INORGANIC CHEMISTRY

SALT ANALYSIS

1. In the scheme given below, **X** and **Y**, respectively, are **[JEE(Advanced) 2023]**

Metal halide $\xrightarrow{\text{aq. NaOH}}$ White precipitate **(P)** + Filtrate **(Q)**

P $\xrightarrow[\text{heat}]{\text{aq.}H_2SO_4,\ PbO_2\text{(excess)}}$ **X** (a coloured species in solution)

Q $\xrightarrow[\text{warm}]{MnO(OH)_2,\ \text{Conc.}H_2SO_4}$ **Y** (gives blue-coloration with KI-starch paper)

(A) CrO_4^{2-} and Br_2 (B) MnO_4^{2-} and Cl_2

(C) MnO_4^{-} and Cl_2 (D) $MnSO_4$ and HOCl

2. A mixture of two salts is used to prepare a solution **S**, which gives the following results :

White precipitate(s) only $\xleftarrow[\text{Room temperature}]{\text{Dilute NaOH(aq.)}}$ S (aq. solution of the salts) $\xrightarrow[\text{Room temperature}]{\text{Dilute HCl(aq.)}}$ White precipitate(s) only

The correct option(s) for the salt mixture is(are) **[JEE(Advanced) 2021]**

(A) $Pb(NO_3)_2$ and $Zn(NO_3)_2$ (B) $Pb(NO_3)_2$ and $Bi(NO_3)_3$

(C) $AgNO_3$ and $Bi(NO_3)_3$ (D) $Pb(NO_3)_2$ and $Hg(NO_3)_2$

Paragraph for Q. No. 3 and 4

The reaction of $K_3[Fe(CN)_6]$ with freshly prepared $FeSO_4$ solution produces a dark blue precipitate called Turnbull's blue. Reaction of $K_4[Fe(CN)_6]$ with the $FeSO_4$ solution in complete absence of air produces a white precipitate **X**, which turns blue in air. Mixing the $FeSO_4$ solution with $NaNO_3$, followed by a slow addition of concentrated H_2SO_4 through the side of the test tube produces a brown ring.

[JEE(Advanced) 2021]

3. Precipitate **X** is

(A) $Fe_4[Fe(CN)_6]_3$ (B) $Fe[Fe(CN)_6]$ (C) $K_2Fe[Fe(CN)_6]$ (D) $KFe[Fe(CN)_6]$

4. Among the following, the brown ring is due to the formation of

(A) $[Fe(NO)_2(SO_4)_2]^{2-}$ (B) $[Fe(NO)_2(H_2O)_4]^{3+}$ (C) $[Fe(NO)_4(SO_4)_2]$ (D) $[Fe(NO)(H_2O)_5]^{2+}$

5. A colorless aqueous solution contains nitrates of two metals, **X** and **Y**. When it was added to an aqueous solution of NaCl, a white precipitate was formed. This precipitate was found to be partly soluble in hot water to give a residue **P** and a solution **Q**. The residue **P** was soluble in aq. NH_3 and also in excess sodium thiosulfate. The hot solution **Q** gave a yellow precipitate with KI. The metals **X** and **Y**, respectively, are **[JEE(Advanced) 2020]**

(A) Ag and Pb (B) Ag and Cd (C) Cd and Pb (D) Cd and Zn

6. Choose the correct statement(s) among the following. **[JEE(Advanced)2020]**

(A) $SnCl_2.2H_2O$ is a reducing agent.

(B) SnO_2 reacts with KOH to form $K_2[Sn(OH)_6]$.

(C) A solution of $PbCl_2$ in HCl contains Pb^{2+} and Cl^- ions.

(D) The reaction of Pb_3O_4 with hot dilute nitric acid to give PbO_2 is a redox reaction.

7. The green colour produced in the borax bead test of a chromium(III) salt is due to – **[JEE(Advanced) 2019]**

(A) $Cr(BO_2)_3$ (B) CrB (C) $Cr_2(B_4O_7)_3$ (D) Cr_2O_3

8. The correct option(s) to distinguish nitrate salts of Mn^{2+} and Cu^{2+} taken separately is (are) :- **[JEE(Advanced) 2018]**

(A) Mn^{2+} shows the characteristic green colour in the flame test

(B) Only Cu^{2+} shows the formation of precipitate by passing H_2S in acidic medium

(C) Only Mn^{2+} shows the formation of precipitate by passing H_2S in faintly basic medium

(D) Cu^{2+}/Cu has higher reduction potential than Mn^{2+}/Mn (measured under similar conditions)

9. The reagent(s) that can selectively precipiate S^{2-} from a mixture of S^{2-} and SO_4^{2-} in aqueous soltuion is(are) : **[JEE(Advanced) 2016]**

(A) $CuCl_2$ (B) $BaCl_2$

(C) $Pb(OOCCH_3)_2$ (D) $Na_2[Fe(CN)_5NO]$

10. In the following reaction sequence in aqueous soluiton, the species **X**, **Y** and **Z** respectively, are – **[JEE(Advanced) 2016]**

$$S_2O_3^{2-} \xrightarrow{Ag^+} \underset{\text{clear solution}}{X} \xrightarrow{Ag^+} \underset{\text{white precipitate}}{Y} \xrightarrow{\text{With time}} \underset{\text{black precipitate}}{Z}$$

(A) $[Ag(S_2O_3)_2]^{3-}$, $Ag_2S_2O_3$, Ag_2S (B) $[Ag(S_2O_3)_3]^{5-}$, Ag_2SO_3, Ag_2S

(C) $[Ag(SO_3)_2]^{3-}$, $Ag_2S_2O_3$, Ag (D) $[Ag(SO_3)_3]^{3-}$, Ag_2SO_4, Ag

11. The pair(s) of ions where BOTH the ions are precipitated upon passing H_2S gas in presence of dilute HCl, is(are) **[JEE(Advanced) 2015]**

(A) Ba^{2+}, Zn^{2+} (B) Bi^{3+}, Fe^{3+}

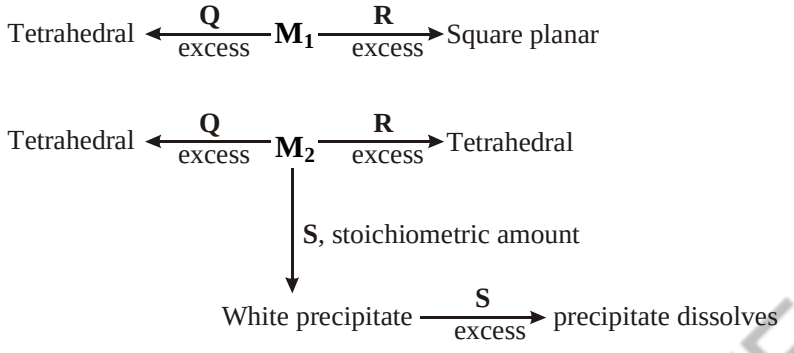
(C) Cu^{2+}, Pb^{2+} (D) Hg^{2+}, Bi^{3+}

12. Among PbS, CuS, HgS, MnS, Ag_2S, NiS, CoS, Bi_2S_3 , and SnS_2 the total number of **BLACK** coloured sulphides is **[JEE(Advanced) 2014]**

Paragraph for Q. 13 and Q. 14

An aqueous solution of metal ion $\mathbf{M_1}$ reacts separately with reagents **Q** and **R** in excess to give tetrahedral and square planar complexes, respectively. An aqueous solution of another metal ion $\mathbf{M_2}$ always forms tetrahedral complexes with these reagents. Aqueous solution of $\mathbf{M_2}$ on reaction with reagent **S** gives white precipitate which dissolves in excess of **S**. The reactions are summarized in the sheme given below. **[JEE(Advanced) 2014]**

SCHEME:



13. $\mathbf{M_1}$, **Q** and **R**, respectively are

(A) Zn^{2+}, KCN and HCl (B) Ni^{2+}, HCl and KCN

(C) Cd^{2+} , KCN and HCl (D) Co^{2+}, HCl and KCN

14. Reagent **S** is

(A) $K_4[Fe(CN)_6]$ (B) Na_2HPO_4 (C) K_2CrO_4 (D) KOH

SOLUTIONS

1. Ans. (C)

Sol. $MnCl_2 + NaOH \rightarrow \underset{\text{(P)}}{Mn(OH)_2}\downarrow + \underset{\text{(Q)}}{NaCl}$

(white ppt.) (Filterate)

$$Mn(OH)_2 \xrightarrow[\text{heat}]{PbO_2+H^+(H_2SO_4)} \underset{\text{Purple}}{MnO_4^- + Pb^{2+}}$$

$$Cl^- \xrightarrow{MnO(OH)_2/\text{conc. } H_2SO_4/\Delta} Cl_2 \xrightarrow{2I^-} \underbrace{(\text{Starch} + I_2)}_{\text{blue coloration}} + 2Cl^-$$

2. Ans. (A, B)

Sol. $Pb(NO_3)_2 \xrightarrow{\text{dil.HCl}} \underset{\text{White PPt.}}{PbCl_2}\downarrow$

$Bi(NO_3)_3 \xrightarrow{\text{dil.HCl}} \underset{\text{Water Soluble}}{BiCl_3}$

$Hg(NO_3)_2 \xrightarrow{\text{dil.HCl}} \underset{\text{Water Soluble}}{HgCl_2}$

$AgNO_3 \xrightarrow{\text{dil.HCl}} \underset{\text{White PPt.}}{AgCl}\downarrow$

$Zn(NO_3)_2 \xrightarrow{\text{dil.HCl}} \underset{\text{Water Soluble}}{ZnCl_2}$

$Pb(NO_3)_2 \xrightarrow{\text{NaOH(dil.)}} \underset{\text{White PPt.}}{Pb(OH)_2}\downarrow$

$Zn(NO_3)_2 \xrightarrow{\text{NaOH(dil.)}} \underset{\text{White PPt.}}{Zn(OH)_2}\downarrow$

$Bi(NO_3)_3 \xrightarrow{\text{NaOH(dil.)}} \underset{\text{White PPt.}}{Bi(OH)_3}\downarrow$

$AgNO_3 \xrightarrow{\text{NaOH(dil.)}} \underset{\text{Brown PPt.}}{Ag_2O}$

$Hg(NO_3)_2 \xrightarrow{\text{NaOH(dil.)}} \underset{\text{Yellow PPt.}}{HgO}\downarrow$

3. Ans. (C)

Sol. $K_4[Fe(CN)_6] \xrightarrow[\text{absence of air}]{FeSO_4} \underset{\text{White precipitate}}{K_2Fe[Fe(CN)_6]}$

$$\downarrow \text{air}$$

$$\underset{\text{(Prussian Blue)}}{Fe_4[Fe(CN)_6]_3}$$

4. Ans. (D)

Sol. $FeSO_4 \xrightarrow[\text{slow addition of conc. } H_2SO_4]{NaNO_3} \left[Fe(H_2O)_5 NO\right]SO_4$ (Brown Ring Complex)

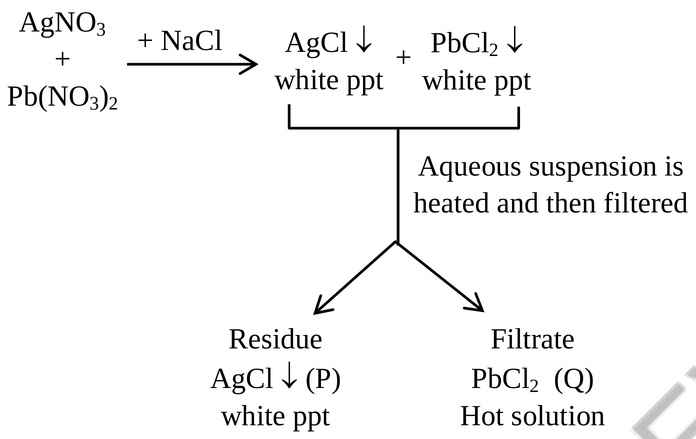
5. Ans. (A)

Sol. X : Ag

P : AgCl

Y : Pb

Q : $PbCl_2$



$AgCl + 2NH_3$ solution $\rightarrow [Ag(NH_3)_2]Cl$

(P) (excess) clear solution

$AgCl + 2Na_2S_2O_3$ solution $\rightarrow Na_3[Ag(S_2O_3)_2] + NaCl$

(P) (excess) clear solution

$PbCl_2 + 2KI \rightarrow PbI_2\downarrow + 2KCl$

Hot solution (yellow ppt)

(Q)

6. Ans. (A, B)

Sol. (A) $SnCl_2.2H_2O$ is a reducing agent since Sn^{2+} tends to convert into Sn^{4+}.

(B) $\underset{\text{(Amphoteric)}}{SnO_2} + \underset{\text{(Base)}}{2KOH_{(aq.)}} + 2H_2O \longrightarrow K_2[Sn(OH)_6]$

(C) First group cations (Pb^{2+}) form insoluble chloride with HCl that is $PbCl_2$ however it is slightly soluble in water and therefore lead +2 ion is never completely precipitated on adding hydrochloric acid in test sample of Pb^{2+}, rest of the Pb^{2+} ions are quantitatively precipitated with H_2S in acidic medium.

So that we can say that filtrate of first group contain solution of $PbCl_2$ in HCl which contains Pb^{2+} and Cl^-

However in the presence of conc. HCl or excess HCl it can produce $H_2[PbCl_4]$

So, we can conclude A, B or A,B,C should be answers.

(D) $\underset{\substack{(2PbO.PbO_2)\\ \text{(mixture of oxides)}}}{Pb_3O_4} + 4HNO_3 \longrightarrow PbO_2(\downarrow) + 2Pb(NO_3)_2 + 2H_2O$

It is not a redox reaction.

7. Ans. (A)

Sol. Chromium (III) salt $\xrightarrow{\Delta}$ Cr_2O_3

Borax $\xrightarrow{\Delta}$ $B_2O_3 + NaBO_2$

$2Cr_2O_3 + 6B_2O_3 \longrightarrow 4\ Cr(BO_2)_3$

8. Ans. (B, D)

Sol. (A) Cu^{+2} and Mn^{+2} both gives green colour in flame test and cannot distinguished.

(B) Cu^{+2} belongs to group-II of cationic radical will gives ppt. of CuS in acidic medium.

(C) Cu^{+2} and Mn^{+2} both form ppt. in basic medium.

(D) $Cu^{+2}/Cu = +0.34$ V (SRP)

$Mn^{+2}/Mn = -1.18$ V (SRP)

9. Ans. (A or A, C)

Sol. (A) $CuCl_2 + S^{2-} \longrightarrow CuS\downarrow + 2Cl^-$

(Sol^n) (Sol^n) (Black ppt.) (Sol^n)

$CuCl_2 + SO_4^{2-} \longrightarrow$ No ppt.

(Sol^n) (Sol^n)

(B) $BaCl_2 + S^{2-} \longrightarrow BaS + 2Cl^-$

(Sol^n) (Sol^n) (No ppt.) (Sol^n)

$BaCl_2 + SO_4^{2-} \longrightarrow BaSO_4\downarrow + 2Cl^-$

(Sol^n) (Sol^n) (White ppt.) (Sol^n)

(C) $Pb(OOCCH_3)_2 + S^{2-} \longrightarrow PbS\downarrow + 2CH_3COO^-$

(Sol^n) (Sol^n) (Black ppt.) (Sol^n)

$Pb(OOCCH_3)_2 + SO_4^{2-} \longrightarrow PbSO_4\downarrow + 2CH_3COO^-$

(Sol^n) (Sol^n) (White ppt.) (Sol^n)

(D) $Na_2[Fe(CN)_5NO] + S^{2-} \longrightarrow Na_4[Fe(CN)_5NOS]$

(Sol^n) (Sol^n) (Purple colour solution)

$Na_2[Fe(CN)_5NO] + SO_4^{2-} \longrightarrow$ No ppt.

(Sol^n) (Sol^n)

Note : $PbSO_4$ Ksp $= 2.5 \times 10^{-8}$ } Which are not given in question

PbS Ksp $= 3 \times 10^{-28}$

As in question selective precipitation is asked PbS will be precipitate much easier than $PbSO_4$ though both are insoluble. Hence answer should be (C) also alongwith (A)

10. Ans. (A)

Sol. $S_2O_3^{2-} \xrightarrow{Ag^+} \underset{\text{(X)}}{[Ag(S_2O_3)_2]^{3-}} \xrightarrow{Ag^+} \underset{\text{(Y)}}{Ag_2S_2O_3\downarrow}$

(X) clear solution

(Y) white precipitate

$\downarrow$ with time

$Ag_2S\downarrow$ (Z) black precipitate

So, X, Y and Z are $[Ag(S_2O_3)_2]^{3-}$, $Ag_2S_2O_3$ and Ag_2S respectively.

11. Ans. (C, D)

Sol. (A) $Ba^{+2} \xrightarrow{H^+/H_2S}$ **No ppt** [because BaS is soluble in water]

$Zn^{+2} \xrightarrow{H^+/H_2S}$ **No ppt** [because Zn^{+2} form ZnS in ammonical solution (IV group) (large K_{sp} of ZnS)]

(B) $Bi^{3+} \xrightarrow{H^+/H_2S} Bi_2S_3\downarrow$ [Bi^{3+} is II group cation]

Brown/black ppt

$Fe^{+3} \xrightarrow{H^+/H_2S} Fe^{+2} + S$ [because in acidic solution Fe^{+3} show redox reaction with H_2S]

(C) $Cu^{+2} \xrightarrow{H^+/H_2S} CuS\downarrow$ [Cu^{+2} is II group cation]

black ppt

$Pb^{2+} \xrightarrow{H^+/H_2S} PbS\downarrow$ [Pb^{2+} is also II group cation]

black ppt

(D) $Hg^{2+} \xrightarrow{H^+/H_2S} HgS\downarrow$ [Hg^{2+} is II group cation]

black ppt

$Bi^{3+} \xrightarrow{H^+/H_2S} Bi_2S_3\downarrow$ [Bi^{3+} II group cation]

black/brown ppt

12. Ans. (6) / (7)

Sol. PbS, CuS, HgS, Ag_2S, NiS, CoS are black

MnS – dirty pink/Buff

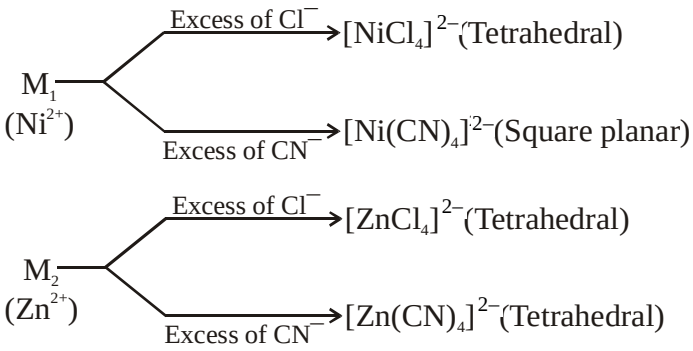
SnS_2 – yellow

Bi_2S_3 – brown / black (brownish black)

13. Ans. (B)

14. Ans. (D)

Sol.



$Zn^{2+} + 2KOH \longrightarrow 2K^{+} + Zn(OH)_2 \downarrow$

M_2 (S) (white ppt)

$Zn(OH)_2 \downarrow$ + excess $2KOH \longrightarrow K_2[Zn(OH)_4]$

(S) (solution)