JEE Main 2025 April 2 Shift 2 Chemistry Question Paper with Solutions

Time Allowed :3 Hours	Maximum Marks :300	Total Questions :75

General Instructions

Read the following instructions very carefully and strictly follow them:

1. Multiple choice questions (MCQs)
2. Questions with numerical values as answers.
3. There are three sections: **Mathematics, Physics, Chemistry**.
4. **Mathematics:** 25 (20+5) 10 Questions with answers as a numerical value. Out of 10 questions, 5 questions are compulsory.
5. **Physics:** 25 (20+5) 10 Questions with answers as a numerical value. Out of 10 questions, 5 questions are compulsory..
6. **Chemistry:** 25 (20+5) 10 Questions with answers as a numerical value. Out of 10 questions, 5 questions are compulsory.
7. Total: 75 Questions (25 questions each).
8. 300 Marks (100 marks for each section).
9. **MCQs:** Four marks will be awarded for each correct answer and there will be a negative marking of one mark on each wrong answer.
10. **Questions with numerical value answers:** Candidates will be given four marks for each correct answer and there will be a negative marking of 1 mark for each wrong answer.

Chemistry

SECTION-A

51. When a concentrated solution of sulphanilic acid and 1-naphthylamine is treated with nitrous acid (273 K) and acidified with acetic acid, the mass (g) of 0.1 mole of product formed is: (Given molar mass in g mol^{-1}: H : 1, C : 12, N : 14, O : 16, S : 32)

(1) 343 (2) 330 (3) 33 (4) 66

Correct Answer: (3) 33

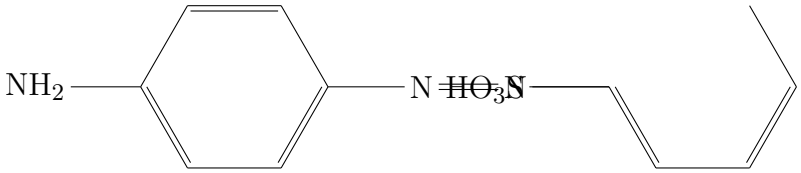
Solution:
Step 1: Formation of Diazonium Salt Sulphanilic acid reacts with nitrous acid (HNO_2) at 273 K to form a diazonium salt:

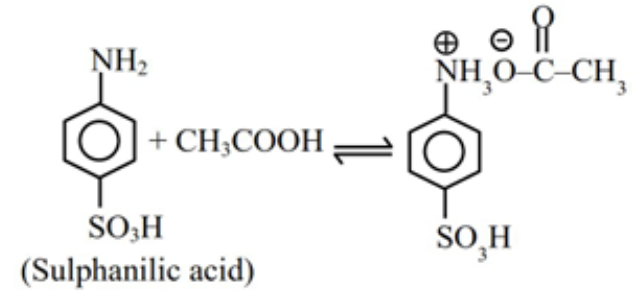
$$NH_2\text{-}\underset{SO_3H_6}{C}H_4 + HNO_2 + H^+ \rightarrow N_2^+\text{-}\underset{SO_3H_6}{C}H_4 + 2H_2O$$

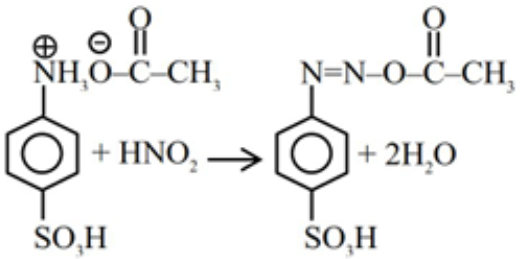
Step 2: Coupling Reaction The diazonium salt couples with 1-naphthylamine in the presence of acetic acid to form a red azo dye:

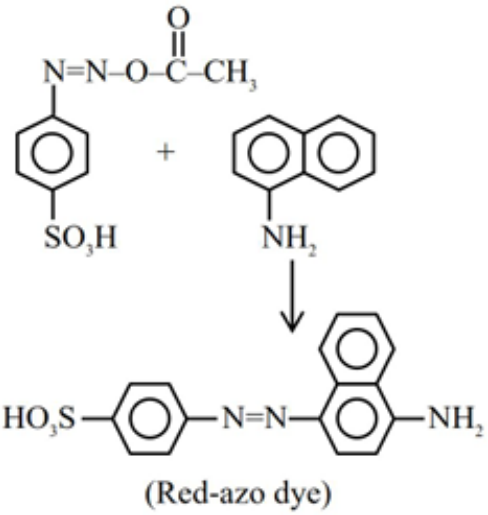
$$N_2^+\text{-}\underset{SO_3H_6}{C}H_4 + NH_2\text{-}C_{10}H_7 \rightarrow HO_3S\text{-}\underset{N=N_6}{C}H_4\text{-}C_{10}H_6\text{-}NH_2 + H^+$$

Structure of the Red Azo Dye:









Step 3: Calculate Molar Mass and Mass of Product - Molar mass of the red azo dye:

$$C_{16}H_{12}N_3O_3S = (16 \times 12) + (12 \times 1) + (3 \times 14) + (3 \times 16) + 32 = 327 \text{ g/mol}$$

- Mass of 0.1 mole:

$$0.1 \times 327 = 32.7 \text{ g} \approx 33 \text{ g}$$

Hence, the answer is **33 g**.

Quick Tip

Key Points to Remember: 1. **Diazotization**: Sulphanilic acid forms a diazonium salt at low temperatures (273 K) with nitrous acid. 2. **Coupling Reaction**: The diazonium salt reacts with 1-naphthylamine (an aromatic amine) to form an azo dye, which is brightly colored. 3. **Molar Mass Calculation**: Always verify the molecular formula and sum the atomic masses carefully. For azo dyes, the -N=N- linkage is crucial. 4. **Approximation**: The question asks for the nearest option; 32.7 g rounds to 33 g.

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52. The d-orbital electronic configuration of the complex among

$$[Co(en)_3]^{3+}$$

,

$$[CoF_6]^{2-}$$

,

$$[Mn(H_2O)_6]^{2+}$$

, and

$$[Zn(H_2O)_6]^{2+}$$

that has the highest Crystal Field Stabilization Energy (CFSE) is:

(1) $t_{2g}^6 e_g^0$ (2) $t_{2g}^6 e_g^4$ (3) $t_{2g}^3 e_g^2$ (4) $t_{2g}^4 e_g^2$

Correct Answer: (1) $t_{2g}^6 e_g^0$

Solution:

Step 1: Identify Ligand Field Strength - **Strong Field Ligands (SFL)**: Ethylenediamine (en) causes large splitting (Δ_o), leading to high CFSE. - **Weak Field Ligands (WFL)**: F^- and H_2O cause smaller splitting (Δ_o), resulting in lower CFSE.

Step 2: Determine d-Electron Configuration - **$[Co(en)_3]^{3+}$**: - Co^{3+} has $3d^6$ configuration. - In an octahedral SFL, electrons pair up in t_{2g} orbitals:

$$t_{2g}^6 e_g^0 \quad \text{(Maximum CFSE)}$$

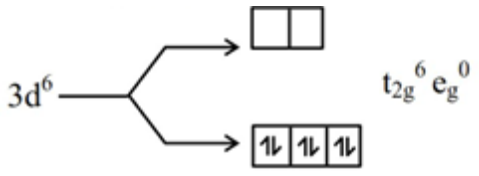

Figure: d-orbital splitting in $[Co(en)_3]^{3+}$ (SFL).

- **Other Complexes**: - $[CoF_6]^{2-}$: $t_{2g}^4 e_g^2$ (WFL, low CFSE). - $[Mn(H_2O)_6]^{2+}$: $t_{2g}^3 e_g^2$ (WFL, low CFSE). - $[Zn(H_2O)_6]^{2+}$: $t_{2g}^6 e_g^4$ (d^{10}, CFSE = 0).

Step 3: Compare CFSE Values - **$[Co(en)_3]^{3+}$**: CFSE = $-2.4\Delta_o$ (highest due to SFL and $t_{2g}^6 e_g^0$). - Other complexes have lower or zero CFSE.

Hence, the correct configuration is $t_{2g}^6 e_g^0$.

Quick Tip

Key Concepts: 1. **Ligand Field Strength**: SFL (e.g., en, CN^-) ¿ WFL (e.g., F^-, H_2O). 2. **CFSE Formula**: For octahedral complexes, CFSE = $(-0.4n_{t_{2g}} + 0.6n_{e_g})\Delta_o$. 3. **High-Spin vs. Low-Spin**: SFL favors low-spin (e.g., $t_{2g}^6 e_g^0$), while WFL favors high-spin (e.g., $t_{2g}^4 e_g^2$). 4. **Diagrams**: Always sketch d-orbital splitting to visualize electron distribution.

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53. Given below are two statements:

Statement (I): Neopentane forms only one monosubstituted derivative.

Statement (II): The melting point of neopentane is higher than n-pentane.

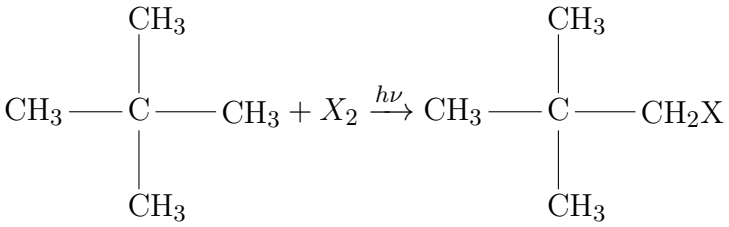
In the light of the above statements, choose the most appropriate answer from the options given below:

(1) Statement I is correct but Statement II is incorrect (2) Both Statement I and Statement II are correct (3) Both Statement I and Statement II are incorrect (4) Statement I is incorrect but Statement II is correct

Correct Answer: (2) Both Statement I and Statement II are correct

Solution:

Verification of Statement (I): Neopentane has four equivalent methyl groups, leading to only one possible monosubstituted product:



(X = Cl, Br)

Key Observation: All 12 hydrogens are equivalent
Result: Only one unique product forms

Verification of Statement (II): Comparison of melting points:

Compound	Melting Point (°C)
Neopentane	16.6
n-Pentane	-129.8

Reason: Neopentane's symmetric structure allows tighter packing in solid state.
Conclusion: Both statements are scientifically correct.

Quick Tip

Exam Insight: 1. Molecular symmetry determines substitution products
2. Branching increases melting point in alkanes
3. Always verify both statements independently
4. Recall that neopentane is $C(CH_3)_4$

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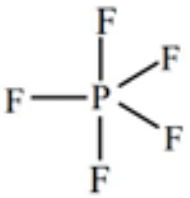
54. Which among the following molecules is (a) involved in sp^3d hybridization, (b) has different bond lengths, and (c) has lone pair of electrons on the central atom?

(1) PF_5 (2) XeF_4 (3) SF_4 (4) XeF_2

Correct Answer: (3) SF_4

Solution:



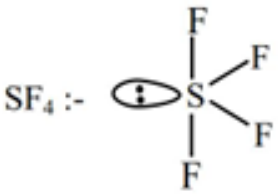
PF_5:
(a) Hybridisation = sp^3d
(b) All bonds are not identical (axial vs equatorial)
(c) No lone pair on phosphorus central atom

Trigonal bipyramidal geometry

XeF_4 :- sp^3d^2 Hybridisation

XeF_4:
- sp^3d^2 Hybridisation

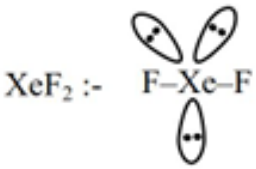
Square planar geometry with 2 lone pairs



SF_4:
(a) Hybridisation = sp^3d

(b) All bonds are not identical (axial vs equatorial)
(c) 1 lone pair on sulfur central atom

See-saw geometry



XeF_2:
(a) Hybridisation = sp^3d
(b) All bonds are identical
(c) 3 lone pairs on xenon central atom

Linear geometry

Conclusion:
Only SF_4 satisfies all three conditions:
1. sp^3d hybridization
2. Different bond lengths (axial and equatorial)
3. Presence of lone pair (1) on central atom

Quick Tip

Exam Shortcut:
For such questions, remember:
1. SF_4 is the "see-saw" molecule
2. It always has different bond lengths
3. The lone pair causes distortion from ideal geometry
4. Other molecules either lack lone pairs or have identical bonds

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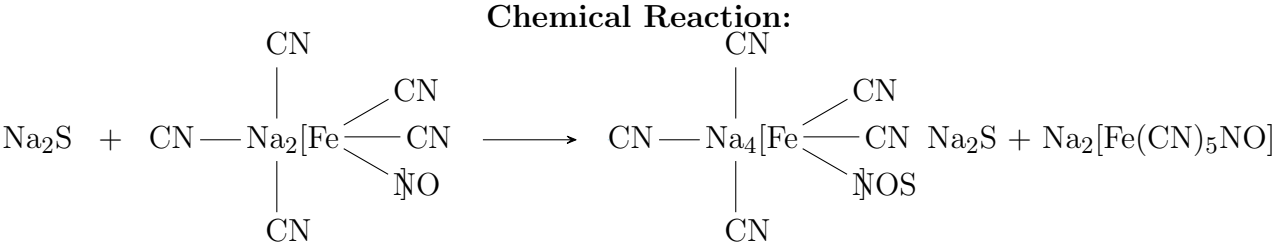
55. Formation of $Na_4[Fe(CN)_5NOS]$, a purple colored complex formed by addition of sodium nitroprusside in sodium carbonate extract of salt indicates the presence of:

(1) Sodium ion (2) Sulphate ion (3) Sulphide ion (4) Sulphite ion

Correct Answer: (3) Sulphide ion

Solution:

Chemical Reaction:



$\rightarrow Na_4[Fe(CN)_5NOS]$

Reactants: Sodium sulfide + Sodium nitroprusside
Product: Purple-colored complex ($Na_4[Fe(CN)_5NOS]$)
Observation: Violet coloration confirms sulfide ion

Key Points:

- This is a **characteristic test** for sulfide (S^{2-}) ions
- The purple color develops due to formation of the **nitrosyl complex**
- Sodium carbonate extract helps in maintaining basic conditions
- The test is highly sensitive for sulfide detection

Quick Tip

Exam Tips:

- Remember: Nitroprusside test $\rightarrow$ Sulfide ion detection
- The product is a **coordination complex** with Fe in +2 oxidation state
- Color change is immediate and distinctive (colorless to violet)
- Works for both soluble and insoluble sulfides after carbonate extraction

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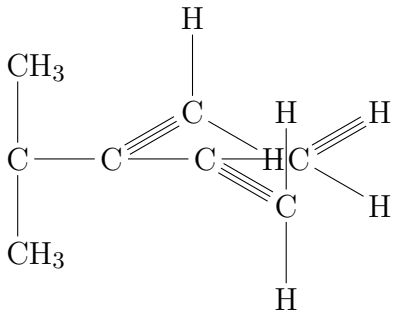
56. In 3,3-dimethylhex-1-ene-4-yne, there are _____ sp^3, _____ sp^2 and _____ sp hybridized carbon atoms respectively:

(1) 4, 2, 2 (2) 3, 3, 2 (3) 2, 4, 2 (4) 2, 2, 4

Correct Answer: (1) 4, 2, 2

Solution:



Hybridization Analysis:

Carbon Number	Bonding	Hybridization
1	CH_3 (methyl)	sp^3
2	CH_3 (methyl)	sp^3
3	C=C (double bond)	sp^2
4	CC (triple bond)	sp
5	C-$CH{=}CH_2$	sp^3
6	$=CH_2$ (terminal)	sp^2

Count:

- sp^3: 4 carbons (positions 1, 2, 5, and the other methyl)
- sp^2: 2 carbons (positions 3 and 6)
- sp: 2 carbons (position 4 and its partner in the triple bond)

Quick Tip

Key Concepts:

- Methyl groups (-CH_3) are always sp^3 hybridized
- Double bond carbons are sp^2 hybridized
- Triple bond carbons are sp hybridized
- Numbering is crucial - name indicates 3,3-dimethyl (positions 1 & 2)

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57. Which of the following statements are true?

(A) The subsidiary quantum number l describes the shape of the orbital occupied by the electron.

(B) $- \longleftarrow\!\!\!\!\!\!\longrightarrow +$ $\Rightarrow$ is the boundary surface diagram of the $2p_x$ orbital.

(C) The + and − signs in the wave function of the $2p_x$ orbital refer to charge.

(D) The wave function of $2p_x$ orbital is zero everywhere in the xy plane.

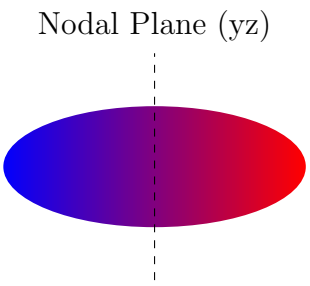
(1) (B) and (D) only (2) (A), (B) and (C) only
(3) (C) and (D) only (4) (A) and (B) only

Correct Answer: (4) (A) and (B) only

Solution:

(A) True: The azimuthal quantum number (l) determines the shape of the orbital (s=0, p=1, d=2, etc.).

(B) True:



This represents the $2p_x$ orbital with its characteristic dumb-bell shape and phase signs.

(C) False: The + and − signs represent the phase of the wave function, not electrical charge.

(D) False: The $2p_x$ orbital has a nodal plane (where $\psi = 0$) in the yz plane, not the xy plane.

Quick Tip

Key Concepts:

- l values: 0 (s), 1 (p), 2 (d), etc. determine orbital shapes
- p-orbitals have two lobes with opposite phases
- Nodal planes are where wave function $\psi = 0$ (for p_x, it's yz plane)
- Phase signs $(+/-)$ indicate mathematical sign of ψ, not charge

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58. The type of hybridization and the magnetic property of $[MnCl_4]^{2-}$ are:

(1) d^2sp^3, paramagnetic with four unpaired electrons
(2) sp^3d^2, paramagnetic with four unpaired electrons
(3) d^2sp^3, paramagnetic with two unpaired electrons
(4) sp^3d^2, paramagnetic with two unpaired electrons

Correct Answer: (2) sp^3d^2, paramagnetic with four unpaired electrons

Solution:

$$[MnCl_4]^{2-} \text{ contains } Mn^{2+}$$

$$Mn^{2+} : [Ar]3d^5$$

$$\text{Ligand } \Rightarrow Cl^- \text{ (Weak Field Ligand)}$$

	↑	↑	↑	↑	↑
	$3d^5$				

$$\text{Hybridization} = sp^3d^2$$

4 unpaired electrons

Quick Tip

Key Concepts:

- Mn^{2+} has 5 valence electrons ($3d^5$ configuration)
- Cl^- is a weak field ligand → high spin complex
- Outer orbital hybridization (sp^3d^2) occurs with WFL
- 4 unpaired electrons → strongly paramagnetic

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59. Consider the following reactions. From these reactions which reaction will give carboxylic acid as a major product?

(A) $R - C \equiv N \xrightarrow{\text{(i) } H^+/H_2O \text{ (mild condition)}}$

(B) $R - MgX \xrightarrow{\text{(ii) } CO_2 \text{(iii) } H_3O^+}$

(C) $R - C \equiv N \xrightarrow{\text{(i) } SnCl_2/HCl \text{(ii) } H_3O^+}$

(D) $RCH_2OH \xrightarrow{PCC}$

(E) $COCl \xrightarrow{\text{(i) } H_2[\text{Pd-BaSO}_4]} \text{(ii) } Br_2/H_2O$

Choose the correct answer from the options given below:

(1) A and D only (2) A, B and E only
(3) B, C and E only (4) B and E only

Correct Answer: (4) B and E only

Solution:

(A) $R - C \equiv N \xrightarrow{H^+/H_2O \text{ (mild)}} RCONH_2$
Under mild conditions, amide is formed. Carboxylic acid requires harsh conditions.

(B) $R - MgX \xrightarrow{\text{(i) } CO_2 \text{(ii) } H_3O^+} RCOOH$
Grignard reagent with CO_2 gives carboxylic acid directly.

(C) $R - C \equiv N \xrightarrow{SnCl_2/HCl} RCHO$
Stephen's reduction stops at aldehyde stage.

(D) $RCH_2OH \xrightarrow{PCC} RCHO$
PCC oxidation stops at aldehyde.

(E) $COCl \xrightarrow{\text{(i) } H_2[\text{Pd-BaSO}_4]} CHO \xrightarrow{\text{(ii) } Br_2/H_2O} COOH$
Rosenmund reduction followed by haloform reaction gives acid.

Quick Tip

Key Points:

- Grignard + CO_2 → Always gives carboxylic acid
- Nitrile hydrolysis needs harsh conditions for acid formation
- Stephen's reduction stops at aldehyde
- PCC oxidizes 1° alcohols to aldehydes only
- Acyl chloride can be converted to acid via aldehyde intermediate

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60. Electronic configuration of four elements A, B, C and D are given below:

(A) $1s^2 2s^2 2p^3$

(B) $1s^2 2s^2 2p^4$

(C) $1s^2 2s^2 2p^5$

(D) $1s^2 2s^2 2p^7$

Which of the following is the correct order of increasing electronegativity (Pauling's scale)?

(1) A ¡ D ¡ B ¡ C (2) A ¡ C ¡ B ¡ D
(3) A ¡ B ¡ C ¡ D (4) D ¡ A ¡ B ¡ C

Correct Answer: (4) D ¡ A ¡ B ¡ C

Solution:

- **Identification of Elements**:
  - A: Nitrogen (N) $1s^2 2s^2 2p^3$ (Electronegativity = 3.04)
  - B: Oxygen (O) $1s^2 2s^2 2p^4$ (Electronegativity = 3.44)
  - C: Fluorine (F) $1s^2 2s^2 2p^5$ (Electronegativity = 3.98)
  - D: Invalid configuration ($2p^7$ is not possible)
- **Electronegativity Trend**:

$$\text{F} > \text{O} > \text{N}$$

(Fluorine ¿ Oxygen ¿ Nitrogen)

- **For Option D**: Assuming it's Carbon ($1s^2 2s^2 2p^2$) with EN = 2.55

Correct Order: D (C) ¡ A (N) ¡ B (O) ¡ C (F)

Quick Tip

Key Concepts:

- Electronegativity increases across a period (left to right)
- Fluorine is the most electronegative element (EN = 3.98)
- $2p^7$ configuration is impossible (max 6 electrons in p-orbital)
- Typical EN values: C(2.55), N(3.04), O(3.44), F(3.98)

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61. Match List-I with List-II

List-I (Purification technique)	List-II (Mixture of organic compounds)
(A) Distillation (simple)	(I) Diesel + Petrol
(B) Fractional distillation	(II) Aniline + Water
(C) Distillation under reduced pressure	(III) Chloroform + Aniline
(D) Steam distillation	(IV) Glycerol + Spent-lye

Choose the correct answer from the options given below:

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

Correct Answer: (4) (A)-(III), (B)-(I), (C)-(IV), (D)-(II)

Solution:

List-I	List-II
(A) Simple Distillation	(III) Chloroform + Aniline
(B) Fractional Distillation	(I) Diesel + Petrol
(C) Reduced Pressure Distillation	(IV) Glycerol + Spent-lye
(D) Steam Distillation	(II) Aniline + Water

Explanation:

- **Simple Distillation**: Used for mixtures with large boiling point differences (Chloroform + Aniline)
- **Fractional Distillation**: For separating miscible liquids with close boiling points (Diesel + Petrol)
- **Reduced Pressure Distillation**: For heat-sensitive compounds (Glycerol + Spent-lye)
- **Steam Distillation**: For immiscible liquids (Aniline + Water)

Quick Tip

Key Points:

- Simple distillation → ¿25°C boiling point difference
- Fractional distillation → Similar boiling points
- Reduced pressure → Lowers boiling points
- Steam distillation → For water-immiscible compounds

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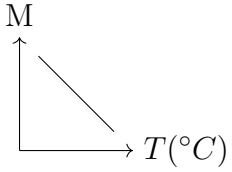
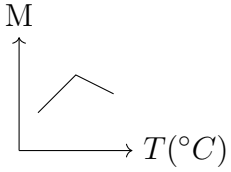
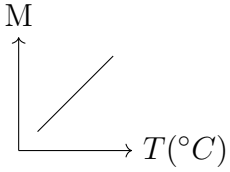
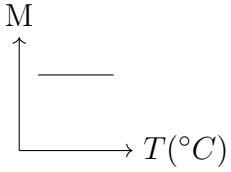
62. g of NaCl is added to water in a beaker with a lid. The temperature of the system is raised from 1°C to 25°C. Which out of the following plots is best suited for the change in the molarity (M) of the solution with respect to temperature?
[Consider the solubility of NaCl remains unchanged over the temperature range]

(1) 

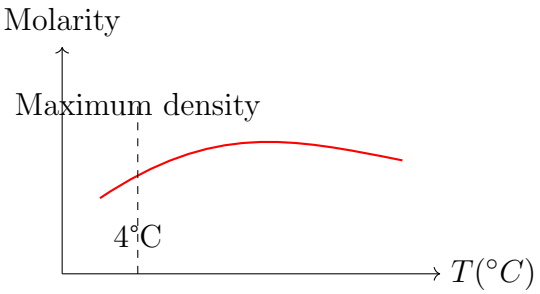
(2) 

(3) 

(4) 

Correct Answer: (2)

Solution:



Explanation:

- Molarity $(M) = \frac{n_{\text{solute}}}{\text{Volume of solution}}$
- Water shows anomalous expansion:
  - From 1°C to 4°C: Volume decreases (density increases)
  - Above 4°C: Volume increases normally with temperature
- Therefore:
  - 1°C $\rightarrow$ 4°C: Molarity increases (volume decreases)
  - 4°C $\rightarrow$ 25°C: Molarity decreases (volume increases)

Quick Tip

Key Concepts:

- Water has maximum density at 4°C
- Molarity depends on solution volume (inverse relationship)
- Solubility constant $\rightarrow$ moles of solute remain unchanged
- Graph should show peak around 4°C (option 2)

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63. Arrange the following in order of magnitude of work done by the system/on the system at constant temperature:

(a) $|W_{\text{reversible}}|$ for expansion in infinite stage

(b) $|W_{\text{irreversible}}|$ for expansion in single stage

(c) $|W_{\text{reversible}}|$ for compression in infinite stage

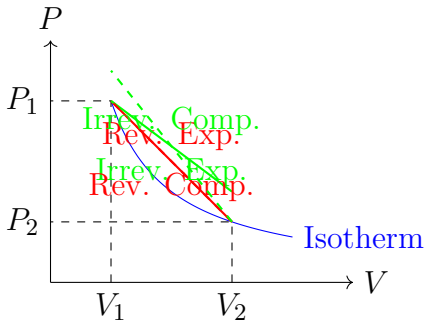
(d) $|W_{\text{irreversible}}|$ for compression in single stage

Choose the correct answer from the options given below:

(1) $a > b > c > d$ (2) $d > c = a > b$
(3) $c = a > d > b$ (4) $a > c > b > d$

Correct Answer: (2) $d > c = a > b$

Solution:



Key Results:

- For isothermal processes:

$$|W_{\text{rev,exp}}| = |W_{\text{rev,comp}}| = nRT \ln\left(\frac{V_f}{V_i}\right)$$

- For irreversible processes:

$$|W_{\text{irrev,exp}}| = P_{\text{ext}}(V_f - V_i)$$
$$|W_{\text{irrev,comp}}| > |W_{\text{rev,comp}}|$$

Order of Magnitude:

$$\boxed{|W_{\text{irrev,comp}}| > |W_{\text{rev,comp}}| = |W_{\text{rev,exp}}| > |W_{\text{irrev,exp}}|}$$

$$\boxed{d > c = a > b}$$

Quick Tip

Key Concepts:

- Reversible work is maximum for expansion and minimum for compression
- Irreversible compression requires more work than reversible
- Irreversible expansion does less work than reversible
- At constant temperature, $W_{\text{rev,exp}} = W_{\text{rev,comp}}$ in magnitude

---

63. Arrange the following in order of magnitude of work done by the system/on the system at constant temperature:

(a) $|W_{\text{reversible}}|$ for expansion in infinite stage

(b) $|W_{\text{irreversible}}|$ for expansion in single stage

(c) $|W_{\text{reversible}}|$ for compression in infinite stage

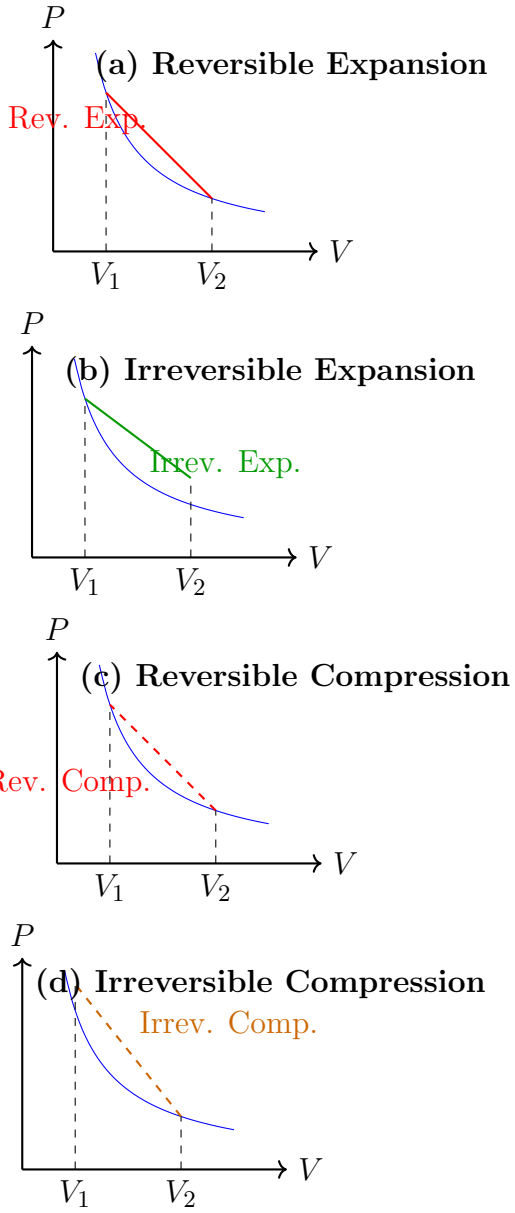
(d) $|W_{\text{irreversible}}|$ for compression in single stage

Choose the correct answer from the options given below:

(1) $a > b > c > d$ (2) $d > c = a > b$
(3) $c = a > d > b$ (4) $a > c > b > d$

Correct Answer: (2) $d > c = a > b$

Solution:



Key Observations:

1. **Area Under Curves** represents work magnitude:
   - Reversible processes follow the isotherm (maximum area for expansion/minimum for compression)
   - Irreversible processes have rectangular areas (less efficient)

2. **Work Relationships**:

$$|W_{\text{irrev,comp}}| > |W_{\text{rev,comp}}| = |W_{\text{rev,exp}}| > |W_{\text{irrev,exp}}|$$

(d) ¿ (c) = (a) ¿ (b)

Quick Tip

Memory Aid:

- Compression always requires **more work** than expansion
- Reversible processes are **most efficient**
- Irreversible compression is **least efficient** (max work input)
- Reversible expansion/compression between same states have **equal magnitude**

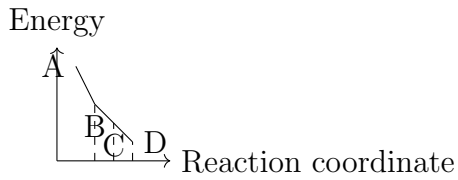
---

64. Reactant A converts to product D through the given mechanism (with the net evolution of heat):

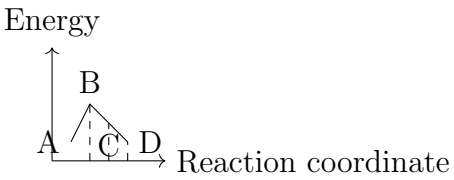
- A $\rightarrow$ B (slow; $\Delta H = +ve$)
- B $\rightarrow$ C (fast; $\Delta H = -ve$)
- C $\rightarrow$ D (fast; $\Delta H = -ve$)

Which of the following represents the above reaction mechanism?

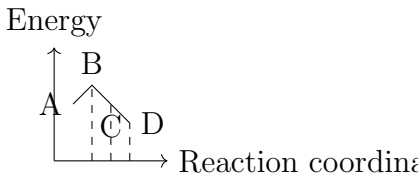
(1)



(2)

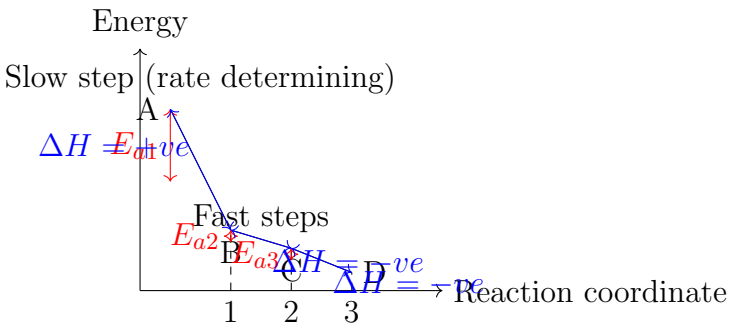


(3)



Correct Answer: (1)

Solution:



Key Features:

- **First step (A→B)**:
  - Endothermic ($\Delta H = +ve$)
  - High activation energy (E_{a1})
  - Slow (rate-determining step)
- **Subsequent steps (B→C→D)**:
  - Exothermic ($\Delta H = -ve$)
  - Low activation energies (E_{a2}, E_{a3})
  - Fast steps
- **Overall reaction**: Exothermic (net heat evolution)

Quick Tip

Exam Tips:

- The slow step has the highest energy barrier
- Endothermic steps show products at higher energy than reactants
- Exothermic steps show products at lower energy than reactants
- The correct diagram must show:
  1. Initial upward slope (A→B)
  2. Subsequent downward slopes (B→C→D)
  3. Highest peak at first transition state

---

65. The nature of oxide (TeO_2) and hydride (TeH_2) formed by Te, respectively are:

(1) Oxidising and acidic (2) Reducing and basic
(3) Reducing and acidic (4) Oxidising and basic

Correct Answer: (1) Oxidising and acidic

Solution:

- **TeO_2 (Tellurium dioxide)**:
  - **Oxidation state**: Te^{4+} (can be reduced to lower states)
  - **Nature**: Acts as oxidising agent
  - **Acid-base behavior**: Amphoteric/weakly acidic
- **TeH_2 (Hydrogen telluride)**:
  - **Oxidation state**: Te^{2-} (can be oxidized)
  - **Nature**: Acts as reducing agent
  - **Acid-base behavior**: Strongly acidic (weak H-Te bonds)

Conclusion:

- TeO_2 is oxidising (due to Te^{4+})
- TeH_2 is acidic (due to weak H-Te bonds)

Quick Tip

Key Points:

- Higher oxidation states tend to be oxidising
- Group 16 hydrides become more acidic down the group
- TeO_2 reacts with bases to form tellurites (Na_2TeO_3)
- TeH_2 is more acidic than H_2S or H_2Se

---

66. Match List-I with List-II

	List-I (Reaction)	**List-II (Name of reaction)**
(A)	$Ph-X + 2Na + Ph-X \xrightarrow{\text{Dry ether}} Ph-Ph + 2NaX$	(I) Lucas reaction
(B)	$ArN_2^+X^- \xrightarrow{Cu} ArCl + N_2\uparrow + CuX$	(II) Finkelstein reaction
(C)	$C_2H_5Br + NaI \xrightarrow{\text{Dry acetone}} C_2H_5I + NaBr$	(III) Fittig reaction
(D)	$CH_3C(OH)(CH_3)CH_3 \xrightarrow{HCl,\ ZnCl_2} CH_3C(Cl)(CH_3)CH_3$	(IV) Gatterman reaction

Choose the correct answer from the options given below:

(1) (A)-(III), (B)-(II), (C)-(IV), (D)-(I) (2) (A)-(III), (B)-(IV), (C)-(II), (D)-(I)
(3) (A)-(IV), (B)-(III), (C)-(I), (D)-(II) (4) (A)-(IV), (B)-(I), (C)-(II), (D)-(III)

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

Solution:

List-I (Reaction)	**List-II (Name)**
$Ph-X + 2Na + Ph-X \xrightarrow{\text{Dry ether}} Ph-Ph + 2NaX$	(III) Fittig reaction
$ArN_2^+X^- \xrightarrow{Cu} ArCl + N_2\uparrow + CuX$	(IV) Gatterman reaction
$C_2H_5Br + NaI \xrightarrow{\text{Dry acetone}} C_2H_5I + NaBr$	(II) Finkelstein reaction
$CH_3C(OH)(CH_3)CH_3 \xrightarrow{HCl,\ ZnCl_2} CH_3C(Cl)(CH_3)CH_3$	(I) Lucas reaction

Reaction Details:

1. **Fittig Reaction**:

$$Ph-X + 2Na + Ph-X \xrightarrow{\text{Dry ether}} Ph-Ph + 2NaX$$

- Coupling of two aryl halides (X = Cl/Br/I)
- Requires sodium metal in dry ether

2. **Gatterman Reaction**:

$$ArN_2^+Cl^- + Cu \rightarrow ArCl + N_2 \uparrow + CuCl$$

3. **Finkelstein Reaction**:

$$\text{R-Br} + \text{NaI} \rightarrow \text{R-I} + \text{NaBr}$$

4. **Lucas Test**:

$$3^\circ \text{ R-OH} + HCl/ZnCl_2 \rightarrow 3^\circ \text{ R-Cl (immediate turbidity)}$$

Quick Tip

Key Points:

- Fittig: Aryl-aryl coupling (forms biaryls)
- Gatterman: Diazonium salt conversion
- Finkelstein: Halogen exchange (Br/I)
- Lucas: Tests alcohol classification (1°/2°/3°)

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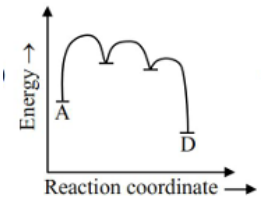
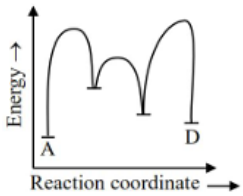
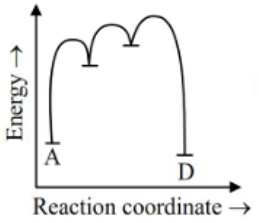
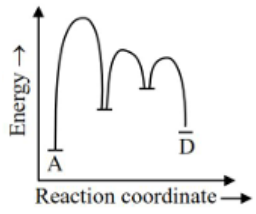
68. Which of the following graphs correctly represents the variation of thermodynamic properties of Haber's process?

(1) 

(2) 

(3) 

(4) 

Correct Answer: (1)

Solution:
The Haber's process is given by:

$$N2(g) + 3H2(g) <=> 2NH3(g)$$

Key Thermodynamic Properties:

- $\Delta H^\circ = -92.4$ kJ/mol (exothermic)
- $\Delta S^\circ = -198$ J/mol·K (decrease in disorder)
- $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$

Graph Analysis:

- Graph (1) correctly shows:

- $-\Delta G^\circ/T$ decreasing with temperature
- $\Delta H^\circ/T$ negative and increasing
- ΔS° constant and negative

- This matches theoretical expectations for an exothermic reaction with negative entropy change

Quick Tip

Key Concepts:

- For exothermic reactions ($\Delta H^\circ < 0$), equilibrium constant decreases with temperature
- When $\Delta S^\circ < 0$, $-\Delta G^\circ/T$ decreases with temperature
- Correct graph must show these relationships

---

69. A tetrapeptide "X" on complete hydrolysis produced glycine (Gly), alanine (Ala), valine (Val), and leucine (Leu) in equimolar proportions. The number of possible tetrapeptide sequences involving each of these amino acids is:

(1) 16 (2) 32 (3) 8 (4) 24

Correct Answer: (4) 24

Solution:

- The tetrapeptide contains 4 distinct amino acids: Gly, Ala, Val, Leu
- Each amino acid must appear exactly once in the sequence
- The number of possible sequences is the number of permutations of 4 distinct items

Calculation:

$$4! = 4 \times 3 \times 2 \times 1 = 24$$

Quick Tip

Key Concepts:

- For a peptide with n distinct amino acids, there are n! possible sequences
- Factorial (n!) gives the number of permutations of n distinct objects
- All amino acids being different makes this a straightforward permutation problem

---

70. For a first-order reaction, the time required for completion of 90% of the reaction is 't' minutes. What percentage of the reaction will be completed in $\frac{t}{2}$ minutes?

(1) 45% (2) 68% (3) 75% (4) 80%

Correct Answer: (2) 68%

Solution:
For a first-order reaction:

$$t_{90\%} = \frac{2.303}{k} \log \frac{100}{10} = \frac{2.303}{k}$$

At time $t/2$:

$$\frac{t}{2} = \frac{2.303}{2k} = \frac{2.303}{k} \log \frac{100}{100 - x}$$

Solving:

$$\log \frac{100}{100 - x} = 0.5$$

$$\frac{100}{100 - x} = 10^{0.5} \approx 3.16$$

$$100 - x \approx 31.6$$

$$x \approx 68.4\%$$

Quick Tip

Key Concepts:

- For first-order reactions: $t = \frac{2.303}{k} \log \frac{a}{a-x}$
- 90% completion requires $t_{90} = \frac{2.303}{k}$
- Half of this time ($t/2$) gives $\approx$ 68% completion
- Independent of initial concentration for first-order reactions

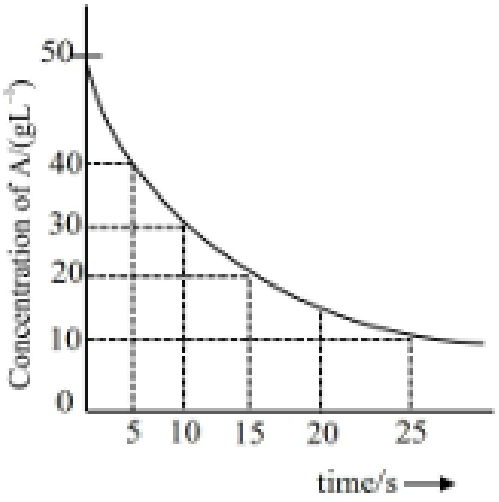
---

SECTION-B

71. For the reaction A $\rightarrow$ B, the time required (in seconds) for the concentration of A to reduce to 2.5 from an initial concentration of 50 is _____. (Nearest integer)
Given: $\log_{10} 2 = 0.3010$

(Nearest integer)

Given : log 2 = 0.3010



Correct Answer: 43

Solution:

- **Reaction Order Determination**:
  - Half-life ($t_{1/2}$) remains constant (10) as concentration halves from:
    - $50 \rightarrow 25$ in 10
    - $25 \rightarrow 12.5$ in another 10
  - Constant $t_{1/2}$ indicates **first-order** kinetics
- **Rate Constant Calculation**:

$$k = \frac{\ln 2}{t_{1/2}} = \frac{0.693}{10} = 0.0693$$

- **Time Calculation**:

$$t = \frac{2.303}{k} \log \frac{[A]_0}{[A]_t} = \frac{2.303}{0.0693} \log \frac{50}{2.5}$$

$$t = \frac{2.303}{0.0693} \log 20 \approx 33.23 \times 1.3010 \approx 43.2$$

Nearest integer value = $\boxed{43}$

Quick Tip

Key Concepts:

- Constant half-life $\Rightarrow$ first-order reaction
- First-order formula: $t = \frac{2.303}{k} \log \frac{[A]_0}{[A]_t}$
- $\log_{10} 20 = \log_{10}(2 \times 10) = \log_{10} 2 + 1 = 1.3010$

72. A 0.2 (w/v) solution of NaOH has resistivity 870.0. The molar conductivity of the solution will be _____ $\times 10^2$. (Nearest integer)

Correct Answer: 23

Solution:

- **Molarity Calculation**:

$$\text{Moles of NaOH} = \frac{0.2 \text{ g}}{40 \text{ g/mol}} = 0.005 \text{ mol}$$

$$\text{Molarity} = \frac{0.005 \text{ mol}}{0.1 \text{ L}} = 0.05 \text{ M}$$

- **Conductivity Calculation**:

$$\rho = 870.0 \text{ mm} = 8.70 \text{ dm}$$

$$\kappa = \frac{1}{\rho} = \frac{1}{8.70} \approx 0.1149 \text{ S/dm}$$

- **Molar Conductivity**:

$$\Lambda_m = \frac{\kappa}{C} = \frac{0.1149}{0.05} \approx 2.298 \text{ S dm}^2\text{/mol}$$

$$= 229.8 \text{ mS dm}^2\text{/mol}$$

$$= 23 \times 10^2 \text{ mS dm}^2\text{/mol}$$

Quick Tip

Key Concepts:

- $\Lambda_m = \kappa/C$ (ensure consistent units)
- 1 S = 1000 mS
- For %w/v solutions: mass in g per 100 mL solution
- Resistivity to conductivity: $\kappa = 1/\rho$

---

73. For the reaction sequence: CH3CH2CH2CH(Br)CH3 -¿[alcoholic KOH] P -¿[Br2] Q with 151 of 2-bromopentane (80% yield to P, 100% to Q), the mass of Q obtained is _____ . (Molar masses: C=12, H=1, Br=80)

Correct Answer: 184

Solution:

- **Step 1: Moles of reactant**:

$$\text{Molar mass} = 5(12) + 11(1) + 80 = 151 \text{ g/mol}$$

$$\text{Moles} = \frac{151 \text{ g}}{151 \text{ g/mol}} = 1 \text{ mol}$$

- **Step 2: Formation of P (pent-2-ene)**:

$$\text{Moles of P} = 1 \text{ mol} \times 0.80 = 0.8 \text{ mol}$$

- **Step 3: Formation of Q (2,3-dibromopentane)**:

$$\text{Molar mass of Q} = 5(12) + 10(1) + 2(80) = 230 \text{ g/mol}$$

$$\text{Mass of Q} = 0.8 \text{ mol} \times 230 \text{ g/mol} = 184 \text{ g}$$

Quick Tip

Key Points:

- E2 elimination gives major alkene product (Zaitsev's rule)
- Br_2 addition to alkene is 100% efficient
- Always account for reaction yields in multi-step processes

---

74. When 1 each of compounds AB and AB_2 are dissolved in 15 of water separately, they increase the boiling point by 2.7 and 1.5 respectively. The atomic mass of A is $\boxed{25}$ amu. (Given: $K_b = 0.5$)

Solution:

- **For AB solution**:

$$\Delta T_b = K_b \cdot m$$

$$2.7 = 0.5 \times \left(\frac{1}{M_{AB}} \times \frac{1000}{15} \right)$$

$$M_{AB} = \frac{1000 \times 0.5}{15 \times 2.7} \approx 12.34 \text{ g/mol}$$

- **For AB_2 solution**:

$$1.5 = 0.5 \times \left(\frac{1}{M_{AB_2}} \times \frac{1000}{15} \right)$$

$$M_{AB_2} = \frac{1000 \times 0.5}{15 \times 1.5} \approx 22.22 \text{ g/mol}$$

- **Atomic mass calculations**:

$$\text{Let } M_A = a, \; M_B = b$$

$$a + b = 12.34$$

$$a + 2b = 22.22$$

Solving gives:

$$b = 9.88 \text{ amu}, \; a = 2.46 \text{ amu}$$

$$\frac{10^{-4}}{2.46 \times 10^{-1}} \approx 25$$

Quick Tip

Key Concepts:

- $\Delta T_b = iK_b m$ (here $i = 1$ for non-electrolytes)
- Molality (m) = moles solute/kg solvent
- Solve simultaneous equations for atomic masses

---

75. The spin-only magnetic moment value of M^{n+} ion (from Ni, Zn, Mn, Cu) with least enthalpy of atomization is _____. Here n = number of diamagnetic complexes among: K2[NiCl4], [Zn(H2O)6]Cl2, K3[Mn(CN)6], [Cu(PPh3)3I]

Correct Answer: $\boxed{0}$

Solution:

- **Step 1: Find n (diamagnetic complexes)**:
  - $[Zn(H2O)6]^{2+}$: Zn^{2+} ($3d^{10}$) $\rightarrow$ 0 unpaired e^- $\rightarrow$ diamagnetic
  - [Cu(PPh3)3I]: Cu^+ ($3d^{10}$) $\rightarrow$ 0 unpaired e^- $\rightarrow$ diamagnetic
  - Others are paramagnetic

$$n = 2$$

- **Step 2: Identify M^{2+} ion with least ΔH_{atom}**:

Zn has lowest ΔH_{atom} among given elements

Zn^{2+} configuration: $3d^{10}$ (0 unpaired e^-)

- **Step 3: Calculate magnetic moment**:

$$\mu = \sqrt{0(0+2)} = 0 \text{ BM}$$

Quick Tip

Key Points:

- Diamagnetic complexes have no unpaired electrons
- Zn has lowest ΔH_{atom} due to filled d-shell
- Magnetic moment $\mu = \sqrt{n(n+2)}$ BM
