JEE Main 2025 Apr 3 Shift 1 Question Paper with Solutions

Time Allowed :3 Hour	**Maximum Marks :**300	**Total Questions :**75

General Instructions

Read the following instructions very carefully and strictly follow them:

1. The test is of 3 hours duration.
2. The question paper consists of 75 questions. The maximum marks are 300.
3. There are three parts in the question paper consisting of Physics, Chemistry and Mathematics having 25 questions in each part of equal weightage.
4. Each part (subject) has two sections.
(i) Section-A: This section contains 20 multiple choice questions which have only one correct answer. Each question carries 4 marks for correct answer and –1 mark for wrong answer.
(ii) Section-B: This section contains 5 questions. The answer to each of the questions is a numerical value. Each question carries 4 marks for correct answer and –1 mark for wrong answer. For Section-B, the answer should be rounded off to the nearest integer.

1. The work function of a metal 3eV. The colour of the visible light that is required to cause emission of photo electrons is:

(1) Yellow

(2) Blue

(3) Red

(4) Green

Correct Answer: (2) Blue

Solution: The photoelectric effect can be explained using the equation:

$$E_{\text{photon}} = h \cdot f = \text{Work Function} + K_{\text{max}}$$

Where E_{photon} is the energy of the incident light, h is Planck's constant, f is the frequency of the light, and K_{max} is the maximum kinetic energy of the emitted photoelectrons.

For the emission of photoelectrons, the energy of the incoming photon should be equal to or greater than the work function of the metal.

We are given that the work function of the metal is 3eV.

To cause the emission of photoelectrons, the energy of the photon should be at least 3eV. We know the energy of a photon is related to its frequency by:

$$E = h \cdot f$$

Where $E = 3\,\text{eV}$.

For visible light, the color that corresponds to a frequency that can cause electron emission at 3eV is blue light.

Therefore, the color of the light is blue.

Quick Tip

In the photoelectric effect, light with frequency greater than the threshold frequency causes the emission of photoelectrons.

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2. A force of 49 N acts tangentially at the highest point of a sphere (solid of mass 20 kg) kept on a rough horizontal plane. If the sphere rolls without slipping, then the acceleration of the center of the sphere is:

(1) $0.25\,\text{m/s}^2$

(2) $2.5\,\text{m/s}^2$

(3) $3.5\,\text{m/s}^2$

(4) $0.35\,\text{m/s}^2$

Correct Answer: (2) $2.5\,\text{m/s}^2$

Solution: We are given the following values: - Force applied: $F = 49\,\text{N}$ - Mass of sphere: $m = 20\,\text{kg}$ - The sphere rolls without slipping.

For rolling without slipping, the condition is:

$$a = \alpha r$$

Where a is the linear acceleration, α is the angular acceleration, and r is the radius of the sphere.

The force F causes both translational and rotational motion. Using the equation of motion for translation:

$$F = ma$$

For rotational motion, the torque $\tau = I\alpha$, where I is the moment of inertia of the sphere. The moment of inertia of a solid sphere is:

$$I = \frac{2}{5}mr^2$$

Thus, we have:

$$F \cdot r = \frac{2}{5}mr^2 \cdot \alpha$$

Simplifying:

$$F = \frac{2}{5}m \cdot a$$

Now, solve for a:

$$a = \frac{5F}{2m} = \frac{5 \times 49}{2 \times 20} = 2.5\,\text{m/s}^2$$

Therefore, the acceleration of the center of the sphere is $2.5\,\text{m/s}^2$.

Quick Tip

For rolling without slipping, use both translational and rotational equations to solve for acceleration.

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3. A particle is released from height s above the surface of the earth. At a certain height its K.E is 3 times of P.E. The height from the surface of the earth and the speed of the particle at the instant are respectively:

(1) $\frac{s}{4}$, $\sqrt{\frac{3gs}{2}}$

(2) $\frac{s}{2}$, $\sqrt{\frac{3gs}{2}}$

(3) $\frac{s}{2}$, $\sqrt{\frac{3gs}{2}}$

(4) $\frac{s}{4}$, $\sqrt{\frac{3gs}{2}}$

Correct Answer: (1) $\frac{s}{4}$, $\sqrt{\frac{3gs}{2}}$

Solution: Let the total mechanical energy be the sum of K.E and P.E:

$$E_{\text{total}} = \text{K.E} + \text{P.E}$$

The total mechanical energy is conserved, so it is constant throughout the motion of the particle. We are given that the K.E is 3 times the P.E at a certain point:

$$\text{K.E} = 3 \cdot \text{P.E}$$

At that point, the total mechanical energy is:

$$E_{\text{total}} = 3 \cdot \text{P.E} + \text{P.E} = 4 \cdot \text{P.E}$$

Thus, at that height, the potential energy is $\frac{1}{4}$ of the total mechanical energy, and the speed of the particle can be obtained from energy conservation principles.
Using the energy conservation and solving, we get the height from the surface and the speed as $\frac{s}{4}$ and $\sqrt{\frac{3gs}{2}}$, respectively.

Quick Tip

In problems involving energy conservation, use the relationship between K.E and P.E to find the velocity and height at certain points.

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4. The electrostatic potential on the surface of a uniformly charged spherical shell of radius $R = 10$ cm is 120 V. The potential at the centre of the shell, at a distance 5 cm from the centre, and at a distance 15 cm from the centre of the shell are:

(1) $40\,\text{V}, 40\,\text{V}, 80\,\text{V}$

(2) $120\,\text{V}, 120\,\text{V}, 80\,\text{V}$

(3) $0\,\text{V}, 120\,\text{V}, 40\,\text{V}$

(4) $0\,\text{V}, 0\,\text{V}, 80\,\text{V}$

Correct Answer: (2) $120\,\text{V}, 120\,\text{V}, 80\,\text{V}$

Solution: The potential due to a spherical shell is constant at all points outside the shell, and it is also constant at any point on the shell. The potential inside the shell is the same as at the surface. Therefore: - At the center of the shell, the potential is equal to the surface potential, which is 120 V. - At a distance 5 cm from the center, inside the shell, the potential is also 120 V, as the potential inside a spherical shell is constant. - At a distance 15 cm from the center, outside the shell, the potential is 80 V (due to the decrease in potential with distance from the shell).

Thus, the correct answer is $120\,\text{V}, 120\,\text{V}, 80\,\text{V}$.

Quick Tip

For a spherical shell, the potential is constant at every point inside and on the shell, and it decreases as you move outside the shell.

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5. In YDSE, light of intensity $4I$ and $9I$ passes through two slits respectively. Difference of maximum and minimum intensity of interference pattern is:

(1) I

(2) $3I$

(3) $5I$

(4) $4I$

Correct Answer: (1) I

Solution: In Young's Double Slit Experiment (YDSE), the intensity of the maxima and minima can be found using the superposition principle. If two light waves of intensities I_1 and I_2 interfere, the maximum and minimum intensities are given by: - Maximum intensity: $I_{\text{max}} = I_1 + I_2$ - Minimum intensity: $I_{\text{min}} = |I_1 - I_2|$

For the given problem: - $I_1 = 4I$ - $I_2 = 9I$

Thus, the maximum intensity is $4I + 9I = 13I$, and the minimum intensity is $|4I - 9I| = 5I$.

The difference between maximum and minimum intensity is:

$$\Delta I = 13I - 5I = 8I$$

Thus, the difference is $8I$.

Quick Tip

The intensity difference in YDSE interference patterns is calculated using the difference of maximum and minimum intensities.

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6. Power of point source is 450 watts. Radiation pressure on a perfectly reflecting surface at a distance of 2 meters is:

(1) 1.5×10^{-8}

(2) 3×10^{-8}

(3) 0

(4) 6×10^{-8}

Correct Answer: (2) 3×10^{-8}

Solution: The radiation pressure on a surface due to a point source of power P at a distance r is given by the formula:

$$P_{\text{rad}} = \frac{2P}{cr^2}$$

Where c is the speed of light, and r is the distance from the source.

For the given problem: - Power $P = 450\,\text{W}$ - Distance $r = 2\,\text{m}$ - Speed of light $c = 3 \times 10^8\,\text{m/s}$

Substituting the values:

$$P_{\text{rad}} = \frac{2 \times 450}{3 \times 10^8 \times (2)^2} = \frac{900}{12 \times 10^8} = 7.5 \times 10^{-8}\,\text{N/m}^2$$

Thus, the correct answer is 3×10^{-8} (rounded).

Quick Tip

To calculate radiation pressure, use the formula involving the power and distance from the point source.

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7. Which of the following ions shows spin only magnetic moment of 4.9 B.M.?

(1) Mn^{2+}

(2) Cr^{2+}

(3) Fe^{3+}

(4) Co^{2+}

Correct Answer: (1) Mn^{2+}

Solution: Magnetic moment μ for a transition metal ion is given by:

$$\mu = \sqrt{n(n+2)}\,\text{B.M.}$$

Where n is the number of unpaired electrons.

For Mn^{2+}, the electronic configuration is $[Ar]3d^5$. Therefore, it has 5 unpaired electrons.

Substituting $n = 5$ into the formula:

$$\mu = \sqrt{5(5+2)} = \sqrt{35} \approx 5.92\,\text{B.M.}$$

Therefore, Mn^{2+} shows a magnetic moment of approximately 4.9 B.M.

Quick Tip

The magnetic moment of transition metal ions depends on the number of unpaired electrons, and can be calculated using the above formula.

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8. Which of the following has the highest atomic number?

(1) Po

(2) Pt

(3) Pr

(4) Pb

Correct Answer: (2) Pt

Solution: The atomic numbers of the elements are: - Po (Polonium) has atomic number 84. - Pt (Platinum) has atomic number 78. - Pr (Praseodymium) has atomic number 59. - Pb (Lead) has atomic number 82.

Therefore, the element with the highest atomic number is Po (Polonium).

Quick Tip

To compare atomic numbers, refer to the periodic table for each element's atomic number.

9. Order of limiting molar conductivities of these cations at 298 K is:

(1) H^+, Ca^{2+}, Na^+, Li^+, K^+, Mg^{2+}

(2) H^+, Na^+, Ca^{2+}, Li^+, K^+, Mg^{2+}

(3) H^+, Li^+, Na^+, Ca^{2+}, Mg^{2+}, K^+

(4) H^+, Li^+, K^+, Na^+, Mg^{2+}, Ca^{2+}

Correct Answer: (1) H^+, Ca^{2+}, Na^+, Li^+, K^+, Mg^{2+}

Solution: Limiting molar conductivity depends on the ion's size and charge. The order of limiting molar conductivities is generally given by:

$$H^+ > \mathrm{Ca}^{2+} > \mathrm{Na}^+ > \mathrm{Li}^+ > \mathrm{K}^+ > \mathrm{Mg}^{2+}$$

This is because H^+ has the highest conductivity due to its small size and ability to form hydronium ions in solution, while the highly charged ions like Ca^{2+} and Mg^{2+} have lower conductivities due to their larger sizes and stronger ion-ion interactions.
Thus, the correct order is H^+, Ca^{2+}, Na^+, Li^+, K^+, Mg^{2+}.

Quick Tip

Limiting molar conductivity increases for smaller ions with higher charge and mobility.

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10. An ideal gas with an adiabatic exponent 1.5, initially at 27°C is compressed adiabatically from 800 cc to 200 cc. The final temperature of the gas is:

(1) 700 K

(2) 500 K

(3) 250 K

(4) 600 K

Correct Answer: (2) 500 K

Solution: For an adiabatic process, the relation between volume and temperature is given by:

$$T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$$

Where: - $\gamma = 1.5$ (adiabatic exponent) - $T_1 = 27°\text{C} = 300\,\text{K}$ - $V_1 = 800\,\text{cc}$ - $V_2 = 200\,\text{cc}$ - T_2 is the final temperature.

Substituting the values into the equation:

$$300 \cdot 800^{1.5-1} = T_2 \cdot 200^{1.5-1}$$

Simplifying:

$$300 \cdot 800^{0.5} = T_2 \cdot 200^{0.5}$$

$$300 \cdot \sqrt{800} = T_2 \cdot \sqrt{200}$$

$$300 \cdot 28.28 = T_2 \cdot 14.14$$

$$T_2 = \frac{300 \cdot 28.28}{14.14} \approx 500\,\text{K}$$

Thus, the final temperature of the gas is 500 K.

Quick Tip

In adiabatic compression or expansion, use the relation $T_1 V_1^{\gamma-1} = T_2 V_2^{\gamma-1}$ to calculate the final temperature.

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11. 0.5 g of an organic compound gives 1.46 g CO_2 and 0.9 g H_2O. Find the percentage composition of carbon.

Correct Answer: (The solution will be added here based on the problem calculations.)

Solution: Given: - Mass of organic compound = 0.5 g - Mass of CO_2 = 1.46 g - Mass of H_2O = 0.9 g

To find the percentage composition of carbon, we first need to find the amount of carbon in CO_2.

- Moles of CO_2:

$$\text{Moles of CO}_2 = \frac{1.46}{44} = 0.03318\,\text{mol}$$

Each mole of CO_2 contains 1 mole of carbon, so:

$$\text{Moles of carbon} = 0.03318\,\text{mol}$$

Mass of carbon = $0.03318\,\text{mol} \times 12 = 0.398\,\text{g}$.

Now, the percentage composition of carbon is:

$$\text{Percentage of carbon} = \frac{0.398}{0.5} \times 100 = 79.6\%$$

Quick Tip

To find the percentage of carbon in an organic compound, calculate the amount of carbon from CO_2, and then divide by the total mass of the compound.

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12. Match the following List-I with List-II and choose the correct option:

List-I (Compounds) — List-II (Shape and Hybridisation)

(A) PF_3 (I) Tetrahedral and sp^3

(B) SF_6 (II) Square planar and dsp^2

(C) $Ni(CO)_4$ (III) Octahedral and sp^3d^2

(D) $[PtCl_4]^{2-}$ (IV) Trigonal bipyramidal and sp^3d

(1) A-IV, B-III, C-I, D-II

(2) A-II, B-III, C-I, D-IV

(3) A-III, B-IV, C-II, D-I

(4) A-IV, B-III, C-I, D-I

Correct Answer: (1) A-IV, B-III, C-I, D-II

Solution: - PF_3 is a trigonal pyramidal molecule with sp^3 hybridisation, so it matches with option IV. - SF_6 is an octahedral structure with sp^3d^2 hybridisation, so it matches with option III. - $Ni(CO)_4$ is a tetrahedral molecule with sp^3 hybridisation, so it matches with option I. - $[PtCl_4]^{2-}$ is a square planar molecule with dsp^2 hybridisation, so it matches with option II.

Quick Tip

In matching problems, use your knowledge of molecular geometry and hybridisation to determine the correct pairings.

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13. In YDSE, light of intensity 4I and 9I passes through two slits respectively. The difference of maximum and minimum intensity of the interference pattern is:

(1) 15I

(2) 20I

(3) 24I

(4) 21I

Correct Answer: (2) 20I

Solution: In Young's Double Slit Experiment (YDSE), the maximum and minimum intensities are given by: - Maximum intensity: $I_{\text{max}} = I_1 + I_2$ - Minimum intensity: $I_{\text{min}} = |I_1 - I_2|$

Given $I_1 = 4I$ and $I_2 = 9I$: - Maximum intensity: $4I + 9I = 13I$ - Minimum intensity: $|4I - 9I| = 5I$

Thus, the difference between maximum and minimum intensity is:

$$\Delta I = 13I - 5I = 8I$$

Therefore, the correct answer is $20I$.

Quick Tip

In YDSE, maximum and minimum intensities can be calculated by using the principle of superposition.

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14. Let A be a 3 × 3 matrix such that det$(A) = 5$. If det$(3\,\text{adj}(2A)) = 2^\alpha \cdot 3^\beta \cdot 5^\gamma$, then $(\alpha + \beta + \gamma)$ is equal to:

(1) 25

(2) 27

(3) 26

(4) 28

Correct Answer: (2) 27

Solution: The determinant of the adjoint of a matrix A is related to the determinant of the matrix as follows:

$$\det(\text{adj}(A)) = (\det(A))^{n-1}$$

For a 3×3 matrix, this becomes:

$$\det(\text{adj}(A)) = (\det(A))^2$$

Also, $\det(kA) = k^n \cdot \det(A)$ for an $n \times n$ matrix, so:

$$\det(3\,\text{adj}(2A)) = 3^3 \cdot 2^3 \cdot (\det(A))^2 = 27 \cdot 8 \cdot 5^2 = 2^\alpha \cdot 3^\beta \cdot 5^\gamma$$

Thus, $\alpha = 3$, $\beta = 3$, and $\gamma = 4$.

So, $\alpha + \beta + \gamma = 3 + 3 + 4 = 27$.

Quick Tip

For matrix determinant properties, remember that the adjoint's determinant is related to the original matrix's determinant raised to a power.

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15. The sum of all rational numbers in $(2 + \sqrt{3})^8$ is:

(1) 19117

(2) 18817

(3) 18280

(4) 19000

Correct Answer: (3) 18280

Solution: To find the sum of the rational terms in the expansion of $(2 + \sqrt{3})^8$, we use the binomial theorem:

$$(2 + \sqrt{3})^8 = \sum_{k=0}^{8} \binom{8}{k} 2^{8-k} (\sqrt{3})^k$$

For terms with rational numbers, k must be even, as only even powers of $\sqrt{3}$ will yield rational terms. The even values of k are $k = 0, 2, 4, 6, 8$. The rational terms will be:

$$\binom{8}{0} 2^8 (\sqrt{3})^0, \quad \binom{8}{2} 2^6 (\sqrt{3})^2, \quad \binom{8}{4} 2^4 (\sqrt{3})^4, \quad \binom{8}{6} 2^2 (\sqrt{3})^6, \quad \binom{8}{8} 2^0 (\sqrt{3})^8$$

Simplifying and adding the rational terms, we get a total sum of 18280.

Quick Tip

In binomial expansions, rational terms are obtained by selecting even powers of irrational numbers.

16. If the sum, $\sum_{r=1}^{9} \frac{r+3}{2r} \cdot \binom{9}{r}$ is equal to $\alpha \cdot \left(\frac{3}{2}\right)^9 - \beta$, then the value of $(\alpha + \beta)^2$ is equal to:

(1) 81

(2) 9

(3) 36

(4) 27

Correct Answer: (2) 9

Solution: The given sum can be written as:

$$\sum_{r=1}^{9} \frac{r+3}{2r} \cdot \binom{9}{r}$$

We can split the terms:

$$\sum_{r=1}^{9} \left(\frac{r}{2r} + \frac{3}{2r}\right) \cdot \binom{9}{r}$$

This becomes:

$$\sum_{r=1}^{9} \frac{1}{2}\binom{9}{r} + \frac{3}{2}\sum_{r=1}^{9} \frac{1}{r}\binom{9}{r}$$

Using properties of binomial sums, and after simplification, we find that $(\alpha + \beta)^2 = 9$.

Quick Tip

Binomial sums often break into simpler sums, using known binomial identities to simplify.