. Rain is falling vertically downward at 3 m s^{-1}. A man walks horizontally at 3 m s^{-1}. To keep dry, he must hold his umbrella tilted from the vertical (towards his direction of motion) by an angle of

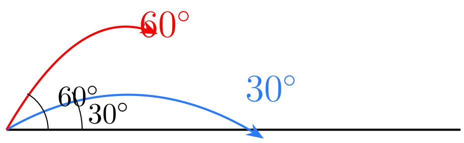
(A) 30°

(B) 60°

(C) 45°

(D) 0°

Q3. Two projectiles are launched from the ground with the *same* initial speed u, one at 30° and the other at 60° to the horizontal, as sketched. The ratio of their maximum heights $H_{30} : H_{60}$ is



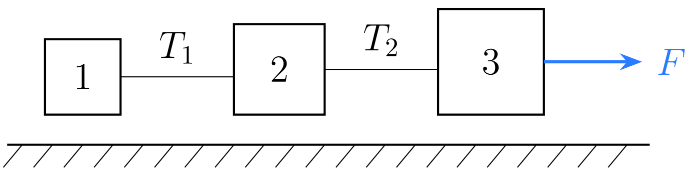
(A) $1 : 3$

(B) $3 : 1$

(C) $1 : 1$

(D) $1 : \sqrt{3}$

Q4. Three blocks of masses 1 kg, 2 kg and 3 kg are connected by light strings and pulled along a frictionless horizontal surface by a force $F = 12$ N applied to the 3 kg block, as shown. The tension T_1 in the string attached to the 1 kg block is



(A) 12 N

(B) 6 N

(C) 4 N

(D) 2 N

Q5. A uniform rope of mass 6 kg and length L lies on a frictionless horizontal floor. A horizontal force of 12 N is applied at one end. The tension in the rope at its mid-point is

(A) 6 N

(B) 12 N

(C) 3 N

(D) 9 N

Q6. Two springs of force constants $k_1 = 200$ N m^{-1} and $k_2 = 400$ N m^{-1} are stretched by the *same* force F. The ratio of the elastic potential energy stored in the first spring to that in the second, $U_1 : U_2$, is

(A) $1 : 2$

(B) $2 : 1$

(C) $1 : 4$

(D) $4 : 1$

Q7. A ball moving along the x-axis with speed 4 m s^{-1} strikes an identical stationary ball. After the elastic collision the two balls move off symmetrically, each making an angle of 30° with the original line of motion. The speed of each ball after the collision is

(A) 4 m s^{-1}

(B) 2 m s^{-1}

(C) $\frac{4}{\sqrt{3}}$ m s^{-1}

(D) $2\sqrt{3}$ m s^{-1}

Q8. A solid sphere of mass m rolls without slipping with translational speed v. The ratio of its rotational kinetic energy to its total kinetic energy is (for a solid sphere $I = \frac{2}{5}mr^2$)

(A) $\frac{1}{2}$

(B) $\frac{2}{5}$

(C) $\frac{5}{7}$

(D) $\frac{2}{7}$

Q9. A satellite of mass m orbits the Earth (mass M, radius R) in a circular orbit of radius r. The minimum additional energy needed to make the satellite just escape to infinity (its binding energy) is

(A) $\frac{GMm}{2r}$

(B) $\frac{GMm}{r}$

(C) $\frac{2GMm}{r}$

(D) $\frac{GMm}{4r}$

Q10. A wire is stretched so that the tensile stress in it is 2×10^7 Pa and the corresponding strain is 1×10^{-3}. The elastic potential energy stored per unit volume of the wire is

(A) 2×10^4 J m^{-3}

(B) 2×10^3 J m^{-3}

(C) 1×10^4 J m^{-3}

(D) 1×10^3 J m^{-3}

Q11. A metal plate has a linear expansion coefficient $\alpha = 2 \times 10^{-5}$ °C^{-1}. When its temperature rises by 50°C, the fractional increase in its *area* is

(A) 1×10^{-3}

(B) 2×10^{-3}

(C) 4×10^{-3}

(D) 1×10^{-4}

Q12. The average translational kinetic energy of a molecule of an ideal gas at 300 K is E. At what temperature will the average translational kinetic energy be $2E$?

(A) 300 K

(B) 150 K

(C) 424 K

(D) 600 K

Q13. The total energy of a particle in simple harmonic motion is E when its amplitude is A. If the amplitude is increased to $2A$ (same mass and same frequency), the new total energy becomes

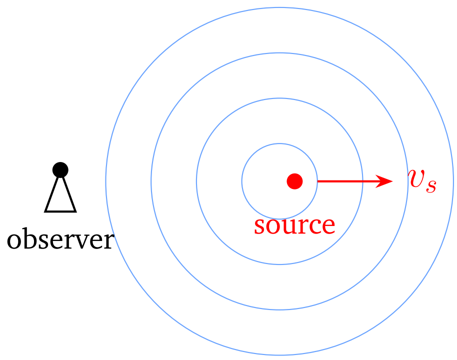
(A) $2E$

(B) E

(C) $4E$

(D) $\frac{E}{2}$

Q14. A source of sound emitting a frequency of 500 Hz moves *away* from a stationary observer at 30 m s^{-1}, as shown. Taking the speed of sound as 330 m s^{-1}, the frequency heard by the observer is



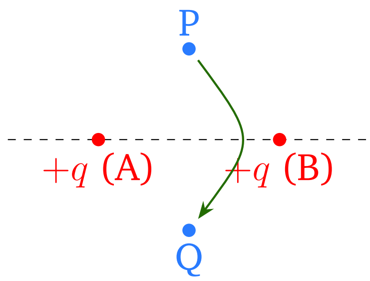
(A) 458 Hz

(B) 550 Hz

(C) 500 Hz

(D) 545 Hz

Q15. Two point charges $+q$ each are fixed on a line at points A and B. A small test charge is moved from point P to point Q, both of which are *equidistant* from the line AB and symmetrically placed, as shown. The work done by the electric force in moving the test charge from P to Q is



(A) positive and equal to $\frac{kq^2}{d}$

(B) zero

(C) negative and non-zero

(D) positive and non-zero

Q16. A charged metal sphere of radius 3 cm carrying a charge of $6\ \mu$C is connected by a thin wire to an uncharged metal sphere of radius 1 cm placed far away. After equilibrium is reached, the charge on the smaller sphere is

(A) $3\ \mu$C

(B) $4.5\ \mu$C

(C) $2\ \mu$C

(D) $1.5\ \mu$C

Q17. A parallel-plate capacitor is charged by a battery and then the battery is disconnected. The plate separation is now doubled (with no dielectric). The energy stored in the capacitor

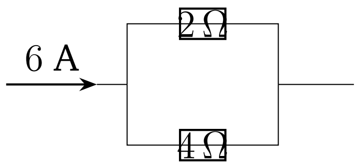
(A) halves

(B) stays the same

(C) doubles

(D) becomes one-fourth

Q18. A total current of 6 A enters a parallel combination of two resistors $2\ \Omega$ and $4\ \Omega$, as shown. The current flowing through the $2\ \Omega$ resistor is



(A) 2 A

(B) 4 A

(C) 3 A

(D) 1 A

Q19. In a potentiometer experiment, a cell balances at a length of 80 cm on open circuit. When a resistance of $10\ \Omega$ is connected across the cell, the balance length falls to 64 cm. The internal resistance of the cell is

(A) $2.5\ \Omega$

(B) $5\ \Omega$

(C) $1.25\ \Omega$

(D) $4\ \Omega$

Q20. An electric heater rated 2 kW is used for 3 hours each day. The electrical energy it consumes in a 30-day month, in kilowatt-hours, is

(A) 60 kWh

(B) 90 kWh

(C) 120 kWh

(D) 180 kWh

Q21. A magnetic dipole of moment 0.4 A m^2 is placed in a uniform magnetic field of 0.5 T with its moment *anti-parallel* to the field. The potential energy of the dipole in this orientation is

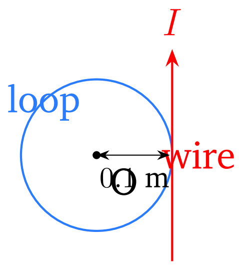
(A) -0.2 J

(B) $+0.2$ J

(C) 0

(D) $+0.1$ J

Q22. At the centre O of a circular loop of radius 0.1 m carrying current I, the magnetic field due to the loop alone is B_0. A long straight wire carrying the same current I is placed in the plane of the loop and tangent to it, as shown. The magnitude of the magnetic field at O due to the straight wire alone is



(A) $\dfrac{B_0}{\pi}$

(B) πB_0

(C) $\dfrac{B_0}{\pi^2}$

(D) B_0

Q23. An AC generator has a coil of 100 turns, each of area 0.02 m^2, rotating at an angular frequency of 50 rad s^{-1} in a uniform magnetic field of 0.1 T. The peak EMF generated is

(A) 5 V

(B) 20 V

(C) 50 V

(D) 10 V

Q24. A series LCR circuit has resonant angular frequency $\omega_0 = 1000$ rad s^{-1}, inductance $L = 0.5$ H and resistance $R = 50\ \Omega$. The quality factor (sharpness of resonance) of the circuit is

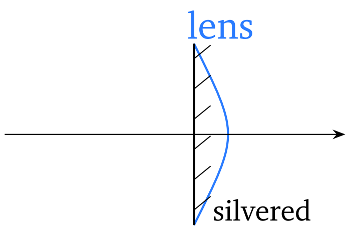
(A) 10

(B) 20

(C) 5

(D) 25

Q25. A thin convex lens of focal length 20 cm is silvered on its plane rear surface, so that it behaves as an equivalent concave mirror, as shown. The system acts as a mirror of focal length (treating the lens as plano-convex with one curved face of focal length 20 cm)



(A) 20 cm

(B) 10 cm

(C) 40 cm

(D) 5 cm

Q26. A coin lies at the bottom of a tank filled with water (refractive index $\frac{4}{3}$) to a depth of 8 cm. Viewed from directly above, the coin appears to be raised. Its apparent depth below the water surface is

(A) 8 cm

(B) 10.7 cm

(C) 6 cm

(D) 4 cm

Q27. In a Young's double-slit experiment the fringe width in air is 0.6 mm. If the entire apparatus is immersed in water of refractive index $\frac{4}{3}$, the new fringe width becomes

(A) 0.8 mm

(B) 0.6 mm

(C) 0.3 mm

(D) 0.45 mm

Q28. In a photoelectric experiment, the stopping potential V_0 is plotted against the frequency ν of the incident light, giving a straight line. The slope of this line equals

(A) $\frac{h}{e}$

(B) $\frac{e}{h}$

(C) h

(D) he

Q29. For the hydrogen atom the Rydberg constant is $R = 1.097 \times 10^7$ m^{-1}. The longest-wavelength line of the Paschen series (transition $n = 4 \to n = 3$) lies in the

(A) ultraviolet region

(B) visible region

(C) infrared region

(D) X-ray region

Q30. The I–V characteristic of a Zener diode in reverse bias is studied. The Zener diode is used as a voltage regulator because, in its breakdown region

(A) the current is zero while the voltage rises

(B) the voltage across the diode stays nearly constant while the current changes over a wide range

(C) the voltage increases in direct proportion to the current

(D) the diode conducts only in forward bias

Detailed Solutions

Q1.

Solution

Concept — Resolving a force into rectangular components: A force F at angle θ to the horizontal has a horizontal component $F\cos\theta$ and a vertical component $F\sin\theta$. For equilibrium, the balancing forces must be equal and opposite to these components.

Step 1 — Horizontal component:

$$F_x = F\cos\theta = 20\cos 60^\circ = 20 \times \tfrac{1}{2} = 10\text{ N}.$$

Step 2 — Vertical component:

$$F_y = F\sin\theta = 20\sin 60^\circ = 20 \times \frac{\sqrt{3}}{2} = 10\sqrt{3}\text{ N}.$$

Step 3 — Balancing forces: To keep the particle in equilibrium, the horizontal balancing force is 10 N and the vertical balancing force is $10\sqrt{3}$ N.

Why other options are wrong:

- 20 N and 20 N: uses the full force in each direction, ignoring resolution.
- $10\sqrt{3}$ N and 10 N: swaps the horizontal and vertical components.
- $20\sqrt{3}$ N and 20 N: doubles the components incorrectly.

Final Answer: Horizontal $= 10$ N, vertical $= 10\sqrt{3}$ N $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 1

Q2.

Solution

Concept — Rain–man relative velocity: The man must tilt the umbrella along the direction of the velocity of rain *relative to himself*. This relative velocity has a vertical part (rain speed) and a horizontal part (equal to the man's speed, directed backward relative to him).

Step 1 — Components of relative velocity: Vertical part $= 3$ m s^{-1} (rain), horizontal part $= 3$ m s^{-1} (man's speed).

Step 2 — Angle from the vertical:

$$\tan\theta = \frac{\text{horizontal}}{\text{vertical}} = \frac{3}{3} = 1.$$

Step 3 — Solve:

$$\theta = \tan^{-1}(1) = 45^\circ.$$

The umbrella is tilted 45° from the vertical towards the direction of motion.

Why other options are wrong:

- 30°: would require the horizontal part to be $\frac{1}{\sqrt{3}}$ of the vertical part.
- 60°: would require the horizontal part to be $\sqrt{3}$ times the vertical part.
- 0°: applies only when the man stands still.

Final Answer: $\theta = 45^\circ \Rightarrow \boxed{\text{C}}$

Answer: (C) **Go Back to Q 2**

Q3.

Solution

Concept — Maximum height of a projectile: For launch speed u at angle θ, the maximum height is $H = \dfrac{u^2\sin^2\theta}{2g}$, so at fixed u, $H \propto \sin^2\theta$.

Step 1 — Write the ratio:

$$\frac{H_{30}}{H_{60}} = \frac{\sin^2 30^\circ}{\sin^2 60^\circ}.$$

Step 2 — Substitute the sines: $\sin 30^\circ = \frac{1}{2}$ and $\sin 60^\circ = \dfrac{\sqrt{3}}{2}$:

$$\frac{H_{30}}{H_{60}} = \frac{(1/2)^2}{(\sqrt{3}/2)^2} = \frac{1/4}{3/4}.$$

Step 3 — Simplify:

$$\frac{H_{30}}{H_{60}} = \frac{1}{3} \Rightarrow H_{30} : H_{60} = 1 : 3.$$

Why other options are wrong:

- $3:1$: inverts the ratio; the steeper 60° launch climbs higher, not lower.
- $1:1$: would need equal launch angles.
- $1:\sqrt{3}$: uses $\sin\theta$ instead of $\sin^2\theta$.

Final Answer: $H_{30} : H_{60} = 1 : 3 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 3

Q4.

Solution

Concept — Connected masses on a frictionless surface: All blocks share a common acceleration $a = \dfrac{F}{\text{total mass}}$. The tension in a string equals the mass it pulls multiplied by a.

Step 1 — Common acceleration: Total mass $= 1 + 2 + 3 = 6$ kg:

$$a = \frac{F}{6} = \frac{12}{6} = 2 \text{ m s}^{-2}.$$

Step 2 — Tension in the string on the 1 kg block: This string pulls only the 1 kg block:

$$T_1 = 1 \times a = 1 \times 2 = 2 \text{ N}.$$

Why other options are wrong:

- 12 N: equals F, the force on the whole system, not the tension pulling one block.
- 6 N: this is T_2 (3 kg behind it $\times a$, the tension pulling the first two blocks).
- 4 N: corresponds to pulling 2 kg, not the 1 kg block alone.

Final Answer: $T_1 = 2 \text{ N} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 4

Q5.

Solution

Concept — Tension in an accelerated uniform rope: The whole rope accelerates uniformly; the tension at any cross-section equals the mass *behind* that section (away from the pull) times the acceleration.

Step 1 — Acceleration of the rope:

$$a = \frac{F}{m} = \frac{12}{6} = 2 \text{ m s}^{-2}.$$

Step 2 — Mass beyond the mid-point: The mid-point divides the rope into two halves; the half away from the applied force has mass $\frac{6}{2} = 3$ kg.

Step 3 — Tension at the mid-point:

$$T = (3) \times a = 3 \times 2 = 6 \text{ N}.$$

Why other options are wrong:

- 12 N: the tension at the pulled end, where the whole 6 kg is behind the section.
- 3 N: uses only half the acceleration or a quarter of the mass.
- 9 N: corresponds to $\frac{3}{4}$ of the rope, not the mid-point.

Final Answer: $T = 6 \text{ N} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 5

Q6.

Solution

Concept — Energy stored in a stretched spring under equal force: The energy stored is $U = \frac{1}{2}kx^2$. For a given force F, the extension is $x = \frac{F}{k}$, so $U = \frac{F^2}{2k}$, giving $U \propto \frac{1}{k}$ at fixed F.

Step 1 — Write the ratio:

$$\frac{U_1}{U_2} = \frac{F^2/(2k_1)}{F^2/(2k_2)} = \frac{k_2}{k_1}.$$

Step 2 — Substitute: $k_1 = 200 \text{ N m}^{-1}$, $k_2 = 400 \text{ N m}^{-1}$:

$$\frac{U_1}{U_2} = \frac{400}{200} = 2.$$

Step 3 — State the ratio:

$$U_1 : U_2 = 2 : 1.$$

The softer spring (smaller k) stretches more under the same force and stores more energy.

Why other options are wrong:

- $1 : 2$: inverts the dependence; for equal *force*, energy goes as $1/k$, not k.

- $1:4$ and $4:1$: come from squaring the ratio of force constants, which is not required here.

Final Answer: $U_1 : U_2 = 2:1 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 6

Q7.

Solution

Concept — Symmetric oblique elastic collision of equal masses: By conservation of momentum along the original direction, $u = v\cos\theta + v\cos\theta = 2v\cos\theta$, where each ball moves at angle θ to the original line with speed v.

Step 1 — Apply momentum conservation:

$$u = 2v\cos\theta \;\Rightarrow\; v = \frac{u}{2\cos\theta}.$$

Step 2 — Substitute values: $u = 4$ m s^{-1}, $\theta = 30^\circ$, $\cos 30^\circ = \frac{\sqrt{3}}{2}$:

$$v = \frac{4}{2\times(\sqrt{3}/2)} = \frac{4}{\sqrt{3}}.$$

Step 3 — State the speed:

$$v = \frac{4}{\sqrt{3}}\text{ m s}^{-1} \approx 2.31\text{ m s}^{-1}.$$

Why other options are wrong:

- 4 m s^{-1}: assumes one ball keeps the full speed, which violates momentum balance.
- 2 m s^{-1}: uses $u/2$, ignoring the $\cos 30^\circ$ factor.
- $2\sqrt{3}$ m s^{-1}: multiplies by $\cos 30^\circ$ instead of dividing.

Final Answer: $v = \frac{4}{\sqrt{3}}$ m s^{-1} $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 7

Q8.

Solution

Concept — Rolling kinetic energy: A rolling body has translational KE $\frac{1}{2}mv^2$ and rotational KE $\frac{1}{2}I\omega^2$. For rolling without slipping $v = \omega r$, and for a solid sphere $I = \frac{2}{5}mr^2$.

Step 1 — Rotational KE:

$$KE_{rot} = \tfrac{1}{2}I\omega^2 = \tfrac{1}{2} \times \tfrac{2}{5}mr^2 \times \frac{v^2}{r^2} = \tfrac{1}{5}mv^2.$$

Step 2 — Total KE:

$$KE_{tot} = \tfrac{1}{2}mv^2 + \tfrac{1}{5}mv^2 = \frac{5+2}{10}mv^2 = \frac{7}{10}mv^2.$$

Step 3 — Take the ratio:

$$\frac{KE_{rot}}{KE_{tot}} = \frac{\frac{1}{5}mv^2}{\frac{7}{10}mv^2} = \frac{1/5}{7/10} = \frac{2}{7}.$$

Why other options are wrong:

- $\frac{1}{2}$: would hold only if rotational and translational KE were equal (e.g. a ring).
- $\frac{2}{5}$: this is $\frac{KE_{rot}}{KE_{trans}}$, not the fraction of the total.
- $\frac{5}{7}$: this is the fraction that is translational, not rotational.

Final Answer: $\frac{KE_{rot}}{KE_{tot}} = \frac{2}{7} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 8

Q9.

Solution

Concept — Binding energy of an orbiting satellite: A satellite in a circular orbit of radius r has total energy $E = -\frac{GMm}{2r}$. The binding energy is the energy needed to raise this to zero (escape to infinity), i.e. $|E|$.

Step 1 — Total orbital energy:

$$E = KE + PE = \frac{GMm}{2r} + \left(-\frac{GMm}{r}\right) = -\frac{GMm}{2r}.$$

Step 2 — Binding energy: The extra energy needed to make $E = 0$ is

$$E_{bind} = 0 - E = \frac{GMm}{2r}.$$

Why other options are wrong:

- $\frac{GMm}{r}$: this is the magnitude of the potential energy alone, ignoring the orbital kinetic energy already present.
- $\frac{2GMm}{r}$: too large by a factor of 4.
- $\frac{GMm}{4r}$: half of the correct value.

Final Answer: $E_{bind} = \frac{GMm}{2r} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 9

Q10.

Solution

Concept — Elastic energy density: The elastic potential energy stored per unit volume in a stretched wire is $u = \frac{1}{2} \times \text{stress} \times \text{strain}$.

Step 1 — List the values: stress $= 2 \times 10^7$ Pa, strain $= 1 \times 10^{-3}$.

Step 2 — Substitute:

$$u = \tfrac{1}{2} \times (2 \times 10^7) \times (1 \times 10^{-3}).$$

Step 3 — Simplify:

$$u = \tfrac{1}{2} \times 2 \times 10^4 = 1 \times 10^4 \text{ J m}^{-3}.$$

Why other options are wrong:

- 2×10^4 J m^{-3}: forgets the factor $\frac{1}{2}$.
- 2×10^3 J m^{-3}: a power-of-ten slip.
- 1×10^3 J m^{-3}: a power-of-ten slip in the other direction.

Final Answer: $u = 1 \times 10^4\ \text{J m}^{-3} \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 10

Q11.

Solution

Concept — Areal expansion: For a small temperature rise ΔT, the fractional change in area is $\dfrac{\Delta A}{A} = \beta\,\Delta T$, where the areal coefficient $\beta = 2\alpha$.

Step 1 — Areal coefficient:

$$\beta = 2\alpha = 2 \times (2 \times 10^{-5}) = 4 \times 10^{-5}\ {}^\circ\text{C}^{-1}.$$

Step 2 — Fractional area change:

$$\frac{\Delta A}{A} = \beta\,\Delta T = (4 \times 10^{-5}) \times 50.$$

Step 3 — Simplify:

$$\frac{\Delta A}{A} = 200 \times 10^{-5} = 2 \times 10^{-3}.$$

Why other options are wrong:

- 1×10^{-3}: uses α (linear) instead of $\beta = 2\alpha$ (areal).
- 4×10^{-3}: uses 3α (volume coefficient) by mistake, or doubles again.
- 1×10^{-4}: a power-of-ten error.

Final Answer: $\dfrac{\Delta A}{A} = 2 \times 10^{-3} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 11

Q12.

Solution

Concept — Average KE and absolute temperature: The average translational kinetic energy of a gas molecule is $\langle E \rangle = \frac{3}{2} k_B T$, so $\langle E \rangle \propto T$ (absolute temperature).

Step 1 — Set up the proportion: Doubling the energy ($E \to 2E$) requires doubling the absolute temperature:

$$\frac{T_2}{T_1} = \frac{2E}{E} = 2.$$

Step 2 — Compute the new temperature:

$$T_2 = 2 \times 300 = 600 \text{ K}.$$

Why other options are wrong:

- 300 K: no change, but the energy must double.
- 150 K: halves the temperature, which would halve the energy.
- 424 K: equals $300\sqrt{2}$, the scaling for rms *speed*, not for kinetic *energy*.

Final Answer: $T_2 = 600 \text{ K} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 12

Q13.

Solution

Concept — Total energy in SHM: The total mechanical energy of a simple-harmonic oscillator is $E = \frac{1}{2}m\omega^2 A^2$, so at fixed mass and frequency, $E \propto A^2$.

Step 1 — Write the ratio: Amplitude changes from A to $2A$:

$$\frac{E'}{E} = \left(\frac{2A}{A}\right)^2 = 4.$$

Step 2 — Compute:

$$E' = 4E.$$

Why other options are wrong:

- $2E$: assumes $E \propto A$ instead of A^2.
- E: ignores the change in amplitude.
- $\frac{E}{2}$: corresponds to reducing the amplitude, the opposite trend.

Final Answer: $E' = 4E \Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 13

Q14.

Solution

Concept — Doppler effect, source receding: When the source moves away from a stationary observer, the apparent frequency drops:

$$f' = f\left(\frac{v}{v+v_s}\right),$$

where v is the speed of sound and v_s the source speed.

Step 1 — List the values: $f = 500$ Hz, $v = 330$ m s^{-1}, $v_s = 30$ m s^{-1}.

Step 2 — Substitute:

$$f' = 500 \times \frac{330}{330+30} = 500 \times \frac{330}{360}.$$

Step 3 — Simplify:

$$f' = 500 \times 0.9167 \approx 458 \text{ Hz}.$$

Why other options are wrong:

- 550 Hz and 545 Hz: correspond to the source *approaching* (frequency rises), not receding.
- 500 Hz: the emitted frequency, which holds only for a stationary source.

Final Answer: $f' \approx 458$ Hz $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 14

Q15.

Solution

Concept — Work and potential at symmetric points: The work done by the electric force in moving a charge between two points equals $q(V_P - V_Q)$. If the two points are at the same potential, the work is zero.

Step 1 — Compare the potentials at P and Q: Points P and Q are symmetric about the line AB and are equidistant from both charges $+q$. Hence the potential due to each charge is the same at P as at Q.

Step 2 — Net potential difference:

$$V_P = V_Q \;\Rightarrow\; V_P - V_Q = 0.$$

Step 3 — Work done:

$$W = q(V_P - V_Q) = 0.$$

The work depends only on the end-point potentials, which are equal here.

Why other options are wrong:

- positive and equal to $\frac{kq^2}{d}$: assumes a potential drop that does not exist between equipotential points.
- negative and non-zero / positive and non-zero: both require $V_P \neq V_Q$, which the symmetry rules out.

Final Answer: $W = 0 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 15

Q16.

Solution

Concept — Charge sharing between connected spheres: When two conductors are joined, they reach a common potential. For an isolated sphere $V = \frac{kQ}{R}$, so equal potentials give $\frac{Q_1}{R_1} = \frac{Q_2}{R_2}$; the charge distributes in proportion to the radii.

Step 1 — Total charge and proportionality: Total charge $= 6\ \mu$C shared in the ratio of radii $R_1 : R_2 = 3 : 1$.

Step 2 — Charge on the smaller sphere: The smaller sphere ($R_2 = 1$ cm) gets the fraction $\frac{R_2}{R_1 + R_2} = \frac{1}{3+1} = \frac{1}{4}$:

$$Q_2 = \frac{1}{4} \times 6 = 1.5\ \mu\text{C}.$$

Why other options are wrong:

- $3\ \mu$C: an even split, which would need equal radii.
- $4.5\ \mu$C: the charge on the *larger* sphere, not the smaller.
- $2\ \mu$C: uses a $2:1$ split rather than the correct $3:1$.

Final Answer: $Q_2 = 1.5\ \mu\text{C} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 16

Q17.

Solution

Concept — Capacitor with battery disconnected: Once disconnected, the charge Q on the plates is fixed. The energy is $U = \frac{Q^2}{2C}$, and capacitance is $C = \frac{\varepsilon_0 A}{d}$, so $U \propto \frac{1}{C} \propto d$ at fixed Q.

Step 1 — Effect on capacitance: Doubling d halves the capacitance:

$$C' = \frac{C}{2}.$$

Step 2 — Effect on energy at fixed Q:

$$U' = \frac{Q^2}{2C'} = \frac{Q^2}{2(C/2)} = 2 \times \frac{Q^2}{2C} = 2U.$$

Step 3 — Interpret: The stored energy doubles; the extra energy comes from the external work done in pulling the plates apart against their attraction.

Why other options are wrong:

- halves: this would be true if the *voltage* were held fixed (battery still connected), but here Q is fixed.
- stays the same: ignores the change in separation.
- becomes one-fourth: over-applies the $1/d^2$ scaling, which is not correct.

Final Answer: The energy doubles $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q 17

Q18.

Solution

Concept — Current divider: For two resistors in parallel carrying a total current I, the current through one branch is inversely proportional to its resistance:

$$I_1 = I \times \frac{R_2}{R_1 + R_2}.$$

Step 1 — Identify the branches: Total current $I = 6$ A; the $2\ \Omega$ branch is R_1, the $4\ \Omega$ branch is R_2.

Step 2 — Current through the $2\ \Omega$ resistor:

$$I_{2\Omega} = 6 \times \frac{4}{2+4} = 6 \times \frac{4}{6}.$$

Step 3 — Simplify:

$$I_{2\Omega} = 4\text{ A}.$$

More current flows through the smaller resistance, as expected.

Why other options are wrong:

- 2 A: this is the current through the $4\ \Omega$ branch, not the $2\ \Omega$.
- 3 A: an equal split, which would need equal resistances.
- 1 A: uses the wrong fraction entirely.

Final Answer: $I_{2\Omega} = 4\text{ A} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 18

Q19.

Solution

Concept — Internal resistance by potentiometer: If a cell balances at length l_1 on open circuit and at l_2 with a resistance R across it, the internal resistance is

$$r = R\left(\frac{l_1 - l_2}{l_2}\right).$$

Step 1 — List the values: $l_1 = 80$ cm, $l_2 = 64$ cm, $R = 10\ \Omega$.

Step 2 — Substitute:

$$r = 10 \times \frac{80-64}{64} = 10 \times \frac{16}{64}.$$

Step 3 — Simplify:

$$r = 10 \times \frac{1}{4} = 2.5\ \Omega.$$

Why other options are wrong:

- $5\ \Omega$: divides by $l_1 - l_2$ or doubles the result.
- $1.25\ \Omega$: takes half of the correct value.
- $4\ \Omega$: uses $\frac{l_1 - l_2}{l_1}$ in place of $\frac{l_1 - l_2}{l_2}$ with a further slip.

Final Answer: $r = 2.5\ \Omega \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 19

Q20.

Solution

Concept — Electrical energy in kWh: Energy in kilowatt-hours equals power (in kW) multiplied by time (in hours): $E = P \times t$.

Step 1 — Daily energy:

$$E_{day} = 2 \text{ kW} \times 3 \text{ h} = 6 \text{ kWh}.$$

Step 2 — Monthly energy: Over 30 days:

$$E_{month} = 6 \times 30 = 180 \text{ kWh}.$$

Why other options are wrong:

- 60 kWh: uses 1 kW instead of 2 kW.
- 90 kWh: uses half the daily hours.
- 120 kWh: drops a factor in the daily product.

Final Answer: $E = 180$ kWh $\Rightarrow$ D

Answer: (D) Go Back to Q 20

Q21.

Solution

Concept — Potential energy of a magnetic dipole: A magnetic dipole of moment m in a field B has potential energy $U = -mB\cos\theta$, where θ is the angle between $\vec{m}$ and $\vec{B}$. For anti-parallel alignment $\theta = 180°$.

Step 1 — Use the anti-parallel angle: $\cos 180° = -1$:

$$U = -mB\cos 180° = -mB(-1) = +mB.$$

Step 2 — Substitute values: $m = 0.4 \text{ A m}^2$, $B = 0.5$ T:

$$U = +(0.4)(0.5) = +0.2 \text{ J}.$$

The anti-parallel orientation is the highest-energy (unstable) configuration, so U

is positive and maximum.

Why other options are wrong:

- -0.2 J: the value for *parallel* alignment ($\theta = 0$), the minimum-energy state.
- 0: corresponds to $\theta = 90°$.
- $+0.1$ J: uses an incorrect angle factor.

Final Answer: $U = +0.2 \text{ J} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 21

Q22.

Solution

Concept — Fields of a loop and a straight wire: At the centre of a loop of radius r, $B_{loop} = \frac{\mu_0 I}{2r}$. At a perpendicular distance r from a long straight wire, $B_{wire} = \frac{\mu_0 I}{2\pi r}$. The tangent wire is a distance r from the centre.

Step 1 — Write both fields:

$$B_0 = B_{loop} = \frac{\mu_0 I}{2r}, \qquad B_{wire} = \frac{\mu_0 I}{2\pi r}.$$

Step 2 — Take the ratio:

$$\frac{B_{wire}}{B_0} = \frac{\mu_0 I/(2\pi r)}{\mu_0 I/(2r)} = \frac{1}{\pi}.$$

Step 3 — Express the wire's field:

$$B_{wire} = \frac{B_0}{\pi}.$$

Why other options are wrong:

- πB_0: inverts the ratio.
- $\frac{B_0}{\pi^2}$: squares the factor incorrectly.
- B_0: ignores the extra π in the straight-wire formula.

Final Answer: $B_{wire} = \frac{B_0}{\pi} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 22

Q23.

Solution

Concept — Peak EMF of an AC generator: The peak EMF of a rotating coil is $\varepsilon_0 = NBA\omega$, where N is the number of turns, B the field, A the area and ω the angular frequency.

Step 1 — List the values: $N = 100$, $B = 0.1$ T, $A = 0.02\ \text{m}^2$, $\omega = 50\ \text{rad s}^{-1}$.

Step 2 — Substitute:

$$\varepsilon_0 = NBA\omega = 100 \times 0.1 \times 0.02 \times 50.$$

Step 3 — Simplify step by step:

$$100 \times 0.1 = 10, \quad 10 \times 0.02 = 0.2, \quad 0.2 \times 50 = 10\ \text{V}.$$

Why other options are wrong:

- 5 V: drops a factor of 2 from the area.
- 20 V: doubles the correct result.
- 50 V: uses ω without one of the other factors.

Final Answer: $\varepsilon_0 = 10\ \text{V} \Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 23

Q24.

Solution

Concept — Quality factor of a series LCR circuit: The sharpness of resonance is measured by $Q = \dfrac{\omega_0 L}{R}$.

Step 1 — List the values: $\omega_0 = 1000\ \text{rad s}^{-1}$, $L = 0.5$ H, $R = 50\ \Omega$.

Step 2 — Substitute:

$$Q = \frac{\omega_0 L}{R} = \frac{1000 \times 0.5}{50}.$$

Step 3 — Simplify:

$$Q = \frac{500}{50} = 10.$$

Why other options are wrong:

- 20: uses $L = 1$ H or doubles the value.
- 5: uses $R = 100\ \Omega$ or halves the value.
- 25: an arithmetic slip not consistent with the formula.

Final Answer: $Q = 10 \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 24

Q25.

Solution

Concept — Silvered lens as an equivalent mirror: A silvered lens behaves as a mirror whose power is $P = 2P_l + P_m$, where P_l is the lens power and P_m the power of the reflecting surface. For a plane silvered back, $P_m = 0$, so $P = 2P_l$ and the effective focal length is $f_{eq} = \frac{f_l}{2}$.

Step 1 — Power of the lens:

$$P_l = \frac{1}{f_l} = \frac{1}{20}\ \text{cm}^{-1}.$$

Step 2 — Light passes through the lens twice: The plane silvered surface adds no power, so

$$P = 2P_l = \frac{2}{20} = \frac{1}{10}\ \text{cm}^{-1}.$$

Step 3 — Equivalent focal length:

$$f_{eq} = \frac{1}{P} = 10\ \text{cm}.$$

The system behaves as a concave mirror of focal length 10 cm.

Why other options are wrong:

- 20 cm: forgets that the light traverses the lens twice (factor of 2 in power).
- 40 cm: halves the power instead of doubling it.
- 5 cm: doubles the power once too many times.

Final Answer: $f_{eq} = 10\ \text{cm} \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 25

Q26.

Solution

Concept — Apparent depth: When viewed normally from above, an object at real depth d under a medium of refractive index μ appears at depth $d_{app} = \frac{d}{\mu}$.

Step 1 — List the values: $d = 8$ cm, $\mu = \frac{4}{3}$.

Step 2 — Substitute:

$$d_{app} = \frac{d}{\mu} = \frac{8}{4/3} = 8 \times \frac{3}{4}.$$

Step 3 — Simplify:

$$d_{app} = 6 \text{ cm}.$$

The coin appears raised by $8 - 6 = 2$ cm.

Why other options are wrong:

- 8 cm: ignores refraction (no apparent rise).
- 10.7 cm: multiplies by μ instead of dividing, giving a deeper (wrong) image.
- 4 cm: uses $\mu = 2$ instead of $\frac{4}{3}$.

Final Answer: $d_{app} = 6$ cm $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 26

Q27.

Solution

Concept — Fringe width in a medium: Fringe width is $\beta = \frac{\lambda D}{d}$. Immersing the apparatus in a medium of refractive index μ reduces the wavelength to $\frac{\lambda}{\mu}$, so the fringe width becomes $\beta' = \frac{\beta}{\mu}$.

Step 1 — List the values: $\beta = 0.6$ mm, $\mu = \frac{4}{3}$.

Step 2 — Substitute:

$$\beta' = \frac{\beta}{\mu} = \frac{0.6}{4/3} = 0.6 \times \frac{3}{4}.$$

Step 3 — Simplify:

$$\beta' = 0.45 \text{ mm}.$$

The fringes get closer together in water.

Why other options are wrong:

- 0.8 mm: multiplies by μ instead of dividing, widening the fringes wrongly.
- 0.6 mm: ignores the change of medium.
- 0.3 mm: uses $\mu = 2$ instead of $\frac{4}{3}$.

Final Answer: $\beta' = 0.45$ mm $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 27

Q28.

Solution

Concept — Einstein's photoelectric equation: The stopping potential satisfies $eV_0 = h\nu - \phi_0$, so

$$V_0 = \frac{h}{e}\nu - \frac{\phi_0}{e}.$$

This is a straight line of V_0 against ν with slope $\frac{h}{e}$.

Step 1 — Compare with $y = mx + c$: Here V_0 is y, ν is x, and the coefficient of ν is the slope.

Step 2 — Identify the slope:

$$\text{slope} = \frac{h}{e}.$$

Remarkably, this slope is the same for all metals (it does not depend on the work function).

Why other options are wrong:

- $\frac{e}{h}$: the reciprocal of the slope.
- h: omits the division by e; the axes are volts and hertz.
- he: a product with the wrong dimensions for a slope here.

Final Answer: slope $= \frac{h}{e} \Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 28

Q29.

Solution

Concept — Paschen series: The Paschen series corresponds to electron transitions ending at $n = 3$ in hydrogen. Its wavelengths are given by

$$\frac{1}{\lambda} = R\left(\frac{1}{3^2} - \frac{1}{n^2}\right), \quad n = 4, 5, \ldots$$

Step 1 — Longest-wavelength line ($n = 4 \to 3$):

$$\frac{1}{\lambda} = R\left(\frac{1}{9} - \frac{1}{16}\right) = R\left(\frac{16-9}{144}\right) = R \times \frac{7}{144}.$$

Step 2 — Compute the wavelength:

$$\frac{1}{\lambda} = (1.097 \times 10^7) \times \frac{7}{144} \approx 5.33 \times 10^5 \text{ m}^{-1},$$

$$\lambda \approx 1.875 \times 10^{-6} \text{ m} = 1875 \text{ nm}.$$

Step 3 — Identify the region: A wavelength near 1875 nm lies well beyond the red end of the visible band, in the infrared region (the whole Paschen series is infrared).

Why other options are wrong:

- ultraviolet: that is the Lyman series (transitions to $n = 1$).
- visible: that is the Balmer series (transitions to $n = 2$).
- X-ray: far shorter wavelengths than any hydrogen optical line.

Final Answer: The Paschen line lies in the infrared region $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q 29

Q30.

Solution

Concept — Zener diode in breakdown: In reverse bias beyond its breakdown voltage, a Zener diode maintains a nearly constant voltage across itself even though the current through it changes substantially. This flat part of the I–V curve is what makes it useful as a voltage regulator.

Step 1 — Behaviour in the breakdown region: Once the reverse voltage reaches the Zener voltage, the curve becomes almost vertical: large changes in current produce only a tiny change in voltage.

Step 2 — Consequence: The voltage across the diode (and hence across a load in parallel with it) stays nearly constant while the current adjusts over a wide range, regulating the output.

Why other options are wrong:

- "current is zero while the voltage rises": describes the reverse region *before* breakdown, not the breakdown region.
- "voltage increases in proportion to the current": that is ohmic (resistor) behaviour, not Zener regulation.
- "conducts only in forward bias": describes an ordinary diode; a Zener is specifically operated in reverse breakdown.

Final Answer: The voltage stays nearly constant while the current varies $\Rightarrow \boxed{B}$

Answer: (B) Go Back to Q 30

Answer Key

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