NEET 2026 Chemistry Code 12

Question Paper with Solutions PDF

Conducted by National Testing Agency (NTA)

General Instructions

(i) The test is of 1 hours duration.

(ii) This test paper consists of 45 questions. The maximum marks are 180.

(iii) Each question carries +4 marks for correct answer and –1 mark for wrong answer.

Chemistry

46. Match List I with List II :

List I (Reaction)	List II (Reagent/Condition)
A. Phenol → Phenol-2,4,6-trisulphonic acid	I. Oleum, Δ
B. Phenol → Benzene	II. Zn dust, Δ
C. Benzenediazonium chloride → Phenol	III. Warm water
D. Phenol → Salicylaldehyde	IV. $CHCl_3$/NaOH

Choose the correct answer from the options given below :

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

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

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

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

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

Solution:

Step 1: Understanding the Concept:

This matches standard organic transformations of aromatic compounds with their necessary chemical reagents.

Step 2: Detailed Explanation:

A. **Sulphonation**: Phenol reacts with concentrated sulfuric acid or oleum to undergo electrophilic substitution. High temperature and Oleum lead to multiple substitutions. (A → I)

B. **Reduction**: Distilling phenol with **Zinc dust** removes the hydroxyl group, reducing it to benzene. (B → II)

C. **Diazonium Hydrolysis**: Benzenediazonium chloride reacts with **warm water** to produce phenol and nitrogen gas. (C → III)

D. **Reimer-Tiemann Reaction**: Phenol reacts with chloroform ($CHCl_3$) and aqueous sodium hydroxide (NaOH) to form salicylaldehyde. (D → IV)

Sequence: A-I, B-II, C-III, D-IV.

Step 3: Final Answer:

Matching gives option (3).

Quick Tip: "Zinc dust" is a classic reagent for removing -OH from an aromatic ring. Reimer-Tiemann ($CHCl_3 + NaOH$) is one of the most frequently tested name reactions.

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47. The major product Z formed in the following sequence of reactions is :

$$\mathbf{C_6H_5\text{-}C_2H_5} \xrightarrow[(i)\ \mathbf{Cl_2,\ UV\ light}]{\mathbf{(monochlorination)}} X \xrightarrow[NH_3]{(ii)} Y \xrightarrow[(iii)\ \mathbf{NaNO_2}/HCl,\ \mathbf{H_2O}]{} Z$$

(1) C_6H_5-N=N-OH

(2) $C_6H_5CH(OH)CH_3$

(3) $C_6H_5CH_2NO_2$

(4) $C_6H_5CH_2NH_2$

Correct Answer: (2) $C_6H_5CH(OH)CH_3$

Solution:

Step 1: Understanding the Concept:

The reaction involves side-chain chlorination of an alkylbenzene, followed by nucleophilic substitution and then diazotization/hydrolysis.

Step 2: Detailed Explanation:

1. **Chlorination**: Ethylbenzene reacts with chlorine in UV light. Substitution occurs at the **benzylic** position because the benzylic radical is more stable. $X = C_6H_5\text{-}CHCl\text{-}CH_3$.
2. **Amination**: Reaction with NH_3 involves substitution of the halogen. $Y = C_6H_5\text{-}CH(NH_2)\text{-}CH_3$.
3. **Diazotization and Hydrolysis**: Since Y is an aliphatic amine (the $-NH_2$ is not directly on the ring), reaction with $NaNO_2/HCl$ forms a highly unstable diazonium salt that decomposes immediately in the presence of water to form an alcohol. $Z = C_6H_5\text{-}CH(OH)\text{-}CH_3$.

Step 3: Final Answer:

The product is 1-phenylethanol, represented as $C_6H_5CH(OH)CH_3$.

Quick Tip: Remember that primary aliphatic amines (R-NH_2) always give alcohols when treated with $NaNO_2/HCl$, unlike aromatic amines which can form stable salts at low temperatures.

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48. In a qualitative analysis, Bi^{3+} is detected by appearance of precipitate of BiO(OH)(s). Calculate pH when the following equilibrium exists at 298 K :

$BiO(OH)(s) \rightleftharpoons BiO^+(aq) + OH^-(aq)$, $K = 4 \times 10^{-10}$

(Given : $\log 2 = 0.3010$**)**

(1) 4.699

(2) 8.714

(3) 9.301

(4) 5.286

Correct Answer: (3) 9.301

Solution:

Step 1: Understanding the Concept:

The equilibrium constant K for this solubility process allows us to determine the concentration of hydroxide ions in a saturated solution.

Step 2: Key Formula or Approach:

1. $K = [BiO^+][OH^-]$
2. Let solubility be s. Then $K = s^2 \implies [OH^-] = \sqrt{K}$.
3. $pOH = -\log[OH^-]$; $pH = 14 - pOH$.

Step 3: Detailed Explanation:

Given $K = 4 \times 10^{-10}$.

$$[OH^-] = \sqrt{4 \times 10^{-10}} = 2 \times 10^{-5} \text{ M}$$

Calculation of pOH:

$$pOH = -\log(2 \times 10^{-5})$$

$$pOH = 5 - \log 2 = 5 - 0.3010 = 4.699$$

Calculation of pH:

$$pH = 14 - 4.699 = 9.301$$

Step 4: Final Answer:

The pH is 9.301.

Quick Tip: Always remember to subtract pOH from 14. Many students mistakenly choose the pOH value (4.7) as the answer. Since the substance produces OH^-, the pH must be basic (> 7).

49. When 1 dm^3 of CO_2 gas is passed over hot coke, the volume of gaseous mixture after complete reaction at STP becomes 1.4 dm^3. The composition of the gaseous mixture at STP is :

(1) 0.6 dm^3 of CO, 0.8 dm^3 of CO_2

(2) 0.8 dm^3 of CO, 0.8 dm^3 of CO_2

(3) 0.8 dm^3 of CO, 0.6 dm^3 of CO_2

(4) 0.6 dm^3 of CO, 0.4 dm^3 of CO_2

Correct Answer: (3) 0.8 dm^3 of CO, 0.6 dm^3 of CO_2

Solution:

Step 1: Understanding the Concept:

Carbon dioxide reacts with solid carbon (coke) to form carbon monoxide. Since we are dealing with gases at STP, volume ratios follow stoichiometric coefficients.

Step 2: Key Formula or Approach:

Reaction: $CO_2(g) + C(s) \rightarrow 2CO(g)$

Step 3: Detailed Explanation:

Let x dm^3 be the volume of CO_2 that reacts.

Initial volume of $CO_2 = 1$ dm^3.

Remaining volume of $CO_2 = (1 - x)$ dm^3.

Volume of CO produced $= 2x$ dm^3.

Total final volume:

$$(1 - x) + 2x = 1.4$$

$$1 + x = 1.4 \implies x = 0.4 \text{ dm}^3$$

Composition of the mixture:

- Volume of CO $= 2x = 2(0.4) = 0.8$ dm^3.
- Volume of $CO_2 = 1 - x = 1 - 0.4 = 0.6$ dm^3.

Step 4: Final Answer:

The mixture consists of 0.8 dm^3 of CO and 0.6 dm^3 of CO_2.

Quick Tip: For every liter of CO_2 that reacts, the total volume increases by one liter. If volume increased by 0.4 L, it means 0.4 L of CO_2 reacted.

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50. Match List I with List II :

List I (Quantum Numbers)	List II (Orbital)
A. $n = 2, l = 1$	I. $3d$
B. $n = 4, l = 0$	II. $2p$
C. $n = 5, l = 3$	III. $4s$
D. $n = 3, l = 2$	IV. $5f$

Choose the correct answer from the options given below :

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

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

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

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

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

Solution:

Step 1: Understanding the Concept:

Orbitals are designated by the principal quantum number n (the coefficient) and the azimuthal quantum number l (represented by a letter).

Step 2: Detailed Explanation:

The letters for l values are: $0 \to s$, $1 \to p$, $2 \to d$, $3 \to f$.

A. $n = 2, l = 1 \rightarrow 2p$. Matches with II.

B. $n = 4, l = 0 \rightarrow 4s$. Matches with III.

C. $n = 5, l = 3 \rightarrow 5f$. Matches with IV.

D. $n = 3, l = 2 \rightarrow 3d$. Matches with I.

The correct sequence is A-II, B-III, C-IV, D-I.

Step 3: Final Answer:

The matching results in option (1).

Quick Tip: Remember the order of letters: s, p, d, f corresponds to 0, 1, 2, 3. You can quickly verify the matches by identifying just one pair (e.g., $2p$) to narrow down the choices.

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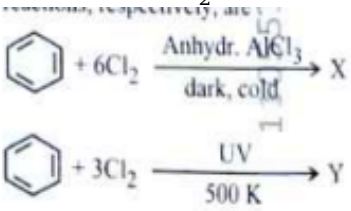
51. The number of chlorine atoms present in the organic products X and Y of the following reactions, respectively, are :

$$\text{Benzene} + 6Cl_2 \xrightarrow{\text{Anhyd. } AlCl_3\text{, dark, cold}} X$$

$$\text{Benzene} + 3Cl_2 \xrightarrow{\text{UV, 500 K}} Y$$



(1) 3 and 6

(2) 6 and 6

(3) 6 and 3

(4) 3 and 3

Correct Answer: (2) 6 and 6

Solution:

Step 1: Understanding the Concept:

Benzene reacts with chlorine in two distinct ways depending on the conditions. The presence of a Lewis acid catalyst leads to electrophilic substitution, while UV light and high temperature promote free radical addition.

Step 2: Detailed Explanation:

1. **Reaction for X:** When benzene is treated with excess chlorine ($6Cl_2$) in the presence of anhydrous $AlCl_3$ in the dark and cold, all six hydrogen atoms of benzene are replaced by chlorine atoms. This is an electrophilic substitution reaction.

$$C_6H_6 + 6Cl_2 \xrightarrow{\text{Anhyd. } AlCl_3} C_6Cl_6 + 6HCl$$

Product X is hexachlorobenzene (C_6Cl_6), which contains **6** chlorine atoms.

2. **Reaction for Y:** When benzene reacts with chlorine ($3Cl_2$) in the presence of ultraviolet light at 500 K, the chlorine atoms add across the double bonds of the aromatic ring. This is an addition reaction.

$$C_6H_6 + 3Cl_2 \xrightarrow{\text{UV, 500 K}} C_6H_6Cl_6$$

Product Y is benzene hexachloride (BHC), also known as Gammexane or Lindane. It contains **6** chlorine atoms.

Step 3: Final Answer:

Both products X and Y contain 6 chlorine atoms.

Quick Tip: Do not confuse "hexachlorobenzene" (substitution product) with "benzene hexachloride" (addition product). Although they sound similar, their structures are completely different, but both happen to have 6 chlorine atoms in these specific excess conditions.

52. In the following reaction sequence, X and Z, respectively are :

$$CH_3CH_2CH_2\text{-}OH + PCl_5 \rightarrow CH_3CH_2CH_2Cl + X + HCl$$
$$CH_3CH_2CH_2Cl \xrightarrow{\text{alc. KOH, } \Delta} Y \xrightarrow[(C_6H_5CO)_2O_2]{HBr} Z$$

(1) $X = POCl_3$; $Z = CH_3\text{-}CH(Br)\text{-}CH_3$

(2) $X = H_3PO_3$; $Z = CH_3CH_2CH_2Br$

(3) $X = H_3PO_3$; $Z = CH_3\text{-}CH(Br)\text{-}CH_3$

(4) $X = POCl_3$; $Z = CH_3CH_2CH_2Br$

Correct Answer: (4) $X = POCl_3$; $Z = CH_3CH_2CH_2Br$

Solution:

Step 1: Understanding the Concept:

This sequence involves the halogenation of an alcohol, dehydrohalogenation of an alkyl halide to form an alkene, and subsequent addition to the alkene.

Step 2: Detailed Explanation:

1. **Reaction 1:** Propan-1-ol reacts with PCl_5 to form 1-chloropropane. The byproducts of this specific reaction are phosphorus oxychloride ($POCl_3$) and hydrogen chloride.

$$CH_3CH_2CH_2OH + PCl_5 \rightarrow CH_3CH_2CH_2Cl + POCl_3\ (X) + HCl$$

Thus, $X = POCl_3$.

2. **Reaction 2:** 1-chloropropane undergoes elimination (dehydrohalogenation) when heated with alcoholic KOH.

$$CH_3CH_2CH_2Cl \xrightarrow{\text{alc. KOH},\Delta} CH_3CH{=}CH_2\ (Y)$$

Product Y is propene.

3. **Reaction 3:** Propene reacts with HBr in the presence of benzoyl peroxide (peroxide). This triggers the **Anti-Markovnikov addition** (Kharasch effect).

$$CH_3CH{=}CH_2 + HBr \xrightarrow{\text{Peroxide}} CH_3CH_2CH_2Br \ (Z)$$

Product Z is 1-bromopropane.

Step 3: Final Answer:

X is $POCl_3$ and Z is $CH_3CH_2CH_2Br$.

Quick Tip: Remember: PCl_5 gives $POCl_3$, while PCl_3 gives H_3PO_3. Also, peroxides only affect the addition of HBr; they have no effect on HCl or HI additions.

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53. Match List I with List II :

List I (Transition metal/complex)	List II (Catalytic Role)
A. V_2O_5	I. Preparation of ammonia
B. Fe	II. Polymerisation of alkynes
C. $PdCl_2$	III. Preparation of H_2SO_4
D. Ni complex	IV. Oxidation of ethyne to ethanal

Choose the correct answer from the options given below :

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

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

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

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

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

Solution:

Step 1: Understanding the Concept:

Transition metals and their compounds are used as catalysts in many industrial chemical processes due to their ability to adopt multiple oxidation states and provide a surface for reactions.

Step 2: Detailed Explanation:

A. V_2O_5: This is the catalyst used in the **Contact Process** for the oxidation of SO_2 to SO_3, which is a key step in the preparation of sulfuric acid (H_2SO_4). (A → III).

B. Fe: Finely divided iron is used as the catalyst in the **Haber Process** for the synthesis of ammonia from nitrogen and hydrogen. (B → I).

C. $PdCl_2$: This is used as a catalyst in the **Wacker Process** for the oxidation of ethyne (or ethene) to ethanal (acetaldehyde). (C → IV).

D. Ni complex: Various nickel complexes are used for the **polymerisation of alkynes** (e.g., ethyne to cyclooctatetraene or benzene). (D → II).

Step 3: Final Answer:

The matching results in sequence A-III, B-I, C-IV, D-II.

Quick Tip: In matching questions, identify the most familiar pair first (e.g., Fe for ammonia) to quickly eliminate incorrect options. Usually, knowing two pairs is sufficient.

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54. Identify the correct statement about ClF_3 from the following options :

(1) It has a trigonal pyramidal geometry with two lone pairs on Cl atom.

(2) It has T-shaped geometry with two lone pairs on Cl atom.

(3) It has a planar trigonal geometry with two lone pairs on Cl atom.

(4) It has T-shaped geometry with three lone pairs on Cl atom.

Correct Answer: (2) It has T-shaped geometry with two lone pairs on Cl atom.

Solution:

Step 1: Understanding the Concept:

The structure and geometry of a molecule can be determined using VSEPR (Valence Shell Electron Pair Repulsion) theory, based on the number of bonding pairs and lone pairs around the central atom.

Step 2: Detailed Explanation:

1. The central atom is Chlorine (Cl), which has 7 valence electrons.

2. There are 3 Fluorine (F) atoms bonded to Cl, contributing 3 electrons for bonding.

3. Total electron pairs = (Valence electrons on central atom + number of monovalent atoms) / 2 = (7 + 3) / 2 = 5.

4. With 5 electron pairs, the hybridization is sp^3d. The electron geometry is trigonal bipyramidal.

5. Out of 5 pairs, 3 are bond pairs (Cl-F) and $5-3=2$ are **lone pairs**.

6. To minimize repulsion, the 2 lone pairs occupy the equatorial positions of the trigonal bipyramid. The resulting molecular shape (ignoring lone pairs) is **T-shaped**.

Step 3: Final Answer:

The molecule has a T-shaped geometry and 2 lone pairs on the Cl atom.

Quick Tip: For molecules with sp^3d hybridization:

3 BP + 2 LP → T-shape (e.g., ClF_3).

2 BP + 3 LP → Linear (e.g., XeF_2).

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55. Calculate emf of the half cell given below :

$$\text{Pt (s)} \mid \text{H}_2\text{ (g, 2 atm)} \mid \text{HCl (aq, 0.02 M)}$$

$$E^0_{\text{H}^+/\text{H}_2} = 0\text{ V}$$

(Given : $\frac{2.303\,\text{RT}}{\text{F}} = 0.059$, $\log 2 = 0.3010$**)**

(1) 0.109 V

(2) 0.035 V

(3) -0.035 V

(4) -0.109 V

Correct Answer: (4) -0.109 V

Solution:

Step 1: Understanding the Concept:

The electrode potential of a hydrogen half-cell under non-standard conditions is calculated using the Nernst Equation for the reduction reaction: $2H^+(aq) + 2e^- \rightarrow H_2(g)$.

Step 2: Key Formula or Approach:

Nernst Equation for this half-cell:

$$E = E^0 - \frac{0.059}{n} \log \frac{P_{H_2}}{[H^+]^2}$$

Step 3: Detailed Explanation:

Given:

$E^0 = 0$ V

$n = 2$ (electrons involved)

$P_{H_2} = 2$ atm

$[H^+] = 0.02$ M $= 2 \times 10^{-2}$ M

Calculation:

$$E = 0 - \frac{0.059}{2} \log \frac{2}{(2 \times 10^{-2})^2}$$

$$E = -0.0295 \log \frac{2}{4 \times 10^{-4}}$$

$$E = -0.0295 \log(0.5 \times 10^4) = -0.0295 \log(5000)$$

$$E = -0.0295 \times (\log 5 + 3)$$

$$E = -0.0295 \times (0.699 + 3) = -0.0295 \times 3.699$$

$$E \approx -0.109 \text{ V}$$

Step 4: Final Answer:

The emf of the half cell is -0.109 V.

Quick Tip: Remember that for a gas electrode, the partial pressure of the gas appears in the numerator of the reaction quotient Q for a reduction half-reaction. Always check if n is 1 or 2 based on your balanced half-reaction.

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56. Match List I with List II :

List I (Order of reaction)	List II (Unit of rate constant)
A. Zero order	I. $mol^{-1}\ L\ s^{-1}$
B. First order	II. $mol^{-2}\ L^2\ s^{-1}$
C. Second order	III. s^{-1}
D. Third order	IV. $mol\ L^{-1}\ s^{-1}$

Choose the correct answer from the options given below :

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

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

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

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

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

Solution:

Step 1: Understanding the Concept:

The unit of the rate constant (k) depends on the order of the reaction (n). The general formula is derived from the rate law: Rate $= k[A]^n$.

Step 2: Key Formula or Approach:

General unit of $k = (mol\ L^{-1})^{1-n} \cdot s^{-1} = mol^{1-n} \cdot L^{n-1} \cdot s^{-1}$.

Step 3: Detailed Explanation:

1. **Zero Order ($n = 0$):** Unit $= mol^1L^{-1}s^{-1} = mol\ L^{-1}\ s^{-1}$. (A $\rightarrow$ IV).
2. **First Order ($n = 1$):** Unit $= mol^0L^0s^{-1} = s^{-1}$. (B $\rightarrow$ III).
3. **Second Order ($n = 2$):** Unit $= mol^{-1}L^1s^{-1} = mol^{-1}\ L\ s^{-1}$. (C $\rightarrow$ I).

4. **Third Order ($n = 3$):** Unit $= \text{mol}^{-2}\text{L}^2\text{s}^{-1} = \text{mol}^{-2}\ \text{L}^2\ \text{s}^{-1}$. (D $\rightarrow$ II).

The matching sequence is A-IV, B-III, C-I, D-II.

Step 4: Final Answer:
Matching the lists results in option (3).

Quick Tip: For any order n, the sum of the powers of 'mol' and 'L' in the unit of k is always zero. For example, in second order: $-1 + 1 = 0$. This is a quick way to check if a unit is possible.

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57. The calculated 'spin-only' magnetic moment of $\text{Ti}^{2+}(3d^2)$ is :

(1) 2.84 BM
(2) 5.92 BM
(3) 4.90 BM
(4) 3.87 BM

Correct Answer: (1) 2.84 BM

Solution:

Step 1: Understanding the Concept:
The magnetic properties of transition metal ions are primarily determined by the number of unpaired electrons. The "spin-only" formula calculates the magnetic moment based solely on these electrons.

Step 2: Key Formula or Approach:
Spin-only magnetic moment $\mu = \sqrt{n(n+2)}$ BM, where n is the number of unpaired electrons.

Step 3: Detailed Explanation:
1. The given ion is Ti^{2+} with a configuration of $3d^2$.

2. According to Hund's Rule, the two electrons will occupy two different d-orbitals with parallel spins.

3. Therefore, the number of unpaired electrons $n = 2$.

4. Calculation:

$$\mu = \sqrt{2(2+2)} = \sqrt{2 \times 4} = \sqrt{8} \text{ BM}$$

$$\mu \approx 2.828 \text{ BM}$$

The closest value in the options is 2.84 BM.

Step 4: Final Answer:

The calculated spin-only magnetic moment is 2.84 BM.

Quick Tip: A useful shortcut: if there are n unpaired electrons, the magnetic moment will be "n.something" BM. For $n = 2$, it must be $2.xx$. For $n = 3$, it's $3.xx$. This allows for immediate elimination of options.

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58. Two products X and Y are formed in the following reaction sequence.

$$\text{Benzene} + CH_3Cl \xrightarrow{\text{Anhyd. } AlCl_3} W \xrightarrow[\text{warm}]{\text{dil. } HNO_3, \text{ dil. } H_2SO_4} X + Y$$

The suitable method that can be used for the separation of products X and Y is :

(1) Continuous extraction

(2) Differential extraction

(3) Fractional distillation

(4) Sublimation

Correct Answer: (3) Fractional distillation

Solution:

Step 1: Understanding the Concept:

The sequence involves Friedel-Crafts alkylation of benzene to form toluene, followed by nitration of toluene. Separation of the resulting isomers depends on their physical properties.

Step 2: Detailed Explanation:

1. **Reaction 1:** Benzene reacts with methyl chloride in the presence of $AlCl_3$ to give toluene (W).
2. **Reaction 2:** Nitration of toluene (dil. HNO_3/dil. H_2SO_4) yields a mixture of ortho-nitrotoluene and para-nitrotoluene (X and Y).
3. Ortho and para isomers are positional isomers. They generally have significant differences in boiling points. While steam distillation is often used for nitrophenols, for these nitrotoluene isomers, **fractional distillation** is the most appropriate technique as they are liquids with distinct boiling points.

Step 3: Final Answer:

The mixture can be separated by fractional distillation.

Quick Tip: Fractional distillation is used for liquid-liquid mixtures with boiling point differences. For solids like naphthalene and benzoic acid, sublimation is used. For ortho and para nitrophenol, steam distillation is the classic choice due to H-bonding.

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59. A bulb is rated at 150 watt, converting 8% energy into light. If energy of one photon is 4.42×10^{-19} J, how many photons are emitted by the bulb per second ?

(1) 1.35×10^{19}

(2) 4.06×10^{19}

(3) 2.71×10^{19}

(4) 27.2×10^{19}

Correct Answer: (3) 2.71×10^{19}

Solution:

Step 1: Understanding the Concept:

Power is the rate of energy emission. To find the number of photons per second, calculate the actual light power and divide it by the energy of a single photon.

Step 2: Key Formula or Approach:

1. Light Power (P_L) = Rated Power × Efficiency
2. Number of photons (N) = P_L / E_{photon}

Step 3: Detailed Explanation:

Given:

Rated Power = 150 W

Efficiency = 8% = 0.08

Energy per photon (E) = 4.42×10^{-19} J

Calculation of Light Power:

$$P_L = 150 \times 0.08 = 12 \text{ Watts (J/s)}$$

Calculation of photon count per second:

$$N = \frac{12 \text{ J/s}}{4.42 \times 10^{-19} \text{ J/photon}}$$

$$N = \frac{12}{4.42} \times 10^{19}$$

$$N \approx 2.7149 \times 10^{19} \text{ photons/s}$$

Step 4: Final Answer:

The bulb emits approximately 2.71×10^{19} photons per second.

Quick Tip: Always convert percentage efficiency to decimal immediately. 1 Watt = 1 Joule per second. The final answer will just be a division problem of power by energy.

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60. In a test tube containing a salt, a few drops of dilute H_2SO_4 was added, which gave colourless vapours having the smell of vinegar. The vapours turned the blue litmus paper red. Identify the correct anion from the following :

(1) Acetate, CH_3COO^-
(2) Carbonate, CO_3^{2-}
(3) Sulphate, SO_4^{2-}
(4) Sulphide, S^{2-}

Correct Answer: (1) Acetate, CH_3COO^-

Solution:

Step 1: Understanding the Concept:
In salt analysis, dilute acids react with specific anions to release gases with unique characteristics.

Step 2: Detailed Explanation:
1. **Observation:** Addition of dilute acid produces "colourless vapours with a smell of vinegar".
2. **Analysis:** The smell of vinegar is characteristic of acetic acid (CH_3COOH).
3. **Reaction:** Acetate salts react with acids like H_2SO_4 to liberate acetic acid.

$$2CH_3COONa + H_2SO_4 \rightarrow Na_2SO_4 + 2CH_3COOH \uparrow$$

4. Since acetic acid is an acid, its vapours will turn moist blue litmus paper red.
- Carbonate gives CO_2 (odourless).
- Sulphide gives H_2S (rotten egg smell).
- Sulphate does not react with dilute H_2SO_4.

Step 3: Final Answer:

The anion is Acetate (CH_3COO^-).

Quick Tip: In qualitative analysis, smell is a vital clue:

Vinegar smell → Acetate

Rotten egg smell → Sulphide

Suffocating smell of burning sulphur → Sulphite

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61. Select the reagents that reduce nitriles to primary amines :

A. (i) $LiAlH_4$; (ii) H_2O

B. Sn + HCl

C. H_2/Ni

D. Na(Hg)/C_2H_5OH

E. Br_2/aq. NaOH

Choose the correct answer from the options given below :

(1) A, B and C only

(2) A, C and D only

(3) A, D and E only

(4) B, D and E only

Correct Answer: (2) A, C and D only

Solution:

Step 1: Understanding the Concept:

Reduction of nitriles ($R-C\equiv N$) involves the addition of four hydrogen atoms to the triple bond, converting it into a primary amine ($R-CH_2-NH_2$).

Step 2: Detailed Explanation:

A. **$LiAlH_4$ followed by water**: This is a strong reducing agent that effectively reduces nitriles to primary amines.

B. **Sn + HCl**: This reagent is typically used for the reduction of nitro compounds (like nitrobenzene to aniline) and is not a standard reagent for nitrile reduction to primary amines.
C. **H_2/Ni**: Catalytic hydrogenation using hydrogen gas in the presence of a metal catalyst like Nickel, Platinum, or Palladium reduces nitriles to primary amines.
D. **Na(Hg)/C_2H_5OH**: Sodium amalgam in ethanol is the reagent for the **Mendius reaction**, which specifically reduces nitriles to primary amines.
E. **Br_2/aq. NaOH**: This is the reagent for **Hoffmann Bromamide Degradation**, which converts an **amide** to an amine with one less carbon atom, not nitriles.

Combining the correct reagents, we get A, C, and D.

Step 3: Final Answer:
The reagents that reduce nitriles to primary amines are A, C, and D.

Quick Tip: Remember the Mendius reaction: Na(Hg) + Ethanol is a classic nitrile-to-amine converter. Hoffmann Bromamide (Br_2/NaOH) is only for amides!

---

62. Identify the *incorrect* statement from the following :

(1) Carbon has the ability to form pπ-pπ multiple bond with itself.
(2) ECl_3 (E = B and Al) is a monomer when E = B and a dimer when E = Al.
(3) Oxygen exhibits only -2 oxidation state.
(4) The order of catenation property of Group 14 elements is C $\gg$ Si > Ge $\approx$ Sn.

Correct Answer: (3) Oxygen exhibits only -2 oxidation state.

Solution:

Step 1: Understanding the Concept:
This question tests general periodic properties and chemical characteristics of p-block elements.

Step 2: Detailed Explanation:

1. **Statement 1**: Carbon, due to its small size and high electronegativity, can form $p\pi - p\pi$ multiple bonds ($C = C, C \equiv C$). This is correct.

2. **Statement 2**: Boron trichloride (BCl_3) is a monomer because the small size of Boron prevents dimer formation, whereas $AlCl_3$ exists as a dimer (Al_2Cl_6) in the vapor phase to achieve an octet. This is correct.

3. **Statement 3**: Oxygen commonly shows a -2 oxidation state, but it also shows -1 in peroxides (H_2O_2), -1/2 in superoxides (KO_2), and even positive states like +2 in OF_2. Therefore, saying it exhibits **only** -2 is incorrect.

4. **Statement 4**: Catenation depends on bond enthalpy. Carbon has the strongest $M - M$ bond, so the order $C \gg Si > Ge \approx Sn$ is correct.

Step 3: Final Answer:

Statement (3) is incorrect.

Quick Tip: The word "only" is usually a red flag in inorganic chemistry statements. Oxygen and Fluorine are the only elements that can force oxygen into a positive oxidation state in OF_2.

---

63. Although +3 oxidation state is most common in lanthanoids, cerium still shows +4 oxidation state because :

(1) Its nearest inert gas is Radon.

(2) After losing one more electron, it acquires $4f^{14}$ electronic configuration.

(3) Its atomic number is 61.

(4) After losing one more electron, it acquires $4f^0$ electronic configuration.

Correct Answer: (4) After losing one more electron, it acquires $4f^0$ electronic configuration.

Solution:

Step 1: Understanding the Concept:

The stability of oxidation states in lanthanoids is often related to the attainment of empty (f^0), half-filled (f^7), or fully-filled (f^{14}) f-subshells.

Step 2: Detailed Explanation:

Cerium (Ce) has the atomic number 58.

Its ground state electronic configuration is $[Xe]4f^1 5d^1 6s^2$.

In the +3 oxidation state (Ce^{3+}), the configuration is $[Xe]4f^1$.

If it loses one more electron to reach the +4 state (Ce^{4+}), its configuration becomes $[Xe]4f^0$.

The $4f^0$ state is exceptionally stable because it corresponds to the noble gas configuration of Xenon.

Step 3: Final Answer:

Cerium shows +4 oxidation state because it attains the stable $4f^0$ configuration.

Quick Tip: Remember the stability milestones: Ce^{4+} (f^0), Gd^{3+} (f^7), and Lu^{3+} (f^{14}). They drive many "anomalous" oxidation state questions in f-block chemistry.

---

64. During Lassaigne's test, the elements present in an organic compound are converted from :

(1) covalent form to covalent form

(2) ionic form to ionic form

(3) covalent form to ionic form

(4) ionic form to covalent form

Correct Answer: (3) covalent form to ionic form

Solution:

Step 1: Understanding the Concept:

Lassaigne's test is used to detect nitrogen, sulfur, and halogens in organic compounds. Organic

compounds are primarily covalent, making these elements difficult to detect directly.

Step 2: Detailed Explanation:

In Lassaigne's test, the organic compound is fused with metallic sodium. This process converts elements from their covalent bonding in the organic molecule into water-soluble ionic salts:

1. Carbon and Nitrogen are converted to Sodium Cyanide ($NaCN$).
2. Sulfur is converted to Sodium Sulfide (Na_2S).
3. Halogens (X) are converted to Sodium Halides (NaX).

These ionic salts can then be easily tested using standard qualitative reagents in the aqueous extract (sodium extract).

Step 3: Final Answer:

Elements are converted from covalent form to ionic form.

Quick Tip: Sodium fusion (Lassaigne's) is essentially "breaking down" covalent organic molecules into simple inorganic ions so we can perform standard lab tests on them.

---

65. The number of hydrogen atoms present in 5.4 g of urea is :

(Given : Molar mass of urea : 60 **g mol^{-1},** N_A **:** 6.022×10^{23} **particles mol^{-1})**

(1) 2.168×10^{23}

(2) 2.168×10^{22}

(3) 1.084×10^{22}

(4) 1.084×10^{23}

Correct Answer: (1) 2.168×10^{23}

Solution:

Step 1: Understanding the Concept:

To find the number of atoms, we first calculate the number of moles of the substance, then the

number of molecules, and finally multiply by the number of atoms of that element per molecule.

Step 2: Key Formula or Approach:

1. Moles $(n) = \frac{\text{Given Mass}}{\text{Molar Mass}}$
2. Number of molecules $= n \times N_A$
3. Total atoms = (Molecules) × (Number of atoms in one molecule)

Step 3: Detailed Explanation:

The formula for urea is NH_2CONH_2.

One molecule of urea contains 4 hydrogen atoms.

Calculation:

1. Moles of urea $= \frac{5.4}{60} = 0.09$ mol.
2. Number of urea molecules $= 0.09 \times 6.022 \times 10^{23} = 0.54198 \times 10^{23}$.
3. Number of Hydrogen atoms $= 4 \times (0.54198 \times 10^{23})$.

$$\text{Total H atoms} = 2.16792 \times 10^{23} \approx 2.168 \times 10^{23}$$

Step 4: Final Answer:

The number of hydrogen atoms is 2.168×10^{23}.

Quick Tip: Always write the chemical formula first (NH_2CONH_2). A common mistake is counting only 2 hydrogens if you just remember the "amino" part. Total H = 4.

---

66. The pair of molecules that are metamers among the following is :

(1) $CH_3CH_2CH_2OH$ and $CH_3-CH(OH)-CH_3$

(2) $CH_3OCH_2CH_2CH_3$ and $CH_3CH_2OCH_2CH_3$

(3) $H_3C-\overset{\overset{O}{\|}}{C}-CH_3$ and $H_3C-CH_2-\overset{\overset{O}{\|}}{C}-H$

(4) $CH_3CH_2CH_2CH_2CH_3$ and $(CH_3)_2CHCH_2CH_3$

Correct Answer: (2) $CH_3OCH_2CH_2CH_3$ and $CH_3CH_2OCH_2CH_3$

Solution:

Step 1: Understanding the Concept:
Metamers are isomers that have the same molecular formula but differ in the distribution of alkyl groups on either side of the functional group (like ether, ketone, ester).

Step 2: Detailed Explanation:
1. **Option 1**: Propan-1-ol and Propan-2-ol. These are **positional isomers** (position of -OH group changes).
2. **Option 2**: Methyl propyl ether ($CH_3-O-C_3H_7$) and Diethyl ether ($C_2H_5-O-C_2H_5$). Both have formula $C_4H_{10}O$ but different alkyl chains around the oxygen atom. These are **metamers**.
3. **Option 3**: Propanone and Propanal. These are **functional isomers** (ketone vs aldehyde).
4. **Option 4**: Pentane and 2-methylbutane. These are **chain isomers**.

Step 3: Final Answer:
The pair in option (2) represents metamers.

Quick Tip: Metamerism is common in ethers, ketones, and esters. Look for a "bridge" atom or group and check if the carbon chains on the left and right are swapped or changed in length.

---

67. Identify the *incorrect* statement from the following :

(1) $P(C_2H_5)_3$ and $As(C_6H_5)_3$ form dπ-dπ bond with transition metals.
(2) Nitrogen can form dπ-pπ bond with oxygen.
(3) Nitrogen can form pπ-pπ multiple bonds with itself.
(4) Phosphorus, arsenic and antimony show catenation property.

Correct Answer: (2) Nitrogen can form dπ-pπ bond with oxygen.

Solution:

Step 1: Understanding the Concept:
Electronic configuration and the availability of d-orbitals determine the types of bonding an element can participate in.

Step 2: Detailed Explanation:
1. **Statement 1**: Phosphorus and Arsenic have empty d-orbitals. They can accept electron density from filled d-orbitals of transition metals to form $d\pi - d\pi$ back bonds. This is correct.
2. **Statement 2**: Nitrogen (N) has the valence shell $n = 2$. The second shell **does not have d-orbitals**. Therefore, it is physically impossible for Nitrogen to form any $d\pi$-related bonds. This statement is incorrect.
3. **Statement 3**: Nitrogen's small size allows effective sideways overlap of p-orbitals to form $p\pi - p\pi$ triple bonds ($N \equiv N$). This is correct.
4. **Statement 4**: Elements of Group 15 show catenation, though much weaker than Group 14. Phosphorus forms P_4, P_n chains, etc. This is correct.

Step 3: Final Answer:
Statement (2) is incorrect because Nitrogen lacks d-orbitals.

Quick Tip: Second-period elements (Li, Be, B, C, N, O, F, Ne) never use d-orbitals for bonding. Any statement claiming they use "d-orbitals" is automatically false.

---

68. Phenolphthalein is used as an indicator for the titration of sodium hydroxide solution against standard solution of oxalic acid. The colour change that is observed at an alkaline pH close to the equivalence point during this titration is :

(1) pinkish red to yellow
(2) yellow to pinkish red
(3) colourless to pink
(4) pink to colourless

Correct Answer: (3) colourless to pink

Solution:

Step 1: Understanding the Concept:

Titration of Sodium Hydroxide (Strong Base) against Oxalic Acid (Weak Acid) results in a basic salt at the equivalence point. An indicator changes color based on the pH range of the solution.

Step 2: Detailed Explanation:

In this titration, the acid is typically in the flask and the base (NaOH) is added from the burette.

1. Initially, the solution in the flask is acidic (Oxalic acid).
2. Phenolphthalein is **colourless** in acidic and neutral solutions ($pH < 8.3$).
3. As the equivalence point is approached and the first excess drop of NaOH is added, the solution becomes slightly alkaline.
4. Phenolphthalein turns **pink** in alkaline conditions ($pH > 10$).

The transition observed is from colourless to pink.

Step 3: Final Answer:

The colour change is from colourless to pink.

Quick Tip: Remember the simple rule for Phenolphthalein: "Acid = clear, Base = pink". In a standard acid-base titration where base is added to acid, the change is always colourless to pink.

---

69. Match List I with List II :

List I	List II
A. C_2H_4	I. 3 σ bonds, 2 π bonds
B. C_2H_2	II. 3 σ bonds, one lone pair
C. CH_4	III. 4 σ bonds
D. NH_3	IV. 5 σ bonds, 1 π bond

Choose the correct answer from the options given below :

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

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

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

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

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

Solution:

Step 1: Understanding the Concept:

Bond counting (sigma and pi bonds) and identifying lone pairs are fundamental to understanding molecular structures and hybridization.

Step 2: Detailed Explanation:

A. **Ethene (C_2H_4)**: Structure is $H_2C = CH_2$. It has 4 C-H σ bonds, 1 C-C σ bond, and 1 C-C π bond. Total: 5 σ, 1 π. (A $\rightarrow$ IV).

B. **Ethyne (C_2H_2)**: Structure is $HC \equiv CH$. It has 2 C-H σ bonds, 1 C-C σ bond, and 2 C-C π bonds. Total: 3 σ, 2 π. (B $\rightarrow$ I).

C. **Methane (CH_4)**: Structure is tetrahedral. It has 4 C-H σ bonds. Total: 4 σ. (C $\rightarrow$ III).

D. **Ammonia (NH_3)**: Structure has 3 N-H σ bonds and one lone pair on the Nitrogen atom. (D $\rightarrow$ II).

Step 3: Final Answer:

Matching gives: A-IV, B-I, C-III, D-II.

Quick Tip: In a multiple bond, the first bond is always a σ bond, and all subsequent bonds are π bonds. (Single = 1σ; Double = 1σ, 1π; Triple = 1σ, 2π).

---

70. At a certain temperature, T (K), during a process, 500 J is absorbed by the system and work of 200 J is done by the system. Then change in internal energy of the system is :

(1) 700 J

(2) 300 J

(3) 400 J

(4) 500 J

Correct Answer: (2) 300 J

Solution:

Step 1: Understanding the Concept:

The First Law of Thermodynamics states that the energy of an isolated system is constant. Change in internal energy (ΔU) is equal to heat absorbed (Q) minus work done (W) by the system.

Step 2: Key Formula or Approach:

$$\Delta U = Q - W$$

Sign conventions:

$Q > 0$ if heat is absorbed by the system.

$W > 0$ if work is done **by** the system.

Step 3: Detailed Explanation:

Given:

1. Heat absorbed by the system, $Q = +500$ J.
2. Work done by the system, $W = +200$ J.

Calculation:

$$\Delta U = 500 - 200$$

$$\Delta U = 300 \text{ J}$$

Step 4: Final Answer:

The change in internal energy is 300 J.

Quick Tip: Think of it as a bank account: "Heat absorbed" is a deposit (+), and "Work done by system" is a withdrawal (-). The balance is your change in internal energy.

---

71. Methane reacts with steam at 1273 K in the presence of nickel catalyst to form :

(1) CO and H_2

(2) CO and H_2O

(3) CO_2 and H_2O

(4) CO_2 and H_2

Correct Answer: (1) CO and H_2

Solution:

Step 1: Understanding the Concept:

Hydrocarbons react with steam at high temperatures in the presence of catalysts to produce a mixture of carbon monoxide and hydrogen, commonly known as water gas or synthesis gas (syngas).

Step 2: Key Formula or Approach:

The general reaction for steam reforming of methane is:

$$CH_4(g) + H_2O(g) \xrightarrow[1273 \text{ K}]{\text{Ni}} CO(g) + 3H_2(g)$$

Step 3: Detailed Explanation:

When methane (CH_4) is heated with steam (H_2O) at 1273 K in the presence of a nickel catalyst, it undergoes a process called steam reforming. This reaction produces one molecule of carbon monoxide (CO) and three molecules of hydrogen gas (H_2). This industrial process is one of the primary methods for large-scale hydrogen production.

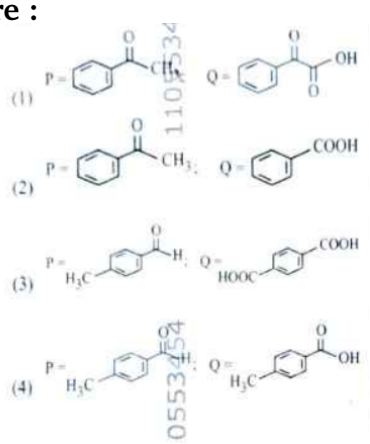
Step 4: Final Answer:

The products formed are CO and H_2.

Quick Tip: The mixture of CO and H_2 produced in this reaction is called "syngas" because it is used for the synthesis of methanol and many hydrocarbons.

---

72. Compound P (C_8H_8O) gives a red orange precipitate with 2,4-DNP reagent and it does not reduce Fehling's reagent. On drastic oxidation with chromic acid, P gives an aromatic product Q that produces effervescence on treating with aq. $NaHCO_3$. Compounds P and Q, respectively, are :



(1) (P: Acetophenone; Q: Benzoic acid)

(2) (P: Propiophenone; Q: Benzoic acid)

(3) (P: Ethylbenzaldehyde; Q: Terephthalic acid)

(4) (P: Acetophenone; Q: Phenylacetic acid)

Correct Answer: (1) (P: Acetophenone; Q: Benzoic acid)

Solution:

Step 1: Understanding the Concept:

1. Reaction with 2,4-DNP indicates the presence of a carbonyl group (aldehyde or ketone).
2. No reaction with Fehling's reagent confirms that it is a ketone (or an aromatic aldehyde, but aromatic ketones like acetophenone are common test cases).
3. Effervescence with $NaHCO_3$ indicates that the oxidation product Q is a carboxylic acid.

Step 2: Detailed Explanation:

1. Compound P has the formula C_8H_8O. The degree of unsaturation is 5 (benzene ring + C=O).
2. P gives a 2,4-DNP test $\rightarrow$ Carbonyl group.
3. P does not reduce Fehling's $\rightarrow$ P is a ketone. In this molecular formula range, acetophenone ($C_6H_5COCH_3$) is the prime candidate.
4. Drastic oxidation of acetophenone with chromic acid (H_2CrO_4) cleaves the alkyl side chain to form benzoic acid (C_6H_5COOH).
5. Benzoic acid (Q) reacts with sodium bicarbonate to release CO_2 gas (effervescence).

Step 3: Final Answer:

P is Acetophenone and Q is Benzoic acid.

Quick Tip: Fehling's reagent only oxidizes aliphatic aldehydes. Aromatic aldehydes and all ketones (aliphatic or aromatic) do not react with Fehling's reagent.

---

73. A solution of copper sulphate is electrolysed for 10 minutes with a current of 1.5 amperes. The mass of copper deposited at cathode is :
(Given : Molar mass of Cu = 63 g mol^{-1}; 1 F = 96487 C mol^{-1})

(1) 2.4036 g

(2) 1.7018 g

(3) 0.5876 g

(4) 0.2938 g

Correct Answer: (4) 0.2938 g

Solution:

Step 1: Understanding the Concept:

According to Faraday's first law of electrolysis, the mass of a substance deposited at an electrode is proportional to the quantity of electricity passed through the electrolyte.

Step 2: Key Formula or Approach:

$$w = ZIt = \frac{M}{n \cdot F} \cdot I \cdot t$$

Where w is mass, M is molar mass, n is number of electrons, F is Faraday's constant, I is current, and t is time in seconds.

Step 3: Detailed Explanation:

Given:

$I = 1.5$ A

$t = 10$ min $= 600$ s

$M = 63$ g/mol

For $Cu^{2+} + 2e^- \rightarrow Cu$, $n = 2$.

Calculation:

$$Q = I \times t = 1.5 \times 600 = 900 \text{ C}$$

$$w = \frac{63}{2 \times 96487} \times 900$$

$$w = \frac{31.5 \times 900}{96487} = \frac{28350}{96487} \approx 0.2938 \text{ g}$$

Step 4: Final Answer:

The mass of copper deposited is 0.2938 g.

Quick Tip: Always convert time to seconds. In competitive exams, you can approximate $F \approx 96500$ for faster calculation if the options are not extremely close.

---

74. The functional group that can be identified through phthalein dye test is :

(1) Phenolic

(2) Alcohol

(3) Aldehyde

(4) Carboxylic acid

Correct Answer: (1) Phenolic

Solution:

Step 1: Understanding the Concept:

The phthalein dye test is a characteristic laboratory test used to identify phenols. It involves the condensation of phenol with phthalic anhydride.

Step 2: Detailed Explanation:

When a phenol is heated with phthalic anhydride in the presence of concentrated sulfuric acid, a condensation reaction occurs to form a phthalein dye. For example, phenol reacting with phthalic anhydride forms **phenolphthalein**.

The resulting mixture is then treated with dilute sodium hydroxide (NaOH). If a phthalein dye is formed, the solution turns a characteristic color (e.g., intense pink for phenolphthalein). This test is specific to the phenolic (-OH group on an aromatic ring) functional group.

Step 3: Final Answer:

The phthalein dye test identifies the phenolic functional group.

Quick Tip: Phenolphthalein is not just an acid-base indicator; its synthesis is the actual "phthalein dye test" for phenols. Different phenols produce different colored dyes (e.g., resorcinol produces fluorescein, which is yellow-green).

---

75. The correct statement with regard to the secondary structure of DNA/RNA is :

(1) DNA possesses a single strand helix structure and contains uracil as one of the four bases.
(2) RNA possesses a single strand helix structure and contains thymine as one of the four bases.
(3) DNA possesses a double strand helix structure and contains thymine as one of the four bases.
(4) RNA possesses a double strand helix structure and contains uracil as one of the four bases.

Correct Answer: (3) DNA possesses a double strand helix structure and contains thymine as one of the four bases.

Solution:

Step 1: Understanding the Concept:
DNA (Deoxyribonucleic acid) and RNA (Ribonucleic acid) have distinct secondary structures and nucleotide base compositions.

Step 2: Detailed Explanation:
1. **DNA**: The secondary structure is a **double-stranded** right-handed helix (proposed by Watson and Crick). It contains four bases: Adenine (A), Guanine (G), Cytosine (C), and **Thymine (T)**.
2. **RNA**: Usually exists as a **single-stranded** helical structure. It contains four bases: Adenine (A), Guanine (G), Cytosine (C), and **Uracil (U)** instead of thymine.

Step 3: Final Answer:
Statement (3) correctly describes DNA's double strand helix and its use of thymine.

Quick Tip: Mnemonics for bases:

DNA: ATGC (At The Gold Coast)

RNA: AUGC (All Universities Go Crazy)

---

76. Identify the correct statements :

A. The molality of 2.5 **g of ethanoic acid (Molar mass :** 60 **g mol**$^{-1}$**) in** 75 **g of benzene solution is** 0.556 **m.**

B. The molarity of a solution containing 5 **g of NaOH (molar mass :** 40 **g mol**$^{-1}$**) in** 450 **mL of solution is** 0.278 **M at** 298 **K.**

C. Aquatic species are more comfortable in cold water.

D. The solubility of gas increases with decrease in pressure.

E. For a binary mixture of A and B, the mole fraction of B will be $\chi_B = \frac{n_A}{n_A+n_B}$**.**

Choose the correct answer from the options given below :

(1) A and C only

(2) A, B and C only

(3) A, D and E only

(4) A and B only

Correct Answer: (2) A, B and C only

Solution:

Step 1: Understanding the Concept:

This question evaluates basic concentration definitions (molality, molarity, mole fraction) and the properties of solubility of gases in liquids.

Step 2: Detailed Explanation:

Statement A: Molality $m = \frac{w_B \times 1000}{M_B \times w_A} = \frac{2.5 \times 1000}{60 \times 75} = \frac{2500}{4500} \approx 0.556$ m. **Correct**.

Statement B: Molarity $M = \frac{w_B \times 1000}{M_B \times V(mL)} = \frac{5 \times 1000}{40 \times 450} = \frac{5000}{18000} \approx 0.278$ M. **Correct**.

Statement C: Solubility of gases (like oxygen) increases with a decrease in temperature. Therefore, there is more dissolved oxygen in cold water, making aquatic species more comfortable. **Correct**.

Statement D: According to Henry's Law, the solubility of a gas is directly proportional to the partial pressure of the gas above the liquid. Solubility *decreases* with a decrease in pressure. **Incorrect**.

Statement E: The mole fraction of B is $\chi_B = \frac{n_B}{n_A+n_B}$. The given formula describes χ_A. **Incorrect**.

Step 3: Final Answer:

Statements A, B, and C are correct.

Quick Tip: Always double-check the numerator for mole fraction. It must match the component being measured. For solubility of gases, remember: "Soda stays fizzy longer in the fridge (cold) and under high pressure."

---

77. Mixture of chloroform and acetone forms a solution with negative deviation from Raoult's law due to :

(1) formation of hydrogen bonding between acetone and chloroform.
(2) increase in escaping tendency of molecules of each component.
(3) stronger intermolecular forces between chloroform molecules than those between chloroform and acetone molecules.
(4) repulsive forces.

Correct Answer: (1) formation of hydrogen bonding between acetone and chloroform.

Solution:

Step 1: Understanding the Concept:

Negative deviation from Raoult's law occurs when the total vapor pressure of the solution is lower than expected. This happens when the attractive forces between the different components (A-B) are stronger than the forces within the pure components (A-A and B-B).

Step 2: Detailed Explanation:

When chloroform ($CHCl_3$) and acetone (CH_3COCH_3) are mixed, a new intermolecular hydrogen bond is formed between the slightly acidic hydrogen of chloroform and the lone pair on the oxygen of acetone.

$$Cl_3C\text{-}H\cdots O{=}C(CH_3)_2$$

These A-B interactions are much stronger than the dipole-dipole interactions present in pure chloroform or pure acetone. Because the molecules are held together more tightly, their escaping tendency into the vapor phase decreases, leading to a negative deviation from Raoult's law.

Step 3: Final Answer:

The negative deviation is due to the formation of hydrogen bonding between the two components.

Quick Tip: Negative deviation → Interaction increases, Volume decreases ($\Delta V_{mix} < 0$), Heat is released ($\Delta H_{mix} < 0$).

---

78. At 298 K, a certain buffer solution contains equal concentrations of X^- and HX. K_b for X^- is 10^{-10}. What is the pH of this buffer solution ?

(1) 2

(2) 10

(3) 4

(4) 6

Correct Answer: (3) 4

Solution:

Step 1: Understanding the Concept:

A buffer solution consisting of a weak acid (HX) and its conjugate base (X^-) follows the Henderson-Hasselbalch equation.

Step 2: Key Formula or Approach:

1. $pH = pK_a + \log\left(\frac{[Salt]}{[Acid]}\right)$
2. $pK_a + pK_b = 14$ (at 298 K)

Step 3: Detailed Explanation:

Given:

$[X^-] = [HX] \implies \log\left(\frac{[X^-]}{[HX]}\right) = \log(1) = 0.$

Thus, $pH = pK_a$.

Find pK_a:

$K_b = 10^{-10} \implies pK_b = -\log(10^{-10}) = 10.$

Using $pK_a + pK_b = 14$:

$pK_a = 14 - 10 = 4.$

Therefore, $pH = 4$.

Step 4: Final Answer:

The pH of the buffer solution is 4.

Quick Tip: When concentrations of conjugate acid and base are equal, the pH equals the pK_a. Always check if you are given K_a or K_b and for which species!

---

79. Identify the *incorrect* statement from the following :

(1) The IUPAC name of the element with atomic number 107 is Unnilseptium.

(2) The largest and the smallest species among Mg, Mg^{2+}, Al and Al^{3+} are Al and Mg^{2+}, respectively.

(3) The similarity in behaviour of Li with Mg is referred to as 'diagonal relationship'.

(4) The oxidation state and covalency of Al in $[AlCl(H_2O)_5]^{2+}$ are 3 and 6 respectively.

Correct Answer: (2) The largest and the smallest species among Mg, Mg^{2+}, Al and Al^{3+} are Al and Mg^{2+}, respectively.

Solution:

Step 1: Understanding the Concept:

Periodic properties like ionic radii, nomenclature of heavy elements, and coordination chemistry properties follow specific trends and rules.

Step 2: Detailed Explanation:

Statement 1: For atomic number 107: 1 (un) + 0 (nil) + 7 (sept) + ium = **Unnilseptium**. Correct.

Statement 2: Let's analyze the sizes:

- Atoms: Mg (period 3, group 2) and Al (period 3, group 13). Moving left to right, radius decreases. So Mg > Al.
- Ions: Mg^{2+} and Al^{3+} are isoelectronic (10 electrons). For isoelectronic species, the higher the nuclear charge, the smaller the radius. Nuclear charge: Al (13) > Mg (12). So $Mg^{2+} > Al^{3+}$.

Therefore, the largest species is **Mg** and the smallest is **Al^{3+}**. Statement 2 is **Incorrect**.

Statement 3: Li and Mg show similar chemical properties due to similar charge/radius ratios. Correct.

Statement 4: In $[AlCl(H_2O)_5]^{2+}$:

- Oxidation state: $x + (-1) + 5(0) = +2 \implies x = +3$.
- Covalency (Coordination number): 1 Cl + 5 H_2O = 6. Correct.

Step 3: Final Answer:

Statement (2) is incorrect.

Quick Tip: For isoelectronic ions, radius $\propto 1/Z$. More protons pull the same number of electrons closer.

---

80. The correct order of increasing metallic character of Na, Be, P, Mg and Si is :

(1) $P < Si < Be < Mg < Na$

(2) $Be < Si < P < Mg < Na$

(3) $P < Si < Na < Mg < Be$

(4) $P < Mg < Be < Si < Na$

Correct Answer: (1) $P < Si < Be < Mg < Na$

Solution:

Step 1: Understanding the Concept:

Metallic character is the tendency of an atom to lose electrons. It increases down a group (due to increasing size/effective shielding) and decreases across a period (due to increasing nuclear charge/decreasing size).

Step 2: Detailed Explanation:

Let's group the elements by their position in the periodic table:

Period 2: Be (Group 2)

Period 3: Na (Group 1), Mg (Group 2), Si (Group 14), P (Group 15)

1. In Period 3: Metallic character decreases across the period.

Order: Na (most) $>$ Mg $>$ Si $>$ P (least).

2. Comparing Be (Period 2) and Mg (Period 3) in Group 2: Metallic character increases down the group.

Order: Mg $>$ Be.

3. Now, compare Be and Si: Although Be is higher up, it is in Group 2 (metal), whereas Si is in Group 14 (metalloid). Be is more metallic than Si.

Combining these observations: $P < Si < Be < Mg < Na$.

Step 3: Final Answer:

The correct increasing order is $P < Si < Be < Mg < Na$.

Quick Tip: Metallic character trend is the **inverse** of electronegativity. Non-metals (P, Si) will always be at the lower end, while alkali metals (Na) will be at the top.

---

81. The correct IUPAC name of the following compound is :

CH_3-CH_2-CH(C_2H_5)-CH_2-CH(CH_3)-CH_2-CH_3

(1) 2,4-diethylhexane

(2) 3,5-diethylhexane

(3) 3-ethyl-5-methylheptane

(4) 3-methyl-5-ethylheptane

Correct Answer: (3) 3-ethyl-5-methylheptane

Solution:

Step 1: Understanding the Concept:

Naming an organic compound involves identifying the longest continuous carbon chain and numbering it to give the lowest possible locants to the substituents, following alphabetical priority.

Step 2: Detailed Explanation:

1. **Identify the Parent Chain:** The longest chain contains 7 carbon atoms, so the parent name is heptane.
2. **Identify Substituents:** There is an ethyl group (-C_2H_5) and a methyl group (-CH_3).
3. **Numbering:**

- Numbering from left to right: Ethyl at C3, Methyl at C5. Set: (3, 5).
- Numbering from right to left: Methyl at C3, Ethyl at C5. Set: (3, 5).

4. **Alphabetical Rule:** Since both directions give the same locant set (3, 5), the substituent that comes first alphabetically (ethyl) gets the lower number.

- Thus, the correct name is 3-ethyl-5-methylheptane.

Step 3: Final Answer:

The IUPAC name is 3-ethyl-5-methylheptane.

Quick Tip: When locant sets are identical from both ends, always give priority to the substituent that appears first in the alphabet. Ethyl (e) beats Methyl (m).

---

82. Match List I with List II :

List I (Complex/ion)	List II (Shape/geometry)
A. $[Pt(Cl_2)(NH_3)_2]$	I. Octahedral
B. $[Co(NH_3)_6]^{3+}$	II. Trigonal bipyramidal
C. $[NiCl_4]^{2-}$	III. Square planar
D. $[Fe(CO)_5]$	IV. Tetrahedral

Choose the correct answer from the options given below :

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

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

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

(4) A-III, B-I, C-IV, D-II (Note: Options 2 and 4 are identical in this version)

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

Solution:

Step 1: Understanding the Concept:
The geometry of coordination complexes is determined by the hybridization of the central metal atom, which depends on its coordination number and electronic configuration.

Step 2: Detailed Explanation:
A. $[Pt(Cl_2)(NH_3)_2]$: Platinum(II) complexes with coordination number 4 are typically dsp^2 hybridized and have a **square planar** geometry. (A $\rightarrow$ III).
B. $[Co(NH_3)_6]^{3+}$: Cobalt(III) with 6 ligands involves d^2sp^3 or sp^3d^2 hybridization, resulting in an **octahedral** geometry. (B $\rightarrow$ I).

C. $[NiCl_4]^{2-}$: Nickel(II) with weak field ligands (Cl) and coordination number 4 is sp^3 hybridized, leading to a **tetrahedral** geometry. (C → IV).

D. $[Fe(CO)_5]$: Iron(0) with 5 CO ligands is dsp^3 hybridized, resulting in a **trigonal bipyramidal** geometry. (D → II).

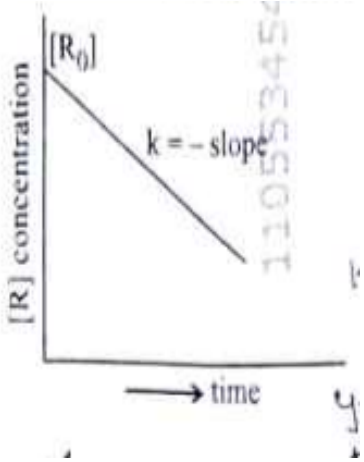
Step 3: Final Answer:

The matching sequence is A-III, B-I, C-IV, D-II.

Quick Tip: Remember that Pt^{2+} and Pd^{2+} almost always form square planar complexes regardless of the ligand strength due to high crystal field splitting.

---

83. For a certain reaction R → Product, the plot of concentration [R] vs time has a negative slope as shown. The order of reaction is :



(1) 0

(2) 1

(3) 2

(4) 2.5

Correct Answer: (1) 0

Solution:

Step 1: Understanding the Concept:

The integrated rate laws for different orders of reactions produce different linear plots.

Step 2: Key Formula or Approach:

For a zero-order reaction: $[\mathrm{R}] = [\mathrm{R}]_0 - kt$.

This matches the equation of a straight line $y = mx + c$ where the slope $m = -k$.

Step 3: Detailed Explanation:

1. If the plot of $[\mathrm{R}]$ vs t is a straight line, it indicates that the rate of change of concentration is independent of the concentration itself.
2. This is the definition of a **zero-order reaction**.
3. For a first-order reaction, a plot of $\ln[\mathrm{R}]$ vs t would be linear.
4. For a second-order reaction, a plot of $1/[\mathrm{R}]$ vs t would be linear.

Step 4: Final Answer:

The order of the reaction is 0.

Quick Tip: Visualize the axes:

Conc vs Time = Linear → 0 order

log(Conc) vs Time = Linear → 1st order

1/Conc vs Time = Linear → 2nd order

---

84. Which one of the following is an ambidentate ligand ?

(1) Ethylenediaminetetraacetate ion

(2) Oxalate

(3) Ethane-1,2-diamine

(4) Thiocyanate

Correct Answer: (4) Thiocyanate

Solution:

Step 1: Understanding the Concept:

An ambidentate ligand is a unidentate ligand that has two or more different donor atoms and can coordinate to a central metal atom through either of these atoms.

Step 2: Detailed Explanation:

1. **EDTA**: A hexadentate ligand. (Not ambidentate).
2. **Oxalate**: A bidentate ligand. (Not ambidentate).
3. **Ethane-1,2-diamine**: A bidentate ligand. (Not ambidentate).
4. **Thiocyanate (SCN^-)**: This ligand can coordinate through the Nitrogen atom (M-NCS, isothiocyanato) or the Sulfur atom (M-SCN, thiocyanato). Because it has two different potential donor atoms, it is an **ambidentate** ligand.

Step 3: Final Answer:

Thiocyanate is the ambidentate ligand.

Quick Tip: Common ambidentate ligands to memorize: NO_2^- (N or O), CN^- (C or N), and SCN^- (S or N).

---

85. Consider the following reaction :

$2A(g) + B(g) \rightarrow 2D(g)$

$\Delta U^\ominus = -10$ **kJ mol**$^{-1}$ **and** $\Delta S^\ominus = -44$ **J K**$^{-1}$ **at** 298 **K.**

Identify the correct option with $\Delta G^\ominus$ **for the reaction and spontaneity of the reaction at** 298 **K.**

(Given : $R = 8.31$ **J mol**$^{-1}$ **K**$^{-1}$**)**

(1) -1.635 kJ mol^{-1}, spontaneous

(2) $+0.6358$ kJ mol^{-1}, non-spontaneous

(3) -0.6358 kJ mol^{-1}, spontaneous

(4) $+1.635$ kJ mol^{-1}, non-spontaneous

Correct Answer: (2) $+0.6358$ kJ mol^{-1}, non-spontaneous

Solution:

Step 1: Understanding the Concept:

To determine spontaneity, we calculate the Gibbs free energy change (ΔG). If $\Delta G < 0$, the reaction is spontaneous; if $\Delta G > 0$, it is non-spontaneous.

Step 2: Key Formula or Approach:

1. $\Delta H = \Delta U + \Delta n_g RT$
2. $\Delta G = \Delta H - T\Delta S$

Step 3: Detailed Explanation:

Given:

$\Delta U^\ominus = -10$ kJ $= -10,000$ J

$\Delta S^\ominus = -44$ J/K; $T = 298$ K; $R = 8.314$

$\Delta n_g = 2 - (2 + 1) = -1$.

Calculation of $\Delta H^\ominus$:

$$\Delta H^\ominus = -10,000 + (-1 \times 8.314 \times 298)$$

$$\Delta H^\ominus = -10,000 - 2477.5 \approx -12477.5 \text{ J}$$

Calculation of $\Delta G^\ominus$:

$$\Delta G^\ominus = -12477.5 - (298 \times -44)$$

$$\Delta G^\ominus = -12477.5 + 13112 = +634.5 \text{ J mol}^{-1}$$

$$\Delta G^\ominus \approx +0.635 \text{ kJ mol}^{-1}$$

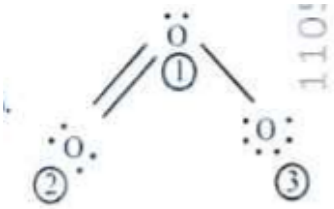
Step 4: Final Answer:

Since ΔG is positive (+0.635 kJ/mol), the reaction is non-spontaneous.

Quick Tip: Always convert kJ to J or vice-versa to ensure all terms in the equation have consistent units. Note that $\Delta G = +0.635$ kJ is very close to zero, suggesting the reaction is nearly at equilibrium.

---

86. The correct formal charges on oxygen atoms numbered 2, 1 and 3 respectively are :



(1) $-1, 0, +1$

(2) $0, +1, -1$

(3) $0, 0, 0$

(4) $+1, 0, -1$

Correct Answer: (2) $0, +1, -1$ (Note: Reviewing numbering order 2, 1, 3)

Solution:

Step 1: Understanding the Concept:

Formal charge is calculated based on the valence electrons, lone pair electrons, and shared bonding electrons.

Step 2: Key Formula or Approach:

$$\text{FC} = V - L - \frac{1}{2}S$$

Where V = Valence electrons, L = Lone pair electrons, S = Shared bonding electrons.

Step 3: Detailed Explanation:

Structure of Ozone (O_3):

Central atom (O-1) forms one double bond and one single bond. It has 1 lone pair.

$$\text{FC}_1 = 6 - 2 - (6/2) = +1$$

Oxygen (O-2) forms a double bond. It has 2 lone pairs.

$$FC_2 = 6 - 4 - (4/2) = 0$$

Oxygen (O-3) forms a single bond. It has 3 lone pairs.

$$FC_3 = 6 - 6 - (2/2) = -1$$

Requested order (2, 1, 3): 0, +1, -1.

Step 4: Final Answer:

The formal charges are $0, +1, -1$.

Quick Tip: The sum of formal charges must equal the total charge on the molecule. For neutral O_3: $0 + (+1) + (-1) = 0$.

---

87. Given below are certain reactions. Identify the reaction for which $K_p \neq K_c$.

(1) $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$

(2) $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$

(3) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

(4) $H_2O(g) + CO(g) \rightleftharpoons H_2(g) + CO_2(g)$

Correct Answer: (3) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

Solution:

Step 1: Understanding the Concept:

The relationship between the equilibrium constants K_p and K_c is determined by the change in the number of moles of gaseous products and reactants.

Step 2: Key Formula or Approach:

$$K_p = K_c(RT)^{\Delta n_g}$$

If $\Delta n_g = 0$, then $K_p = K_c$. If $\Delta n_g \neq 0$, then $K_p \neq K_c$.

Step 3: Detailed Explanation:

1. $\Delta n_g = 2-(1+1) = 0 \implies K_p = K_c$.
2. $\Delta n_g = 2-(1+1) = 0 \implies K_p = K_c$.
3. $\Delta n_g = 2-(1+3) = -2$. Since $\Delta n_g \neq 0$, $K_p \neq K_c$.
4. $\Delta n_g = (1+1)-(1+1) = 0 \implies K_p = K_c$.

Step 4: Final Answer:

Reaction (3) has $K_p \neq K_c$.

Quick Tip: Always check the physical states. Only include gaseous moles in the calculation of Δn_g.

---

88. Given below is an expression for the rate constant of a first order reaction occurring at a certain temperature, T (K).

$\ln k = 14.34 - \frac{1.25\times10^4}{T}$

The energy of activation in kcal mol^{-1} for the reaction is :

(Given : k in s^{-1}, R = 1.987 cal mol^{-1} K^{-1})

(1) 12.42

(2) 14.34

(3) 18.63

(4) 24.84

Correct Answer: (4) 24.84

Solution:

Step 1: Understanding the Concept:

The temperature dependence of the rate constant is given by the Arrhenius equation.

Step 2: Key Formula or Approach:

1. $k = \mathrm{A}e^{-\mathrm{E}_a/\mathrm{RT}} \implies \ln k = \ln \mathrm{A} - \frac{\mathrm{E}_a}{\mathrm{RT}}$
2. Compare given equation with $\ln k = \ln \mathrm{A} - \frac{\mathrm{E}_a}{\mathrm{R}} \cdot \frac{1}{\mathrm{T}}$.

Step 3: Detailed Explanation:

From comparison:

$$\frac{\mathrm{E}_a}{\mathrm{R}} = 1.25 \times 10^4$$

$$\mathrm{E}_a = 1.25 \times 10^4 \times \mathrm{R}$$

$$\mathrm{E}_a = 1.25 \times 10^4 \times 1.987 \text{ cal/mol}$$

$$\mathrm{E}_a = 24837.5 \text{ cal/mol}$$

To convert to kcal/mol:

$$\mathrm{E}_a = \frac{24837.5}{1000} \text{ kcal/mol} \approx 24.84 \text{ kcal/mol}$$

Step 4: Final Answer:

The activation energy is 24.84 kcal mol^{-1}.

Quick Tip: Always match the coefficients of 1/T in both equations. Be careful with units like calories vs kilocalories.

---

89. The following two reactions give the same foul smelling product Z.

$\mathbf{C_2H_5Cl \xrightarrow{X} Z}$

$\mathbf{C_2H_5NH_2 \xrightarrow[\Delta]{CHCl_3/\text{ethanolic KOH}} Z}$

X and Z, respectively, are :

(1) X = AgCN; Z = $\mathrm{C_2H_5CN}$

(2) X = KCN; Z = C_2H_5CN

(3) X = KCN; Z = C_2H_5NC

(4) X = AgCN; Z = C_2H_5NC

Correct Answer: (4) X = AgCN; Z = C_2H_5NC

Solution:

Step 1: Understanding the Concept:

The second reaction is the Carbylamine reaction, a characteristic test for primary amines that produces foul-smelling isocyanides.

Step 2: Detailed Explanation:

1. **Reaction 2**: $C_2H_5NH_2 + CHCl_3 + 3KOH \rightarrow C_2H_5NC\ (Z) + 3KCl + 3H_2O$.

The foul-smelling product Z is ethyl isocyanide (C_2H_5NC).

2. **Reaction 1**: Alkyl halides react with AgCN to primarily form isocyanides because Ag-C bond is covalent, making the Nitrogen atom the nucleophilic center. Reaction with KCN would produce cyanides (RCN).

$$C_2H_5Cl + AgCN \rightarrow C_2H_5NC\ (Z) + AgCl$$

Thus, X = AgCN and Z = C_2H_5NC.

Step 3: Final Answer:

X is AgCN and Z is C_2H_5NC.

Quick Tip: Remember: KCN → Cyanide (-CN); AgCN → Isocyanide (-NC). The foul smell is the signature of an isocyanide.

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90. Match List I with List II :

List I (Complex)	List II (Type of isomerism)
A. $[Pt(NH_3)_2Cl_2]$	I. Optical
B. $[Co(en)_3]^{3+}$	II. Solvate
C. $[Co(NH_3)_5NO_2]Cl_2$	III. Geometrical
D. $[Cr(H_2O)_6]Cl_3$	IV. Linkage

Choose the correct answer from the options given below :

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

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

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

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

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

Solution:

Step 1: Understanding the Concept:

Isomerism in coordination compounds can be structural (linkage, solvate, etc.) or stereoisomerism (geometrical, optical).

Step 2: Detailed Explanation:

A. $[Pt(NH_3)_2Cl_2]$: This square planar complex exhibits **geometrical** isomerism (cis and trans). (A $\rightarrow$ III).

B. $[Co(en)_3]^{3+}$: This octahedral complex with three bidentate ligands is chiral and exhibits **optical** isomerism. (B $\rightarrow$ I).

C. $[Co(NH_3)_5NO_2]Cl_2$: The nitro ligand is ambidentate (can bond through N or O), exhibiting **linkage** isomerism. (C $\rightarrow$ IV).

D. $[Cr(H_2O)_6]Cl_3$: This complex can exchange water molecules in the coordination sphere with counter ions (like Cl), exhibiting **solvate** (hydrate) isomerism. (D $\rightarrow$ II).

Step 3: Final Answer:

The matching sequence is A-III, B-I, C-IV, D-II.

Quick Tip: Ambidentate ligands (NO_2, SCN) are the hallmark of linkage isomerism. $[M(en)_3]$ type complexes are the most classic examples of purely optical isomerism in inorganic chemistry.
