J.D. LEE Concise Inorganic Chemistry for JEE Main & Advanced

# JEE Advanced/ Multidisciplinary PYQs with Answers and Solutions

## ANSWERS WITH EXPLANATION

### Chapter 1 Structure of an Atom

1. Number of atoms per unit cell

$$Z = 4$$

Edge length a = 400pm = $4.0 \times 10^{-8}$ cm

Volume of Unit cell

$V = a^3 = (4.0 \times 10^{-8})^3 = 6.4 \times 10^{-23}\ cm^3$

Mass of Unit cell

$$m = \frac{Z \times M}{N_A} = \frac{4 \times 105.6}{6 \times 10^{23}} = 7.04 \times 10^{-22}\ g$$

Density

$$\rho = \frac{m}{v} = \frac{7.04 \times 10^{-22}}{6.4 \times 10^{-23}} = 11.0\ g/cm^3$$

### Chapter 2 Periodic Table and Periodic Properties

1. $C = 1 \times 10^{-3}$ M, $K_a = 4 \times 10^{-11}$, $K_w = 1 \times 10^{-14}$

For weak acid

$[H^+]^2 = CK_a + K_w$

$[H^+]^2 = (1 \times 10^{-3})\ (4 \times 10^{-11}) + 1 \times 10^{-14}$
$= 5 \times 10^{-14}$

$[H^+] = \sqrt{5} \times 10^{-7} \approx 2.24 \times 10^{-7}$

Hence X = 2.24.

### Chapter 3 Chemical Bonding

1. Only A and D are correct.

2. Thermal decomposition of **silver nitrate ($AgNO_3$)** produces:

$$2AgNO_3 \rightarrow 2Ag + 2NO_2 + O_2$$

**Paramagnetic** gases formed are **$NO_2$** and **$O_2$**. $O_2$ has **higher number of unpaired electrons**.

- Total electrons = **16**
- Molecular orbital (MO) filling:

$(\sigma_{1s})^2(\sigma^*_{1s})^2(\sigma_{2s})^2(\sigma^*_{2s})^2(\sigma_{2pz})^2(\pi_{2px})^2(\pi_{2py})^2$
$(\pi_{2px})^1(\pi_{2py})^1$

**Unpaired electrons** = **2** (In $\pi^*$ orbitals).
Hence $O_2$ has **more unpaired electrons.**
The **antibonding molecular orbitals** are:

$\sigma^*_{1s}$ (2 electrons)

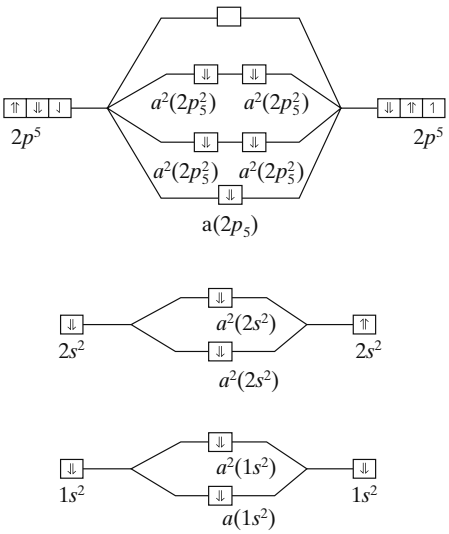
$\sigma^*_{2s}$ (2 electrons)

$\pi^*_{2px}$ (1 electron)

$\pi^*_{2py}$ (1 electron)

Total number of electrons in antibonding orbitals = **2 + 2 + 1 + 1 = 6**.

**3.**




**Hence the correct option is (C).**

**4.** **$Ni(CO)_4$ number of electrons is 84.**

$[Cr(CO)_4]^{-4} = 84$

**Only 1 of the given options is isoelectronic, hence the right answer is 1.**

**5.** Vander Waals cubic form

$$PV_m^3 - (Pb + RT)V_m^2 + aV_m - ab = 0$$

$\rightarrow$ Coefficient of $V_m^2 = -(Pb + RT)$

$\rightarrow$ Coefficient of $V_m = +a$

Required ratio $= \dfrac{-(Pb + RT)}{a}$

$Pb = 300 \times 0.060 = 18$

$RT = 0.082 \times 300$

$= 24.6$

$= \dfrac{-(18 + 24.6)}{6.0} = -7.1$

**6.** C: Dipole-induced dipole interaction depends on polarizability not temperature $\rightarrow$ true

D: Non polar molecules attract due to London dispersion force $\rightarrow$ true

**7.** $Ba(NO_3)_2 + 2NaIO_3 \rightarrow Ba(IO_3)_2 + 2NaNO_3$

Moles mixed

$Ba^{2+} = 200 \text{ mL} \times 0.010 \text{ M} = 2 \text{ mmol}$

$IO_3^- = 100 \text{ mL} \times 0.10 \text{ M} = 10 \text{ mmol}$

After precipitation

$Ba^{2+}$ consumed = 2 mmol

$IO_3^-$ consumed = 4 mmol

Excess $IO_3^-$ = 6 mmol

Total volume = 300 mL

$[IO_3^-] = \dfrac{6}{300} = \dfrac{1}{50}$ M

Let solubility of $Ba(IO_3)_2$ = S

$K_{sp} = [Ba^{2+}][IO_3^-]^2$

$1.58 \times 10^{-9} = S\left(\dfrac{1}{50}\right)^2$

$S = 1.58 \times 10^{-9} \times 2500$

$= 3.95 \times 10^{-6}$ M

**8.** Actual rate:

$$r = k\,[A]\,[R]$$

Pseudo – first order assumption

$[R] \approx [R]_0 \rightarrow r' = K'\,[A] = K\,[R]_0\,[A]$

Given

$$[R]_0 = 10\,[A]_0$$

At 40% completion of reaction

$[A] = 0.6\,[A]_0$

$[R] = [R]_0 - 0.4\,[A]_0 = 10[A]_0 - 0.4[A]_0$
$= 9.6[A]_0$

Actual rate at this stage

$r = k\,(0.6\,[A]_0)\,(9.6\,[A]_0) = 5.76k\,[A]_0^2$

Pseudo rate

$r' = k\,[0.6[A]_0)\,(10\,[A]_0) = 6.0\,k\,[A]_0^2$

Relative error

$\% \text{ error} = \dfrac{r' - r}{r} \times 100$

$= \dfrac{6.0 - 5.76}{5.76} \times 100$

$\approx 4.17\%$

## Chapter 4 Hydrolysis

1. The given compound **dimethyldichlorosilane** (**$SiCl_2(CH_3)_2$**) reacts with water to form a **tetrameric cyclic product** (**X**), which is a **cyclotetrasiloxane** of formula **$[(CH_3)_2SiO]_4$**.

   The reaction is:

$$4SiCl_2(CH_3)_2 + 4H_2O \rightarrow [(CH_3)_2SiO]_4 + 8HCl$$

   **4 moles** of **$SiCl_2(CH_3)_2$** produce **1 mole** of the cyclic product **X.**

   **Molar Mass Calculation:**

   - **$SiCl_2(CH_3)_2$**:

$$28 + (2 \times 35.5) + (2 \times 12) + (6 \times 1) = 129 \text{ g/mol}$$

   - **Tetrameric Product X: $[(CH_3)_2SiO]_4$**

$$4 \times [(28) + (2 \times 12) + (6 \times 1) + 16] = 4 \times 74 = 296 \text{ g/mol}$$

   **Moles of $SiCl_2(CH_3)_2$ Present:**

   Given mass = **516 g**

   Moles of $SiCl_2(CH_3)_2 = \frac{516}{129} = 4$ moles

   From the reaction equation:

   - **4 moles** of **$SiCl_2(CH_3)_2$** produce **1 mole** of **X**.

   So, moles of **X** formed (theoretical) = **1 mole**.

   Given yield = **75%**, so actual product obtained:

$$1 \times \frac{75}{100} = 0.75 \text{ moles}$$

   Mass of **X** = 0.75 × 296 = 222 g.

## Chapter 5 Coordination Compounds

1. $Cr^{3+}$ ($d^3$): 3 unpaired $e^-$, $\mu = \sqrt{15} = 3.87$ BM.

   $Cu^{3+}$ ($d^8$): Octahedral, high spin (weak $F^-$), 2 unpaired $e^-$, $\mu = \sqrt{8} = 2.84$ BM.

   Correct: **(A) 3.87** and **2.84**.

2.

| | Cis | trans |
|---|---|---|
| $[Pt(NH_3)_4(Cl)(Br)]Cl.Br$ | (achiral) | (achiral) |
| $[Pt(NH_3)_4Br_2]Cl_2$ | (achiral) | (achiral) |
| $[Pt(NH_3)_4Cl_2]Br_2$ | (achiral) | (achiral) |

3. $[Ni(CO)_4]$: $Ni^0$ with 4 ligands → tetrahedral.

   $[Ni(CN)_4]^{2-}$: $Ni^{2+}$ with strong field $CN^-$ ligands → square planar geometry ($d^8$ configuration prefers square planar).

   Hence (C) is incorrect. Remaining all options are correct.

4. **(I)** $[Cr(CN)_6]^{4-}$
   - Chromium (Cr) has an atomic number of 24.
   - In this complex, the oxidation state of Cr can be found as:

$$x + 6(-1) = -4 \Rightarrow x = +2$$

   - The electronic configuration of $Cr^{2+}$ is $[Ar]3d^4$, meaning it has a **$d^4$** configuration.
   - $CN^-$ is a strong field ligand, leading to a **low-spin** complex (R).
   - A $d^4$ configuration suggests **$t_2g$ orbitals contain 4 electrons** (P).
   - So, I → R, T.

   **(II)** $[RuCl_6]^{2-}$
   - Ruthenium (Ru) has an atomic number of 44.
   - Oxidation state of Ru:

$$x + 6(-1) = -2 \Rightarrow x = +4$$

   - This means Ru is is the +4 oxidation state, so it matches (S).
   - So, II→ **S.**

   **(III)** $[Cr(H_2O)_6]^{2+}$
   - Again, $Cr^{2+}$ has a $d^4$ configuration.
   - $H_2O$ is weak field ligand, so it forms a high-spin complex.
   - The spin-only magnetic moment ($\mu$) is given by:

$$\mu\sqrt{n(n+2)}$$

   For $d^4$ (high-spin, unpaired electrons = 4):

$$\mu = \sqrt{4(4+2)} = \sqrt{24} \approx 4.9\ BM$$

   - So, III → Q, T.

   **(IV)** **$[Fe(H_2O)_6]^{2+}$**
   - Fe has an atomic of 26.
   - Oxidation state of Fe:

$$x + 6\,(0) = +2 \Rightarrow x = +2$$

$Fe^{2+}$ has a $d^6$ configuration.

$H_2O$ is a weak field ligand, leading to a high-spin complex with **four unpaired electrons**.

The spin-only moment**:**

$$\mu = \sqrt{4(4+2)} = 4.9BM$$

So, IV→ P, Q.

**5.** $Pb(NO_3)_2 + 2NaCl \rightarrow PbCl_2$

$PbCl_2 + 2HCl \rightarrow [PbCl_4]^{-2}$

**6.** **(P)** $t_{2g}^6\, e_g^0$

- This represents a **low-spin $d^6$ configuration,** meaning it occurs in a **strong field ligand environment.**
- **Example:** $[Co(NH_3)_6]^{3+}$ **($Co^{3+}$, $d^6$ low-spin due to $NH_3$ being a strong ligand).**
- **Possible Match: (3)** $[Co(NH_3)_6]^{3+}$.

**(Q)** $t_{2g}^3\, e_g^2$

- This corresponds to a **high-spin $d^5$ configuration,** meaning a weak field ligand is present.
- **Example: $[Mn(H_2O)_6]^{2+}$ ($Mn^{2+}$, $d^5$, high-spin with weak field ligand $H_2O$)**.
- **Match: (2)** $[Mn(H_2O)_6]^{2+}$.

**(R)** $e_t^2\, t_{2g}^3$

- This represents a **tetrahedral $d^7$ configuration,** meaning the metal ion is likely $Co^{2+}$ in a weak field ligand environment.
- **Example:** $[CoCl_4]^{2-}$ **($Co^{2+}$, $d^7$, tetrahedral with $Cl^-$ ligands).**
- **Match: (5)** $[CoCl_4]^{2-}$.

**(S)** $t_{2g}^4\, e_g^2$

- This corresponds to a **high-spin $d^5$ configuration**, meaning a weak ligand like $Cl^-$ is present.
- **Example: $[FeCl_4]^-$ ($Fe^{3+}$, $d^5$, high-spin tetrahedral complex with $Cl^-$)**.
- **Match: (4)** $[FeCl_4]^-$.

**7.** The given complex **$[Pt(NH_3)_2Br_2]$** exhibits **geometrical (cis-trans) isomerism,** as it is a square planar complex with a **$MA_2X_2$** type structure.

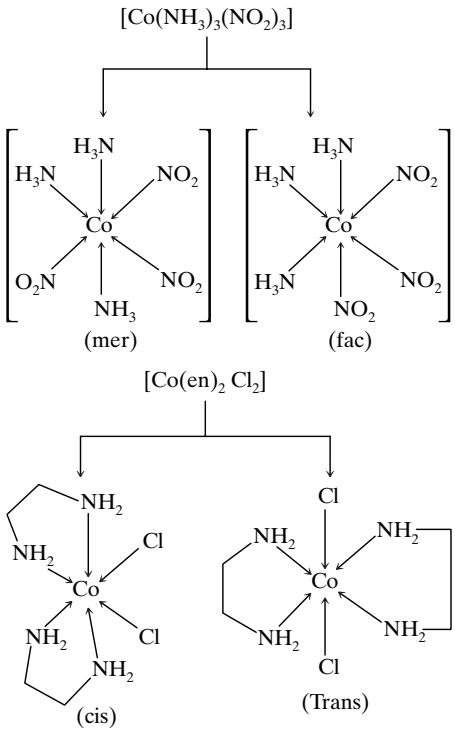
**(A)** **$[Pt(en)(SCN)_2]$** This is a square planar complex, but **"en" (ethylenediamine) is a bidentate ligand,** meaning there are no two identical **monodentate ligands** in cis/trans positions. Thus, it does not show the same type of isomerism.

**(B)** **$[Zn(NH_3)_2Cl_2]$**: **Zn(II) typically forms tetrahedral complexes**, and tetrahedral geometry does not allow for **cis-trans isomerism**.

**(C)** **$[Pt(NH_3)_2Cl_4]$**: This is an **octahedral** complex with the general formula **$MA_2X_2$,** which can exhibit **cis-trans isomerism** similar to **$[Pt(NH_3)_2Br_2]$**.

**(D)** **$[Cr(en)_2(H_2O)(SO_4)]^+$**: This is an **octahedral complex** with **bidentate (en) ligands,** and it can exhibit **geometrical isomerism** where **$H_2O$ and $SO_4^{2-}$ can be in cis or trans positions**.

**8.**




**9.** $[Mn(NH_3)_6]^{3+}(d^4)$, high spin, 4 $e^-$: Paramagnetic.

$[MnCl_6]^{3-}$ $(d^4)$, high spin: Paramagnetic.

$[FeF_6]^{3-}$ $(d^5)$, high spin: Paramagnetic.

$[CoF_6]^{3-}$ $(d^6)$, high spin: Paramagnetic.

$[Fe(NH_3)_6]^{3+}$ ($d^5$), high spin: Paramagnetic.

$[Co(en)_3]^{3+}$ ($d^6$), low spin: Diamagnetic.

Total = **1**.

**10.** $[Co(CN)_4]^{4-} \rightarrow$ Tetrahedral

$[Co(CO)_3(NO)] \rightarrow$ Tetrahedral

$XeF_4 \rightarrow$ Square planar

$[PCl_4]^{+} \rightarrow$ Tetrahedral

$[PdCl_4]^{2-} \rightarrow$ Square Planar

$[ICl_4]^{-} \rightarrow$ Square planar

$[Cu(CN)_4]^{3-} \rightarrow$ Tetrahedral

$P_4 \rightarrow$ Tetrahedral

**11.** $3KI + 2K_3[Fe(CN)_6] \rightarrow 2K_4[Fe(CN)_6] + KI_3$

$$3ZnCl_2 + \underset{\text{Excess}}{2K_4[Fe(CN)_6]} \rightarrow \underset{\text{White ppt.(Q)}}{K_2Zn_3[Fe(CN)_6]^2}$$

$$2ZnCl_2 + K_4[Fe\,(CN)_6] \rightarrow \underset{\text{White ppt.(Q)}}{Zn_2[Fe(CN)_6]} + 4KCl$$

**12.** The ligand field strength decreases in the order

$$CN^- > NH_3 > H_2O > Cl^-$$

Strong field ligands produce greater crystal field splitting and therefore absorb radiation of shorter wavelength (higher energy)

**13.** **(A)** $Ne_2$: Bond order = 0 (Correct)

**(B)** $F_2$: HOMO is $\pi^*2p$ ($\pi$-type), not $\sigma$(Incorrect)

**(C)** $O_2^+$: Removing one electron from antibonding orbital increases bond order, so bond energy of $O_2^+$ is greater than $O_2$; Statement follow smaller (Incorrect)

**(D)** $Li_2$ has larger bond length than $B_2$ (Correct)

**14.** $[M_nBr_6]^{3-}$ : $Mn^{3+} = d^4$, high spin $\rightarrow$ n = 4

$\mu = \sqrt{4(4+2)} = \sqrt{24} = 4.90$ BM

$[M_n(CN)_6]^{3-}$ : $Mn^{3+} = d^4$, low spin $\rightarrow$ n = 2

$\mu = \sqrt{2(2+2)} = \sqrt{8} = 2.82$ BM

Sum = 4.90 + 2.82 = 7.72 BM

## *Chapter 6 Metallurgy*

**1.** Packing fraction $(f) = \dfrac{3\times\frac{4}{3}\pi r_+^3 + 1\times\frac{4}{3}\pi r_-^3}{a^3}$

$$= \frac{1\times\frac{4}{3}\pi\left[3\left(\frac{r_+}{r_-}\right)^3 + 1\right]}{\left(\frac{a}{r_-}\right)^3}$$

Now $2r_- = a$

$\therefore \dfrac{a}{r_-} = 2$

Also, $\dfrac{r_+}{r_-} = 0.414$

So, $f = \dfrac{1\times\frac{4}{3}\times 3.14[3\times(0.414)^3 + 1]}{(2)^3}$

$= 0.634 \approx 0.63$

**2.** **(A)** PbS + PbO: Self-reduction, correct.

**(B)** **Copper silicate:** Incorrect, forms $FeSiO_3$.

**(C)** **Blister copper:** Correct, via self-reduction.

**(D)** **Cyanide process:** Correct, Zn precipitates gold.

**3.** $Sn + HCl \rightarrow SnCl_2$.

$SnCl_2$ reduces nitrobenzene ($C_6H_5NO_2$) to aniline, forming $[C_6H_5NH_3]$ Cl.

1.29 g of salt (M = 129g): 0.01 mol.

$3C_6H_5NO_2 + SnCl_2 \rightarrow 3C_6H_5NH_3Cl$.

$y = 0.01$ mol nitrobenzene $= 0.01 \times 123 = 1.23$g.

$x = (0.01/3) \times 119 = 3.57$ g.

**4.** **(A)** **2500°C:** Incorrect, electrolysis is at ~950°C.

**(B)** **Neutralization:** Correct, Bayer's process.

**(C)** **Dissolution in** NaOH: Correct, Bayer's process.

**(D)** **Electrolysis with** $Na_3AlF_6$: Correct, Hall-Héroult process.

**5.** $PbS + HNO_3 \rightarrow PbSO_4 + NO$.

**(A) Paramagnetic:** NO has 1 unpaired electron. **True.**

**(B) Bent:** No is linear (as $NO^+$ in solution). **False.**

**(C) Acidic oxide:** NO is neutral. **False.**

**(D) Colorless:** NO is colorless (unlike $NO_2$). **True.**

**6.** $X = 8 \times \frac{1}{8} + 6 \times \frac{1}{2} + \frac{1}{2} \times 8$

$= 1 + 3 + 4 = 8$

$2r = \frac{\sqrt{3}}{4} a;$

$r = \frac{\sqrt{3}}{8} a$

Packing fraction =

$$\frac{\text{number of atoms} \times \text{volume of one atom}}{\text{volume of unit cell}} \times 100\%$$

$$= \frac{8 \times \frac{4}{3} \times 3.14 \times \left(\frac{\sqrt{3}}{8} a\right)^3}{a^3} \times 100\%$$

$= 35\%$

**7. (A) Limestone for silicate:** Correct from slag.

**(B) 4% carbon:** Correct, in pig iron.

**(C)** $CO_2$ **to** CO: Correct, via coke.

**(D)** $NO_2$: Incorrect, exhaust is CO, $CO_2$.

**8. (A) Malachite to cuprite:** Incorrect, forms Cu.

**(B) Calamine to Zincite:** Correct, $ZnCO_3 \rightarrow ZnO$.

**(C) Copper pyrites with silica:** Correct, removes iron.

**(D) Silver with KCN:** Correct, cyanide process.

**9.** For X:

$$\text{P.E} = \frac{z \times \frac{4}{3}\pi(r_x)^3}{a_1^3} = \frac{4 \times \frac{4}{3}\pi(r_x)^3}{(L_x)^3} = \frac{4 \times \frac{4}{3}\pi(r_x)^3}{\left(\frac{4}{\sqrt{2}} r_x\right)^3}$$

$= 0.24\ \pi$

For Y:

$$\text{P.E} = \frac{z \times \frac{4}{3}\pi(r_y)^3}{a_2^3} = \frac{2 \times \frac{4}{3}\pi(r_y)^3}{(L_y)^3} = \frac{2 \times \frac{4}{3}\pi(r_y)^3}{\left(\frac{4}{\sqrt{3}} r_y\right)^3}$$

$= 0.22\pi$

For Z:

$$\text{P.E} = \frac{z \times \frac{4}{3}\pi(r_z)^3}{a_3^3} = \frac{1 \times \frac{4}{3}\pi(r_z)^3}{(L_z)^3} = \frac{1 \times \frac{4}{3}\pi(r_z)^3}{(2r_z)^3}$$

$= \frac{\pi}{6} = 0.17\pi$

Hence option A is correct.

$4r_y = \sqrt{3} L_y \qquad 2r_z = L_z$

$L_y = \frac{4r_y}{\sqrt{3}}$

$$\frac{L_y}{L_z} = \frac{4r_y}{\sqrt{3} \times 2r_z} = \frac{2r_y}{\sqrt{3} r_z} = \frac{2r_y}{\sqrt{3} \cdot \frac{\sqrt{3}}{2} r_y} = \frac{4}{3}$$

$L_y > L_z$

Hence B is correct.

$$d_x = \frac{4 \times M_x}{\left(\frac{4r_x}{\sqrt{2}}\right)^3 \times N_A}$$

$$d_y = \frac{2 \times M_y}{\left(\frac{4r_y}{\sqrt{3}}\right)^3 \times N_A}$$

$$r_y = \frac{8}{\sqrt{3}} r_x, \frac{M_x}{M_y} = \frac{1}{2}$$

$$\frac{d_x}{d_y} = \frac{512}{2\sqrt{2}} = \frac{256}{\sqrt{2}}$$

Hence Density of X is more than Y, hence D is correct.

**10.** $M_{1-x}\ Y_x$ On: Fraction of $M^{2+}$ = 1/3, so $M^{3+}$ = 2/3.
Charge balance: $(1 - x)(2) + (2/3)(3) + x\ (3) = 2n$.
Solve with stoichiometry, $x = 0.75$.

**11.** Reduction in acidic medium

$$Cr^{6+} \rightarrow Cr^{3+}$$

Each Cr gains 3 electron

To produce 1 mole of $Cr^{3+}$:

Electrons required = $3mole^{-} = 3F$

$Q = 3 \times 96500 = 289500$ C

Time: 48.25 min = $48.25 \times 60 = 2895$ Sec

$$I = \frac{Q}{T} = \frac{289500}{2895} = 100A$$

**12.** Electrolysis reaction

$$2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$$

Moles of water

$$144g \div 18 = 8 \text{ mol}$$

From stoichiometry

$$8 \text{ mol } H_2O \rightarrow 8 \text{ mol } H_2 + 4 \text{ mol } O_2$$

Total moles of gas formed

$$n = 8 + 4 = 12 \text{ mol}$$

Expansion work at constant pressure

$$W = n\,RJ$$

$$W = 12 \times 8{\cdot}3 \times 300 = 29880J$$

$$W = 29{\cdot}88KJ$$

## *Chapter 7 Qualitative Salt Analysis*

**1.** Dil. HCl: $Pb^{2+}$ and $Ag^{+}$ form white ppt ($PbCl_2$, AgCl).

$H_2S$: $Pb^{2+}$, $Bi^{3+}$, $Hg^{2+}$ precipitate as sulphides.

**(A)** $Pb^{2+}$, $Zn^{2+}$: $Pb^{2+}$ fits both tests, $Zn^{2+}$ does not precipitate. **True.**

**(B)** $Pb^{2+}$, $Bi^{3+}$: Both fit. **True.**

**(C)** $Ag^{+}$, $Bi^{3+}$: Both fit. **True.**

**(D)** $Pb^{2+}$, $Hg^{2+}$: $Hg^{2+}$ forms $Hg_2Cl_2$, not white ppt with HCl. **False.**

**2.** Brown ring: $FeSO_4 + NO \rightarrow [Fe(NO)(H_2O)_5]^{2+}$.

Option (D) matches the complex.

**3.** **(I)** **Aniline:** P (N → Prussian blue), S (bromine water → white ppt).

**(II)** **o-Cresol:** T (phenol with $FeCl_3$ → violet).

**(III)** **Cysteine:** Q (S → blood red with nitroprusside), R (acidic, effervescence with $NaHCO_3$).

**(IV)** **Caprolactam:** P (N → Prussian blue).

Option (D) matches: I → P, S; II → T; III → Q, R; IV → P.

**4.** S: $H_2S$ in dilute HCL → Group II → $Cu^{2+}$

R: $NH_4OH + NH_4Cl$ → Group III → $Al^{3+}$

P: $H_2S$ in presence of $NH_4OH$ (basic medium) → Group IV → $Mn^{2+}$

Q: $(NH_4)_2CO_3 + NH_4OH$ → Group V → $Ba^{2+}$

P → 3, Q → 4, R → 2, S → 1

**5.** Sodium nitroprusside complex

$$[Fe(CN)_5NO]^{2-}$$

In presence of sulphide ion ($S^{2-}$) the No ligand is converted to thionitrosyl

$$NO \rightarrow NOS^{-}$$

which gives purple color in the test

## *Chapter 9 The's-Block Elements and Their Compounds*

**1.** Osmotic pressure from height

$$\pi = \rho gh$$

$$\rho = 1000 \text{ kg/m}^3, g = 10, h = 0.02 \text{ m}$$

$$\pi = 1000 \times 10 \times 0.02 = 200 \text{ Pa}$$

Concentration

$$2.00 \text{ g/dm}^3 = 2.0 \text{ kg/m}^3$$

Osmotic pressure relation

$$\pi = \frac{C}{M} RT \Rightarrow M = \frac{CRT}{\pi}$$

$RT = 8.3 \times 300 = 2490$

$$M = \frac{2 \times 2490}{200} = 24.9 \text{ kg/mol}$$

$= 2.49 \times 10^4$ g/mol

$X = 2.49$

**2.** Combustion of butane

$$C_4H_{10} + \frac{13}{2}O_2 \rightarrow 4CO_2 + 5H_2O$$

Standard Gibs energy change

$\Delta G^o = [4(-394) + 5(-237)] - [(-18)]$

$\Delta G^o = (-1576 - 1185 + 18)$KJ

$= -2743$ KJ mol$^{-1}$

Number of electrons transferred

$n = 26$

Cell potential

$$E = \frac{|\Delta G^\circ|}{nF} = \frac{2743}{26}\frac{KJ}{F}$$

$$= 105.5 \frac{KJ}{F}$$

$$E = \frac{105.5 \times 10^3}{F} \text{Volts}$$

$X = 105.5$

## *Chapter 10 The p-Block Elements and their Compounds*

**1.** **(A)** $H_3PO_3$ **disproportionation:** $4H_3PO_3 \rightarrow 3H_3PO_4 + PH_3$. **True**.

**(B)** $H_3PO_3$ **reducing,** $H_3PO_4$ **not:** $H_3PO_3$ (+3) can oxidize, $H_3PO_4$ (+5) cannot. **True**.

**(C)** $H_3PO_3$ **monobasic:** Dibasic (2 OH). **False**.

**(D)** P – H **not ionizable:** Correct, only OH ionizes. **True.**

**2.** $ClO_2 + O_3 \rightarrow Cl_2O_6$

$Cl_2O_6$: Two Cl, one +5, one +7 (as $[ClO_2]^+ [ClO_4]^-$).

Average = (5 + 7)/2 = 6.

**3.** $Cu(NO_3)_2$: 3.74g = 3.74/188 = 0.02 mol.

$2Cu^{2+} + 41^- \rightarrow 2CuI + I_2$ (brown solution).

$I_2 + H_2S \rightarrow 2HI + S(X = S)$.

0.01 mol $I_2 \rightarrow$ 0.01 mol S = 0.01 × 32 = 0.32 g.

**4.** $P_4$: 1.24 g = 1.24/124 = 0.01 mol.

$P_4 + 3NaOH + 3H_2O \rightarrow PH_3 + 3NaH_2PO_2$ ($Q = PH_3$).

0.01 mol $P_4 \rightarrow$ 0.01 mol $PH_3$.

$2PH_3 + 3CuSO_4 \rightarrow Cu_3P_2 + 3H_2SO_4$.

0.01 mol $PH_3 \rightarrow (3/2) \times 0.01 = 0.015$ mol $CuSO_4 = 0.015 \times 159.5 = 2.38$ g.

**5.** $Xe + O_2F_2 \rightarrow XeF_2 + O_2$ ($P = XeF_2$)

$XeF_2 + 2H_2O \rightarrow Xe + 2HF + \frac{1}{2}O_2$

1 mol $XeF_2 \rightarrow$ 2 mol HF

**6.** $HClO_3 + HCl \rightarrow ClO_2 + H_2O$ ($ClO_2$ is paramagnetic)

$ClO_2 + O_3 \rightarrow Cl_2O_6 + O_2$

**7.** $$\underset{(P)}{MnCl_2} \xrightarrow{2NaOH} \underset{(Q)}{\underset{(White)}{Mn(OH)_2} \downarrow} + 2NaCl$$

$$\underset{(P)}{Mn(OH)_2} \xrightarrow[aq.H_2SO_4]{PbO_2\,(excess)} \underset{(X)}{HMnO_4}\,(purple)$$

$$\underset{(Q)}{NaCl} \xrightarrow[\underset{(warm)}{conc.H_2SO_4}]{MnO(OH)_2} \underset{(Y)}{Cl_2}$$

$Cl_2 + KI - Starch \rightarrow$ Blue colouration

**8.** **(P)** $P_2O_3 + H_2O \rightarrow H_3PO_3$: 2
**(Q)** $P_4 + NaOH + H_2O \rightarrow PH_3$ : 3
**(R)** $PCl_5 + CH_3COOH \rightarrow POCl_3$: 4
**(S)** $H_3PO_2 + AgNO_3 \rightarrow H_3PO_4$: 5
Matches D: P → 2, Q → 3, R → 4, S → 5.

**9.** $[SiO_4]^{4-}$: 4 sigma bonds, tetrahedral, $sp^3$. **Yes**.

$SO_2Cl_2$: 4 sigma bonds, tetrahedral, $sp^3$. **Yes**.

$XeF_2$: 2 sigma bonds, 3 lone pairs, linear, $sp^3d$. **Not** $sp^3$.

$SF_4$: 4 sigma bonds, 1 lone pair, seesaw, $sp^3d$. **Not** $sp^3$.

$ClF_3$: 3 sigma bonds, 2 lone pairs, T-shaped, $sp^3d$. **Not** $sp^3$.

$Ni(CO)_4$: 4 sigma bonds, tetrahedral, $sp^3$. **Yes**.

$XeO_2F_2$: 4 sigma bonds, 1 lone pair, seesaw, $sp^3d$. **Not** $sp^3$.

$[PtCl_4]^{2-}$: 4 sigma bonds, square planar, $dsp^2$. **Not** $sp^3$.

$XeF_4$: 4 sigma bonds, 2 lone pairs, square planar, $sp^3d^2$. **Not** $sp^3$.

$SOCl_2$: 3 sigma bonds, 1 lone pair, trigonal pyramidal, $sp^3$. **Yes**.

$[I_3]^+$: 2 sigma bonds + 2 lone pairs, $sp^3$. **Yes.**

**10.** $Br_3O_8$: Central Br is + 6, two terminal Br are + 5 (as $BrO_4$). No Br at 0. Total = 0.

$F_2O$: O is –2, F is +1. No atoms at 0. Total = 0.

$H_2S_4O_6$: Tetrathionate ($S_4O_6^{2-}$). Two central S are 0 (S-S bond), two terminal S are +5 (as $SO_3$). Total = 2.

$H_2S_5O_6$: Pentathionate ($S_5O_6^{2-}$). Three central S are 0 (S-S-S), two terminal S are +5. Total = 3.

$C_3O_2$: Carbon suboxide (O = C = C = C = O). Central C is 0, two terminal C are + 2. Total = 1.

Sum = 0 + 0 + 2 + 3 + 1 = 6.

**11.** $3HNO_2 \rightarrow 2NO + NO_3^- + H_3O^+$

**Hence (A).**

**12.** $XeF_2$: Xe (8 $e^-$), 2 sigma bonds, 3 lone pairs. Steric number = 5, trigonal bipyramidal, linear shape. Matches (5).

$XeF_4$: Xe (8 $e^-$), 4 sigma bonds, 2 lone pairs. Steric number = 6, octahedral, square planar shape. Matches (3).

$XeO_3$: Xe (8 $e^-$), 3 sigma bonds, 1 lone pair. Steric number = 4, tetrahedral, trigonal pyramidal shape. Matches (2).

$XeO_3F_2$: Xe (8 $e^-$), 5 sigma bonds, 0 lone pairs. Steric number = 5, trigonal bipyramidal. Matches (4).

Option (B): P → (5), Q → (3), R → (2), S → (4).

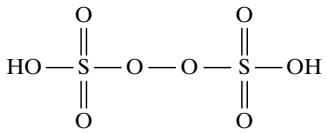
**13.** $PCl_5$ in polar solvents ionizes: $PCl_5 \rightarrow [PCl_4]^+ [PCl_6]^-$.

With $F_2$, forms: $[PCl_4]^+ [PF_6]^-$ (complete substitution in anion).

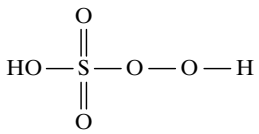
Partial substitution: $[PCl_4]^+ [PCl_4F_2]^-$ as an intermediate.

Option (B): $[PCl_4]^+ [PCl_4F_2]^-$ and $[PCl_4]^+ [PF_6]^-$.

**14.**



$H_2S_2O_8$



$H_2SO_5$

(B) and (D) are correct options.

**15.** Heating $NH_4NO_2$ at 60 – 70°C

$$NH_4NO_2 \rightarrow N_2 + 2H_2O$$

So, X = $N_2$

Heating $NH_4NO_3$ at 200 – 250°C

$$NH_4NO_3 \rightarrow N_2O + 2H_2O$$

So, Y = $N_2O$

**16.** On complete hydrolysis, interhalogen compound give oxyanions where the less electronegative halogen forms the oxyanion.

$$ICl \rightarrow IO^-, \quad ClF_3 \rightarrow ClO_2^-, \quad BrF_5 \rightarrow BrO_3^-$$

**17.** $H_3PO_3$ (B) → Structure: $HPO(OH)_2$ → P–H bond

$H_3PO_2$ (D) → Structure: $H_2PO(OH)$ → two P–H bonds

## *Chapter 11 The d-Block Elements and some of their Compounds*

**1. (A)** $Cd + Ni^{+2} \rightarrow Cd^{+2} + Ni$

$$E_{cell} = 0.40 + (-24) - \frac{0.0591}{2}\log\frac{0.001}{0.1}$$
$$= 0.16 + \frac{0.0591}{2} \times 2$$
$$= 6.64 + 0.551$$
$$= 0.71(+ve)$$

**(B)** $E_{cell} = 0.40 + (-0.44) - \frac{0.591}{2}\log\frac{0.01}{0.1}$

$$= -0.04 + \frac{0.591}{2} \times 2$$
$$= -0.04 + 0.06$$
$$= 0.02(+ve)$$

**(C)** $E_{cell} = 0.24 + (-0.13) + \frac{.0591}{2} \times 2$

$$= 0.11 + 0.06$$
$$= 0.33(+ve)$$

**(D)** $E_{cell} = 0.24 + (-0.44) + \frac{0.0591}{2} \times 2$

$$-0.20 + 0.006 = -0.14(-ve)$$

**2.** meq of $Fe^{+2}$ = meq of $KMnO_4$.

$x \times 10^{-2} \times 1000 \times 1 = 12.5 \times 0.03 \times 5 \times 10$

$x = 1.875$ mole

Moles of $Fe^{+2} = x \times 10^{-2} = 1.875 \times 10^{-2}$.

wt. of $Fe^{+2} = 1.875 \times 10^{-2} \times 56$.

Hence percentage of $Fe^{+2}$.

$$= \frac{1.875 \times 10^{-2} \times 56}{5.6} \times 100\% = 18.75\%$$

**3.** Half-reactions.

$5H_2S \rightarrow 5S + 10H^+ + 10e^-$

$2MnO_4^- + 16H^+ + 10e^- \rightarrow 2Mn^{2+} + 8H_2O$

Add the balanced half-reactions.

$2MnO_4^-(aq) + 5H_2S(g) + 6H^+(aq) \rightarrow 2Mn^{2+}(aq) + 5S(s) + 8H_2O(l)$

From the equation, 5 moles of $H_2S$ produce 8 moles $H_2O$. $x = 8$.

From the balanced half-reactions, 10 electrons are transferred per 5 moles $H_2S$. $y = 10$.

**Calculation of $(x + y)$:**

$$x + y = 8 + 10 = 18$$

**4.** Anode: $N_2H_4 + 4OH^- \rightarrow N_2 + 4H_2O + 4e^-$. **(A) True.**

Cathode: $O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$. **(C) True.**

**(B) False:** $N_2H_4$ oxidizes at the anode, not cathode.

**(D) True:** Side reactions may produce $NO_x$.

**5.** Check 4f electron configuration

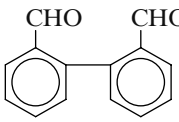
$\rightarrow La^{3+}; 4f^0 \rightarrow$ diamagnetic

$Ce^{4+}; 4f^0 \rightarrow$ diamagnetic

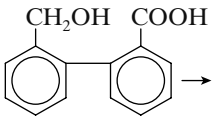
$\rightarrow Yb^{2+}; 4f^{14} \rightarrow$ diamagnetic

$Lu^{3+}; 4f^{14} \rightarrow$ diamagnetic

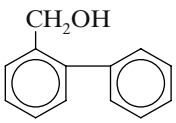
**6.** By reaction



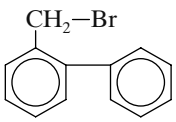

→ **(P)** → 100% → 8 moles



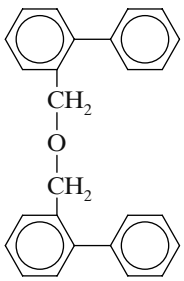

→ **(Q)** → 50% → 4 moles




→ **(R)** → 50% → 2 moles




→ **(T)** → 50% → 1 moles




→ **(S)** → 50% → 0.5 moles

The amount of S produced (in grams)

$$= \frac{1}{2} \times 350 = 175 \text{ grams}$$

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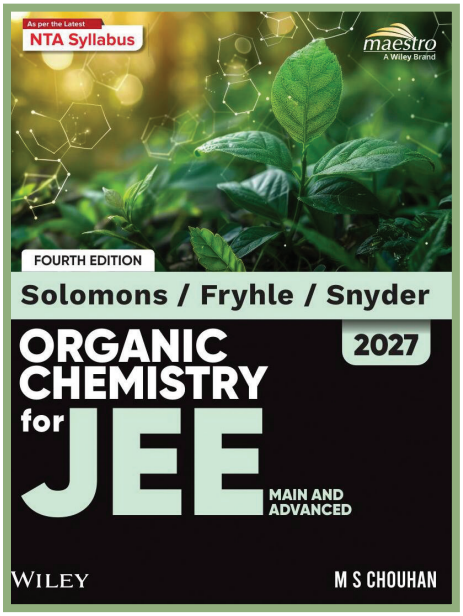


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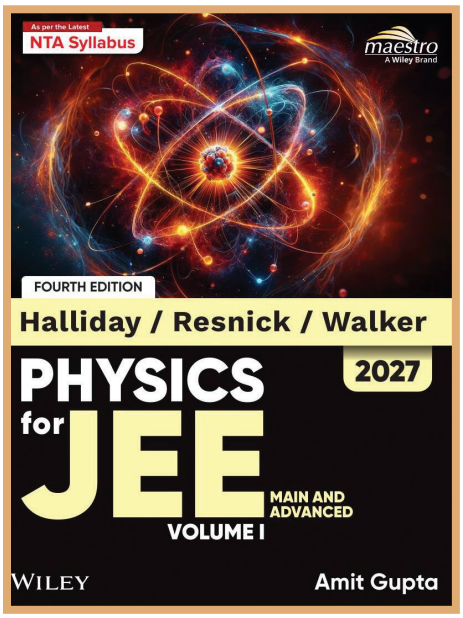


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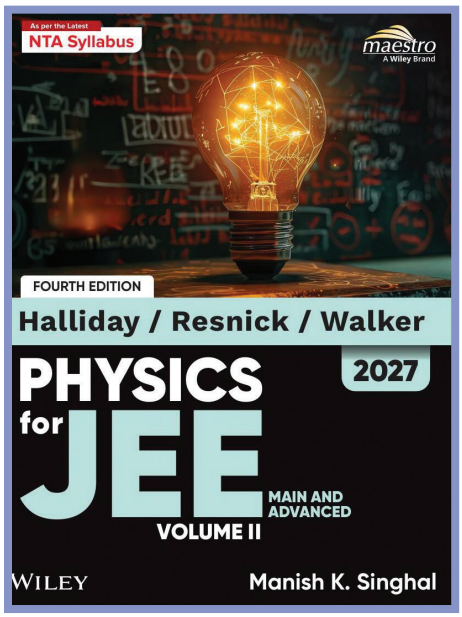


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