

Maharashtra Board Class 12 Physics Question Paper with Solutions(Memory Based)

Time Allowed :3 Hours

Maximum Marks :70

Total questions :5

General Instructions

Read the following instructions very carefully and strictly follow them:

1. Each activity has to be answered in full sentence/s. One word answers will not be given complete credit. Just the correct activity number written in case of options will not be given credit.
2. Web diagrams, flow charts, tables, etc. are to be presented exactly as they are with answers.
3. In point 2 above, just words without the presentation of the activity format, will not be given credit. Use of colour pencils/pens etc. is not allowed. (Only blue/black pens are allowed.)
4. Multiple answers to the same activity will be treated as wrong and will not be given any credit.
5. Maintain the sequence of the Sections/Question Nos./Activities throughout the activity sheet.

1. What will be the shape of a liquid meniscus for an obtuse angle of contact?

Correct Answer: Convex meniscus

Solution:

Concept: The shape of a liquid meniscus depends on the angle of contact (θ) between the liquid and the container wall.

Step 1: Angle of contact definition Angle of contact is the angle between the tangent to the liquid surface and the solid surface, measured inside the liquid.

Step 2: Cases based on angle

- $\theta < 90^\circ$ (acute angle): Adhesive forces $>$ cohesive forces \rightarrow liquid wets the surface \rightarrow **concave meniscus**. Example: Water in glass.
- $\theta > 90^\circ$ (obtuse angle): Cohesive forces $>$ adhesive forces \rightarrow liquid does not wet the surface \rightarrow **convex meniscus**. Example: Mercury in glass.

Step 3: Given condition Since the angle of contact is obtuse ($> 90^\circ$):

Meniscus shape = Convex

Final Answer:

Convex meniscus

Quick Tip

Angle of contact rule: Acute angle \rightarrow Concave meniscus Obtuse angle \rightarrow Convex meniscus Mercury in glass is the classic convex example.

2. Define magnetization and state its SI unit.

Correct Answer: Magnetization is defined as the magnetic dipole moment per unit volume of a material. Its SI unit is A/m (ampere per metre).

Solution:

Concept: Magnetization describes how strongly a material becomes magnetized when placed in a magnetic field. It represents the alignment of magnetic dipoles within a substance.

Step 1: Definition Magnetization (M) is defined as:

$$M = \frac{\text{Magnetic dipole moment}}{\text{Volume}}$$

It indicates the net magnetic moment per unit volume of the material.

Step 2: Physical meaning When a material is placed in an external magnetic field: - Magnetic domains align - Net magnetic dipole moment develops This gives rise to magnetization.

Step 3: SI unit Magnetic dipole moment has unit:

$$\text{A}\cdot\text{m}^2$$

Dividing by volume (m^3):

$$\frac{\text{A}\cdot\text{m}^2}{\text{m}^3} = \text{A/m}$$

Final Answer:

Magnetization (M) = magnetic moment per unit volume, unit = A/m

Quick Tip

Magnetization = Magnetic moment density. Always remember unit: Ampere per metre (A/m).

3. State the First Law of Thermodynamics.

Correct Answer: The First Law of Thermodynamics states that energy can neither be created nor destroyed, but only transformed from one form to another. The heat supplied to a system is partly used to increase its internal energy and the rest is used to do work.

Solution:

Concept: The First Law of Thermodynamics is based on the principle of conservation of energy applied to thermodynamic systems.

Step 1: Statement It states that the total energy of an isolated system remains constant. Energy may change form (heat, work, internal energy) but cannot be created or destroyed.

Step 2: Mathematical expression If heat Q is supplied to a system and work W is done by the system, then:

$$Q = \Delta U + W$$

where: ΔU = change in internal energy.

Step 3: Interpretation - Part of heat increases internal energy. - Remaining heat is used in doing external work.

Final Form:

$$Q = \Delta U + W$$

Quick Tip

First Law = Energy conservation in thermodynamics. Heat supplied = Increase in internal energy + Work done.

4. State and prove the Law of Conservation of Angular Momentum.

Correct Answer: The Law of Conservation of Angular Momentum states that if the net external torque acting on a system is zero, the total angular momentum of the system remains constant in magnitude and direction.

Solution:

Concept: Angular momentum is the rotational analogue of linear momentum. It depends on the moment of inertia and angular velocity of a body.

Step 1: Definition of angular momentum For a particle:

$$\vec{L} = \vec{r} \times \vec{p}$$

For a rigid body rotating about a fixed axis:

$$L = I\omega$$

where I = moment of inertia, ω = angular velocity.

Step 2: Relation between torque and angular momentum Torque is defined as:

$$\vec{\tau} = \frac{d\vec{L}}{dt}$$

This is the rotational form of Newton's second law.

Step 3: Condition for conservation If the net external torque on the system is zero:

$$\vec{\tau}_{\text{ext}} = 0$$

Then:

$$\frac{d\vec{L}}{dt} = 0$$

Step 4: Integrating

$$\frac{d\vec{L}}{dt} = 0 \Rightarrow \vec{L} = \text{constant}$$

Thus angular momentum remains conserved.

Step 5: Alternative form For a rotating rigid body:

$$I_1\omega_1 = I_2\omega_2$$

This shows that if moment of inertia changes, angular velocity adjusts to keep angular momentum constant.

Conclusion: In absence of external torque, angular momentum remains conserved in both magnitude and direction.

Quick Tip

No external torque \rightarrow Angular momentum conserved. Example: Figure skater spins faster when pulling arms inward.

5. Explain the phenomenon of surface tension on the basis of molecular theory.

Correct Answer: Surface tension arises due to cohesive forces between liquid molecules. Molecules inside the liquid experience balanced forces, while surface molecules experience an inward net force, causing the surface to behave like a stretched elastic membrane.

Solution:

Concept: Surface tension is explained by intermolecular forces acting between liquid molecules, particularly cohesive forces.

Step 1: Molecules inside the liquid A molecule deep inside a liquid is surrounded by other molecules on all sides. Cohesive forces act equally in all directions, so the net force is zero.

Step 2: Molecules at the surface A surface molecule has: - Neighbouring molecules below and sideways - Very few molecules above (air)

Thus, cohesive forces are unbalanced and act inward.

Step 3: Result of inward force Due to this inward pull: - Surface molecules are drawn closer together - Surface area tends to decrease

This gives rise to surface tension.

Step 4: Surface behaves like a stretched membrane The liquid surface acts like an elastic film trying to contract, similar to a stretched rubber sheet.

Step 5: Molecular energy explanation Surface molecules possess higher potential energy than interior molecules. To minimize energy, the liquid reduces surface area, producing surface tension effects.

Conclusion: Surface tension is caused by unbalanced cohesive molecular forces at the liquid surface, making the surface contract and behave like a stretched membrane.

Quick Tip

Inside liquid → Balanced forces Surface molecules → Inward pull → Surface tension
That's why drops become spherical.

6. Obtain the differential equation of linear simple harmonic motion (SHM).

Correct Answer: The differential equation of linear SHM is:

$$\frac{d^2x}{dt^2} + \omega^2x = 0$$

where ω is the angular frequency.

Solution:

Concept: Simple harmonic motion (SHM) is a type of oscillatory motion in which the restoring force is directly proportional to displacement and directed towards the mean position.

Step 1: Restoring force in SHM In SHM, restoring force is proportional to displacement and opposite in direction:

$$F \propto -x$$

$$F = -kx$$

where k is a constant.

Step 2: Apply Newton's second law

$$F = ma$$

$$m \frac{d^2x}{dt^2} = -kx$$

Step 3: Rearranging

$$\frac{d^2x}{dt^2} + \frac{k}{m}x = 0$$

Step 4: Define angular frequency Let:

$$\omega^2 = \frac{k}{m}$$

Substitute into the equation.

Final Differential Equation

$$\frac{d^2x}{dt^2} + \omega^2x = 0$$

Interpretation: This equation shows that acceleration is always proportional to displacement and directed towards the equilibrium position, which is the defining property of SHM.

Quick Tip

SHM key idea: Restoring force \propto displacement and opposite in direction. That always leads to:

$$\frac{d^2x}{dt^2} + \omega^2x = 0$$

7. State Lenz's Law and explain how it follows the law of conservation of energy.

Correct Answer: Lenz's Law states that the direction of induced current in a circuit is such that it opposes the change in magnetic flux that produces it. This opposition ensures that energy is not created from nothing and thus supports the law of conservation of energy.

Solution:

Concept: Lenz's Law is a consequence of Faraday's law of electromagnetic induction and determines the direction of induced current.

Step 1: Statement of Lenz's Law The induced emf or current is always in such a direction that the magnetic field produced by it opposes the change in magnetic flux causing it.

Mathematically included as the negative sign in Faraday's law:

$$\mathcal{E} = -\frac{d\Phi}{dt}$$

Step 2: Example of increasing flux Consider a magnet moving towards a conducting loop. - Magnetic flux through the loop increases. - Induced current produces a magnetic field opposing the approaching magnet.

This creates a repulsive force.

Step 3: Energy consideration To push the magnet towards the loop, external work must be done against this repulsive force. This mechanical work is converted into electrical energy (induced current).

Step 4: If Lenz's law were not true If the induced current supported the change instead of opposing it: - Magnet would accelerate without external work. - Energy would be produced without input. This would violate conservation of energy.

Step 5: Conclusion Thus, Lenz's Law ensures that: - Induction always resists the cause producing it. - Energy input is required for energy output. Hence it is consistent with the law of conservation of energy.

Quick Tip

Lenz's Law = Nature resists change. Induced current always opposes flux change → Prevents free energy → Ensures energy conservation.

8. Derive an expression for the time period of a conical pendulum.

Correct Answer: The time period of a conical pendulum is:

$$T = 2\pi\sqrt{\frac{l \cos \theta}{g}}$$

where l is the length of the string and θ is the angle with the vertical.

Solution:

Concept: A conical pendulum consists of a mass tied to a string moving in a horizontal circular path such that the string makes a constant angle θ with the vertical.

The motion is uniform circular motion with centripetal force provided by components of tension.

Step 1: Forces acting on the bob Let tension in the string be T . Resolve tension into components:

- Vertical component: $T \cos \theta$ balances weight
- Horizontal component: $T \sin \theta$ provides centripetal force

Step 2: Vertical equilibrium

$$T \cos \theta = mg \quad \dots (1)$$

Step 3: Centripetal force Radius of circular path:

$$r = l \sin \theta$$

Centripetal force:

$$T \sin \theta = \frac{mv^2}{r}$$

$$T \sin \theta = \frac{mv^2}{l \sin \theta} \quad \dots (2)$$

Step 4: Divide equations (2) by (1)

$$\frac{T \sin \theta}{T \cos \theta} = \frac{mv^2 / (l \sin \theta)}{mg}$$

$$\tan \theta = \frac{v^2}{gl \sin \theta}$$

Step 5: Solve for velocity

$$v^2 = gl \sin \theta \tan \theta = gl \frac{\sin^2 \theta}{\cos \theta}$$

$$v = \sqrt{\frac{gl \sin^2 \theta}{\cos \theta}}$$

Step 6: Time period of circular motion

$$T = \frac{2\pi r}{v}$$

$$T = \frac{2\pi l \sin \theta}{\sqrt{\frac{gl \sin^2 \theta}{\cos \theta}}}$$

Step 7: Simplify

$$T = 2\pi \sqrt{\frac{l \cos \theta}{g}}$$

Final Expression:

$$T = 2\pi \sqrt{\frac{l \cos \theta}{g}}$$

Quick Tip

Conical pendulum shortcut: Replace effective length by $l \cos \theta$ in simple pendulum formula. So:

$$T = 2\pi \sqrt{\frac{l \cos \theta}{g}}$$

9. Show that the root mean square (RMS) speed of gas molecules is directly proportional to the square root of the absolute temperature.

Correct Answer:

$$v_{\text{rms}} = \sqrt{\frac{3kT}{m}} \Rightarrow v_{\text{rms}} \propto \sqrt{T}$$

Solution:

Concept: According to the kinetic theory of gases, the average kinetic energy of gas molecules is directly proportional to the absolute temperature.

Step 1: Kinetic energy of one molecule The translational kinetic energy of a molecule is:

$$KE = \frac{1}{2}mv^2$$

For RMS speed:

$$\frac{1}{2}mv_{\text{rms}}^2$$

Step 2: Relation from kinetic theory Average kinetic energy of a gas molecule:

$$\frac{1}{2}mv_{\text{rms}}^2 = \frac{3}{2}kT$$

where k = Boltzmann constant T = absolute temperature

Step 3: Solve for RMS speed

$$mv_{\text{rms}}^2 = 3kT$$

$$v_{\text{rms}}^2 = \frac{3kT}{m}$$

$$v_{\text{rms}} = \sqrt{\frac{3kT}{m}}$$

Step 4: Proportionality Since k and m are constants for a given gas:

$$v_{\text{rms}} \propto \sqrt{T}$$

Conclusion: The RMS speed of gas molecules is directly proportional to the square root of the absolute temperature.

Quick Tip

Temperature increases \rightarrow molecular speed increases. Doubling temperature does NOT double speed — it increases by $\sqrt{2}$.