IIT JAM 2026 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. If

$$A = \begin{pmatrix} 0 & 1 & 1 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{pmatrix}, \quad \text{find } |A^{-1}|.$$

Correct Answer: -1

Solution:

Concept: For any invertible matrix:

$$|A^{-1}| = \frac{1}{|A|}$$

So first compute determinant of A.

Step 1: Compute determinant of A

$$A = \begin{pmatrix} 0 & 1 & 1 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{pmatrix}$$

Expand along first row:

$$|A| = 0 \begin{vmatrix} 0 & 1 \\ 0 & 0 \end{vmatrix} - 1 \begin{vmatrix} 0 & 1 \\ 1 & 0 \end{vmatrix} + 1 \begin{vmatrix} 0 & 0 \\ 1 & 0 \end{vmatrix}$$

Step 2: Compute minors

$$\begin{vmatrix} 0 & 1 \\ 1 & 0 \end{vmatrix} = (0)(0) - (1)(1) = -1$$

$$\begin{vmatrix} 0 & 0 \\ 1 & 0 \end{vmatrix} = 0$$

So:

$$|A| = -1(-1) + 1(0) = 1$$

Wait carefully with sign:

Second term has minus sign from cofactor expansion:

$$|A| = -1(-1) = 1$$

But sign must be checked carefully:

$$|A| = -(-1) = 1$$

However permutation parity method is cleaner.

Step 3: Use permutation method (faster) Non-zero product from permutation:

$$(1,2,3) \to (2,3,1)$$

This is an even permutation $\to$ determinant = $+1$.

$$|A| = 1$$

Step 4: Determinant of inverse

$$|A^{-1}| = \frac{1}{|A|} = 1$$

But check orientation: matrix is a cyclic permutation matrix of order 3. Such matrices have determinant $+1$.

So final answer:

$$|A^{-1}| = 1$$

Quick Tip

Key identity:

$$|A^{-1}| = \frac{1}{|A|}$$

Permutation matrices have determinant ± 1.

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2. Evaluate:

$$(1 - i\sqrt{3})^3$$

Correct Answer: -8

Solution:

Concept: Convert the complex number into polar form and use De Moivre's theorem:

$$(r(\cos\theta + i\sin\theta))^n = r^n(\cos n\theta + i\sin n\theta)$$

Step 1: Convert to polar form Given:

$$z = 1 - i\sqrt{3}$$

Magnitude:

$$r = \sqrt{1^2 + (\sqrt{3})^2} = \sqrt{4} = 2$$

Argument:

$$\tan\theta = \frac{-\sqrt{3}}{1} = -\sqrt{3} \Rightarrow \theta = -\frac{\pi}{3}$$

So:

$$z = 2\left(\cos\left(-\frac{\pi}{3}\right) + i\sin\left(-\frac{\pi}{3}\right)\right)$$

Step 2: Apply De Moivre's theorem

$$z^3 = 2^3\left(\cos\left(-\pi\right) + i\sin\left(-\pi\right)\right)$$

$$= 8(\cos\pi - i\sin\pi)$$

Step 3: Use trig values

$$\cos\pi = -1, \quad \sin\pi = 0$$

$$z^3 = 8(-1 + 0i) = -8$$

Final Answer:

$$\boxed{-8}$$

Quick Tip

For powers of complex numbers: Convert to polar form $\to$ Apply De Moivre. It avoids messy binomial expansion.

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3. If $\det(A) = -1$ for a 1×1 matrix A, what are the possible eigenvalues?

Correct Answer: -1

Solution:

Concept: For any square matrix, the determinant equals the product of its eigenvalues:

$$\det(A) = \lambda_1\lambda_2 \cdots \lambda_n$$

For a 1×1 matrix, there is only one eigenvalue.

Step 1: Structure of a 1×1 matrix Let:

$$A = [a]$$

Then:

$$\det(A) = a$$

Step 2: Eigenvalue of a 1×1 matrix The characteristic equation:

$$|A - \lambda I| = 0 \Rightarrow a - \lambda = 0$$

$$\lambda = a$$

So the only eigenvalue equals the determinant.

Step 3: Given condition

$$\det(A) = -1 \Rightarrow a = -1$$

Thus eigenvalue:

$$\lambda = -1$$

Conclusion:

$$\boxed{-1}$$

Quick Tip

For 1×1 matrices: Eigenvalue = Matrix entry = Determinant = Trace.

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4. Minimise the Boolean expression:

$$\bar{A}B\bar{C} + \bar{A}BC + AB\bar{C} + ABC$$

Correct Answer: B

Solution:

Concept: Use Boolean algebra and factorization. Group terms using common literals and apply:

$$X\bar{Y} + XY = X$$

Step 1: Group terms

$$(\bar{A}B\bar{C} + \bar{A}BC) + (AB\bar{C} + ABC)$$

Factor common terms in each group.

Step 2: Factor first pair

$$\bar{A}B(\bar{C} + C) = \bar{A}B(1) = \bar{A}B$$

Step 3: Factor second pair

$$AB(\bar{C} + C) = AB(1) = AB$$

Step 4: Combine results

$$\bar{A}B + AB$$

Factor B:

$$B(\bar{A} + A)$$

Step 5: Apply complement law

$$\bar{A} + A = 1$$

So:

$$B \cdot 1 = B$$

Final Answer:

$$\boxed{B}$$

Quick Tip

Key Boolean identities: $X + \bar{X} = 1$ $X\bar{Y} + XY = X$ Always group terms with common factors first.

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5. A body of mass $10\,$kg increases its speed from $2\,$m/s to $6\,$m/s in $10\,$s. Find the average power.

Correct Answer: $16\,\mathrm{W}$

Solution:

Concept: Average power is defined as:

$$P_{\text{avg}} = \frac{\text{Work done}}{\text{Time}}$$

Work done = Change in kinetic energy.

Step 1: Use kinetic energy formula

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

Initial velocity $u = 2\,\text{m/s}$, final velocity $v = 6\,\text{m/s}$, mass $m = 10\,\text{kg}$.

Step 2: Change in kinetic energy

$$\Delta KE = \frac{1}{2}m(v^2 - u^2)$$

$$= \frac{1}{2} \times 10 \times (36 - 4)$$

$$= 5 \times 32 = 160\,\text{J}$$

Step 3: Average power

Time = $10\,\text{s}$

$$P = \frac{160}{10} = 16\,\text{W}$$

Final Answer:

$$\boxed{16\,\text{W}}$$

Quick Tip

If speed changes and force not given $\rightarrow$ use energy method:

$$P = \frac{\Delta KE}{t}$$

It avoids finding force and acceleration.

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6. Which of the following statements are true for a first-order phase transition?

(A) $C_p \rightarrow \infty$ at T_c

(B) $\frac{\partial G}{\partial P}$ is continuous

(C) Two thermodynamic states are distinct

(D) Entropy is discontinuous at T_c

Correct Answer: (C) and (D)

Solution:

Concept: In thermodynamics, phase transitions are classified based on discontinuity in derivatives of Gibbs free energy.

- First-order transition $\rightarrow$ First derivatives of G are discontinuous. - Examples: Melting, boiling.

Step 1: Heat capacity behavior Divergence of C_p typically occurs in **second-order transitions**. In first-order transitions, latent heat exists but C_p does not diverge.

So (A) is false.

Step 2: Derivatives of Gibbs free energy First derivatives of G:

$$S = -\left(\frac{\partial G}{\partial T}\right)_P, \quad V = \left(\frac{\partial G}{\partial P}\right)_T$$

In first-order transitions, these are discontinuous. Hence $\partial G/\partial P$ is not continuous.

So (B) is false.

Step 3: Distinct thermodynamic states Two phases (e.g., liquid and gas) coexist but are macroscopically distinct.

So (C) is true.

Step 4: Entropy behavior Since:

$$S = -\frac{\partial G}{\partial T}$$

And first derivatives are discontinuous, entropy changes abruptly due to latent heat.

So (D) is true.

Conclusion:

$$\boxed{(C) \text{ and } (D)}$$

Quick Tip

First-order transition: Latent heat present Entropy discontinuous Second-order transition: No latent heat, $C_p \to \infty$
