IIT JAM 2026 Chemistry Question Paper with Solutions

Time Allowed :3 Hour	**Maximum Marks :**100	**Total Questions :**65

General Instructions

Please read the following instructions carefully:

1. The examination is of 3 hours duration. There are a total of 60 questions carrying 100 marks. The entire paper is divided into three sections, A, B and C. All sections are compulsory. Questions in each section are of different types.
2. Section A contains a total of 30 Multiple Choice Questions (MCQ). Each MCQ type question has four choices out of which only one choice is the correct answer. Questions Q.1 – Q.30 belong to this section and carry a total of 50 marks. Q.1 – Q.10 carry 1 mark each and Questions Q.11 – Q.30 carry 2 marks each.
3. Section B contains a total of 10 Multiple Select Questions (MSQ). Each MSQ type question is similar to MCQ but with a difference that there will be more than one choices that are correct out of the four given choices. The candidate gets full credit if he/she selects all the correct answers only and no wrong answers. Questions Q.31 – Q.40 belong to this section and carry 2 marks each with a total of 20 marks.
4. Section C contains a total of 20 Numerical Answer Type (NAT) questions. For these NAT type questions, the answer is a real number which needs to be entered using the virtual keyboard on the monitor. No choices will be shown for these type of questions. Questions Q.41 – Q.60 belong to this section and carry a total of 30 marks. Q.41 – Q.50 carry 1 mark each and Questions Q.51 – Q.60 carry 2 marks each.
5. In all sections, questions not attempted will result in zero mark. In Section A (MCQ), wrong answer will result in NEGATIVE marks. For all 1-mark questions, 1/3 marks will be deducted for each wrong answer. For all 2-mark questions, 2/3 marks will be deducted for each wrong answer. In Section B (MSQ), there is NO NEGATIVE and NO PARTIAL marking provisions. There is NO NEGATIVE marking in Section C (NAT) as well.
6. Only Virtual Scientific Calculator is allowed. Charts, graph sheets, tables, cellular phone or other electronic gadgets are NOT allowed in the examination hall.
7. A Scribble Pad will be provided for rough work.

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1. Find the number of P–O–P (pyrophosphate) bonds present in P_4O_8.

Solution:

Step 1: Understand P–O–P bond.
A P–O–P bond is a bridging oxygen atom connecting two phosphorus atoms.
Such bonds are also called pyrophosphate linkages.

Step 2: Use oxidation state method.
In P_4O_8, assume oxidation state of phosphorus = x.
Since oxygen has oxidation state -2, we write:

$$4x + 8(-2) = 0.$$

$$4x - 16 = 0.$$

$$4x = 16.$$

$$x = +4.$$

Step 3: Count terminal P=O bonds.
Phosphorus in +4 oxidation state generally forms:
One P=O double bond and three P–O single bonds.

Total oxygen atoms = 8.

If each phosphorus forms one terminal P=O bond, total terminal oxygens = 4.

Remaining oxygens =

$$8 - 4 = 4.$$

Step 4: Determine P–O–P bridges.
Each bridging oxygen connects two phosphorus atoms.
Thus number of P–O–P bonds equals number of bridging oxygens.

Hence, number of P–O–P bonds =

$$\boxed{4}.$$

Quick Tip

Total oxygen atoms minus terminal P=O oxygens gives number of bridging oxygens. Each bridging oxygen corresponds to one P–O–P bond.

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2. Determine the shape of ClF_3 using VSEPR theory.

Solution:

Step 1: Find total valence electrons.
Chlorine has 7 valence electrons.
Each fluorine has 7 valence electrons.

Total valence electrons:

$$= 7 + 3(7) = 28.$$

Step 2: Determine number of electron pairs around central atom.
Chlorine forms three bonds with fluorine atoms.
Thus, 3 bonding pairs are present.

Remaining electrons on chlorine:

$$7 - 3 = 4 \text{ electrons}$$

which form 2 lone pairs.

Hence total electron pairs around chlorine:

$$3 \text{ bonding pairs} + 2 \text{ lone pairs} = 5.$$

Step 3: Determine electron geometry.
Five electron pairs correspond to:

$$\text{Trigonal Bipyramidal electron geometry.}$$

Step 4: Arrange lone pairs.
According to VSEPR, lone pairs occupy equatorial positions to minimize repulsion.
Two equatorial positions are occupied by lone pairs.

Remaining three positions are occupied by fluorine atoms.

Step 5: Molecular shape.
After placing lone pairs, the molecular geometry becomes:

$$\boxed{\text{T-shaped}}.$$

Quick Tip

For 5 electron pairs (trigonal bipyramidal arrangement), if there are 2 lone pairs, the molecular shape becomes T-shaped.

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3. List the compounds of Xenon having one lone pair on the central atom.

Solution:

Step 1: Understand valence electrons of Xenon.
Xenon (Xe) has 8 valence electrons.
While forming compounds, some electrons are used in bonding and remaining electrons form lone pairs.

Step 2: Check common Xenon compounds.

(i) XeF_2
Electron pairs around Xe = 5 (2 bonding + 3 lone pairs).
Hence, 3 lone pairs are present.

(ii) XeF_4
Electron pairs around Xe = 6 (4 bonding + 2 lone pairs).
Hence, 2 lone pairs are present.

(iii) XeF_6
Electron pairs around Xe = 7 (6 bonding + 1 lone pair).
Hence, 1 lone pair is present.

(iv) XeO_3
Total electron domains = 4 (3 bonding + 1 lone pair).
Hence, 1 lone pair is present.

(v) $XeOF_4$
Total electron domains = 6 (5 bonding + 1 lone pair).

Hence, 1 lone pair is present.

Step 3: Final Answer.
Compounds of Xenon having **one lone pair** are:

$$\boxed{XeF_6,\ XeO_3,\ XeOF_4}.$$

Quick Tip

To find lone pairs on Xenon, subtract number of bonding pairs from 4 (since Xe has 8 valence electrons = 4 pairs).

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4. Write the van der Waals equation and explain the van der Waals isotherm (P–V curve).

Solution:

Step 1: Van der Waals Equation.
The ideal gas equation is:

$$PV = nRT.$$

Van der Waals modified it to account for:
1. Finite volume of gas molecules
2. Intermolecular attraction

The van der Waals equation is:

$$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT.$$

Where:
a = measure of intermolecular attraction
b = excluded volume of gas molecules

Step 2: Explanation of Corrections.

Pressure correction:

$$P_{real} = P_{ideal} - \frac{an^2}{V^2}.$$

The term $\frac{an^2}{V^2}$ corrects for intermolecular attraction.

Volume correction:

$$V_{real} = V_{container} - nb.$$

The term nb accounts for finite molecular volume.

Step 3: Van der Waals Isotherm (P–V Curve).

When plotting pressure vs volume at constant temperature:

1. At high temperature ($T > T_c$):
Curve resembles ideal gas behaviour (smooth decrease).

2. At critical temperature ($T = T_c$):
Curve shows a point of inflection (critical point).

3. At low temperature ($T < T_c$):
Curve shows a characteristic S-shaped region.
This region represents liquid–gas phase transition.

The flat portion after Maxwell correction represents coexistence of liquid and vapour phases.

Step 4: Critical Constants.
At critical point:

$$\left(\frac{\partial P}{\partial V}\right)_T = 0$$
$$\left(\frac{\partial^2 P}{\partial V^2}\right)_T = 0.$$

Critical constants are:

$$V_c = 3nb,$$
$$P_c = \frac{a}{27b^2},$$
$$T_c = \frac{8a}{27Rb}.$$

Final Answer:
The van der Waals equation is:

$$\boxed{\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT}$$

and its P–V curve shows deviation from ideal behaviour with a characteristic S-shaped isotherm below critical temperature.

Quick Tip

The S-shaped region in van der Waals isotherm indicates phase transition. At the critical point, the curve has an inflection point.

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5. Langmuir isotherm

(A) Multilayer adsorption
(B) Very high temperature θ vs P curve with intercept
(C) Very low temperature θ vs P curve with slope
(D) Reciprocal form gives $\theta = \dfrac{KP}{1+KP}$

Correct Answer: (D) Reciprocal form gives $\theta = \dfrac{KP}{1+KP}$

Solution:

Step 1: Understand Langmuir adsorption isotherm.
Langmuir isotherm assumes monolayer adsorption on a homogeneous surface.
All adsorption sites are identical and there is no interaction between adsorbed molecules.

Step 2: Mathematical expression.
The Langmuir isotherm equation is:

$$\theta = \frac{KP}{1+KP}$$

where θ is fractional surface coverage, K is adsorption equilibrium constant, and P is pressure.

Step 3: Evaluation of options.
(A) Incorrect — Langmuir theory is limited to monolayer adsorption.
(B) and (C) Not defining statements of Langmuir isotherm.
(D) Correct — It gives the exact mathematical form of Langmuir isotherm.

Step 4: Conclusion.
Hence, option (D) is correct.

Quick Tip

Langmuir isotherm always represents monolayer adsorption and follows $\theta = \dfrac{KP}{1+KP}$.

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6. Find the interplanar spacing d_{hkl} (in Å) using Bragg's law.
Given: $n = 1$, $\lambda = 1.54\,\text{Å}$
Use Bragg's law: $n\lambda = 2d\sin\theta$.

Solution:

Step 1: Write Bragg's Law.
Bragg's law is given by:

$$n\lambda = 2d\sin\theta.$$

We are given:

$$n = 1, \quad \lambda = 1.54\,\text{Å}.$$

Step 2: Rearrange for d.

$$d = \frac{n\lambda}{2\sin\theta}.$$

Substituting $n = 1$:

$$d = \frac{1.54}{2\sin\theta}.$$

Step 3: Final Expression.
Thus, interplanar spacing is:

$$\boxed{d = \frac{1.54}{2\sin\theta}\,\text{Å}}.$$

(If θ is given, substitute directly to compute numerical value.)

Quick Tip

In X-ray diffraction problems, always remember Bragg's law: $n\lambda = 2d\sin\theta$. If first order reflection is given ($n = 1$), the formula simplifies significantly.

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7. For the reaction:

$$N_2O_3(g) \rightarrow NO(g) + NO_2(g)$$

If the degree of dissociation is $\alpha = 0.2$, find Δn_g and total number of moles at equilibrium (starting with 1 mole).

Solution:

Step 1: Find Δn_g.
Number of gaseous moles on product side = 2
Number of gaseous moles on reactant side = 1

$$\Delta n_g = 2 - 1 = 1.$$

Step 2: Initial moles.
Assume 1 mole of N_2O_3 initially.

Initial moles:

$$N_2O_3 = 1, \quad NO = 0, \quad NO_2 = 0.$$

Step 3: Change in moles.
If degree of dissociation = $\alpha = 0.2$, then moles dissociated:

$$= 1 \times 0.2 = 0.2.$$

Thus:

$$N_2O_3 \text{ left} = 1 - 0.2 = 0.8.$$

$$NO = 0.2.$$

$$NO_2 = 0.2.$$

Step 4: Total moles at equilibrium.

$$n_{total} = 0.8 + 0.2 + 0.2 = 1.2.$$

Final Answers:

$$\boxed{\Delta n_g = 1}$$

$$\boxed{n_{total} = 1.2}$$

Quick Tip

For dissociation reactions, total moles increase if $\Delta n_g > 0$. Always use: initial moles → change using α → equilibrium moles.

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8. The radioactive decay is given as:

$$^{238}_{92}U \to ^{210}_{82}Pb + 7\alpha + x\beta^-.$$

Find the value of x.

Solution:

Step 1: Understand the decay process.
Each α-particle emission reduces:
Mass number by 4
Atomic number by 2

Each β^- emission increases:
Atomic number by 1
Mass number remains unchanged

Step 2: Apply mass number conservation.
Initial mass number = 238.

After 7 α emissions:

$$238 - 7(4) = 238 - 28 = 210.$$

Final nucleus has mass number 210, which matches ^{210}Pb.
Thus mass balance is satisfied.

Step 3: Apply atomic number conservation.
Initial atomic number = 92.

After 7 α emissions:

$$92 - 7(2) = 92 - 14 = 78.$$

Let number of β^- emissions be x.

Each β^- increases atomic number by 1.

Final atomic number becomes:

$$78 + x.$$

Given final atomic number of Pb = 82.

$$78 + x = 82.$$

$$x = 4.$$

Final Answer:

$$\boxed{x = 4}.$$

Quick Tip

Remember: α emission decreases atomic number by 2. β^- emission increases atomic number by 1. Always balance both mass number and atomic number.

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9. Among the following compounds of Xenon, identify those having exactly one lone pair on Xenon:
XeF_2, XeO_2F_2, XeO_3, XeO_3F_2, $XeOF_2$.

Solution:

Step 1: Basic idea.
Xenon has 8 valence electrons = 4 electron pairs.
Number of lone pairs on Xe = 4 (number of bonds formed by Xe).
(Each σ bond counts as one bonding pair.)

Step 2: Analyze each compound.

(i) XeF_2
Number of σ bonds = 2.
Lone pairs on Xe = $4 - 2 = 2$ pairs left? Actually total electron domains = 5 (AX_2E_3).
Thus, 3 lone pairs are present.

(ii) XeO_2F_2
Total σ bonds = 4 (2 Xe=O and 2 Xe–F; each contributes one σ bond).
Thus bonding pairs = 4.
Remaining lone pairs = $4 - 4 = 0$?

But electron domain counting gives AX_4E_1.
Hence, 1 lone pair is present.

(iii) XeO_3
Three Xe=O bonds → 3 σ bonds.
Thus bonding pairs = 3.
Remaining lone pairs = $4 - 3 = 1$.

Hence, 1 lone pair is present.

(iv) XeO_3F_2
Total σ bonds = 5.
Bonding pairs = 5.
Remaining lone pairs = $4 - 5$ not possible → actually AX_5E_1.
Hence, 1 lone pair present.

(v) $XeOF_2$
Total σ bonds = 3.
Thus bonding pairs = 3.
Remaining lone pairs = $4 - 3 = 1$.
Hence, 1 lone pair is present.

Step 3: Final Answer.
Compounds having exactly one lone pair on Xe are:

$$\boxed{XeO_2F_2,\ XeO_3,\ XeO_3F_2,\ XeOF_2}.$$

Quick Tip

For Xenon compounds, count total σ bonds first. Number of lone pairs $= 4$ (number of σ bonds). Then verify using VSEPR notation $\mathrm{AX}_m\mathrm{E}_n$.

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10. Isothermal compressibility of an ideal gas

$$-\frac{1}{V}\left(\frac{dV}{dP}\right)_T$$

is equal to

(A) $\dfrac{nR}{P}$
(B) nR
(C) R
(D) $\dfrac{1}{P}$

Correct Answer: (D) $\dfrac{1}{P}$

Solution:

Step 1: Write the ideal gas equation.
For an ideal gas,

$$PV = nRT$$

At constant temperature T,

$$V = \frac{nRT}{P}$$

Step 2: Differentiate with respect to pressure.

$$\frac{dV}{dP} = -\frac{nRT}{P^2}$$

Step 3: Substitute in compressibility expression.
Isothermal compressibility is defined as:

$$\kappa_T = -\frac{1}{V}\left(\frac{dV}{dP}\right)_T$$

Substituting values:

$$\kappa_T = -\frac{1}{\frac{nRT}{P}}\left(-\frac{nRT}{P^2}\right)$$

$$\kappa_T = \frac{P}{nRT}\cdot\frac{nRT}{P^2}$$

$$\kappa_T = \frac{1}{P}$$

Step 4: Conclusion.
Hence, the isothermal compressibility of an ideal gas is $\frac{1}{P}$.

Quick Tip

For an ideal gas, always remember: Isothermal compressibility $\kappa_T = \frac{1}{P}$. It depends only on pressure and not on temperature.

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11. Which of the following has the highest melting point?

(A) LiBr
(B) NaBr
(C) $MgBr_2$
(D) $AlBr_3$

Correct Answer: (B) NaBr

Solution:

Step 1: Understand factors affecting melting point of ionic compounds.
Melting point mainly depends on lattice energy.
Higher lattice energy → stronger ionic bonding → higher melting point.
Lattice energy depends on:
- Charge on ions
- Size of ions (smaller size → stronger attraction)

Step 2: Compare the given compounds.

(A) LiBr → Li^+ is very small and highly polarizing. It increases covalent character (Fajan's rule), lowering melting point.

(B) NaBr → Na^+ is larger than Li^+ and less polarizing. Hence, bonding is more ionic and lattice energy remains high.

(C) $MgBr_2$ → Though Mg^{2+} has higher charge, it strongly polarizes Br^-, increasing covalent character and reducing melting point.

(D) $AlBr_3$ → Highly covalent in nature and exists as dimer (Al_2Br_6), so it has low melting point.

Step 3: Conclusion.
Among the given options, NaBr is the most ionic and thus has the highest melting point.

Quick Tip

Use Fajan's rule: Small highly charged cations increase covalent character, which lowers melting point. More ionic character → higher melting point.

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12. Compare the M–C bond length in the following complexes:
$Na_2[Mn(CO)_4], \quad Na[Mn(CO)_5], \quad Na[Mn(CO)_6].$

Solution:

Step 1: Understand metal–CO bonding.
In metal carbonyl complexes, bonding involves:
1. σ-donation from CO to metal.
2. π-back bonding from metal to CO.

Greater π-back bonding strengthens M–C bond and shortens M–C bond length.

Step 2: Effect of oxidation state.
More negative charge on complex → higher electron density on metal.
Higher electron density → stronger π-back bonding.
Stronger back bonding → shorter M–C bond.

Now compare charges:

$$[Mn(CO)_4]^{2-} \quad (\text{in } Na_2[Mn(CO)_4])$$

$$[Mn(CO)_5]^- \quad (\text{in } Na[Mn(CO)_5])$$
$$[Mn(CO)_6]^0 \quad (\text{neutral})$$

Electron density order on metal:

$$2- > 1- > 0.$$

Thus back bonding strength:

$$[Mn(CO)_4]^{2-} > [Mn(CO)_5]^- > [Mn(CO)_6].$$

Step 3: Final order of M–C bond length.
Stronger back bonding → shorter bond.

Hence bond length order (shortest to longest):

$$\boxed{[Mn(CO)_4]^{2-} < [Mn(CO)_5]^- < [Mn(CO)_6]}.$$

Or in decreasing bond length:

$$\boxed{[Mn(CO)_6] > [Mn(CO)_5]^- > [Mn(CO)_4]^{2-}}.$$

Quick Tip

More negative charge on metal carbonyl complex increases π-back bonding, which shortens the M–C bond.

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13. Given $C_p = a + bT$
$a = 19.5, \quad b = 0.042, \quad n = 1$ mole
Temperature changes from $27°C$ **to** $327°C$.
Find ΔH.

Solution:

Step 1: Convert temperature to Kelvin.

$$T_1 = 27^\circ C = 300\,K$$

$$T_2 = 327^\circ C = 600\,K$$

Step 2: Use formula for enthalpy change.

$$\begin{aligned}\Delta H &= \int_{T_1}^{T_2} C_p\,dT \\ &= \int_{T_1}^{T_2} (a + bT)\,dT\end{aligned}$$

Step 3: Integrate.

$$\Delta H = a(T_2 - T_1) + \frac{b}{2}(T_2^2 - T_1^2)$$

Step 4: Substitute values.

$$T_2 - T_1 = 600 - 300 = 300$$

$$\begin{aligned}T_2^2 - T_1^2 &= 600^2 - 300^2 \\ &= 360000 - 90000 \\ &= 270000\end{aligned}$$

Now calculate:

$$\Delta H = 19.5(300) + \frac{0.042}{2}(270000)$$

$$= 5850 + (0.021)(270000)$$

$$= 5850 + 5670$$

$$= 11520$$

Final Answer:

$$\boxed{\Delta H = 11520}$$

(Units depend on given C_p, typically J/mol.)

Quick Tip

If C_p is temperature dependent, always integrate: $\Delta H = \int C_p \, dT$. Remember to convert temperature to Kelvin.

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14. T-shape geometry is shown by

(A) XeF_2
(B) SO_2
(C) IO_4^-
(D) BrF_3

Correct Answer: (D) BrF_3

Solution:

Step 1: Use VSEPR theory.
T-shape geometry corresponds to AX_3E_2 type molecule.
This means 5 electron pairs (trigonal bipyramidal arrangement) with 2 lone pairs occupying equatorial positions.

Step 2: Analyze each option.

(A) $XeF_2 \rightarrow AX_2E_3 \rightarrow$ Linear geometry.

(B) $SO_2 \rightarrow AX_2E \rightarrow$ Bent geometry.

(C) $IO_4^- \rightarrow AX_4 \rightarrow$ Tetrahedral geometry.

(D) $BrF_3 \rightarrow AX_3E_2 \rightarrow$ Trigonal bipyramidal electron geometry with 2 lone pairs $\rightarrow$ T-shaped molecular geometry.

Step 3: Conclusion.
Therefore, BrF_3 shows T-shaped geometry.

Quick Tip

T-shape geometry arises from AX_3E_2 type molecules. Remember: 5 electron pairs → 2 lone pairs in equatorial positions → T-shape.

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15. Which of the following has tetrahedral coordination?

(A) CdI_2
(B) CsCl
(C) ZnS (sphalerite)
(D) ZnS (wurtzite)

Correct Answer: (C) ZnS (sphalerite), (D) ZnS (wurtzite)

Solution:

Step 1: Understand tetrahedral coordination.
In tetrahedral coordination, each cation is surrounded by 4 anions arranged at the corners of a tetrahedron.
Coordination number = 4.

Step 2: Analyze each compound.

(A) CdI_2 → Layered structure → Octahedral coordination (Coordination number = 6).

(B) CsCl → Cubic structure → Coordination number = 8 (body-centered cubic type).

(C) ZnS (sphalerite) → Zinc blende structure → Each Zn^{2+} surrounded by 4 S^{2-} → Tetrahedral coordination.

(D) ZnS (wurtzite) → Hexagonal structure → Also tetrahedral coordination (Coordination number = 4).

Step 3: Conclusion.
Both sphalerite and wurtzite forms of ZnS have tetrahedral coordination.

Quick Tip

ZnS exists in two polymorphic forms: zinc blende (cubic) and wurtzite (hexagonal). Both have coordination number 4 (tetrahedral).