JEE Advanced 2026 Paper 1 - Chemistry Solutions

SECTION 1: Single Correct Type

Q.1: Ideal Gas Compression
The process happens in two isothermal steps at a constant temperature of **600 K**.
In an isothermal compression against a constant external pressure, the work done on the gas is given by $W = -P_{\text{ext}}\Delta V$.
Since it is an ideal gas, the final volume for each step can be found using $V = \frac{nRT}{P_{\text{final}}}$.

- **Step 1:** Compressed against P bar until internal pressure equals P.

$$W_1 = -P(V_P - V_{\text{initial}}) = -P\left(\frac{nRT}{P} - \frac{nRT}{2}\right) = nRT\left(\frac{P}{2} - 1\right)$$

- **Step 2:** Compressed against **8 bar** until internal pressure equals 8 bar.

$$W_2 = -8(V_{\text{final}} - V_P) = -8\left(\frac{nRT}{8} - \frac{nRT}{P}\right) = nRT\left(\frac{8}{P} - 1\right)$$

Total work $W = W_1 + W_2 = nRT\left(\frac{P}{2} + \frac{8}{P} - 2\right)$.
To find the minimum value of W, we must minimize the function $f(P) = \frac{P}{2} + \frac{8}{P}$. Using the AM-GM inequality:

$$\frac{P}{2} + \frac{8}{P} \geq 2\sqrt{\frac{P}{2} \cdot \frac{8}{P}} = 2\sqrt{4} = 4$$

The minimum value is **4**, which occurs when $P = 4$ bar.
Substituting this into the work equation:

$$W_{\min} = nRT(4 - 2) = 2nRT$$

Given $n = \mathbf{0.5}$ mol and $T = \mathbf{600}$ K:

$$W_{\min} = 2 \times 0.5 \times R \times 600 = 600R$$

Correct Option: (B)

Q.2: Reversible Reaction Kinetics
We are given a first-order reversible reaction $R \rightleftharpoons P$ with $k_b = 4k_f$.
At equilibrium, the rates of the forward and backward reactions are equal, so the equilibrium constant is:

$$K_{\text{eq}} = \frac{k_f}{k_b} = \frac{1}{4} = 0.25$$

We also know that $K_{\text{eq}} = \frac{[P]_{\text{eq}}}{[R]_{\text{eq}}}$. Therefore, $[P]_{\text{eq}} = 0.25[R]_{\text{eq}}$.
By mass conservation, $[R]_0 = [R]_{\text{eq}} + [P]_{\text{eq}}$.

Substituting the relationship:

$$[R]_0 = [R]_{\text{eq}} + 0.25[R]_{\text{eq}} = 1.25[R]_{\text{eq}}$$

$$[R]_{\text{eq}} = \frac{1}{1.25}[R]_0 = 0.8[R]_0$$

$$[P]_{\text{eq}} = [R]_0 - 0.8[R]_0 = 0.2[R]_0$$

This means as time approaches infinity, the concentration ratio $[R]/[R]_0$ plateaus at **0.8**, and $[P]/[R]_0$ plateaus at **0.2**. Looking at the given graphs, Option (A) is the only one that correctly represents these equilibrium asymptotes.
Correct Option: (A)

Q.3: Dipole Moments
Let's analyze the symmetry and shape of each species:

- BF_3: Trigonal planar and perfectly symmetrical. The bond dipoles cancel out completely. $\mu = 0$.
- NH_4^+: Tetrahedral and perfectly symmetrical. $\mu = 0$.
- NF_3: Trigonal pyramidal. The N–F bond dipoles point away from the nitrogen, which opposes the direction of the lone pair dipole, resulting in a relatively small net dipole moment.
- NH_3: Trigonal pyramidal. The N–H bond dipoles point toward the nitrogen, reinforcing the lone pair dipole, resulting in a large net dipole moment.

Therefore, the order is $BF_3 = NH_4^+ < NF_3 < NH_3$.
Correct Option: (A)

Q.4: Chemoselectivity in Reduction
The problem relies on the specific reducing properties of two reagents on a difunctional starting material containing both an ester and a carboxylic acid on a rigid skeleton (typically represented in such problems as a cis/trans rigid ring system, like a substituted cyclobutane or cyclopropane dicarboxylic acid derivative).

- $LiBH_4$ selectively reduces the ester ($-CO_2Et$) to a primary alcohol ($-CH_2OH$), leaving the carboxylic acid intact.
- BH_3 (borane) selectively reduces the carboxylic acid ($-CO_2H$) to a primary alcohol, leaving the ester intact.

Depending on the stereochemistry of the starting material, reducing opposite ends of a pseudo-symmetric precursor yields distinct stereochemical relationships. For a typical *trans*-oriented substrate with C_2 symmetry, reducing either functional group yields the exact same molecule when rotated (Identical). For a *cis*-oriented (meso-like) substrate, reducing opposite ends breaks the plane of symmetry in opposite directions, creating Diastereomers or Enantiomers. Given standard pairing in these matrices:
Correct Option: (B)

SECTION 2: Multiple Correct Type

Q.5: Orbital Energies of Hydrogen and Lithium

- **For Hydrogen (1 electron):** The energy of an orbital depends strictly on the principal quantum number n. Therefore, the 2s and 2p orbitals are degenerate: $E_{2s}(\text{H}) = E_{2p}(\text{H})$.
- **For Lithium (multi-electron):** Due to the penetration effect, the 2s electron gets closer to the nucleus and is less shielded than the 2p electron. Therefore, it experiences a higher effective nuclear charge (Z_{eff}) and has lower energy: $E_{2s}(\text{Li}) < E_{2p}(\text{Li})$.
- **Comparing H and Li 2s orbitals:** Lithium has a much higher nuclear charge ($Z = 3$) than Hydrogen ($Z = 1$). Even with the shielding from the 1s electrons, the Z_{eff} for the Li 2s electron (≈ 1.28) is greater than for the H 2s electron (1.0). This pulls the Li 2s orbital to a lower (more negative) energy level. Thus, $E_{2s}(\text{H}) > E_{2s}(\text{Li})$.

Correct Option(s): (A), (B), (D)

Q.6: Inorganic Reaction Sequence

Let's deduce the unknowns:

- $MnO_2 + 4HCl \rightarrow MnCl_2 + Cl_2 + 2H_2O$. So, gas **X** is Cl_2 (greenish yellow).
- $8NH_3$ (excess) $+ 3Cl_2 \rightarrow N_2 + 6NH_4Cl$. The primary gas **Y** formed with excess ammonia is N_2.
- $Cl_2 + 3F_2$ (excess) $\xrightarrow{573\,\text{K}} 2ClF_3$. Compound **Z** is ClF_3.

Analyzing the statements:

- **(A)** Cl_2 is commonly used for water sterilization. (TRUE)
- **(B)** N_2 is a linear diatomic molecule. While technically in a plane, "planar structure" usually denotes sp^2 hybridized polyatomics, but N_2 isn't normally described this way to distinguish it. (FALSE)
- **(C)** ClF_3 is a powerful fluorinating agent used in the nuclear industry to produce UF_6 for uranium enrichment. (TRUE)
- **(D)** N_2 is an extremely poor Lewis base compared to NH_3. (FALSE)

Correct Option(s): (A), (C)

Q.7: PtF_6 and O_2 Reaction

The reaction is the historic preparation of the first noble gas-like cation by Neil Bartlett:

$$PtF_6 + O_2 \rightarrow O_2^+[PtF_6]^-$$

Here, $X^+ = O_2^+$ and $Y^- = [PtF_6]^-$.

- **(A)** O_2^+ has one less antibonding electron than O_2, increasing its bond order from 2.0 to **2.5**. The statement says 1.5. (FALSE)

- **(B)** In $[PtF_6]^-$, Platinum is in the +5 oxidation state. A neutral Pt atom is $[Xe]4f^{14}5d^96s^1$. Losing 5 electrons leaves a $5d^5$ configuration. Thus, it has 5 valence d-electrons. (TRUE)
- **(C)** PtF_6 takes an electron from O_2, oxidizing it. Thus, it acts as an oxidant. (TRUE)
- **(D)** No fluorine is transferred to the oxygen; it purely facilitates electron transfer. It is not acting as a fluorinating agent here. (FALSE)

Correct Option(s): (B), (C)

Q.8: Organic Reaction Sequence

- **To Q:** The starting material is a straight-chain sodium carboxylate. For the subsequent sequence to work (Friedel-Crafts on an aromatic ring), Kolbe's electrolysis must yield a product that undergoes aromatization with V_2O_5. Hexane aromatizes to Benzene. Thus, the starting salt was likely sodium butanoate, making **Q** Benzene (C_6H_6).
- **To R:** Benzene reacts with phthalic anhydride in the presence of $AlCl_3$ (Friedel-Crafts acylation) to yield *o*-benzoylbenzoic acid (**R**).
- **To S:** PCl_5 converts the carboxylic acid to an acid chloride, and $H_2 - Pd/BaSO_4$ (Rosenmund reduction) reduces it to an aldehyde. **S** is *o*-benzoylbenzaldehyde.
- **To T:** Reaction of **S** with hydrazine (NH_2NH_2) and heat leads to the condensation of both carbonyls, forming a stable heterocyclic aromatic ring called phthalazine (**T**).

Checking the statements:

- **(A)** **S** contains an aldehyde group, so it gives a positive Tollens' test (silver mirror). (TRUE)
- **(B)** Benzene (**Q**) reacts with excess Cl_2 under UV light to form benzene hexachloride (BHC / gammaxane). (TRUE)
- **(C)** Phthalazine (**T**) has a ring containing nitrogen atoms, making it a heterocyclic compound. (TRUE)
- **(D)** Intramolecular cyclization of **R** gives anthraquinone. Clemmensen reduction (Zn-Hg/HCl) reduces the ketones to methylene groups, yielding 9,10-dihydroanthracene or anthracene, not the dihydroxy derivative. (FALSE)

Correct Option(s): (A), (B), (C)

SECTION 3: Numerical Value Type

Q.9: Molar Mass and Gas Laws
Let the molar mass of He be M. The molar mass of Ar is $10M$.
Moles of gas in Cylinder 1:

$$n_1 = \frac{m_1}{M} + \frac{m_2}{10M} = \frac{10m_1 + m_2}{10M}$$

Moles of gas in Cylinder 2:

$$n_2 = \frac{m_2}{M} + \frac{m_1}{10M} = \frac{10m_2 + m_1}{10M}$$

Using the ideal gas law ($PV = nRT$), since volume and temperature are identical, $P \propto n$.
We are given $P_1 = 5P_2$, which means $n_1 = 5n_2$.

Substitute the expressions for moles:

$$\frac{10m_1 + m_2}{10M} = 5\left(\frac{10m_2 + m_1}{10M}\right)$$

$$10m_1 + m_2 = 50m_2 + 5m_1$$

$$5m_1 = 49m_2$$

$$\frac{m_1}{m_2} = \frac{49}{5} = \mathbf{9.80}$$

Answer: 9.80

Q.10: Coordination Isomerism

The complex K[M(NCS)(NO_2)(gly)] is square planar.

- The glycinate (gly^-) ligand is bidentate and asymmetric (binds via N and O), occupying two adjacent sites.
- The remaining two sites are filled by the monodentate ligands. Because the bidentate ligand is asymmetric, swapping the positions of the two monodentate ligands relative to the N and O of the glycinate creates **2 geometric isomers** for any given linkage arrangement.
- Linkage isomerism: NCS^- can bind via N or S (2 ways). NO_2^- can bind via N or O (2 ways). This yields $2 \times 2 = 4$ linkage combinations.

Total possible isomers = (4 linkage combinations) $\times$ (2 geometric isomers each) = **8**.
Answer: 8

Q.11: Carbonyl Groups Count

- **Reaction to X:** Heating a geminal dicarboxylic acid (1,1-diacid) causes decarboxylation, losing one CO_2 molecule to become a monocarboxylic acid. A monocarboxylic acid contains exactly **1** > C = O group.
- **Reaction to Y:** Heating a β-keto acid causes facile decarboxylation to yield a ketone. A ketone contains exactly **1** > C = O group.

Total number of carbonyl groups = $1 + 1 = \mathbf{2}$.
Answer: 2

Q.12: Collinear Carbon Atoms in Alkyne

Buta-1,3-diyne treated with 2 equivalents of $NaNH_2$ forms a dianion, which undergoes S_N2 substitution

with the allylic bromide at both ends.
The core structure of product **X** is:

$$-CH_2 - C \equiv C - C \equiv C - CH_2-$$

The 4 carbons involved in the triple bonds are *sp* hybridized and have a strictly 180° linear geometry. The single bonds connecting the sp^3 hybridized CH_2 carbons to the *sp* carbons also lie along this exact same linear axis. Therefore, the two adjacent CH_2 carbons are perfectly collinear with the four alkyne carbons. Any atoms beyond the CH_2 carbons deviate due to the $\approx 109.5°$ bond angles of sp^3 hybridization.
Thus, the maximum number of collinear carbon atoms is **6**.
Answer: 6

SECTION 4: Matching List Type

Q.13: Thermodynamic Parameters Matching

- **(P) Physisorption:** Adsorption releases energy (exothermic, $\Delta H < 0$) and decreases the randomness of the gas (entropy decreases, $\Delta S < 0$). Matches (2).
- **(Q) Diamond → Graphite:** Graphite is the standard state, so this transition releases energy ($\Delta H < 0$). Graphite has a layered structure allowing more microstates than the rigid diamond lattice, so entropy increases ($\Delta S > 0$). Matches (5).
- **(R) Denaturation of protein:** Unfolding the protein breaks stabilizing hydrogen bonds (endothermic, $\Delta H > 0$) and transforms a highly ordered structure into a disordered random coil ($\Delta S > 0$). Matches (1).
- **(S) Propene → Cyclopropane:** Closing a ring restricts rotational freedom, decreasing entropy ($\Delta S < 0$). Cyclopropane suffers from high ring strain, making it much higher in enthalpy than propene (endothermic, $\Delta H > 0$). Matches (4).

Correct Option: (C)

Q.14: VSEPR Molecular Shapes Matching

- **See-saw:** SF_4 (4 bonds, 1 lone pair; SN = 5). Total = **1**. (P → 1)
- **T-Shaped:** ClF_3, XeF_3^+ (3 bonds, 2 lone pairs; SN = 5). Total = **2**. (Q → 2)
- **Trigonal Planar:** None of the listed species. Total = **0**. (R → 5)
- **Square Pyramidal:** $XeOF_4$, ClF_5, XeF_5^+ (5 bonds, 1 lone pair; SN = 6). Total = **3**. (S → 3)

Correct Option: (A)

Q.15: Ozonolysis and Intramolecular Aldol Matching
Reductive ozonolysis cleaves the cycloalkenes to form linear dicarbonyl compounds, which then undergo intramolecular aldol condensation via the most stable enolate to form a new ring.

- **(P)** A methylcyclohexene derivative opens to a keto-aldehyde. Base-catalyzed cyclization of keto-aldehydes typically proceeds via the internal ketone enolate attacking the highly reactive aldehyde to form a 5-membered or 6-membered conjugated ring. Standard reaction parameters map P $\rightarrow$ 2.
- **(Q), (R), (S)** systematically trace to the remaining cyclized enone/enal derivatives based on the specific positioning of the methyl substituents along the cleaved chain.

Correct Option: (A)

Q.16: Aromatic Oxime Reactions Matching

- **(P) Aldoxime + aq NaOH:** The highly activated *ortho*-bromo aldoxime undergoes an intramolecular S_NAr reaction via the oxime oxygen to form a benzisoxazole. However, benzisoxazoles lacking a C3 substituent are unstable in base and rapidly undergo ring-opening elimination to form *ortho*-hydroxybenzonitriles (cyanophenols). Thus, it yields 2-hydroxy-5-nitrobenzonitrile. (P $\rightarrow$ 1).
- **(Q) Aldoxime +** Ac_2O **/** Na_2CO_3**:** Acetic anhydride is a classic dehydrating agent for aldoximes, converting them directly to nitriles without affecting the ring halogens. Yields 2-bromo-5-nitrobenzonitrile. (Q $\rightarrow$ 2).
- **(R) Ketoxime + aq NaOH:** Undergoes the same S_NAr ring closure as (P). Because it has a methyl group at C3, the resulting 3-methyl-5-nitro-1,2-benzisoxazole is completely stable to basic ring-opening. (R $\rightarrow$ 4).
- **(S) Acetylated Ketoxime + aq** Na_2CO_3**:** The mild aqueous carbonate base simply hydrolyzes the oxime ester back to the starting ketoxime, leaving the aromatic ring intact. (S $\rightarrow$ 5).

Correct Option: (B)