

# QUALITATIVE ANALYSIS (CATIONS)

## CONTENTS

Particular	Page No.
<b>Theory</b>	<b>01 – 23</b>
<b>Exercise - 1</b>	<b>24 – 28</b>
Part - I : Subjective Questions	
Part - II : Only One Option Correct Type	
Part - III : Match the Columns	
<b>Exercise - 2</b>	<b>29 – 33</b>
Part - I : Only One Option Correct Type	
Part - II : Single or Double Digit Integer Type Questions	
Part - III : One or More Than One Options Correct Type	
Part – IV : Comprehensions	
<b>Exercise - 3</b>	<b>34 – 37</b>
Part - I : JEE(ADVANCED) / IIT-JEE Problems (Previous Years)	
Part - II : JEE(MAIN) / AIEEE Problems (Previous Years)	
<b>Answers</b>	<b>38 – 40</b>
<b>Additional Problems For Self Practice (APSP)</b>	<b>41 – 54</b>
Part - I : PRACTICE TEST-1 (IIT-JEE (MAIN Pattern))	
Part - II : NATIONAL STANDARD EXAMINATION IN CHEMISTRY (NSEC) STAGE-I	
Part - III : HIGH LEVEL PROBLEMS (HLP)	
Part – IV : PRACTICE TEST-2 (IIT-JEE (ADVANCED Pattern))	
<b>APSP Answers</b>	<b>55 – 56</b>
<b>APSP Solutions</b>	<b>56 – 63</b>

### JEE(Advanced) Syllabus

**Qualitative Analysis (Cations):** Groups I to V (only  $\text{Ag}^+$ ,  $\text{Hg}^{2+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Pb}^{2+}$ ,  $\text{Bi}^{3+}$ ,  $\text{Fe}^{3+}$ ,  $\text{Cr}^{3+}$ ,  $\text{Al}^{3+}$ ,  $\text{Ca}^{2+}$ ,  $\text{Ba}^{2+}$ ,  $\text{Zn}^{2+}$ ,  $\text{Mn}^{2+}$  and  $\text{Mg}^{2+}$ ); Nitrate, halides (excluding fluoride), sulphate and sulphide.

### JEE(Main) Syllabus

**Qualitative Analysis: Chemical Principle involved in the qualitative salt analysis:**

**Cations:**  $\text{Pb}^{2+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Al}^{3+}$ ,  $\text{Fe}^{3+}$ ,  $\text{Zn}^{2+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{Ba}^{2+}$ ,  $\text{Mg}^{2+}$ ,  $\text{NH}_4^+$ .

**Anions:**  $\text{CO}_3^{2-}$ ,  $\text{S}^{2-}$ ,  $\text{SO}_4^{2-}$ ,  $\text{NO}_3^-$ ,  $\text{NO}_2^-$ ,  $\text{Cl}^-$ ,  $\text{Br}^-$ ,  $\text{I}^-$ .

(Insoluble salts excluded).



# QUALITATIVE ANALYSIS (Cations)

## PART-II

**Analysis of CATIONS (Basic Radicals) : Classification of cation in different groups :**

**Table : 1**

Group	Group reagent	Basic radical	Composition and colour of precipitate
Zero	NaOH or Ca(OH) <sub>2</sub> , heat if required	NH <sub>4</sub> <sup>+</sup> , K <sup>+</sup> , Na <sup>+</sup>	Ammonia gas is evolved.
1.	dil. HCl	Ag <sup>+</sup>	AgCl ; White
		Hg <sub>2</sub> <sup>2+</sup>	Hg <sub>2</sub> Cl <sub>2</sub> ; White
		Pb <sup>2+</sup>	PbCl <sub>2</sub> ; White
2.(A)	H <sub>2</sub> S in presence of dil. HCl (Insoluble in YAS)	Hg <sup>2+</sup>	HgS ; Black
		Pb <sup>2+</sup>	PbS ; Black
		Bi <sup>3+</sup>	Bi <sub>2</sub> S <sub>3</sub> ; Black
		Cu <sup>2+</sup>	CuS ; Black
		Cd <sup>2+</sup>	CdS ; Yellow
2.(B)	H <sub>2</sub> S in presence of dil. HCl (Soluble in YAS)	As <sup>3+</sup>	As <sub>2</sub> S <sub>3</sub> ; Yellow
		Sb <sup>3+</sup>	Sb <sub>2</sub> S <sub>3</sub> ; Orange
		Sn <sup>2+</sup>	SnS ; Brown
		Sn <sup>4+</sup>	SnS <sub>2</sub> ; Yellow
3.	NH <sub>4</sub> OH in presence of NH <sub>4</sub> Cl	Fe <sup>3+</sup>	Fe(OH) <sub>3</sub> ; Reddish brown
		Cr <sup>3+</sup>	Cr(OH) <sub>3</sub> ; Green
		Al <sup>3+</sup>	Al(OH) <sub>3</sub> ; Gelatinous white
4.	H <sub>2</sub> S in presence of NH <sub>4</sub> OH and NH <sub>4</sub> Cl	Zn <sup>2+</sup>	ZnS ; White
		Mn <sup>2+</sup>	MnS ; Buff (or Pink)
		Co <sup>2+</sup>	CoS ; Black
		Ni <sup>2+</sup>	NiS ; Black
5.	(NH <sub>4</sub> ) <sub>2</sub> CO <sub>3</sub> in presence of NH <sub>4</sub> OH	Ba <sup>2+</sup>	BaCO <sub>3</sub> ; White
		Sr <sup>2+</sup>	SrCO <sub>3</sub> ; White
		Ca <sup>2+</sup>	CaCO <sub>3</sub> ; White
6.	Na <sub>2</sub> HPO <sub>4</sub> in presence of NH <sub>4</sub> OH	Mg <sup>2+</sup>	Mg(NH <sub>4</sub> )PO <sub>4</sub> ; White

[YAS = Yellow ammonium sulphide. (NH<sub>4</sub>)<sub>2</sub>S<sub>x</sub>].

There are some important points which should be kept in mind while doing the analysis of cations.

- Group 1<sup>st</sup> radicals** (Ag<sup>+</sup>, Pb<sup>2+</sup>, Hg<sub>2</sub><sup>2+</sup>) are precipitated as chloride because the solubility product of these chlorides (AgCl, PbCl<sub>2</sub>, Hg<sub>2</sub>Cl<sub>2</sub>) is less than the solubility products of chlorides of all other metal ions, which remain in solution. Lead chloride is slightly soluble in water and therefore, lead is never completely precipitated by adding dilute hydrochloric acid to a sample; the rest of the lead ions are precipitated with H<sub>2</sub>S in acidic medium together with the cations of the second group.
- Group 2<sup>nd</sup> radicals** are precipitated as sulphides because of their low solubility products whereas sulphides of other metals remain in solution because of their high solubility products. HCl acts as a source of H<sup>+</sup> which decreases the concentration of S<sup>2-</sup> due to common ion effect. Hence, the concentration of S<sup>2-</sup> ion is too low that it exceeds only the solubility products of the metal sulphides of II<sup>nd</sup> group.



We can not use  $\text{H}_2\text{SO}_4$  in place of  $\text{HCl}$  because some cations of higher groups i.e.  $v^{\text{th}}$  group will also precipitate as their sulphates like  $\text{BaSO}_4$ ,  $\text{SrSO}_4$ ,  $\text{CaSO}_4$  etc.

$\text{HNO}_3$  can't be used in place of  $\text{HCl}$ .  $\text{HNO}_3$  is a powerful oxidising agent.  $\text{HNO}_3$  will oxidize  $\text{H}_2\text{S}$  forming sulphur (yellow precipitate) or colloidal solution causing confusion with  $\text{CdS}$ ,  $\text{As}_2\text{S}_3$  even though  $\text{Cd}^{2+}$ ,  $\text{As}^{3+}$  will be absent. The colloidal solution is white-yellow and that cannot be filtered causing unnecessary trouble.

3. **Group 3<sup>rd</sup> radicals** are precipitated as hydroxides and the addition of  $\text{NH}_4\text{Cl}$  suppresses the ionisation of  $\text{NH}_4\text{OH}$  so that only the group 3 cations are precipitated as hydroxides because of their low solubility products.

(i) Excess of  $\text{NH}_4\text{Cl}$  should not be added, as manganese will precipitate as  $\text{MnO}_2 \cdot \text{H}_2\text{O}$

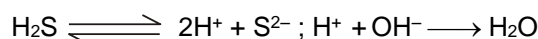
(ii)  $(\text{NH}_4)_2\text{SO}_4$  cannot be used in place of  $\text{NH}_4\text{Cl}$  because the  $\text{SO}_4^{2-}$  will also give the precipitate of  $\text{BaSO}_4$ ,  $\text{SrSO}_4$  etc.

(iii) While proceeding for 3<sup>rd</sup> group from 2<sup>nd</sup> group, the filtrate of 2<sup>nd</sup> group is boiled off to remove the dissolved  $\text{H}_2\text{S}$  and then one drop of concentrated  $\text{HNO}_3$  is added and again boil so that if  $\text{Fe}^{2+}$  is present is oxidised to  $\text{Fe}^{3+}$ . The  $K_{\text{sp}}$  of  $\text{Fe}^{2+}$  is higher than  $\text{Fe}^{3+}$ , therefore, it is partially precipitated and will thus interfere in the analysis of 4<sup>th</sup> group radicals. In our scheme  $\text{Fe}^{2+}$  is not there even if it is present, we shall report only  $\text{Fe}^{3+}$  ( $\text{Fe}^{2+}$  needs other special tests).

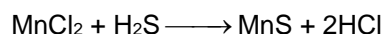
(iv) If the medium remains acidic the hydroxides do not precipitate and we would think that  $\text{Fe}^{3+}$ ,  $\text{Al}^{3+}$ ,  $\text{Cr}^{3+}$  are absent even though they may be present.

(v) In place of  $\text{NH}_4\text{OH}$ ,  $\text{NaOH}$  solution can't be used for the precipitation as their hydroxides because in excess of it we get soluble complexes of  $\text{Al}^{3+}$  and  $\text{Cr}^{3+}$ .

4. **In 4<sup>th</sup> group**, ammonium hydroxide increases the ionisation of  $\text{H}_2\text{S}$  by removing  $\text{H}^+$  from  $\text{H}_2\text{S}$  as unionised water.



Now the excess of  $\text{S}^{2-}$  ions is available and hence the ionic products of group 4<sup>th</sup> group cations exceeds their solubility products and will be precipitated. In case  $\text{H}_2\text{S}$  is passed through a neutral solution, incomplete precipitation will take place due to the formation of  $\text{HCl}$ , which decreases the ionisation of  $\text{H}_2\text{S}$ . For example



5. **In 5<sup>th</sup> group** the reagent ammonium carbonate should be added in alkaline or neutral medium. In the absence of ammonia or ammonium ions, magnesium will also be precipitated.

### PREPARATION OF ORIGINAL SOLUTION (O.S) :

Original solution is used for the analysis of basic radicals except  $\text{NH}_4^+$ . It is prepared by dissolving given salt or mixture in a suitable solvent as follows :

- $\text{H}_2\text{O}$
- dil  $\text{HCl}$
- conc.  $\text{HCl}$

Salt or Mixt. +  $\text{H}_2\text{O} \xrightarrow{\Delta}$  soluble (then  $\text{H}_2\text{O}$  is suitable solvent)

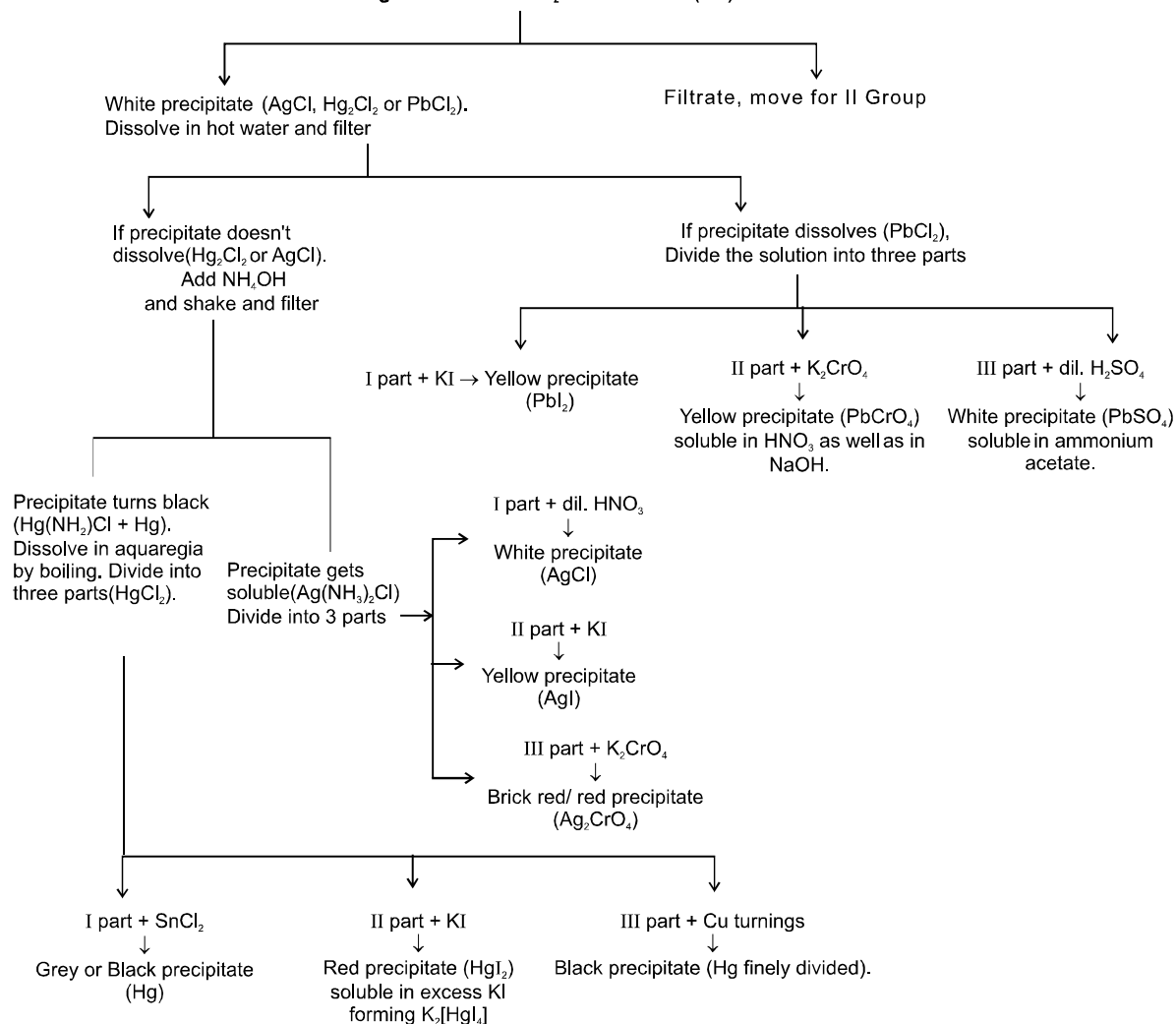
If given salt or mixture is insoluble in  $\text{H}_2\text{O}$  then it is dissolved in dil  $\text{HCl}$ .

Salt or Mixt. + dil  $\text{HCl} \xrightarrow{\Delta}$  soluble (then dil  $\text{HCl}$  is taken as solvent)

If given salt or mixture is insoluble in dilute  $\text{HCl}$  then it is dissolved in conc.  $\text{HCl}$ .

Salt or Mixt. + conc.  $\text{HCl} \xrightarrow{\Delta}$  soluble

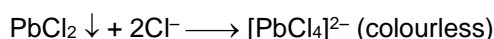
In this way after selecting suitable solvent, given salt or mixture is dissolved in small quantity in the solvent and filtered. Obtained filtrate is called as original solution (O.S.) and that is used for the detection of basic radicals except  $\text{NH}_4^+$ .

Section (A) : 1<sup>st</sup> Group1<sup>st</sup> GROUP ( $\text{Pb}^{2+}$ ,  $\text{Hg}_2^{2+}$ ,  $\text{Ag}^+$ ) :Original Solution in  $\text{H}_2\text{O}$  + dilute  $\text{HCl}$  (2M)1. LEAD ION ( $\text{Pb}^{2+}$ ) :

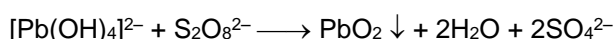
- **Dilute HCl solution:** White precipitate is formed in cold solution.



White precipitate is soluble in hot water. White precipitate is also soluble in concentrated HCl or concentrated KCl or excess dil. HCl.



- **Sodium hydroxide solution:** White precipitate is formed which is soluble in excess of the reagent.



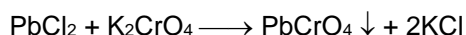
- **Potassium iodide solution:** A yellow precipitate is formed which is soluble in excess more concentrated (6M) solution of the reagent. Yellow precipitate of  $\text{PbI}_2$  is moderately soluble in boiling water to give a colourless solution.



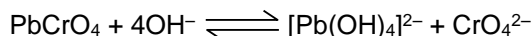
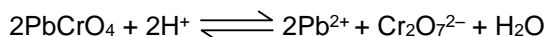


Yellow precipitate reappears on dilution with water. Yellow precipitate of  $\text{PbI}_2$  does not dissolve in excess of dilute solution of  $\text{KI}$ .

- **Potassium chromate solution (in neutral, acetic acid or ammonia solution) :** A yellow precipitate is formed.

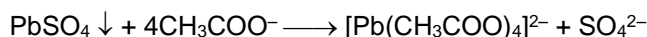
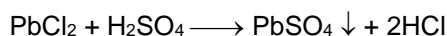


Yellow precipitate is soluble in sodium hydroxide and  $\text{HNO}_3$  (nitric acid).



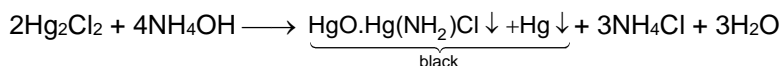
Both reversible reactions on buffering the solution with ammonia or acetic acid respectively,  $\text{PbCrO}_4$  reprecipitates.

- **Ammonia solution:** With ammonia solution,  $\text{Pb}^{2+}$  gives a white precipitate of lead hydroxide.
- $$\text{Pb}^{2+} + 2\text{NH}_4\text{OH} \longrightarrow \text{Pb}(\text{OH})_2 \downarrow + 2\text{NH}_4^+$$
- **Dilute  $\text{H}_2\text{SO}_4$ :** White precipitate is formed which is soluble in more concentrated ammonium acetate (6M) solution or ammonium tartrate in the presence of ammonia.

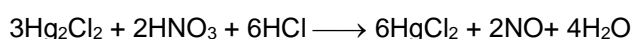


## 2. MERCURY(I) ION ( $\text{Hg}_2^{2+}$ ) :

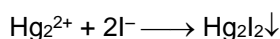
- **Dilute HCl solution :** White precipitate is formed in cold solution.
- $$\text{Hg}_2^{2+} + 2\text{HCl} \longrightarrow \text{Hg}_2\text{Cl}_2 \downarrow (\text{white}) + 2\text{H}^+$$
- **Ammonia solution :** A mixture of mercury metal (black precipitate) and basic mercury (II) amido chloride (white precipitate) is formed.



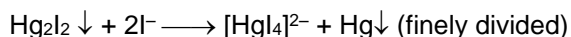
- **Dissolution of white precipitate ( $\text{Hg}_2\text{Cl}_2$ ) in aquaregia :**



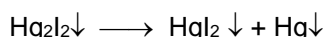
- **Potassium iodide solution :** A green precipitate is formed.



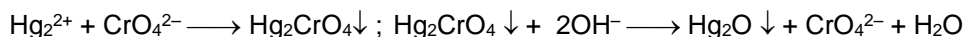
Green precipitate in excess of reagent undergoes disproportionation reaction and a soluble  $[\text{HgI}_4]^{2-}$  ions and black mercury are formed.



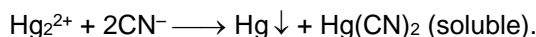
Boiling the mercury (I) iodide precipitate with water, disproportionation takes place and a mixture of red mercury (II) iodide precipitate and black mercury is formed.



- **Potassium chromate solution :** A red crystalline precipitate is formed which turns black when solution of sodium hydroxide is added.



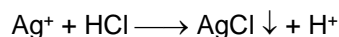
- **Potassium cyanide solution :** A black precipitate of mercury is obtained



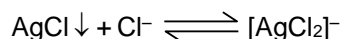


### 3. SILVER ION ( $\text{Ag}^+$ ) :

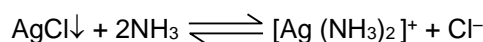
- **Dilute hydrochloric acid/soluble chlorides** : White precipitate is formed.



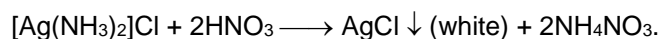
The precipitate obtained after filtration is soluble in concentrated HCl.



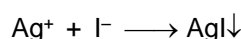
On dilution with water, the equilibrium shifts back to the left and the precipitate reappears. Dilute ammonia solution dissolves the precipitate forming a soluble complex.



Dilute nitric acid or hydrochloric acid neutralizes the excess ammonia and the precipitate reappears because the equilibrium is shifted backwards.



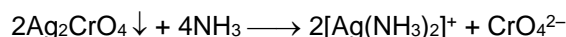
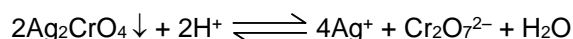
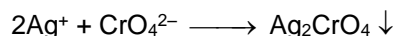
- **Potassium iodide solution**: A bright yellow precipitate is formed which is insoluble in dilute ammonia but partially soluble in concentrated ammonia.



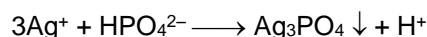
The yellow precipitate is soluble in KCN and in  $\text{Na}_2\text{S}_2\text{O}_3$ .



- **Potassium chromate solution**: Red precipitate is formed which is soluble in dilute  $\text{HNO}_3$  and in ammonia solution.

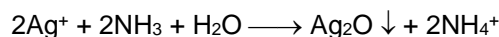


- **Disodium hydrogen phosphate solution**: In neutral solution a yellow precipitate is formed with the reagent.

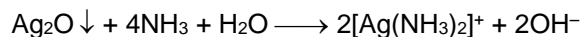


The yellow precipitate is soluble in nitric acid and ammonia solution.

- **Ammonia solution** : Brown precipitate is formed.



Precipitate dissolves in ammonia.



### II<sup>nd</sup> Group ( $\text{Hg}^{2+}$ , $\text{Pb}^{2+}$ , $\text{Bi}^{3+}$ , $\text{Cu}^{2+}$ , $\text{Cd}^{2+}$ , $\text{As}^{3+}$ , $\text{Sb}^{3+}$ , $\text{Sn}^{2+}$ )

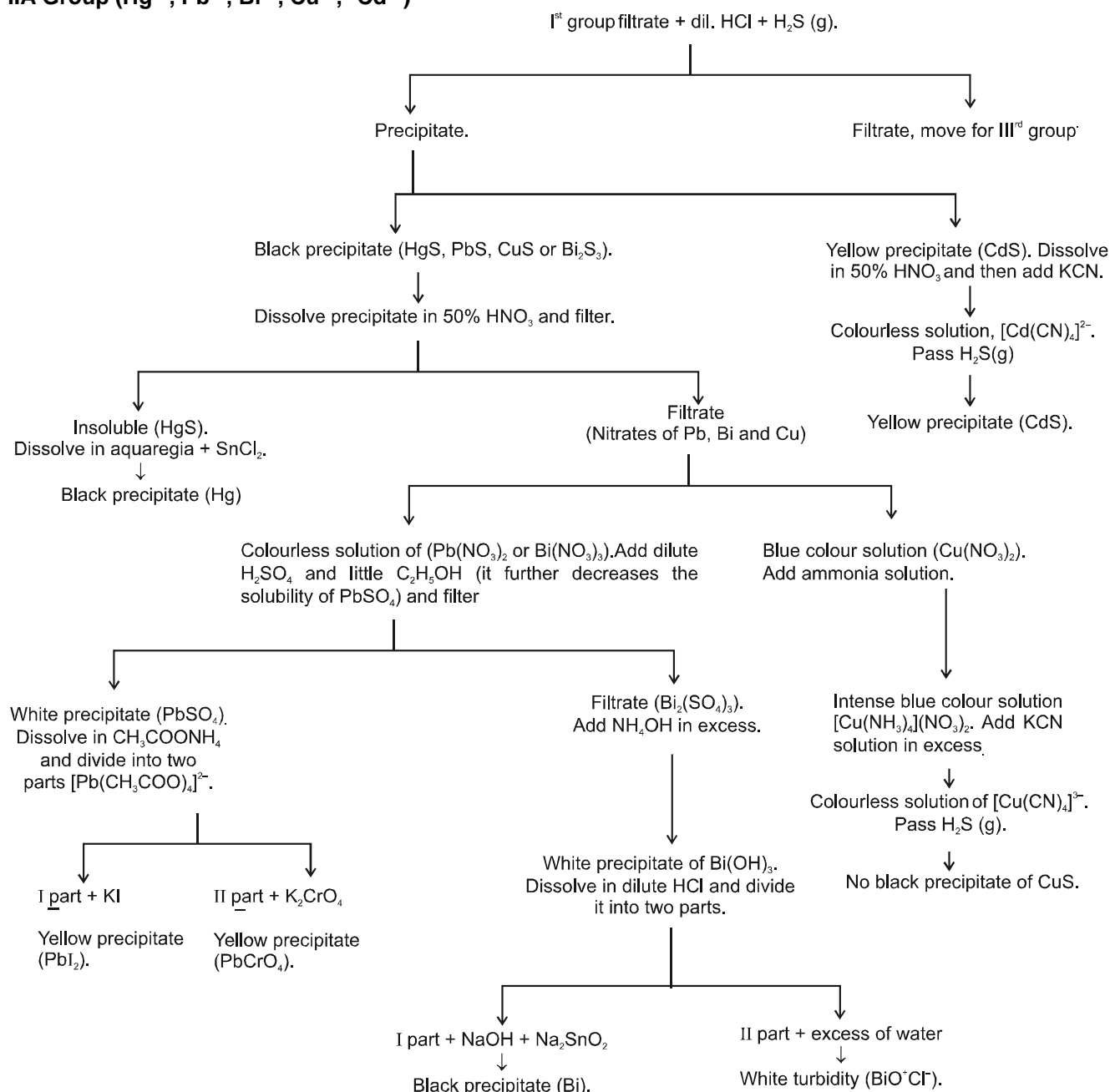
On the basis of the solubility of the precipitates of the sulphides of II group cations in yellow ammonium sulphide, they have been classified into two subgroups as given below :

**IIA** :  $\text{HgS}$ ,  $\text{PbS}$ ,  $\text{CuS}$ ,  $\text{Bi}_2\text{S}_3$ , all black but  $\text{CdS}$  is yellow. All insoluble in yellow ammonium sulphide.

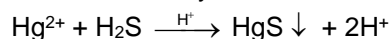
**IIB** :  $\text{SnS}_2$ ,  $\text{As}_2\text{S}_3$  are yellow,  $\text{Sb}_2\text{S}_3$  is orange &  $\text{SnS}$  is dark brown All soluble in yellow ammonium sulphide.



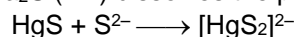
## Section (B) : II A Group

IIA Group ( $\text{Hg}^{2+}$ ,  $\text{Pb}^{2+}$ ,  $\text{Bi}^{3+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Cd}^{2+}$ )1. MERCURY (II) ION ( $\text{Hg}^{2+}$ ) :

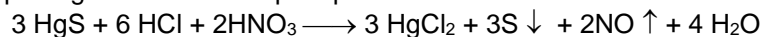
- **Precipitation with  $\text{H}_2\text{S}$  in acidic medium** : Black precipitate is formed. Precipitate insoluble in water, hot dilute  $\text{HNO}_3$ , alkali hydroxides, or colourless ammonium sulphide.



☞  $\text{Na}_2\text{S}$  (2M) dissolves the precipitate forming soluble complex.



☞ Aqua regia dissolves the precipitate.



Under these circumstance  $\text{HgCl}_2$  is undissociated. When solution is heated white precipitate of sulphur dissolves forming  $\text{H}_2\text{SO}_4$ .





- **Stannous chloride solution** : When added in moderate amounts silky white precipitate is formed.  

$$2\text{HgCl}_2 + \text{SnCl}_2 \longrightarrow \text{SnCl}_4 + \text{Hg}_2\text{Cl}_2 \downarrow$$
 If more reagent is added, Hg (I) chloride is reduced to black precipitate of mercury.  

$$\text{Hg}_2\text{Cl}_2 + \text{SnCl}_2 \longrightarrow \text{SnCl}_4 + 2\text{Hg} \downarrow$$
- **Potassium iodide solution** : On slow addition red precipitate is formed.  

$$\text{Hg}^{2+} + 2\text{I}^- \longrightarrow \text{HgI}_2 \downarrow$$
 Precipitate dissolves in excess of KI forming colourless soluble complex.  

$$\text{HgI}_2 + 2\text{I}^- \longrightarrow [\text{HgI}_4]^{2-}$$
 KCN does not have any effect.
- **Copper chips , sheet or coin** : A black precipitate of mercury is formed.  

$$\text{Hg}^{2+} + \text{Cu} \longrightarrow \text{Hg} \downarrow + \text{Cu}^{2+}$$
- **Sodium hydroxide solution** : When added in small quantity brownish-red precipitate of varying composition is formed and in stoichiometric amounts precipitate turns to yellow when Hg (II) oxide is formed.  

$$\text{Hg}^{2+} + 2\text{OH}^- \longrightarrow \text{HgO} \downarrow + \text{H}_2\text{O}$$
 Precipitate is insoluble in excess reagent but dissolves readily in acids and this can be used to differentiate Hg (I) from Hg (II).
- **Ammonia solution** : White precipitate of mixed composition (Mercury (II) oxide + Mercury (II) amido nitrate) is formed with metal nitrate.  

$$2\text{Hg}^{2+} + \text{NO}_3^- + 4\text{NH}_3 + \text{H}_2\text{O} \longrightarrow \text{HgO} \cdot \text{Hg}(\text{NH}_2)\text{NO}_3 \downarrow + 3\text{NH}_4^+$$
- **Cobalt (II) thiocyanate test** : When reagent is added to an aqueous solution of  $\text{Hg}^{2+}$  ions and the walls of the test tube is stirred with a glass rod, deep-blue crystalline precipitate is formed.  

$$\text{Hg}^{2+} + \text{Co}^{2+} + 4\text{SCN}^- \longrightarrow \text{Co}^{+2} [\text{Hg}(\text{SCN})_4]^{-2} \downarrow \text{ or } \text{Hg} [\text{Co}(\text{NCS})_4] \downarrow$$
 In place of Cobalt (II) thiocyanate,  $\text{Co}(\text{CH}_3\text{COO})_2$  and  $\text{NH}_4\text{SCN}$  can be added to the aqueous solution of  $\text{Hg}^{2+}$  ions.

## 2. COPPER ION ( $\text{Cu}^{2+}$ ) :

- **Precipitation with  $\text{H}_2\text{S}$  in acidic medium** : Black precipitate is formed.  

$$\text{Cu}^{2+} + \text{H}_2\text{S} \xrightarrow{\text{H}^+} \text{CuS} \downarrow + 2\text{H}^+$$
 Precipitate is insoluble in boiling dilute (M)  $\text{H}_2\text{SO}_4$  (distinction from cadmium), in  $\text{NaOH}$ ,  $\text{Na}_2\text{S}$  and  $(\text{NH}_4)_2\text{S}$ . Precipitate dissolves in hot concentrated  $\text{HNO}_3$   

$$3\text{CuS} + 8\text{HNO}_3 \longrightarrow 3\text{Cu}(\text{NO}_3)_2 \text{ (blue)} + 2\text{NO} + 4\text{H}_2\text{O} + 3\text{S}$$
 When boiled for longer S is oxidised to  $\text{H}_2\text{SO}_4$  and a clear solution of  $\text{Cu}(\text{NO}_3)_2$  is obtained.  
 KCN dissolves the precipitate forming a clear solution.  

$$2\text{CuS} \downarrow + 8\text{CN}^- \longrightarrow 2[\text{Cu}(\text{CN})_4]^{3-} + \text{S}_2^{2-} \text{ (disulphide ion)}$$
- **Ammonia solution** : When added sparingly a blue precipitate of basic salt (basic copper sulphate) is formed with  $\text{CuSO}_4$ .  

$$2\text{Cu}^{2+} + \text{SO}_4^{2-} + 2\text{NH}_3 + 2\text{H}_2\text{O} \longrightarrow \text{Cu}(\text{OH})_2 \cdot \text{CuSO}_4 \downarrow + 2\text{NH}_4^+$$
 It is soluble in excess of reagent forming a deep blue colouration.  

$$\text{Cu}(\text{OH})_2 \cdot \text{CuSO}_4 \downarrow + 8\text{NH}_3 \longrightarrow 2[\text{Cu}(\text{NH}_3)_4]^{2+} + \text{SO}_4^{2-} + 2\text{OH}^-$$
- **Sodium hydroxide in cold solution** : A blue precipitate is formed.  

$$\text{Cu}^{2+} + 2\text{OH}^- \longrightarrow \text{Cu}(\text{OH})_2 \downarrow$$

$$\text{Cu}(\text{OH})_2 \downarrow \xrightarrow{\text{Heat}} \text{CuO} \downarrow \text{ (black)} + \text{H}_2\text{O}$$
- **Potassium iodide** : It gives a white precipitate of Cu(I) iodide but the solution is intensely brown because of the formation of tri-iodide ions (or iodine).  

$$2\text{Cu}^{2+} + 5\text{I}^- \longrightarrow \text{CuI} \downarrow + \text{I}_3^-$$
 The solution becomes colourless and a white precipitate is visible when excess of sodium thiosulphate solution is added.  

$$\text{I}_3^- + 2\text{S}_2\text{O}_3^{2-} \longrightarrow 3\text{I}^- + \text{S}_4\text{O}_6^{2-}$$
 These reactions are used in quantitative analysis for the iodometric determination of copper.
- **Potassium ferrocyanide (Potassium hexacyanidoferrate (II)) solution** :  $\text{Cu}^{2+}$  ions gives brown/chocolate brown precipitate.  

$$2\text{Cu}^{2+} + \text{K}_4\text{Fe}(\text{CN})_6 \longrightarrow \text{Cu}_2[\text{Fe}(\text{CN})_6] \downarrow + 4\text{K}^+$$

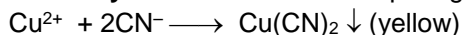
$$2[\text{Fe}(\text{CN})_6]^{3-} + 3\text{Cu}^{2+} \longrightarrow \text{Cu}_3[\text{Fe}(\text{CN})_6]_2 \downarrow \text{ (green)}$$







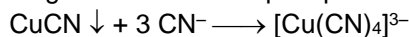
(vi) **Potassium cyanide** : When added sparingly forms first a yellow precipitate.



Precipitate quickly decomposes into CuCN and cyanogen.

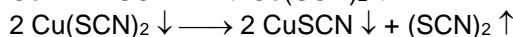
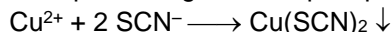


Excess reagent dissolves the precipitate forming a colourless soluble complex.

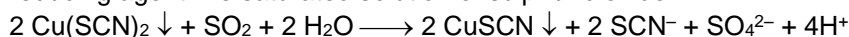


Complex is so stable that  $\text{H}_2\text{S}$  cannot precipitate Cu (I) sulphide (distinction from cadmium).

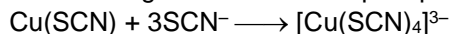
- **Potassium thiocyanate solution** : The  $\text{Cu}^{+2}$  ions solution initially gives a black precipitate which then slowly decomposes to give white precipitate of Cu(I) thiocyanate.



☞ Cu (II) thiocyanate can be immediately converted into Cu(I) thiocyanate by adding a suitable reducing agent like saturated solution of sulphur dioxide.

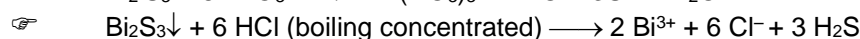
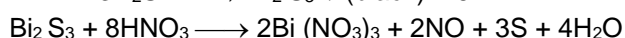


Excess reagent dissolves the precipitate forming a colourless soluble complex.

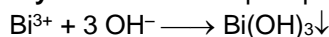


### 3. BISMUTH ION ( $\text{Bi}^{3+}$ ) :

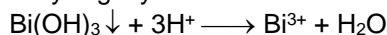
- **Precipitation with  $\text{H}_2\text{S}$  in acidic medium** : Black precipitate is formed which is insoluble in cold dilute  $\text{HNO}_3$  and yellow ammonium sulphide.



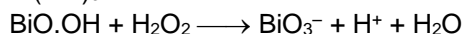
- **Sodium hydroxide** : White precipitate is formed with the reagent.



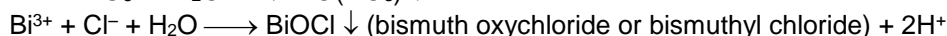
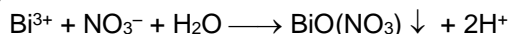
Very slightly soluble in excess reagent in cold solution but soluble in acids.



☞ Precipitate on boiling loses water and turns yellowish white which is oxidised to  $\text{BiO}_3^-$  by  $\text{H}_2\text{O}_2$ .

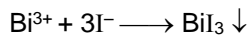


- **Dilution with water** : Solution of bismuth salts gives white precipitate when water is added in larger quantity.

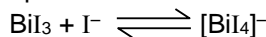


Soluble in mineral acids (dilute) but insoluble in tartaric acid (distinction from antimony) and in alkali hydroxide (distinction from tin).

- **Potassium iodide** : When the reagent is added dropwise to a solution containing  $\text{Bi}^{3+}$  ions, a black precipitate is formed.

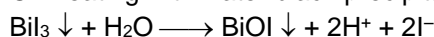


The precipitate dissolves in excess KI forming orange coloured soluble complex.



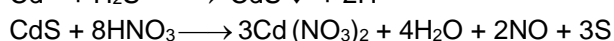
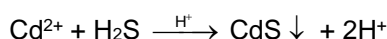
On dilution the reaction is reversed and black  $\text{BiI}_3$  is reprecipitated.

☞ On heating with water black precipitate of  $\text{BiI}_3$  turns orange.



### 4. CADMIUM ION ( $\text{Cd}^{2+}$ ) (\*Not in JEE advance syllabus) :

- **Precipitation with  $\text{H}_2\text{S}$  in acidic medium** : Yellow precipitate is formed which dissolves in hot dilute  $\text{HNO}_3$ .



☞ Precipitate does not dissolve in KCN.



- **Ammonia solution (Dropwise addition)** : Ammonium hydroxide first gives white precipitate of  $\text{Cd}(\text{OH})_2$  which gets dissolve in excess of reagent forming a soluble complex.
 
$$\text{Cd}^{2+} + 2 \text{NH}_3 + 2 \text{H}_2\text{O} \rightleftharpoons \text{Cd}(\text{OH})_2 \downarrow + 2 \text{NH}_4^+$$

$$\text{Cd}(\text{OH})_2 \downarrow + 4 \text{NH}_3 \longrightarrow [\text{Cd}(\text{NH}_3)_4]^{2+} + 2 \text{OH}^-$$
- **Potassium cyanide** : Initially a white precipitate of  $\text{Cd}(\text{CN})_2$  is formed which in excess of reagent dissolves forming a soluble complex.
 
$$\text{Cd}^{2+} + 2 \text{CN}^- \longrightarrow \text{Cd}(\text{CN})_2 \downarrow$$

$$\text{Cd}(\text{CN})_2 \downarrow + 2 \text{CN}^- \longrightarrow [\text{Cd}(\text{CN})_4]^{2-}$$

The colourless soluble complex is not too stable, therefore, reacts with  $\text{H}_2\text{S}$  gas forming a yellow precipitate of  $\text{CdS}$ .

$$[\text{Cd}(\text{CN})_4]^{2-} + \text{H}_2\text{S} \longrightarrow \text{CdS} \downarrow + 2 \text{H}^+ + 4 \text{CN}^-$$

☞ KI forms no precipitate (distinction from Copper)

## 5. LEAD ION ( $\text{Pb}^{2+}$ ) :

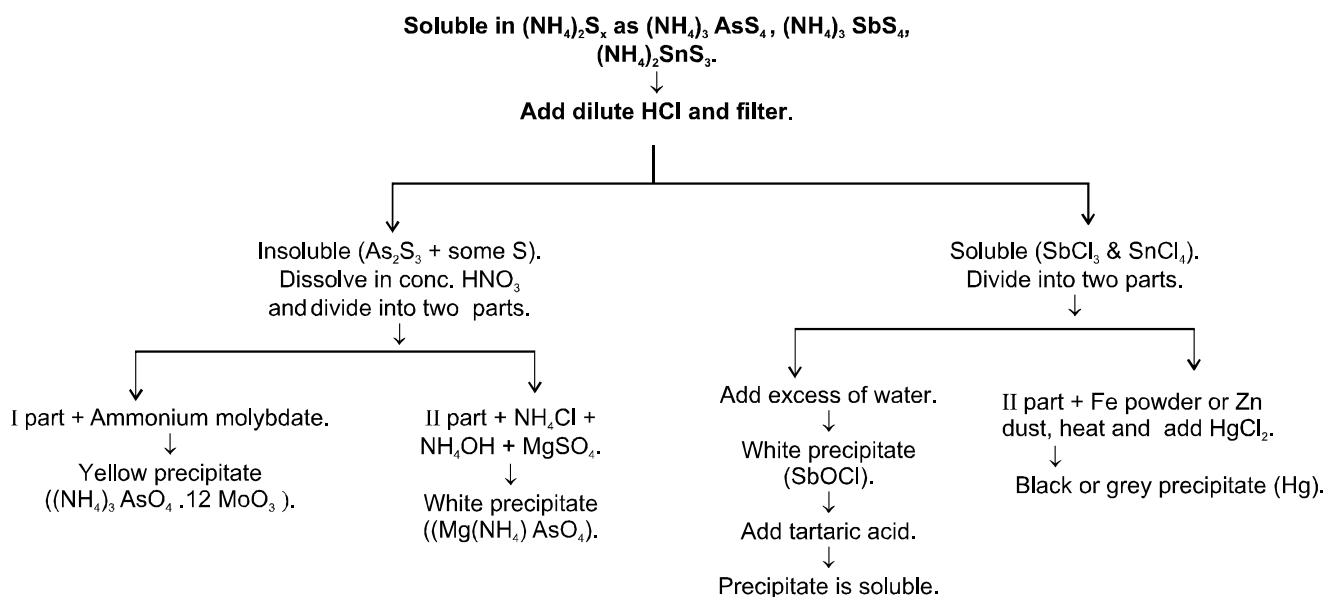
- **Precipitation with  $\text{H}_2\text{S}$  in acidic medium** : Black precipitate is formed which is soluble in hot dilute  $\text{HNO}_3$ .
 
$$\text{Pb}^{2+} + \text{H}_2\text{S} \longrightarrow \text{PbS} \downarrow (\text{black}) + 2 \text{H}^+$$

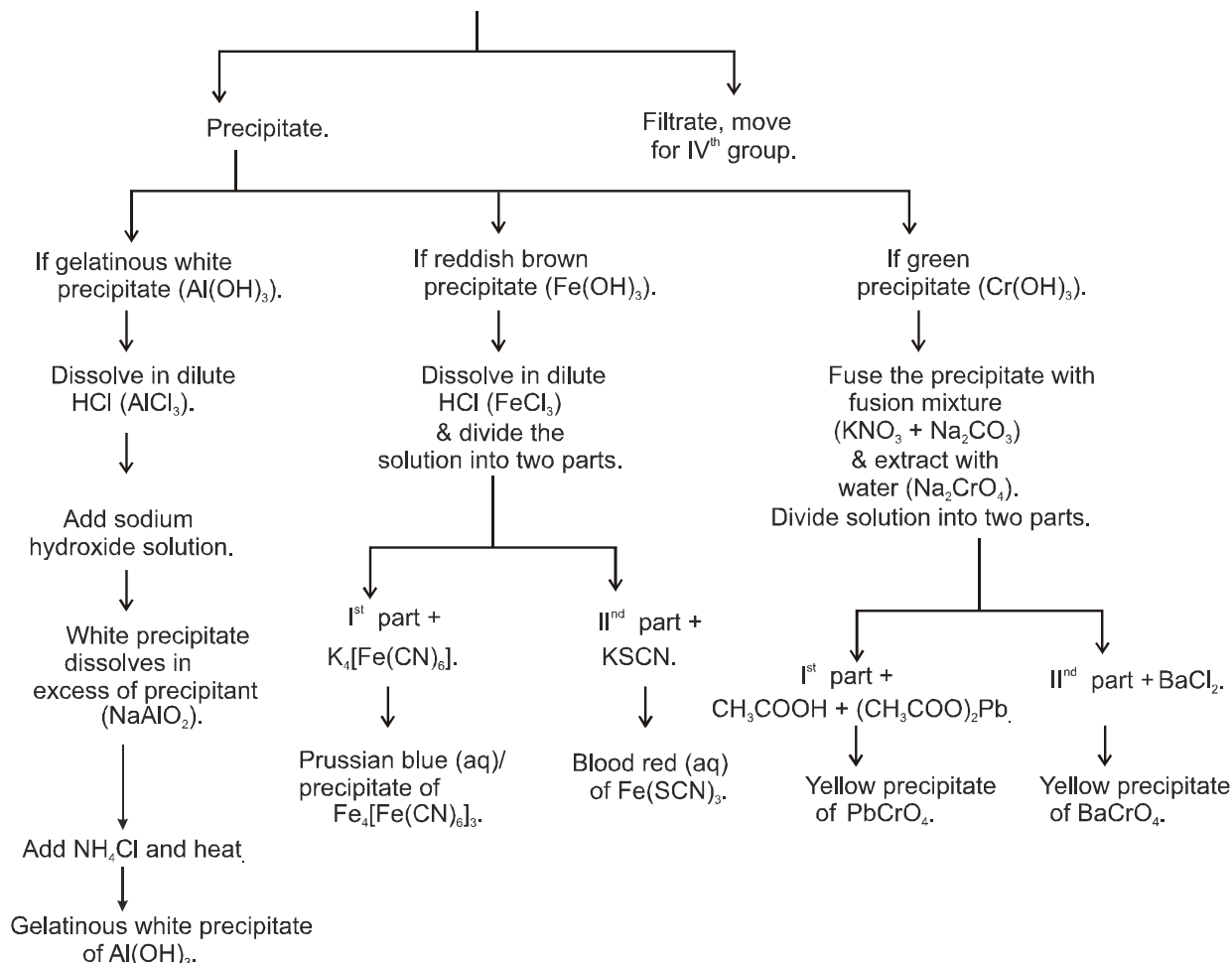
$$3 \text{PbS} + 8 \text{HNO}_3 \longrightarrow 3 \text{Pb}(\text{NO}_3)_2 + 2 \text{NO} + 4 \text{H}_2\text{O} + 3 \text{S}$$
- **Dilute  $\text{H}_2\text{SO}_4$**  : White precipitate is formed which is soluble in ammonium acetate.
 
$$\text{Pb}(\text{NO}_3)_2 + \text{H}_2\text{SO}_4 \longrightarrow \text{PbSO}_4 \downarrow (\text{white}) + 2 \text{HNO}_3$$

$$\text{PbSO}_4 + 2 \text{CH}_3 \text{COONH}_4 \longrightarrow (\text{CH}_3\text{COO})_2 \text{Pb} + (\text{NH}_4)_2\text{SO}_4 + 2 \text{NH}_4\text{CH}_3\text{COO}$$
- **Potassium iodide** : Yellow precipitate is formed which is soluble in excess more concentrated (6M) solution of the reagent. Yellow precipitate of  $\text{PbI}_2$  is moderately soluble in boiling water to give a colourless solution.
 
$$(\text{CH}_3\text{COO})_2 \text{Pb} + 2 \text{KI} \longrightarrow 2 \text{CH}_3 \text{COOK} + \text{PbI}_2 \downarrow (\text{yellow})$$
- **Potassium chromate** : Yellow precipitate is formed.
 
$$(\text{CH}_3\text{COO})_2 \text{Pb} + \text{K}_2\text{CrO}_4 \longrightarrow 2 \text{CH}_3 \text{COOK} + \text{PbCrO}_4 \downarrow (\text{yellow})$$

## Section (C) : IIB Group

IIB Group ( $\text{As}^{3+}$ ,  $\text{Sb}^{3+}$ ,  $\text{Sn}^{2+}$ ,  $\text{Sn}^{4+}$ ) (Not in JEE advance syllabus)



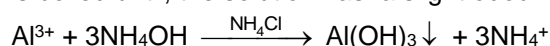
Section (D) : III<sup>rd</sup> GroupIII<sup>rd</sup> Group ( $\text{Al}^{3+}$ ,  $\text{Cr}^{3+}$ ,  $\text{Fe}^{3+}$ )II Group Filtrate  $\xrightarrow{\text{Boiloff}}$   $\text{H}_2\text{S} \uparrow$  then add conc.  $\text{HNO}_3$  (1-2) drops +  $\text{NH}_4\text{Cl}$  (solid) +  $\text{NH}_4\text{OH}$ 

☞ Concentrated  $\text{HNO}_3$  is added to oxidise  $\text{Fe}^{2+}$  to  $\text{Fe}^{3+}$  if present.

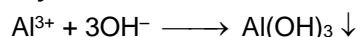
☞ Solid  $\text{NH}_4\text{Cl}$  should be added in excess other wise cations like  $\text{Zn}$ ,  $\text{Mn}$ ,  $\text{Mg}$  may be precipitated here. To much excess of  $\text{NH}_4\text{Cl}$  should be avoided other wise  $\text{Cr}$  is not precipitated and  $\text{Al}$  may form a colloidal solution.

1. ALUMINIUM ION ( $\text{Al}^{3+}$ ) :

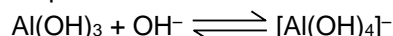
- **Precipitation with  $\text{NH}_4\text{OH}$  in presence of  $\text{NH}_4\text{Cl}$  :** White gelatinous precipitate is formed which is slightly soluble in excess reagent. The solubility is decreased in the presence of ammonium salt. A small portion of the precipitate passes into the solution as colloidal  $\text{Al}(\text{OH})_3$  (Aluminium hydroxide sol), the sol is coagulated on boiling the solution or upon the addition of soluble salt yielding a precipitate of  $\text{Al}(\text{OH})_3$ , known as  $\text{Al}(\text{OH})_3$  gel. For complete precipitation, add ammonia solution in excess and the mixture is boiled until, the solution has a slight odour of  $\text{NH}_3$ .



- **Sodium hydroxide :** A solution containing  $\text{Al}^{3+}$  ions give a white precipitate with the reagent.

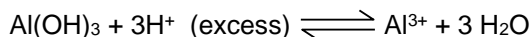
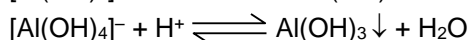
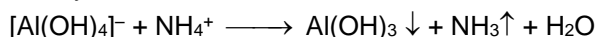


White precipitate dissolves in excess sodium hydroxide according to following reaction.





The reaction is reversible and any reagent, which will reduce the hydroxyl ion concentration sufficiently should cause the reaction to proceed from right to left with the consequent precipitation of aluminium hydroxide. This may be effected with a solution of ammonium chloride (the hydroxyl ion concentration is reduced owing to the formation of the weak base ammonia, which can be readily removed as ammonia gas by heating) or by the addition of acid; in the latter case, a large excess of acid causes the precipitated hydroxide to redissolve.



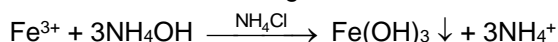
- **Dry test :** Aluminium compounds when heated with sodium carbonate upon charcoal gives a white infusible solid, which glows when hot. If the residue is moistened with a little cobalt nitrate solution and again heated, a blue infusible mass is obtained.



Use of excess cobalt nitrate solution should be avoided since this will produce black cobalt oxide ( $\text{Co}_3\text{O}_4$ ) upon ignition, which will mask the blue colour.

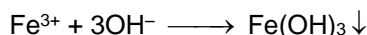
## 2. IRON ION ( $\text{Fe}^{3+}$ ) :

- **Precipitation with  $\text{NH}_4\text{OH}$  in presence of  $\text{NH}_4\text{Cl}$  :** Gelatinous reddish brown precipitate is formed which is insoluble in excess reagent but soluble in acids.

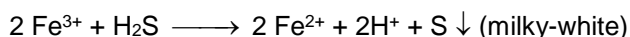


Precipitation of iron(II) hydroxide occurs with ammonia solution. If larger amounts of ammonium ions are present, the dissociation of  $\text{NH}_4\text{OH}$  is suppressed and the concentration of  $\text{OH}^-$  ions is lowered to such an extent that solubility product of iron (II) hydroxide,  $\text{Fe}(\text{OH})_2$  is not attained and precipitation does not occur.

- **Sodium hydroxide solution :** Reddish brown precipitate is formed insoluble in excess reagent (distinction from aluminium and chromium).



- **$\text{H}_2\text{S}$  gas in acidic solution :**  $\text{Fe}^{3+}$  reduces to  $\text{Fe}^{2+}$ .



If a neutral solution of iron (III) chloride is added to a freshly prepared saturated solution of  $\text{H}_2\text{S}$ , bluish colouration appears first, followed by precipitation of sulphur. The blue colour is due to a colloidal solution of sulphur of extremely small particle size.

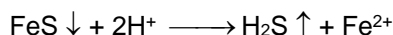


This reaction can be used to test the freshness of  $\text{H}_2\text{S}$  solution.

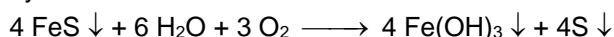
- **Ammonium sulphide solution :** Black precipitate consisting of  $\text{Fe}(\text{II})$  sulphide and sulphur is formed.



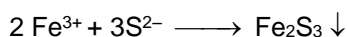
In  $\text{HCl}$ , the black precipitate of  $\text{Fe}(\text{II})$  sulphide dissolves and white precipitate of sulphur becomes visible.



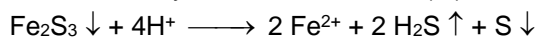
The damp iron (II) sulphide precipitate, when exposed to air, is slowly oxidised to brown iron(III) hydroxide.



From alkaline solutions of ammonium sulphide, black iron(III) sulphide is obtained.

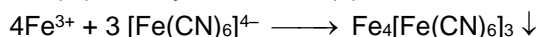


On acidification with hydrochloric acid, iron (III) ions are reduced to iron (II) ions and sulphur is formed.

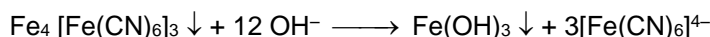




- **Potassium ferrocyanide (Potassium hexacyanidoferrate(II))** : Intense blue precipitate (Prussian blue) of iron(III) hexacyanidoferrate(II) is formed.



This is insoluble in dilute acids but decomposes in concentrated HCl. A large excess of the reagent dissolves it partly or entirely, when an intense blue solution is obtained. Sodium hydroxide turns the precipitate red.

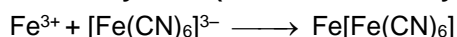


☞ Oxalic acid also dissolves Prussian blue forming a blue-solution.

#### Important :

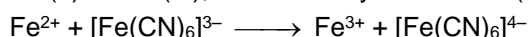
If iron(III) chloride is added to an excess of potassium hexacyanidoferrate (II), a product with the composition of  $\text{K}_3\text{Fe}[\text{Fe}(\text{CN})_6]$  is formed. This tends to form colloidal solutions ("soluble Prussian blue") and can not be filtered.

- **Potassium ferricyanide (Potassium hexacyanidoferrate(III))** : A brown colouration is formed.

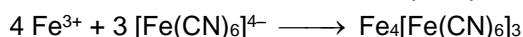


☞ Upon adding hydrogen peroxide or some tin(II) chloride solution, the hexacyanidoferrate(III) part of the compound is reduced and Prussian blue is precipitated.

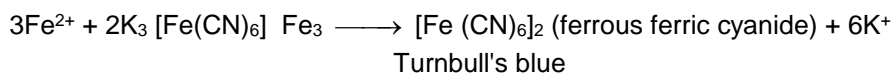
☞  $\text{Fe}^{2+}$  gives dark blue precipitate with potassium ferricyanide. First hexacyanidoferrate(III) ions oxidise iron(II) to iron(III), when hexacyanidoferrate(II) is formed.



and these ions combine to form a precipitate called Turnbull's blue.

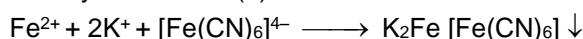


**Note :** Composition of this precipitate is identical to that of Prussian blue. Earlier the composition suggested was  $\text{Fe}_3[\text{Fe}(\text{CN})_6]_2$ , hence different name.



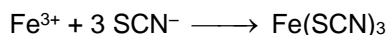
☞ Fe(II) in ammonical solution gives red solution with DMG— colouration fades on standing due to the oxidation of the iron(II) complex. Fe (III) does not give such complex.

☞ In complete absence of air, Fe(II) ions produces white precipitate with potassium hexacyanidoferrate(II).



Under ordinary atmospheric conditions a pale-blue precipitate is formed.

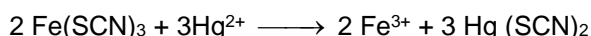
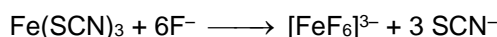
- **Potassium thiocyanate (Potassium sulphocyanide)** : In slightly acidic medium, a deep red colouration is produced due to the formation of a non-dissociated iron(III) thiocyanate complex.



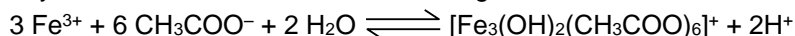
This neutral molecule can be extracted by ether or amyl alcohol.

☞ With pure Fe(II) ions no colouration is obtained.

☞ Fluorides and Hg(II) ions bleach the red colour.

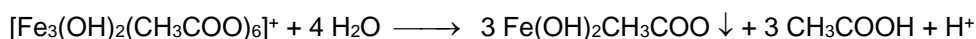


- **Sodium acetate solution** : A deep red colouration is obtained owing to the formation of  $[\text{Fe}_3(\text{OH})_2(\text{CH}_3\text{COO})_6]^+$ . The reaction becomes complete only if the strong acid which is formed, is removed by the addition of an excess of the reagent, which acts as a buffer.



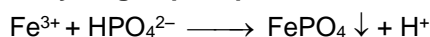


This deep red coloured solution on dilution with water and boiling gives reddish brown precipitate of basic ferric acetate.



The excess of acetate ion acts as a buffer and the reaction goes to completion.

- **Disodium hydrogen phosphate solution** : A yellowish–white precipitate is formed.



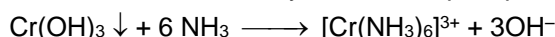
The reaction is reversible, because a strong acid is formed which dissolves the precipitate. It is advisable to add small amounts of sodium acetate, which acts as a buffer.

### 3. CHROMIUM ION ( $\text{Cr}^{3+}$ ) :

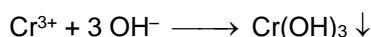
- **Precipitation with  $\text{NH}_4\text{OH}$  in presence of  $\text{NH}_4\text{Cl}$**  : A grey-green to green gelatinous precipitate is formed.



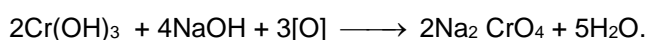
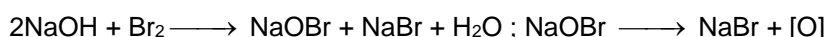
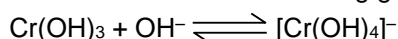
Precipitate is slightly soluble in excess of reagent in cold forming pink or violet coloured solution. On boiling the solution, chromium hydroxide is reprecipitated.



- **Sodium hydroxide solution** : A green precipitate is formed.

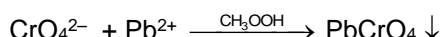


The reaction is reversible. On addition of acids the precipitate dissolves. In excess of reagent the precipitate dissolves readily forming chromites, the solution is green. The reaction is reversible ; on (slight) acidification and also on boiling green precipitate of chromium(III) hydroxide is obtained.

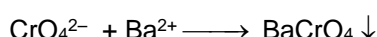


The yellow solution of  $\text{Na}_2\text{CrO}_4$  gave the following reactions with lead acetate, barium chloride and silver nitrate solutions.

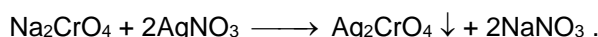
**(a) Lead acetate solution** : Yellow precipitate is formed.



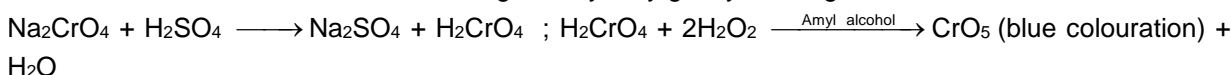
**(b) Barium chloride solution** : Yellow precipitate is formed owing to the formation of barium chromate which is insoluble in acetic acid.



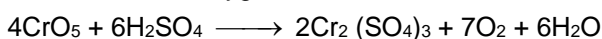
**(c) Silver nitrate solution** : Red/Brick red precipitate is formed owing to the formation of silver chromate which is soluble in ammonia solution and its acidified solution turns to orange because of the formation of dichromate.

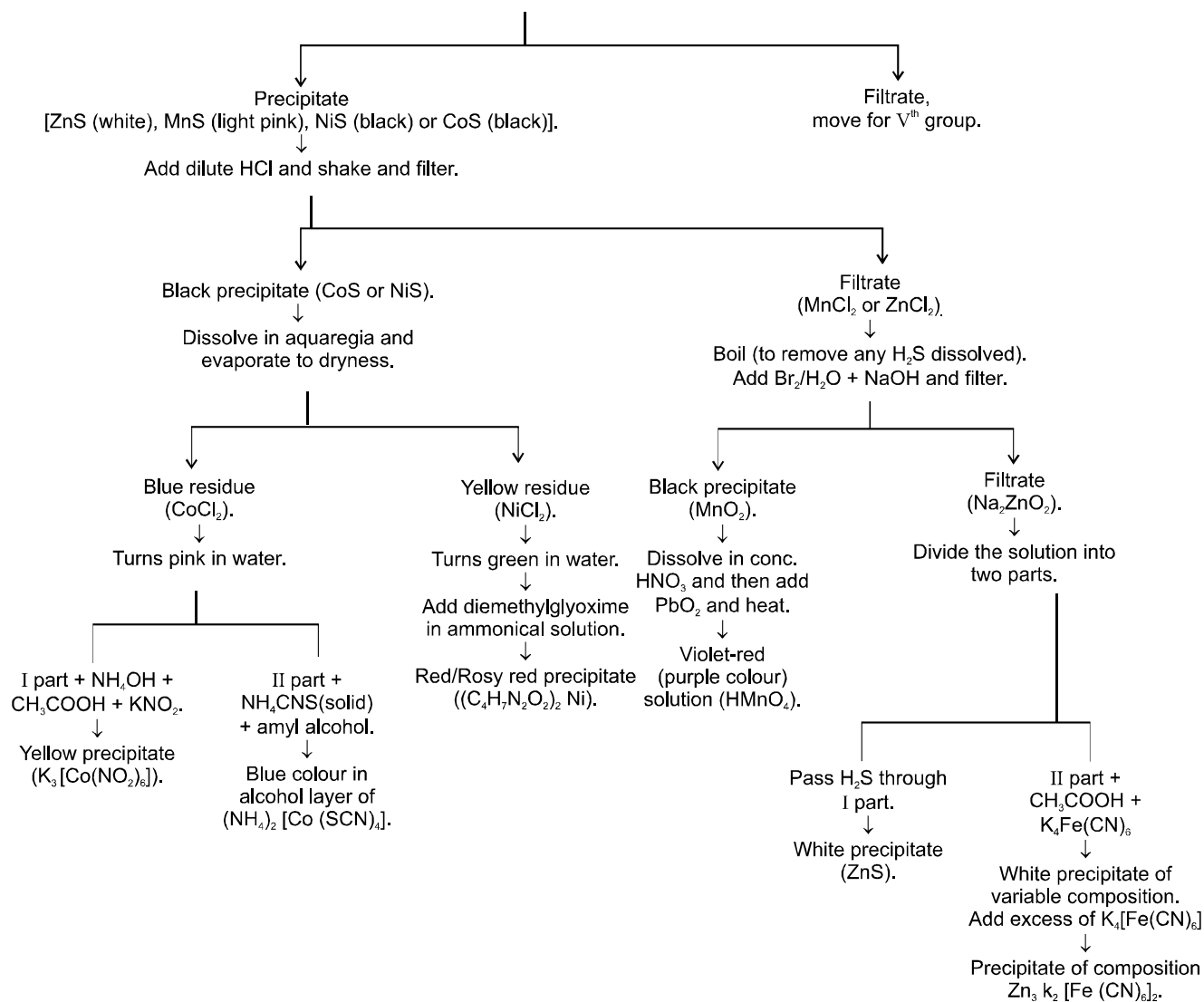


- **Acidified  $\text{H}_2\text{O}_2$  test** : On acidifying the yellow solution with dilute sulphuric acid and adding few drops of ether or amyl alcohol to the mixture and finally adding some hydrogen peroxide, blue colouration is formed which can be extracted into the organic layer by gently shaking.

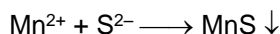


Blue colouration fades slowly due to the decomposition of perchromic acid (or chromium peroxide ) with the liberation of oxygen.

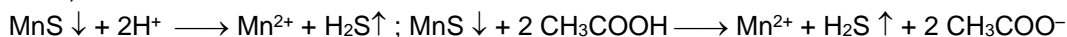


Section (E) : IV<sup>th</sup> GroupIV<sup>th</sup> GROUP ( $\text{Zn}^{2+}$ ,  $\text{Mn}^{2+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Co}^{2+}$ ) :III Group filtrate +  $\text{NH}_4\text{OH}$  (excess) &  $\text{NH}_4\text{Cl}$ , then pass  $\text{H}_2\text{S}$ 1. MANGANESE ION ( $\text{Mn}^{2+}$ ) :

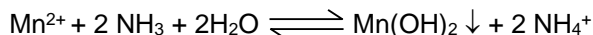
- **Precipitation with  $\text{H}_2\text{S}$  in presence of  $\text{NH}_4\text{OH}$  +  $\text{NH}_4\text{Cl}$**  : A buff coloured (light pink) precipitate is formed.



It is readily soluble in mineral acids (distinction with Ni and Co) and even in acetic acid (distinction with Ni, Co and Zn).

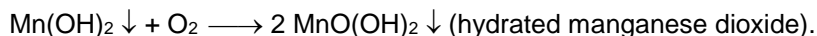
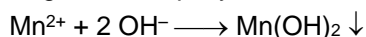


- **Ammonia solution** : Partial precipitation of white manganese(II) hydroxide takes place.



The precipitate is soluble in ammonium salts when the reaction proceeds towards left.

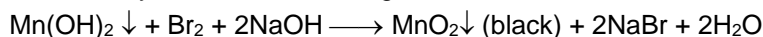
- **Sodium hydroxide solution** : Initially white precipitate of  $\text{Mn}(\text{OH})_2$  is formed which is insoluble in excess reagent and rapidly oxidised on exposure to air, becoming brown.





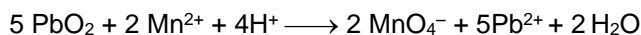


☞ With sodium hydroxide and bromine water initially a white precipitate is formed which immediately turns to black owing to the formation of  $\text{MnO}_2$ .

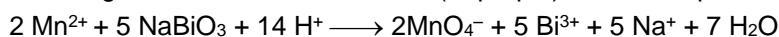


☞  $\text{Mn}(\text{OH})_2 \downarrow + \text{H}_2\text{O}_2 \longrightarrow \text{MnO}(\text{OH})_2 \downarrow (\text{brown}) + \text{H}_2\text{O}$

● **Lead dioxide ( $\text{PbO}_2$ ) and concentrated nitric acid** : On boiling a dilute solution of manganese(II) ions with lead dioxide and a little concentrated nitric acid and allowing the suspended solid containing unattacked lead dioxide to settle, the supernatant liquid acquired a violet-red (or purple) colour due to permanganic acid.



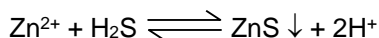
● **Sodium bismuthate ( $\text{NaBiO}_3$ ) solution** : When sodium bismuthate ( $\text{NaBiO}_3$ ) is added to a cold solution of manganese(II) ions in dilute nitric acid or in dilute sulphuric acid and the mixture stirred and then excess reagent filtered off, a violet-red (or purple) solution of permanganate is produced.



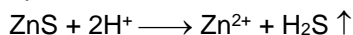
☞  $2 \text{Mn}(\text{NO}_3)_2 + 2 \text{Pb}_3\text{O}_4 + 26 \text{HNO}_3 \xrightarrow{\Delta} 2 \text{HMnO}_4 (\text{violet-red/purple}) + 15 \text{Pb}(\text{NO}_3)_2 + 12 \text{H}_2\text{O}$

## 2. ZINC ION ( $\text{Zn}^{2+}$ ) :

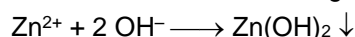
● **Precipitation with  $\text{H}_2\text{S}$  in presence of  $\text{NH}_4\text{OH} + \text{NH}_4\text{Cl}$**  : A white precipitate is formed. In neutral solutions, precipitation is partial as  $\text{H}^+$  ions concentration produced depressed the ionisation of  $\text{H}_2\text{S}$ .



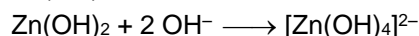
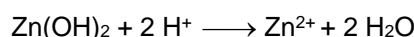
The precipitate is soluble in dilute  $\text{HCl}$ .



● **Sodium hydroxide solution** : A white gelatinous precipitate is formed.



The precipitate is soluble in acids as well as in excess of the reagent.

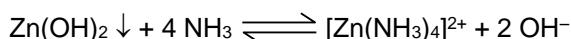
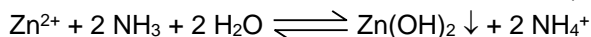


☞ Thus, zinc hydroxide is amphoteric in nature.

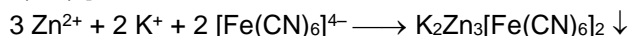
☞  $[\text{Zn}(\text{OH})_4]^{2-} + \text{S}^{2-} \longrightarrow \text{ZnS} \downarrow (\text{white}) + 4 \text{OH}^-$

● **Ammonia solution** : A white gelatinous precipitate is formed which is readily soluble in excess of the reagent and in solutions of ammonium salts forming the tetraamminezinc(II).

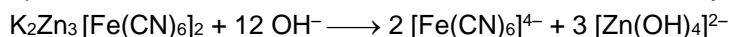
Non-precipitation of  $\text{Zn}(\text{OH})_2$  by ammonia solution in the presence of  $\text{NH}_4\text{Cl}$  is due to the lowering of  $\text{OH}^-$  ion concentration to such a value that the  $K_{sp}$  of  $\text{Zn}(\text{OH})_2$  is not attained.



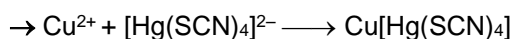
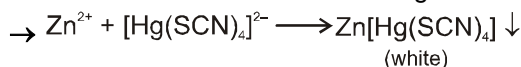
● **Potassium ferrocyanide (Potassium hexacyanidoferrate(II)) solution** : A white precipitate of variable composition is formed. If excess reagent is added, the composition of precipitate is  $\text{K}_2\text{Zn}_3[\text{Fe}(\text{CN})_6]_2$ .



The precipitate is insoluble in dilute acids, but dissolves in sodium hydroxide readily.



This reaction can be used to distinguish zinc from aluminium.



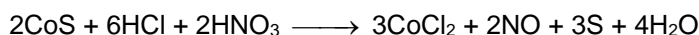
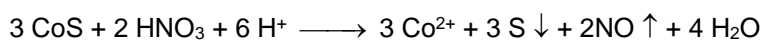
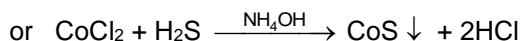
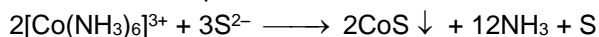
\* In the presence of the copper ions, the copper complex Co-precipitated with that of zinc complex and colour become violet.





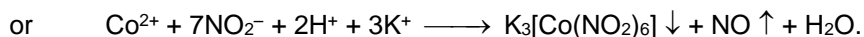
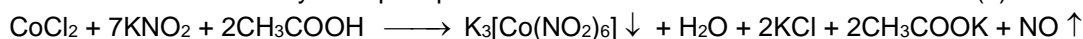
### 3. COBALT ION ( $\text{Co}^{2+}$ ) : (Not in JEE advance syllabus)

- **Precipitation with  $\text{H}_2\text{S}$  in presence of  $\text{NH}_4\text{OH} + \text{NH}_4\text{Cl}$  :** A black precipitate is formed. The black precipitate of  $\text{CoS}$  is insoluble in dilute  $\text{HCl}$  or acetic acid but hot concentrated  $\text{HNO}_3$  or aquaregia dissolves it and white sulphur remains. On longer heating the mixture becomes clear as because sulphur is oxidised to sulphate.

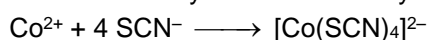


☞ Solution on evaporation to dryness gives blue residue ( $\text{CoCl}_2$ ) which turns pink on adding water.

- **Potassium nitrite solution :** A yellow precipitate is formed from neutral solution of cobalt(II) ions.

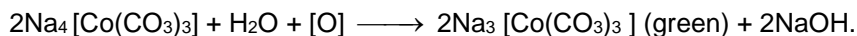
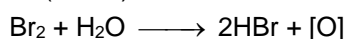
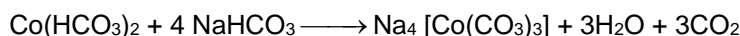
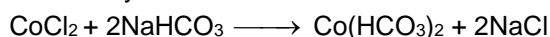


- **Ammonium thiocyanate solution :** A neutral or acid solution of cobalt(II) gives a blue colouration in amyl alcohol or ether layer when a few crystals of ammonium thiocyanate are added.



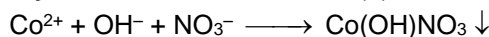
☞ In amyl alcohol or ether, the free acid  $\text{H}_2[\text{Co}(\text{SCN})_4]$  is formed and dissolved by the organic solvent (distinction from nickel)

- **Sodium bicarbonate and bromine water test :** To the test solution sodium bicarbonate is added in excess followed by the bromine water. The mixture is slightly heated, the solution turns apple green.

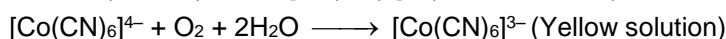
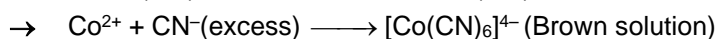
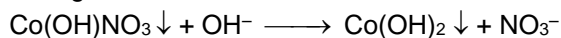


☞ Green solution of sodium cobaltcarbonate is obtained.

- **Sodium hydroxide solution :** Cobalt(II) nitrate in cold gives a blue basic salt.



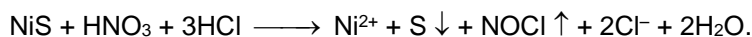
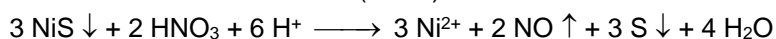
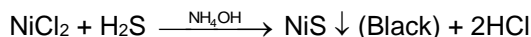
Upon warming with excess alkali, the basic salt is converted into a pink precipitate of  $\text{Co}(\text{II})$  hydroxide.



### 4. NICKEL ION ( $\text{Ni}^{2+}$ ) : (Not in JEE advance syllabus)

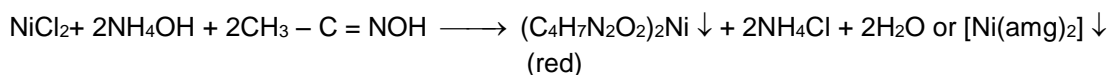
- **Precipitation with  $\text{H}_2\text{S}$  in presence of  $\text{NH}_4\text{OH} + \text{NH}_4\text{Cl}$  :**

A black precipitate is formed which is insoluble in cold dilute  $\text{HCl}$  and  $\text{CH}_3\text{COOH}$  but dissolves in hot concentrated  $\text{HNO}_3$  and in aquaregia.



☞ Solution on evaporation to dryness gives yellow residue ( $\text{NiCl}_2$ ) which turns green on adding water.

- **Dimethylglyoxime reagent :** A red precipitate is obtained from the solution just made alkaline or acid solutions buffered with sodium acetate.



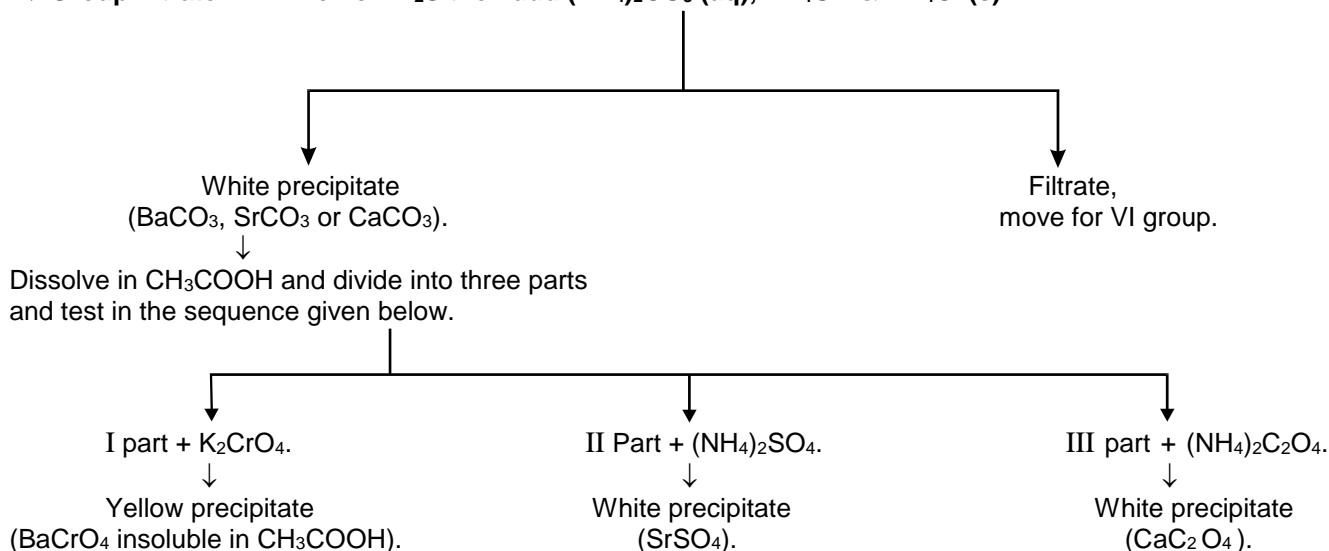


- ☞ Fe(II) ions give red colouration, bismuth gives yellow precipitate and cobalt gives brown colouration with DMG in ammoniacal solutions.
- ☞  $\text{Ni}^{2+}$  gives black precipitate ( $\text{Ni}_2\text{O}_3$ ) with sodium bicarbonate and bromine water on heating where as  $\text{Co}^{2+}$  gives green coloured solution, this is the point of difference.
- $$\text{NiCl}_2 + 2\text{NaHCO}_3 \longrightarrow \text{NiCO}_3 + 2\text{NaCl} + \text{H}_2\text{O} ; 2\text{NiCO}_3 + [\text{O}] \longrightarrow \text{Ni}_2\text{O}_3 \downarrow (\text{black}) + 2\text{CO}_2$$

## Section (F) : V<sup>th</sup>, VI<sup>th</sup> and Zero Group

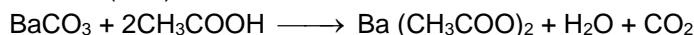
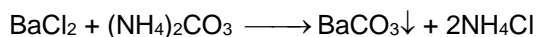
### V<sup>th</sup> Group ( $\text{Ba}^{2+}$ , $\text{Sr}^{2+}$ , $\text{Ca}^{2+}$ ) :

IV Group filtrate  $\longrightarrow$  Boil off  $\text{H}_2\text{S}$  then add  $(\text{NH}_4)_2\text{CO}_3$  (aq),  $\text{NH}_4\text{OH}$  &  $\text{NH}_4\text{Cl}$  (s)

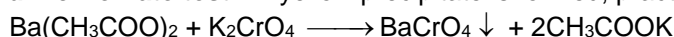


#### 1. BARIUM ION ( $\text{Ba}^{2+}$ ) :

- **Precipitation with  $(\text{NH}_4)_2\text{CO}_3$  in presence of  $\text{NH}_4\text{OH}$  +  $\text{NH}_4\text{Cl}$  :** A white precipitate is formed which is soluble in acetic acid and dilute mineral acids

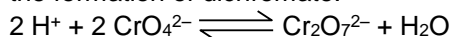


- **Potassium chromate test :** A yellow precipitate is formed, practically insoluble in water



- ☞ Precipitate is insoluble in dilute acetic acid (distinction from strontium and calcium) but readily soluble in mineral acids.

- ☞ Addition of acid to  $\text{K}_2\text{CrO}_4$  changes the yellow colour of the solution to reddish–orange due to the formation of dichromate.

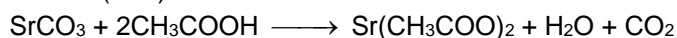
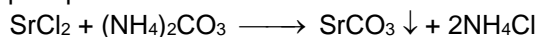


- ☞ The solubility products of  $\text{SrCrO}_4$  and  $\text{CaCrO}_4$  are much larger than for  $\text{BaCrO}_4$  and hence they require a larger  $\text{CrO}_4^{2-}$  ion concentration to precipitate them. The addition of acetic acid to the  $\text{K}_2\text{CrO}_4$  solution lowers the  $\text{CrO}_4^{2-}$  ion concentration sufficiently to prevent the precipitation of  $\text{SrCrO}_4$  and  $\text{CaCrO}_4$  but it is maintained high enough to precipitate  $\text{BaCrO}_4$ .

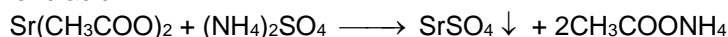
#### 2. STRONTIUM ION ( $\text{Sr}^{2+}$ ) :

- **Precipitation with  $(\text{NH}_4)_2\text{CO}_3$  in presence of  $\text{NH}_4\text{OH}$  +  $\text{NH}_4\text{Cl}$  :**

A white precipitate is formed which is soluble in acetic acid.



- **Ammonium sulphate solution :** A white precipitate is formed which is slightly soluble in boiling hydrochloric acid.

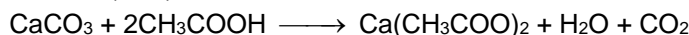
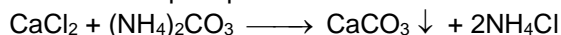




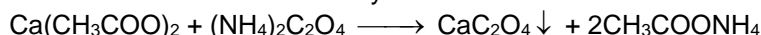
- ☞ The solubility of the precipitate in water is low but not negligible.
  - ☞ The precipitate is insoluble in ammonium sulphate solution even on boiling (Distinction from calcium—forms a soluble complex  $(\text{NH}_4)_2[\text{Ca}(\text{SO}_4)_2]$  and slightly soluble in boiling HCl.
  - ☞ It is almost completely converted into the corresponding carbonates by boiling with a concentrated solution of sodium carbonate.
- $$\text{SrSO}_4 + \text{CO}_3^{2-} \rightleftharpoons \text{SrCO}_3 \downarrow + \text{SO}_4^{2-}$$

### 3. CALCIUM ION ( $\text{Ca}^{2+}$ ) :

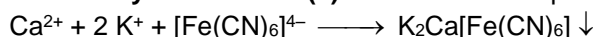
- **Precipitation with  $(\text{NH}_4)_2\text{CO}_3$  in presence of  $\text{NH}_4\text{OH} + \text{NH}_4\text{Cl}$  :** A white precipitate is formed. The precipitate is soluble in water which contains excess carbonic acid (e.g freshly prepared soda water) because of the formation of soluble hydrogen carbonate. On boiling precipitate reappears again, as  $\text{CO}_2$  is removed. The precipitate is also soluble in acetic acid.



- **Ammonium oxalate solution (concentrated) :** A white precipitate is formed. The precipitation is facilitated by making the solution alkaline. The precipitate is practically insoluble in water ( $K_{\text{sp}} = 2.6 \times 10^{-9}$ ), insoluble in acetic acid but readily soluble in mineral acids.



- **Potassium hexacyanidoferrate (II) solution :** White precipitate of a mixed salt is produced.



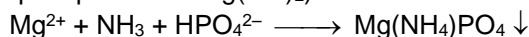
In presence of ammonium chloride the test is more sensitive and in this case  $\text{K}^+$  is replaced by  $\text{NH}_4^+$  ions in the precipitate.

- ☞ This test can be used to distinguish, calcium from strontium, barium and magnesium ions.
- ☞ The confirmatory test for the basic radicals of (V) group have to be done in the order of  $\text{Ba}^{2+}$ ,  $\text{Sr}^{2+}$  then  $\text{Ca}^{2+}$  (i.e BSC) because  $\text{Ba}^{2+}$  give positive test with all the reagents used in the confirmatory test of these group radicals,  $\text{K}_2\text{CrO}_4$ ,  $(\text{NH}_4)_2\text{SO}_4$  &  $(\text{NH}_4)_2\text{C}_2\text{O}_4$ . So performs the test for  $\text{Sr}^{2+}$  with  $(\text{NH}_4)_2\text{SO}_4$  only when  $\text{Ba}^{2+}$  is absent. Similarly  $\text{Sr}^{2+}$  gives the test with both  $(\text{NH}_4)_2\text{SO}_4$  and  $(\text{NH}_4)_2\text{C}_2\text{O}_4$ . So proceeds with  $\text{Ca}^{2+}$  only when  $\text{Sr}^{2+}$  is absent otherwise it will respond to ammonium oxalate test.

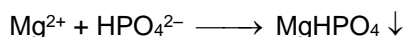
### VI<sup>th</sup> GROUP :

#### 1. MAGNESIUM ION ( $\text{Mg}^{2+}$ ) :

- **Disodium hydrogen phosphate solution :** To the filtrate of V group or  $\text{Mg}^{2+}$  ions solution add 1 ml  $(\text{NH}_4)_2\text{C}_2\text{O}_4$  solution and heat if white precipitate is formed then filter it. Now to filtrate add a solution of disodium hydrogen phosphate. A white crystalline precipitate is formed in the presence of  $\text{NH}_4\text{Cl}$  (prevent precipitation of  $\text{Mg}(\text{OH})_2$ ) and ammonia solution.

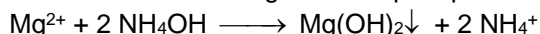


- ☞ Precipitate is sparingly soluble in water, soluble in acetic acid and in mineral acids.
  - ☞ The precipitate separates slowly from dilute solutions because of its tendency to form supersaturated solution. This may be overcome by cooling and by rubbing the test tube beneath the surface of the liquid with a glass rod.
- A white flocculent precipitate of magnesium hydrogen phosphate is obtained in neutral solutions.

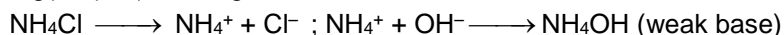
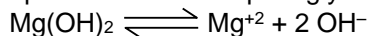


- ☞ Ammonium phosphate can also be used.

- **Ammonia solution :** A white gelatinous precipitate is formed.



The precipitate obtained is sparingly soluble in water but readily soluble in ammonium salts.



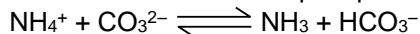
$\text{NH}_4^+$  ions 'remove'  $\text{OH}^-$  causing the hydroxide to dissolve more. Not possible with NaCl.



- **Ammonium carbonate solution** : A white precipitate of basic magnesium carbonate is obtained in the absence of  $\text{NH}_4^+$  salts.



In the presence of  $\text{NH}_4^+$  salts no precipitation occurs, because the equilibrium



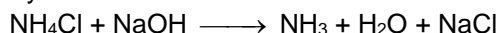
is shifted towards the formation of  $\text{HCO}_3^-$  ions.  $K_{sp}$  of the precipitate being high ( $K_{sp}$  of pure  $\text{MgCO}_3$  is  $1 \times 10^{-5}$ ), the concentration of carbonate ions necessary to produce a precipitate is not attained.

- **Titan yellow (a water soluble yellow dyestuff)** : It is adsorbed by  $\text{Mg}(\text{OH})_2$  producing a deep red colour or precipitate.  
Dissolved the precipitate in dilute HCl (minimum quantity) and to 1 drop of this add 1 drop of NaOH solution (2 M) followed by 1 drop of titan yellow solution a deep red colour solution or precipitate is obtained.  
☞  $\text{Ba}^{2+}$  and  $\text{Ca}^{2+}$  do not react but intensify the colour.

## ZERO GROUP :

### 1. AMMONIUM ION ( $\text{NH}_4^+$ ) :

**Sodium hydroxide solution** : Ammonia gas is evolved on warming the solution containing ammonium salt and sodium hydroxide.



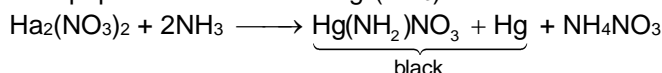
☞ The gas can be identified by the following characteristics / reactions.

— Its characteristics smell.

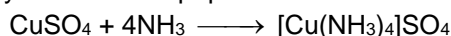
— The evolution of the white fumes of ammonium chloride when a glass rod dipped in dilute HCl is held in the vapour.



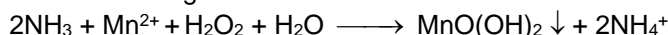
— Its ability to turn filter paper moistened with  $\text{Hg}_2(\text{NO}_3)_2$  solution black.



— Its ability to turn filter paper moistened with  $\text{CuSO}_4$  solution deep blue.

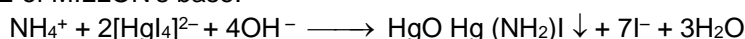


— Filter paper moistened with a solution of manganese (II) chloride and hydrogen peroxide made alkaline with ammonia gives a brown colour due to the oxidation of manganese.



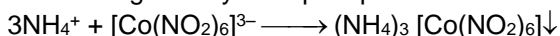
- **Nessler's reagent (Alkaline solution of potassium tetraiodidomercurate(II))** :

Brown precipitate or brown or yellow colouration is obtained according to the amount of ammonia or ammonium ions present. The precipitate is a basic mercury (II) amido-iodide. It is also known as "IODIDE of MILLON's base.



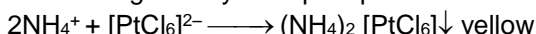
- **Sodium hexanitrito-N-cobaltate (III) solution** :

$\text{NH}_4^+$  ions gives a yellow precipitate with the reagent.



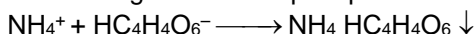
- **Hexachloridoplatinate (IV) solution (i.e., hexachloroplatinic acid)** :

$\text{NH}_4^+$  ions gives a yellow precipitate with the reagent.



- **Saturated sodium hydrogen tartrate solution ( $\text{NaHC}_4\text{H}_4\text{O}_6$ )** :

$\text{NH}_4^+$  ions gives a white precipitate with the reagent.





### MISCELLANEOUS SOLVED PROBLEMS (MSPs)

1. Which of the following precipitate(s) does / do not dissolve in excess of ammonia solution ?  
 (A)  $\text{Zn(OH)}_2$  (B)  $\text{Ni(OH)}_2$  (C)  $\text{Al(OH)}_3$  (D) (B) and (C) both  
**Ans.** (C)  
**Sol.** (A)  $\text{Zn(OH)}_2 + 4 \text{NH}_3 \longrightarrow [\text{Zn(NH}_3)_4]^{2+}$  (colourless solution) +  $2\text{OH}^-$   
 (B)  $\text{Ni(OH)}_2 \downarrow + 6\text{NH}_3 \longrightarrow [\text{Ni(NH}_3)_6]^{2+}$  (deep blue solution) +  $2\text{OH}^-$   
 (C)  $\text{Al(OH)}_3 + \text{NH}_3 \longrightarrow$  No reaction.
2. Chocolate brown precipitate is formed with :  
 (A)  $\text{Cu}^{2+}$  ions and  $[\text{Fe(CN)}_6]^{3-}$  (B)  $\text{Cu}^{2+}$  ions and  $[\text{Fe(CN)}_6]^{4-}$   
 (C)  $\text{Fe}^{3+}$  ions and  $[\text{Fe(CN)}_6]^{4-}$  (D)  $\text{Fe}^{2+}$  ions and dimethylglyoxime  
**Ans.** (B)  
**Sol.** (A)  $\text{Cu}_3 [\text{Fe(CN)}_6]_2 \downarrow$  (green) ; (B)  $\text{Cu}_2 [\text{Fe(CN)}_6] \downarrow$  (chocolate brown)  
 (C)  $\text{Fe}_4 [\text{Fe(CN)}_6]_3 \downarrow$  (Prussian blue) ; (D) red solution of iron(II) dimethylglyoxime.
3. Colour of cobalt chloride solution is :  
 (A) pink (B) black (C) colourless (D) green  
**Ans.** (A)  
**Sol.** Anhydrous  $\text{Co(II)}$  salts are blue in colour while hydrated  $\text{Co(II)}$  salts are pink/red.
4. A red colouration or precipitate is not obtained when :  
 (A)  $\text{Fe}^{3+}$  reacts with potassium thiocyanate (B)  $\text{Fe}^{2+}$  reacts with dimethylglyoxime.  
 (C)  $\text{Hg}^{2+}$  reacts with potassium iodide. (D) None  
**Ans.** (D)  
**Sol.** (A)  $\text{Fe}^{3+} + 3\text{SCN}^- \longrightarrow \text{Fe(SCN)}_3$  (red solution)  
 (B) Red solution of iron(II) dimethylglyoxime.  
 (C)  $\text{Hg}^{2+} + 2\text{I}^- \longrightarrow \text{HgI}_2$  (red).
5. **Statement-1** : Addition of  $\text{NH}_4\text{OH}$  to an aqueous solution of  $\text{BaCl}_2$  in presence of  $\text{NH}_4\text{Cl}$  (excess) precipitates  $\text{Ba(OH)}_2$ .  
**Statement-2** :  $\text{Ba(OH)}_2$  is water soluble.  
 (A) Both Statement-1 and Statement-2 are true and Statement-2 is the correct explanation of Statement-1.  
 (B) Both Statement-1 and Statement-2 are true but Statement-2 is not correct explanation of Statement-1.  
 (C) Statement-1 is true but Statement-2 is false.  
 (D) Statement-1 is false but Statement-2 is true  
**Ans.** (D)  
**Sol.**  $\text{Ba}^{2+}$  ions does not give any precipitate with  $\text{NH}_4\text{OH}$  solution in excess of  $\text{NH}_4\text{Cl}$  because product formed,  $\text{Ba(OH)}_2$  is soluble in water
6. **Statement-1** : Sodium meta aluminate on boiling with ammonium chloride produces white gelatinous precipitate.  
**Statement-2** : Aluminium hydroxide is formed which is not soluble in water  
 (A) Both Statement-1 and Statement-2 are true and Statement-2 is the correct explanation of Statement-1.  
 (B) Both Statement-1 and Statement-2 are true but Statement-2 is not correct explanation of Statement-1.  
 (C) Statement-1 is true but Statement-2 is false.  
 (D) Statement-1 is false but Statement-2 is true  
**Ans.** (A)  
**Sol.**  $[\text{Al(OH)}_4]^- \xrightarrow[\text{boil}]{\text{NH}_4\text{Cl}} \text{Al(OH)}_3 \downarrow + \text{OH}^-$



7. Which of the following statement(s) is (are) incorrect?

- (A)  $\text{Fe}^{2+}$  ions give a dark blue precipitate with potassium hexacyanidoferrate (III) solution.  
 (B)  $\text{Fe}^{3+}$  ions give intense blue precipitate with potassium hexacyanidoferrate (II) solution.  
 (C)  $\text{Fe}^{3+}$  ions give a brown colouration with potassium hexacyanidoferrate (III) solution.  
 (D)  $\text{Fe}^{2+}$  ions give a deep red colouration with ammonium thiocyanate.

Ans. (D)

- Sol. (A)  $\text{Fe}^{2+} + [\text{Fe}(\text{CN})_6]^{3-} \longrightarrow \text{Fe}_3[\text{Fe}(\text{CN})_6]_2$   
 (B)  $4\text{Fe}^{3+} + 3[\text{Fe}(\text{CN})_6]^{4-} \longrightarrow \text{Fe}_4[\text{Fe}(\text{CN})_6]_3 \downarrow$  (intense blue)  
 (C)  $\text{Fe}^{3+} + [\text{Fe}(\text{CN})_6]^{3-} \longrightarrow \text{Fe}[\text{Fe}(\text{CN})_6]$  (brown colouration)  
 (D)  $\text{Fe}^{3+} + 4\text{SCN}^- \longrightarrow \text{Fe}(\text{SCN})_3$  (deep red colouration)  
 $\text{Fe}^{2+} + 4\text{SCN}^- \longrightarrow$  No reaction

8. Consider the following statements :

**S<sub>1</sub>** :  $\text{Cu}^{2+}$  ions are reduced to  $\text{Cu}^+$  by potassium iodide and potassium cyanide both, when taken in excess

**S<sub>2</sub>** :  $\text{H}_2\text{S}$  will precipitate the sulphide of all the metals from the solutions of chlorides of Cu, Zn and Cd if the solution are aqueous.

**S<sub>3</sub>** : The presence of magnesium is confirmed in qualitative analysis by the formation of a white crystalline precipitate of  $\text{MgNH}_4\text{PO}_4$ .

**S<sub>4</sub>** : Calomel on reaction with potassium iodide gives red precipitate.

and arrange in the order of true /false.

- (A) TTFF (B) TFTF (C) TTTT (D) TTTF

Ans. (D)

Sol. **S<sub>1</sub>**, **S<sub>2</sub>** and **S<sub>3</sub>** are correct statements.

**S<sub>4</sub>** :  $\text{Hg}_2^{2+} + 2\text{I}^- \longrightarrow \text{Hg}_2\text{I}_2 \downarrow$  (green) [Calomel :  $\text{Hg}_2\text{Cl}_2$ ]

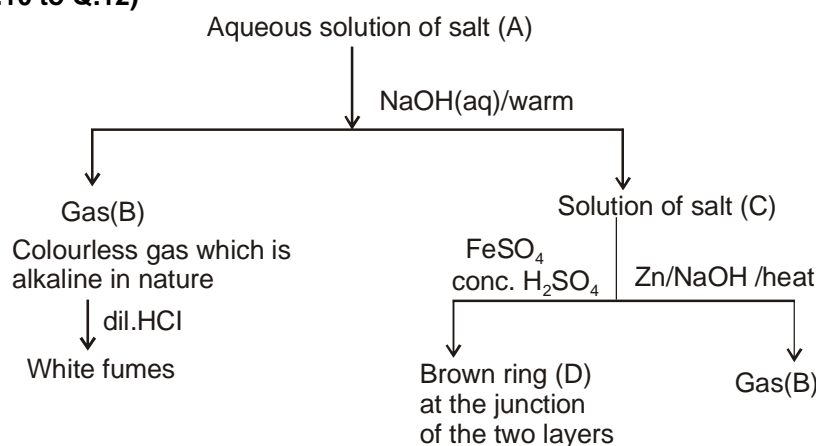
9. Which of the following pair (s) of ions would be expected to form precipitate when dilute solutions are mixed?

- (A)  $\text{NH}_4^+$ ,  $[\text{Co}(\text{NO}_2)_6]^{3-}$  (B)  $\text{NH}_4^+$ ,  $\text{CO}_3^{2-}$  (C)  $\text{Fe}^{3+}$ ,  $\text{OH}^-$  (D)  $\text{Ba}^{2+}$ ,  $\text{SO}_4^{2-}$

Ans. (A,C,D)

- Sol. (A)  $\text{NH}_4^+ + [\text{Co}(\text{NO}_2)_6]^{3-} \longrightarrow (\text{NH}_4)_3[\text{Co}(\text{NO}_2)_6] \downarrow$  (yellow)  
 (B) Ammonium and alkali metal carbonates are water soluble.  
 (C)  $\text{Fe}^{3+} + \text{OH}^- \longrightarrow \text{Fe}(\text{OH})_3 \downarrow$  (reddish - brown)  
 (D)  $\text{Ba}^{2+} + \text{SO}_4^{2-} \longrightarrow \text{BaSO}_4 \downarrow$  (white)

### Comprehension (Q.10 to Q.12)



Salt (A) on heating gives a colourless neutral gas which supports combustion.

From the aforesaid, flow diagram, answer the following questions.





10. The compound (A) contains the following acid radical.

- (A)  $\text{NO}_2^-$  (B)  $\text{NO}_3^-$  (C)  $\text{Br}^-$  (D)  $\text{SO}_3^{2-}$

Ans. (B)

Sol.  $\text{NO}_3^-$  and  $\text{NO}_2^-$  both give brown ring test and reduction of  $\text{NO}_3^-$  and  $\text{NO}_2^-$  both give ammonia which with dilute HCl gives dense white fumes.

if  $\text{NH}_4\text{NO}_3 \xrightarrow{\Delta} \text{N}_2\text{O} + 2\text{H}_2\text{O}$ ;  $\text{N}_2\text{O}$  supports the combustion

but  $\text{NH}_4\text{NO}_2 \xrightarrow{\Delta} \text{N}_2 + 2\text{H}_2\text{O}$ ; Nitrogen does not support combustion.

Hence, the anion is  $\text{NO}_3^-$ .

11. The basic radical of salt (A) and gas B both give brown precipitate with Nessler's reagent. The composition of the brown precipitate is :

- (A)  $(\text{NH}_4)_2[\text{HgI}_4]$  (B)  $\text{Hg}(\text{NH}_2)\text{NO}_3$  (C)  $\text{HgO} \cdot \text{Hg}(\text{NH}_2)\text{I}$  (D)  $(\text{NH}_4)_3[\text{Co}(\text{NO}_2)_6]$

Ans. (C)

Sol.  $\text{NH}_4^+ + 2[\text{HgI}_4]^{2-} + 4\text{OH}^- \longrightarrow \text{HgO} \cdot \text{Hg}(\text{NH}_2)\text{I} \downarrow + 7\text{I}^- + 3\text{H}_2\text{O}$

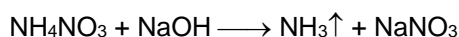
12. Which of the following statement is correct ?

- (A) Salt (A) gives yellow precipitate with chloroplatinic acid as well as with sodium cobaltinitrite.  
 (B) The brown ring is formed due to the formation of nitroso ferrous sulphate  $[\text{Fe}(\text{NO})]^{2+}\text{SO}_4^{2-}$ .  
 (C) Salt 'C' reacts with silver nitrate solution to form white precipitate.  
 (D) (A) and (B) both.

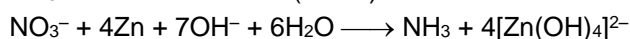
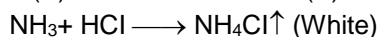
Ans. (D)

Sol. (A)  $2\text{NH}_4^+ + [\text{PtCl}_6]^{2-} \longrightarrow (\text{NH}_4)_2[\text{PtCl}_6] \downarrow$  (yellow)  
 $3\text{NH}_4^+ + [\text{Co}(\text{NO}_2)_6]^{3-} \longrightarrow (\text{NH}_4)_3[\text{Co}(\text{NO}_2)_6] \downarrow$  (yellow)  
 (B)  $2\text{NO}_3^- + 4\text{H}_2\text{SO}_4 + 6\text{Fe}^{2+} \longrightarrow 6\text{Fe}^{3+} + 2\text{NO} \uparrow + 4\text{SO}_4^{2-} + 4\text{H}_2\text{O}$   
 $\text{SO}_4^{2-} + \text{Fe}^{2+} + \text{NO} \longrightarrow [\text{Fe}(\text{NO})]^{2+} \text{SO}_4^{2-}$   
 (C)  $\text{AgNO}_3 + \text{NaNO}_3 \longrightarrow$  No reaction.  
 If the anion is  $\text{NO}_2^-$  then  $\text{Ag}^+ + \text{NO}_2^- \longrightarrow \text{AgNO}_2 \downarrow$  (white)

#### Reactions :



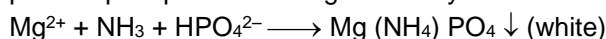
(A) (B) (C)



#### True/False :

13. Magnesium is precipitated from its salt solution as only magnesium ammonium phosphate by adding disodium hydrogen phosphate solution in absence of ammonium chloride and aqueous ammonia.

Sol. (False) Precipitation is carried out in presence of ammonium chloride and aqueous ammonia as they prevent precipitation of magnesium hydroxide.

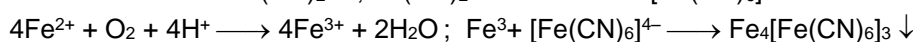


14. When a solution of nitrite acidified with dilute hydrochloric acid is treated with solid urea, the nitrite is decomposed, and nitrogen and carbon dioxide are evolved.

Sol. (True)  $\text{CO}(\text{NH}_2)_2 + \text{HNO}_2 \longrightarrow 2\text{N}_2 \uparrow + \text{CO}_2 \uparrow + 3\text{H}_2\text{O}$ .

15. Solution of alkali metal cyanide containing freshly prepared iron (II) sulphate solution and dilute  $\text{H}_2\text{SO}_4$  on exposure to air produces prussian blue precipitate

Sol. (True)  $\text{Fe}^{2+} + 2\text{CN}^- \longrightarrow \text{Fe}(\text{CN})_2 \downarrow$ ;  $\text{Fe}(\text{CN})_2 \downarrow + 4\text{CN}^- \longrightarrow [\text{Fe}(\text{CN})_6]^{4-}$

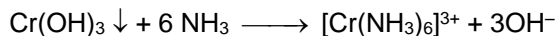


**Subjective :**

16. What happens when ?

- (A) Aqueous solution of  $\text{CrCl}_3$  is added to ammonia solution.  
 (B) Ammonium carbonates reacts with  $\text{MgCl}_2$  (i) in absence of ammonium salts and (ii) in presence of ammonium salts :

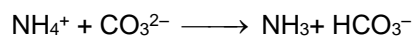
**Sol.** (A)  $\text{Cr}^{3+} + 3\text{NH}_3 + 3\text{H}_2\text{O} \longrightarrow \text{Cr(OH)}_3 \downarrow (\text{green}) + 3\text{NH}_4^+$   
 $\text{Cr(OH)}_3$  precipitate formed becomes slightly soluble in excess of precipitant in cold forming a violet or pink solution containing  $[\text{Cr(NH}_3)_6]^{3+}$  complex ions.



(B) (i)  $5\text{Mg}^{2+} + 6\text{CO}_3^{2-} + 7\text{H}_2\text{O} \longrightarrow 4\text{MgCO}_3 \cdot \text{Mg(OH)}_2 \cdot 5\text{H}_2\text{O} \downarrow + 2\text{HCO}_3^-$

White precipitate of basic magnesium carbonate is formed.

(ii) In presence of ammonium salts no precipitation occurs, because the equilibrium



is shifted towards the formation of  $\text{HCO}_3^-$  ions.

17. Salts given in column (I) reacts with the excess of reagents given in column (II) and form white /coloured precipitates. Select the correct options for the salts given in column (I) with the reagent(s) given in the column (II)

	Column-I		Column-II
(A)	$\text{Zn(NO}_3)_2$	(p)	Sodium hydroxide
(B)	$\text{Cu(NO}_3)_2$	(q)	Ammonia solution
(C)	$\text{Fe(NO}_3)_3$	(r)	Disodium hydrogen phosphate
(D)	$\text{Ag(NO}_3)_2$	(s)	Potassium ferrocyanide

**Ans.** (A - r, s) ; (B - p, r, s) ; (C - p, q, r) ; (D - p, q, r, s)

**Sol.** (A)  $\text{Zn}^{2+} + 2\text{OH}^- \longrightarrow \text{Zn(OH)}_2 \downarrow (\text{white})$  ;  
 $\text{Zn(OH)}_2 + 2\text{OH}^- \longrightarrow [\text{Zn(OH)}_4]^{2-}$  (colourless soluble complex)  
 $\text{Zn}^{2+} + 2\text{NH}_3 + 2\text{H}_2\text{O} \longrightarrow \text{Zn(OH)}_2 \downarrow (\text{white}) + 2\text{NH}_4^+$   
 $\text{Zn(OH)}_2 \downarrow + 4\text{NH}_3 \longrightarrow [\text{Zn(NH}_3)_4]^{2+}$  (colour less soluble complex) +  $2\text{OH}^-$   
 $3\text{Zn}^{2+} + 2\text{HPO}_4^{2-} \longrightarrow \text{Zn}_3(\text{PO}_4)_2 \downarrow (\text{white}) + 2\text{H}^+$   
 $3\text{Zn}^{2+} + 2\text{K}^+ + 2[\text{Fe(CN)}_6]^{4-} \longrightarrow \text{K}_2\text{Zn}_3[\text{Fe(CN)}_6]_2 \downarrow (\text{bluish white})$

(B)  $\text{Cu}^{2+} + 2\text{OH}^- \longrightarrow \text{Cu(OH)}_2 \downarrow (\text{blue})$   
 $\text{Cu}^{2+} + 4\text{NH}_3 \longrightarrow [\text{Cu(NH}_3)_4]^{2+}$  (deep blue soluble complex)  
 $\text{Cu}^{2+} + 2\text{HPO}_4^{2-} \longrightarrow \text{Cu}_3(\text{PO}_4)_2 \downarrow (\text{blue}) + 2\text{H}^+$   
 $\text{Cu}^{2+} + [\text{Fe(CN)}_6]^{4-} \longrightarrow \text{Cu}_2[\text{Fe(CN)}_6] \downarrow (\text{chocolate brown})$

(C)  $\text{Fe}^{3+} + 3\text{OH}^- \longrightarrow \text{Fe(OH)}_3 \downarrow (\text{reddish brown})$   
 $\text{Fe}^{3+} + 3\text{NH}_3 + 3\text{H}_2\text{O} \longrightarrow \text{Fe(OH)}_3 \downarrow (\text{reddish brown}) + 3\text{NH}_4^+$   
 $\text{Fe}^{3+} + \text{HPO}_4^{2-} \longrightarrow \text{FePO}_4 \downarrow (\text{yellowish-white}) + \text{H}^+$   
 $4\text{Fe}^{3+} + 3[\text{Fe(CN)}_6]^{4-} \longrightarrow \text{Fe}_4[\text{Fe(CN)}_6]_3 \downarrow (\text{intense blue}) \xrightarrow[\text{K}_4[\text{Fe(CN)}_6]]{\text{excess}} \text{KFe}^{\text{III}}[\text{Fe(CN)}_6]^{\text{II}}$   
 (soluble prussian blue)

(D)  $2\text{Ag}^+ + 2\text{OH}^- \longrightarrow \text{Ag}_2\text{O} \downarrow (\text{brown}) + \text{H}_2\text{O}$   
 $2\text{Ag}^+ + 2\text{NH}_3 + \text{H}_2\text{O} \longrightarrow \text{Ag}_2\text{O} \downarrow (\text{brown}) + 2\text{NH}_4^+$   
 $4\text{Ag}^+ + \text{HPO}_4^{2-} \longrightarrow \text{Ag}_3\text{PO}_4 \downarrow (\text{yellow}) + \text{H}^+$   
 $4\text{Ag}^+ + 3[\text{Fe(CN)}_6]^{4-} \longrightarrow \text{Ag}_4[\text{Fe(CN)}_6] \downarrow (\text{white})$





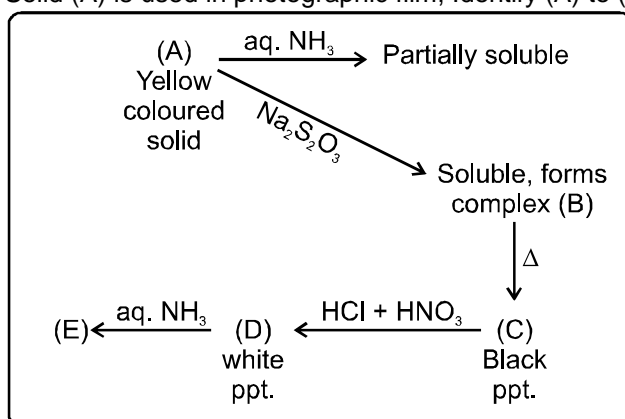
## Exercise-1

Marked questions are recommended for Revision.

### PART - I : SUBJECTIVE QUESTIONS

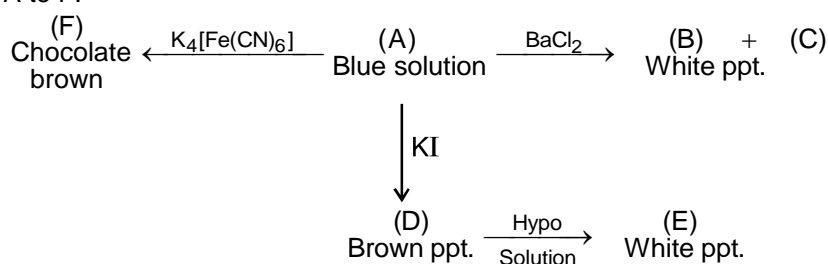
#### Section (A) : I<sup>st</sup> Group

- A-1. Name of one chloride which is soluble in hot water as well as in excess of HCl.
- A-2. Why do lead salts turn black on keeping for a long time in the laboratory ?
- A-3. A metal salt forms a yellow precipitate (P) with potassium iodide solution and black precipitate (Q) with acidified  $H_2S$ . Yellow precipitate (P) dissolve in excess of concentrated solution of KI and ppt. reappears on dilution. Then metal salt could be and also write the chemical equation.
- A-4. When calomel reacts with ammonia solution, a black precipitate is formed. Write the chemical equation and also name the reaction nature.
- A-5. What products are formed when precipitate formed by the reaction of  $Hg_2^{2+}$  ions and excess of sodium hydroxide solution is boiled ?
- A-6. A metal salt forms a green precipitate with KI solution and white ppt with KCl. This green precipitate under goes disproportionation reaction in excess of reagent which results in a soluble compound and black precipitate then write the chemical equations and identify the cation in the original sample.
- A-7. Why bright yellow precipitate of AgI is soluble in KCN and  $Na_2S_2O_3$  solution.
- A-8. Solid (A) is used in photographic film, Identify (A) to (E) ?



#### Section (B) : II A Group

- B-1. Why  $Na_2S$  cannot be used in place of  $H_2S$  (in presence of HCl) as a reagent for II<sup>nd</sup> group cations ?
- B-2. Does sodium hydroxide solution can be used to differentiate Hg(I) from Hg(II) ?
- B-3. What happens when white precipitate of  $Bi(OH)_3$  is boiled ?
- B-4. Identify A to F.





### Section (C) : IIB Group

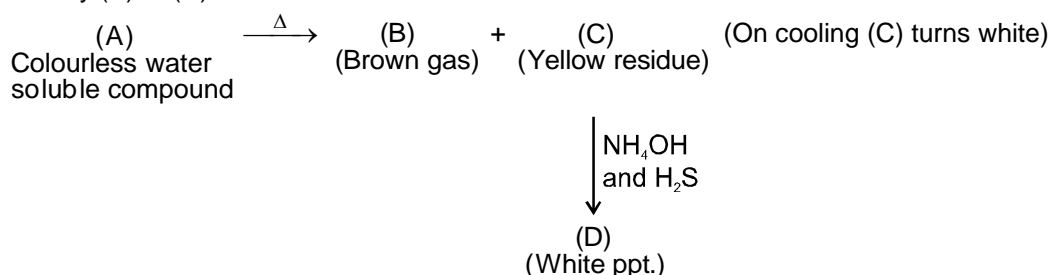
- C-1.** An original solution is prepared in conc. HCl when diluted a white ppt. is formed. What does it indicate ?
- C-2.** Why  $\text{HNO}_3$  can not be used in place of HCl as a reagent ( $\text{H}_2\text{S}$  in presence of HCl) for II<sup>nd</sup> group cations?
- C-3.** A chloride of an element (X) forms yellow precipitate with  $\text{H}_2\text{S}$  in acidic medium. This yellow precipitate is soluble in Conc.  $\text{HNO}_3$  due to formation of compound (Y). Compound (Y) gives ammonium molybdate test then find the metal salt (X).
- C-4.** Identify (A) based on the following facts :
- (A) reduces  $\text{HgCl}_2$  solution to white ppt. changing to grey.
  - (A) turns  $\text{FeCl}_3$  yellow coloured solution to green.
  - (A) gives white ppt. with NaOH soluble in excess of NaOH.
  - (A) gives yellow dirty ppt. on passing  $\text{H}_2\text{S}$  gas, soluble in yellow ammonium sulphide (YAS).
  - (A) gives chromyl chloride test.

### Section (D) : III<sup>rd</sup> Group

- D-1.** Why is the original solution boiled with conc.  $\text{HNO}_3$  in group III ?
- D-2.** Do Fe(III) salts and Fe(II) salts both give red colouration with dimethylglyoxime in ammonical solution. If not then which iron salt gives red colouration with dimethylglyoxime ?
- D-3.** Which colour precipitate is formed by Fe(II) salt with potassium ferrocyanide, (i) in complete absence of air and (ii) under ordinary atmospheric conditions ?

### Section (E) : IV<sup>th</sup> Group

- E-1.** Partial precipitation of  $\text{Mn}^{2+}$  as  $\text{Mn}(\text{OH})_2$  occurs with ammonia solution but the precipitate is soluble in ammonium salts. Explain ?
- E-2.** Why Zn(II) salt is not precipitated as  $\text{Zn}(\text{OH})_2$  by ammonia solution in the presence of excess of ammonium chloride ?
- E-3.** In the absence of copper ion, zinc ion form a white precipitate with the ammonium tetrathio-cyanatomercurate(II) How the presence of  $\text{Cu}^{2+}$  ion affect this test ?
- E-4.** Identify (A) to (D).



### Section (F) : V<sup>th</sup>, VI<sup>th</sup> and Zero Group

- F-1.** What is the formula of iodide of Millon's base ?
- F-2.** What happens when ammonia gas is passed into a solution of sodium cobaltinitrite ?
- F-3.** What will happen if the precipitation of V<sup>th</sup> group cation by ammonium carbonate is replaced by  $\text{Na}_2\text{CO}_3$ ?
- F-4.** What happens when ammonium sulphate solution is added to a solution containing both  $\text{Sr}^{2+}$  and  $\text{Ca}^{2+}$  ions?
- F-5.** Which colour precipitate is obtained when a solution of  $\text{Ca}^{2+}$  ions reacts with potassium ferrocyanide.



## PART - II : ONLY ONE OPTION CORRECT TYPE

### Section (A) : I<sup>st</sup> Group

- A-1.** A metal nitrate reacts with KI solution to give yellow precipitate which on addition of excess of more concentrated solution (6 M) of KI dissolves forming a solution. The cation of metal nitrate is :  
 (A)  $\text{Hg}_2^{2+}$  (B)  $\text{Ag}^+$  (C)  $\text{Pb}^{2+}$  (D)  $\text{Cu}^{2+}$
- A-2.** Three separate samples of a solution of a single salt gave these results. One formed a white precipitate with excess ammonia solution, one formed a white precipitate with dilute NaCl solution and one formed a black precipitate with  $\text{H}_2\text{S}$ . The salt could be :  
 (A)  $\text{AgNO}_3$  (B)  $\text{Pb}(\text{NO}_3)_2$  (C)  $\text{Hg}(\text{NO}_3)_2$  (D)  $\text{Mn}(\text{NO}_3)_2$
- A-3.** Consider the following observation :  
 $\text{M}^{n+} + \text{HCl (dilute)} \longrightarrow \text{white precipitate} \xrightarrow{\Delta} \text{water soluble} \xrightarrow{\text{CrO}_4^{2-}} \text{yellow precipitate}.$   
 The metal ion  $\text{M}^{n+}$  will be :  
 (A)  $\text{Hg}_2^{2+}$  (B)  $\text{Ag}^+$  (C)  $\text{Pb}^{2+}$  (D)  $\text{Sn}^{2+}$
- A-4.** When calomel reacts with  $\text{NH}_4\text{OH}$  solution the compound formed is :  
 (A)  $\text{Hg}_2\text{Cl}_2$  (B)  $\text{Hg}(\text{NH}_2)\text{Cl}$  (C)  $\text{Hg}(\text{NH}_3)_2\text{Cl}$  (D)  $\text{HgCl}_2 \cdot \text{NH}_3$
- A-5.** Consider the following equilibrium :  
 $\text{AgCl} \downarrow + 2\text{NH}_3 \rightleftharpoons [\text{Ag}(\text{NH}_3)_2]^+ + \text{Cl}^-$   
 White ppt of  $\text{AgCl}$  appears on adding  
 (A)  $\text{NH}_3$  (B) aq.  $\text{NaBr}$  (C) aq.  $\text{HNO}_3$  (D) aq.  $\text{NH}_4\text{I}$
- A-6.**  $\text{AgCl}$  with  $\text{NH}_3$  forms a complex :  
 (A)  $[\text{Ag}(\text{NH}_3)_2]\text{Cl}$  (B)  $\text{AgNO}_3$  (C)  $[\text{Ag}(\text{NH}_2)_2]\text{Cl}$  (D)  $\text{Ag mirror}$

### Section (B) : IIA Group

- B-1.** Sometimes yellow turbidity appears while passing  $\text{H}_2\text{S}$  gas even in slightly acidic medium in the absence of II group radicals. This is because :  
 (A) sulphur is present in the mixture as impurity.  
 (B) IV group radicals are precipitated as sulphides.  
 (C) of the oxidation of  $\text{H}_2\text{S}$  gas by some acid radicals.  
 (D) III group radicals are precipitated as hydroxides.
- B-2.**  $\text{H}_2\text{S}$  in the presence of  $\text{HCl}$  precipitates II group but not IV group because :  
 (A)  $\text{HCl}$  activates  $\text{H}_2\text{S}$   
 (B)  $\text{HCl}$  increases concentration of  $\text{Cl}^-$   
 (C)  $\text{HCl}$  decreases concentration of  $\text{S}^{2-}$   
 (D)  $\text{HCl}$  lowers the solubility of  $\text{H}_2\text{S}$  in solution
- B-3.** When small amount of  $\text{SnCl}_2$  is added to a solution of  $\text{Hg}^{2+}$  ions, a silky white precipitate is obtained. The silky white precipitate is due to the formation of :  
 (A)  $\text{Hg}_2\text{Cl}_2$  (B)  $\text{SnCl}_4$  (C)  $\text{Sn}$  (D)  $\text{Hg}$
- B-4.** When excess of dilute  $\text{NH}_4\text{OH}$  is added to an aqueous solution of copper sulphate an intense blue colour is developed. This is due to the formation of :  
 (A)  $[\text{Cu}(\text{NH}_3)_6]^{2+}$  (B)  $\text{Cu}(\text{OH})_2$  (C)  $[\text{Cu}(\text{NH}_3)_4]^{2+}$  (D)  $(\text{NH}_4)_2\text{SO}_4$
- B-5.** A black sulphide is formed by the action of  $\text{H}_2\text{S}$  on :  
 (A) cupric chloride (B) cadmium chloride (C) zinc chloride (D) ferric chloride.
- B-6.** Which one of the following salts will produce clear and transparent original solution in 2M  $\text{HCl}$  ?  
 (A)  $\text{Ag}_2\text{CO}_3$  (B)  $\text{Pb}(\text{CO}_3)$  (C)  $\text{Hg}_2\text{CO}_3$  (D)  $\text{CuCO}_3$
- B-7.** When bismuth chloride is poured into a large volume of water the white precipitate produced is of :  
 (A)  $\text{BiO} \cdot \text{OH}$  (B)  $\text{Bi}_2\text{O}_3$  (C)  $\text{BiOCl}$  (D)  $\text{Bi}(\text{OH})_3$
- B-8.** In which of the following pairs the precipitates are red and black coloured respectively and both precipitates are soluble in excess KI solution ?  
 (A)  $\text{HgI}_2, \text{Hg}_2\text{I}_2$  (B)  $\text{HgI}_2, \text{BiI}_3$  (C)  $\text{Cu}_2\text{I}_2, \text{AgI}$  (D)  $\text{CdI}_2, \text{PbI}_2$



- B-9.** A metal chloride original solution (i.e. O.S) on mixing with  $K_2CrO_4$  solution gives a yellow precipitate soluble in aqueous sodium hydroxide. The metal may be :  
 (A) mercury (B) iron (C) silver (D) lead

### Section (C) : IIB Group

- C-1.** Which of the following metal sulphide is soluble in YAS (yellow ammonium sulphide) :  
 (A) HgS (B) PbS (C)  $Bi_2S_3$  (D)  $Sb_2S_3$
- C-2.** When white crystalline precipitate of magnesium ammonium arsenate is treated with acidified silver nitrate solution, precipitate of silver arsenate is formed. The colour of precipitate is :  
 (A) Yellow (B) Brownish red (C) White (D) Brownish black

### Section (D) : III<sup>rd</sup> Group

- D-1.** When  $NH_4Cl$  is added to a solution of  $NH_4OH$  :  
 (A) the dissociation of  $NH_4OH$  increases.  
 (B) the concentration of  $OH^-$  increases.  
 (C) the concentrations of both  $OH^-$  and  $NH_4^+$  increase.  
 (D) the concentration of  $OH^-$  ion decreases.
- D-2.** To avoid the precipitation of Hydroxides of  $Zn^{2+}$ ,  $Mn^{2+}$  and  $Ni^{2+}$  along with those of  $Fe^{3+}$ ,  $Al^{3+}$  and  $Cr^{3+}$  the third group solution should be :  
 (A) Concentrated  $HNO_3$  is added (B) Treated with excess of  $NH_4Cl$   
 (C) Concentrated  $H_2SO_4$  is added (D) Treated with excess of  $NH_4OH$
- D-3.** An inorganic lewis acid (X) fumes in moist air, and intensity of fumes increases when and rod dipped in  $NH_4OH$  is brought near to it. An acidic solution of (X) on addition of  $NH_4Cl$  and  $NH_4OH$  gives a precipitate which dissolves in NaOH solution. A solution of (X) does not give precipitate with  $H_2S$ . Hence, compound (X) is  
 (A)  $FeCl_3$  (B)  $AlCl_3$  (C)  $CrCl_3$  (D)  $ZnCl_2$
- D-4.** An original solution of an inorganic salt in dilute HCl gives a brown colouration with potassium hexacyanidoferrate (III) and reddish brown colouration with sodium acetate solution. The cation of the salt is :  
 (A)  $Ni^{2+}$  (B)  $Fe^{3+}$  (C)  $Cu^{2+}$  (D) none
- D-5.**  $Fe(OH)_3$  and  $Cr(OH)_3$  precipitates can be completely separated by :  
 (A) Aq.  $NH_3$  (B) HCl (C) NaOH/ $H_2O_2$  (D)  $H_2SO_4$

### Section (E) : IV<sup>th</sup> Group

- E-1.** A coloured solution of a salt gives following reactions.  
 (i) It gives white precipitate with sodium hydroxide which becomes brown on exposure to air.  
 (ii) It gives white precipitate with ammonia solution which is soluble in ammonium salts.  
 (A)  $Mn^{2+}$  (B)  $Zn^{2+}$  (C)  $Al^{3+}$  (D)  $Ni^{2+}$
- E-2.** A metal salt form precipitate with  $H_2S$  in presence of ( $NH_4OH + NH_4Cl$ ) and this precipitate is soluble in acetic acid then metal sulphide could be :  
 (A) ZnS (B) CoS (C) MnS (D) NiS
- E-3.** To increase significantly the concentration of free  $Zn^{2+}$  ion in a solution of the complex ion  $[Zn(NH_3)_4]^{2+}$   
 $Zn^{2+}(aq) + 4NH_3(aq) \rightleftharpoons [Zn(NH_3)_4]^{2+}(aq)$   
 add to the solution some :  
 (A)  $H_2O$  (B) HCl (aq) (C)  $NH_3(aq)$  (D)  $NH_4Cl(aq)$
- E-4.** An aqueous solution of colourless metal sulphate M, gives a white precipitate with  $NH_4OH$ . This was soluble in excess of  $NH_4OH$ . On passing  $H_2S$  gas through this solution a white precipitate is formed. The metal M in the salt is :  
 (A) Ca (B) Ba (C) Al (D) Zn
- E-5.** A metal salt solution when treated with dimethyl glyoxime and  $NH_4OH$  gives a rose red complex. The metal is :  
 (A) Ni (B) Zn (C) Co (D) Mn.



- E-6.** The ion that can not be precipitated by  $\text{H}_2\text{S}$  in presence of dil.  $\text{HCl}$ .  
 (A)  $\text{Pb}^{2+}$  (B)  $\text{Bi}^{3+}$  (C)  $\text{Cu}^{2+}$  (D)  $\text{Ni}^{2+}$

### Section (F) : V<sup>th</sup>, VI<sup>th</sup> and Zero Group

- F-1.** Aqueous Solution of  $\text{BaBr}_2$  gives yellow precipitate with :  
 (A)  $\text{K}_2\text{CrO}_4$  (B)  $\text{AgNO}_3$  (C)  $(\text{CH}_3\text{COO})_2\text{Pb}$  (D) (A) and (B) both
- F-2.** The addition of  $\text{K}_2\text{CO}_3$  (aq) to the following solution is expected to produce a precipitate in every case but that one which does not produce precipitate is :  
 (A)  $\text{BaCl}_2$ (aq) (B)  $\text{CaBr}_2$ (aq) (C)  $\text{Na}_2\text{SO}_4$ (aq) (D)  $\text{Pb}(\text{NO}_3)_2$  (aq)
- F-3.** An aqueous solution of salt gives white precipitate with  $\text{AgNO}_3$  solution as well as with dilute  $\text{H}_2\text{SO}_4$ . It may be  
 (A)  $\text{Pb}(\text{NO}_3)_2$  (B)  $\text{Ba}(\text{NO}_3)_2$  (C)  $\text{BaCl}_2$  (D)  $\text{CuCl}_2$
- F-4.**  $\text{Mg}$  is not precipitated in V group because :  
 (A)  $\text{MgCO}_3$  is soluble in water. (B)  $K_{sp}$  of  $\text{MgCO}_3$  is high.  
 (C)  $\text{MgCO}_3$  is soluble in  $\text{NH}_4\text{OH}$ . (D) None.
- F-5.** A metal salt solution form a yellow ppt with potassium chromate in acetic acid, a white ppt with dilute sulphuric acid but gives no ppt with sodium chloride or iodide it is :  
 (A) Lead carbonate (B) Basic lead carbonate  
 (C) Barium nitrate (D) Strontium nitrate
- F-6.** A white crystalline substance dissolves in water. On passing  $\text{H}_2\text{S}$  in this solution, a black precipitate is obtained. The black precipitate dissolves completely in hot  $\text{HNO}_3$ . On adding a few drops of concentrated  $\text{H}_2\text{SO}_4$ , a white precipitate is obtained. This precipitate is that of :  
 (A)  $\text{BaSO}_4$  (B)  $\text{SrSO}_4$  (C)  $\text{PbSO}_4$  (D)  $\text{CdSO}_4$
- F-7.** The yellow precipitate formed by passing ammonia into Nessler's reagent in due to the formation of  
 (A)  $\text{HgI}_4^{2-}$  (B)  $\text{NH}_2\text{O}-\text{Hg}-\text{HgI}$   
 (C)  $\text{NH}_2-\text{Hg}-\text{O}-\text{Hg}-\text{I}$  (D)  $\text{NH}_3-\text{Hg}-\text{I}$

## PART - III : MATCH THE COLUMN

1. Match the precipitates listed in column-I with their suitable solvents listed in column-II.

	Column I		Column II
	(precipitate)		(solvent)
(A)	$\text{AgCl} \downarrow$ (white)	(p)	Concentrated $\text{HCl}$ .
(B)	$\text{CuS} \downarrow$ (black)	(q)	Dilute ammonia solution (excess).
(C)	$\text{Zn}(\text{OH})_2 \downarrow$ (white)	(r)	Potassium cyanide solution.
(D)	$\text{BaCO}_3 \downarrow$ (white)	(s)	Hot 50% nitric acid.
		(t)	Sodium hydroxide solution.

2. Match the basic radicals listed in column-I with the properties listed in column-II.

	Column-I		Column-II
	(Basic radical)		(Properties)
(A)	$\text{Mn}^{2+}$	(p)	Forms coloured metaborate in oxidising flame in borax bead test.
(B)	$\text{Cr}^{3+}$	(q)	Forms white precipitate with sodium hydroxide but on exposure to air turns rapidly brown.
(C)	$\text{Al}^{3+}$	(r)	With both potassium cyanide (not in excess) and ammonia solution separately forms reddish brown precipitate.
(D)	$\text{Fe}^{3+}$	(s)	With excess of sodium hydroxide forms soluble complex but on adding acid to soluble complex, a precipitate is obtained which redissolves on adding excess of acid.



## Exercise-2

Marked questions are recommended for Revision.

### PART - I : ONLY ONE OPTION CORRECT TYPE

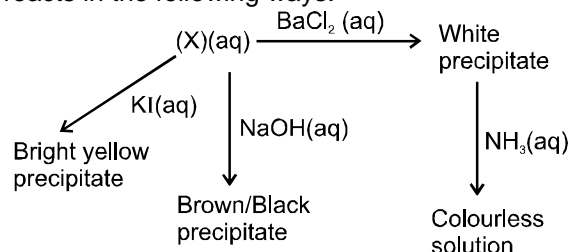
- Which of the following compound does not gives ppt with dil. HCl ?  
(A)  $\text{AgNO}_3$  (B)  $\text{Pb}(\text{NO}_3)_2$  (C)  $\text{Hg}_2(\text{NO}_3)_2$  (D)  $\text{Hg}(\text{NO}_3)_2$
- KI gives precipitate with all the cations given :  
(A)  $\text{Ag}^+$ ,  $\text{Hg}_2^{2+}$ ,  $\text{Pb}^{2+}$  (B)  $\text{Cu}^{2+}$ ,  $\text{Zn}^{2+}$ ,  $\text{Ni}^{2+}$  (C)  $\text{Na}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$  (D)  $\text{Ag}^+$ ,  $\text{Ca}^{2+}$ ,  $\text{Sr}^{2+}$
- Three test tubes A, B, C cation  $\text{Pb}^{2+}$ ,  $\text{Hg}_2^{2+}$  and  $\text{Ag}^+$  (but unknown to each, aqueous solution NaOH is added in excess). Following changes occur.  
A : Black ppt, B : Brown ppt, which dissolve in  $\text{NH}_3$ , C : White ppt but dissolves in excess of NaOH  
A, B and C contain respectively :  
(A)  $\text{Pb}^{2+}$ ,  $\text{Hg}_2^{2+}$ ,  $\text{Ag}^+$  (B)  $\text{Hg}_2^{2+}$ ,  $\text{Ag}^+$ ,  $\text{Pb}^{2+}$   
(C)  $\text{Ag}^+$ ,  $\text{Pb}^{2+}$ ,  $\text{Hg}_2^{2+}$  (D)  $\text{Ag}^+$ ,  $\text{Hg}_2^{2+}$ ,  $\text{Pb}^{2+}$

- Salt mixture  $\xrightarrow{\text{dil. HCl}}$  white ppt.  $\xrightarrow{\text{Heated and filtered under hot condition}}$  Filtrate  $\xrightarrow{\text{Cooled}}$  white needle like crystal

Residue  $\xrightarrow{\text{NH}_3 \text{ Sol.}}$  Clear solution

salt mixture contains cations of :  
(A)  $\text{Pb}^{2+}$  and  $\text{Hg}^{2+}$  (B)  $\text{Pb}^{2+}$  and  $\text{Hg}_2^{2+}$  (C)  $\text{Pb}^{2+}$  and  $\text{Ag}^+$  (D) None of these

- A compound (X) reacts in the following ways.



The compound (X) is likely to be

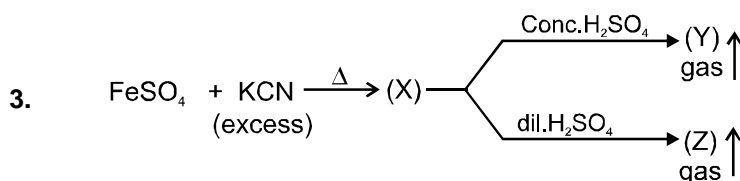
- (A)  $\text{Pb}(\text{NO}_3)_2$  (B)  $\text{CaCrO}_4$  (C)  $\text{Hg}(\text{NO}_3)_2$  (D)  $\text{AgNO}_3$
- When excess of  $\text{SnCl}_2$  is added to a solution of  $\text{HgCl}_2$ , a white ppt turning grey is obtained. The grey colour is due to the formation of :  
(A)  $\text{Hg}_2\text{Cl}_2$  (B)  $\text{SnCl}_2$  (C) Sn (D) Hg
  - An aqueous solution of a substance gives a white ppt. on treatment with dil HCl, which dissolves on heating. When hydrogen sulphide is passed through the hot acidic solution, a black ppt is obtained. The substance is a:  
(A)  $\text{Hg}^{2+}$  salt (B)  $\text{Cu}^{2+}$  salt (C)  $\text{Ag}^+$  salt (D)  $\text{Pb}^{2+}$  salt
  - Three separate sample of a solution of a single salt gave these results one formed a white precipitate with excess of ammonia solution, one formed a white precipitate with dil. NaCl solution and one formed a black precipitate with  $\text{H}_2\text{S}$ . The salt could be :  
(A)  $\text{AgNO}_3$  (B)  $\text{Pb}(\text{NO}_3)_2$  (C)  $\text{Hg}(\text{NO}_3)_2$  (D)  $\text{MnSO}_4$
  - A pale green crystalline metal salt of M dissolves freely in water. On standing it gives a brown ppt on addition of aqueous NaOH. The metal salt solution also gives a black ppt on bubbling  $\text{H}_2\text{S}$  in basic medium. An aqueous solution of the metal salt decolourizes the pink colour of the permanganate solution. The metal in the metal salt solution is :  
(A) copper (B) aluminum (C) lead (D) iron



10.  $K_4[Fe(CN)_6]$  can be used to precipitate one or more out of  $Fe^{2+}$ ,  $Fe^{3+}$ ,  $Zn^{2+}$ ,  $Cu^{2+}$ ,  $Ca^{2+}$  :  
 (A) only  $Fe^{2+}$ ,  $Fe^{3+}$  (B) only  $Fe^{3+}$ ,  $Zn^{2+}$ ,  $Cu^{2+}$  (C) all but not  $Ca^{2+}$  (D) all of these.
11. Ferric alum gives deep red colour with  $NH_4SCN$  due to the formation of :  
 (A)  $Al(SCN)_3$  (B)  $[Fe(SCN)_3]^-$  (C)  $Fe(SCN)_3$  (D) None of these.
12. Nessler's reagent is used to detect.  
 (A)  $CrO_4^{2-}$  (B)  $PO_4^{3-}$  (C)  $MnO_4^-$  (D)  $NH_4^+$
13. On the addition of a solution containing  $CrO_4^{2-}$  &  $CH_3COOH$  acid to the solution of  $Ba^{2+}$ ,  $Sr^{2+}$  and  $Ca^{2+}$  ions, the ppt obtained first will be of :  
 (A)  $CaCrO_4$  (B)  $SrCrO_4$  (C)  $BaCrO_4$  (D) a mixture of all the three
14. A salt on treatment with dil. HCl gives a pungent smelling gas and a yellow precipitate. The salt gives green flame when tested. The solution gives a yellow precipitate with potassium chromate. The salt is :  
 (A)  $NiSO_4$  (B)  $BaS_2O_3$  (C)  $PbS_2O_3$  (D)  $CuSO_4$
15. A chloride dissolves appreciably in cold water. When placed on a platinum wire in Bunsen flame, no distinctive colour is noticed. The cation of chloride is :  
 (A)  $Mg^{2+}$  (B)  $Ba^{2+}$  (C)  $Pb^{2+}$  (D)  $Ca^{2+}$
16. In fifth group,  $(NH_4)_2CO_3$  is added to precipitate out the carbonates. We do not add  $Na_2CO_3$  because :  
 (A)  $CaCO_3$  is soluble in  $Na_2CO_3$   
 (B)  $Na_2CO_3$  increases the solubility of fifth group carbonates  
 (C)  $MgCO_3$  will be precipitated out in fifth group  
 (D) none
17. A metal salt solution forms a yellow precipitate with potassium chromate in acetic acid, a white precipitate with dilute sulphuric acid, but gives no precipitate with sodium chloride or iodide, it is :  
 (A) lead salt (B) silver salt (C) barium salt (D) strontium salt

## PART - II : SINGLE AND DOUBLE VALUE INTEGER TYPE

1. An aqueous solution contains  $Hg^{2+}$ ,  $Hg_2^{2+}$ ,  $Pb^{2+}$ ,  $Ag^+$ ,  $Bi^{3+}$  and  $Cd^{2+}$ . Out of these, how many ions will produce white precipitate with dilute HCl ?
2. A solution of  $Hg^{2+}$  ion on treatment with a solution of cobalt(II) thiocyanate gives rise to a deep blue crystalline precipitate. Then the coordination number of mercury in the deep blue coloured compound is:



The sum of number of  $p\pi-p\pi$  bonds present in gas (Y) & (Z) ?

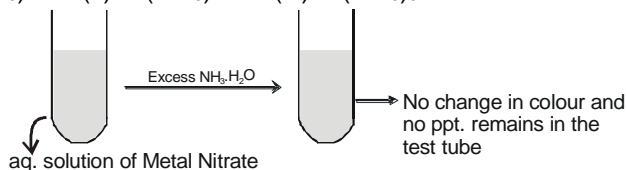
4. An alcoholic solution of dimethylglyoxime is added to an aqueous solution of nickel(II) chloride. Slow addition of ammonium hydroxide led to the precipitation of a bright-red coloured metal complex. Find out the number of hydrogen bonds present in the structure of the complex.
5. In how many of the following reactions, one of the product is obtained as a yellow precipitate :  
 (a)  $Ba^{2+} + CrO_4^{2-} \longrightarrow$  product  
 (b)  $NH_4^+ + [PtCl_6]^{2-} \longrightarrow$  product  
 (c)  $NH_4^+ + [Co(NO_2)_6]^{3-} \longrightarrow$  product  
 (d)  $Ca^{2+} + [Fe(CN)_6]^{4-} + K^+ \longrightarrow$  product  
 (e)  $Sr^{2+} + CO_3^{2-} \longrightarrow$  product





6. Total number of metal nitrates given below, which give the following reaction,

- (i)  $\text{AgNO}_3$       (ii)  $\text{Pb}(\text{NO}_3)_2$       (iii)  $\text{Cu}(\text{NO}_3)_2$       (iv)  $\text{Cd}(\text{NO}_3)_2$   
 (v)  $\text{Zn}(\text{NO}_3)_2$       (v)  $\text{Ni}(\text{NO}_3)_2$       (vi)  $\text{Al}(\text{NO}_3)_3$



7. Aqueous  $\text{CuSO}_4$  decolorizes on addition of excess KCN due to formation of complex (A).

In complex "A". If

- (i) Number of d orbitals participating in hybridisation is / are 'a'  
 (ii) Coordination number of Cu is "c".

then find  $8a + 5c$ .

8.  $\text{Co}^{2+} + \text{CN}^- \longrightarrow$  "A" (reddish brown) ppt.

"A" +  $\text{CN}^-$  (excess)  $\longrightarrow$  "B" (brown solution)

"B" +  $\text{O}_2 + 2\text{H}_2\text{O} \longrightarrow$  "C" (yellow solution)

then find (a + b) for complex "C" if

a = coordination number of Co

b = charge on complex (consider the magnitude)

9. How many of the following reactions give yellow ppt.

- (i)  $\text{NaBr} + \text{AgNO}_3 \longrightarrow$       (ii)  $\text{NaI} + \text{AgNO}_3 \longrightarrow$   
 (iii)  $\text{NaBr} + \text{Pb}(\text{NO}_3)_2 \longrightarrow$       (iv)  $\text{NaI} + \text{Pb}(\text{NO}_3)_2 \longrightarrow$   
 (v)  $\text{Na}_2\text{S} + \text{Cd}(\text{CH}_3\text{COO})_2 \longrightarrow$       (vi)  $\text{K}_2\text{CrO}_4 + \text{Pb}(\text{CH}_3\text{COO})_2 \longrightarrow$   
 (vii)  $\text{K}_2\text{CrO}_4 + \text{AgNO}_3 \longrightarrow$       (viii)  $\text{NaBr} + \text{Chlorine water (excess)} \longrightarrow$

### PART - III : ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

1. Which of the following is/are correctly matched ?

- (A)  $\text{BiI}_3 \downarrow \longrightarrow$  Black precipitate      (B)  $\text{CuI} \downarrow \longrightarrow$  White precipitate  
 (C)  $\text{PbI}_2 \downarrow \longrightarrow$  Yellow precipitate      (D)  $\text{HgI}_2 \downarrow \longrightarrow$  Red precipitate

2. Which of the following are completely soluble in concentrated ammonia solution?

- (A)  $\text{AgCl}$       (B)  $\text{AgBr}$       (C)  $\text{Ag}_2\text{CrO}_4$       (D)  $\text{AgI}$

3.  $\text{Hg}_2\text{I}_2 \downarrow$  (green)  $\xrightarrow[\text{with } \text{H}_2\text{O}]{\text{boiled}}$  products

Which of the following statement is / are correct with respect to the products ?

- (A) Black precipitate of mercury(I) oxide is formed.  
 (B) Violet colour gas is evolved.  
 (C) Red precipitate of  $\text{HgI}_2$  is formed.  
 (D) Mercury is obtained

4. Which of the following cations form coloured (not white) precipitates with aqueous solution of KI and this precipitate does not dissolve in excess of reagent ?

- (A)  $\text{Hg}^{2+}$       (B)  $\text{Hg}_2^{2+}$       (C)  $\text{Ag}^+$       (D)  $\text{Cu}^{2+}$

5. Which of the following statements is/are true ?

- (A)  $\text{Ag}^+$  ions do not give white precipitate with excess of concentrated HCl.  
 (B)  $\text{Cu}^{2+}$  ions produce a white precipitate when KCN solution is added in a small quantity, and allowed to stand.  
 (C)  $\text{Hg}^{2+}$  ions give deep blue precipitate with cobalt acetate and ammonium thiocyanate.  
 (D) Black precipitate of  $\text{BiI}_3$  turns orange when heated with water.





6. KI solution is the reagent for the analysis of :  
 (A)  $\text{Hg}^{2+}$  (B)  $\text{Pb}^{2+}$  (C)  $\text{Ag}^+$  (D)  $\text{Cu}^{2+}$
7. Which of the following metal sulphide are in brown/black in colour ?  
 (A)  $\text{HgS}$  (B)  $\text{PbS}$  (C)  $\text{Bi}_2\text{S}_3$  (D)  $\text{Sb}_2\text{S}_3$
8. Which of the following cations form(s) black precipitate(s) with  $\text{H}_2\text{S}$  (g) ?  
 (A)  $\text{Cu}^{2+}$  (B)  $\text{Sb}^{3+}$  (C)  $\text{Pb}^{2+}$  (D)  $\text{Bi}^{3+}$
9. Which of the following mixture of cations can be separated by adding excess  $\text{NH}_3$  solution ?  
 (A)  $\text{Zn}^{2+}$ ,  $\text{Mn}^{2+}$  (B)  $\text{Zn}^{2+}$ ,  $\text{Cd}^{2+}$  (C)  $\text{Zn}^{2+}$ ,  $\text{Pb}^{2+}$  (D)  $\text{Zn}^{2+}$ ,  $\text{Cu}^{2+}$
10.  $\text{CoCl}_2 + \text{KNO}_2 + \text{CH}_3\text{COOH} \longrightarrow [\text{X}] + \text{H}_2\text{O} + \text{KCl} + \text{CH}_3\text{COOK} + \text{NO}$   
 (Unbalanced equation)  
 Which is / are correct for 'X' ?  
 (A) X is a yellow crystalline solid which is insoluble in water.  
 (B) X is a green coloured compounds known as Rinman's green.  
 (C) IUPAC name of X is potassium hexanitrito -N- cobaltate (II)  
 (D) The compound X is an inner orbital complex.
11. Which of the following is/are correct for potassium ferrocyanide ?  
 (A) It gives a brown precipitate with  $\text{Cu}^{2+}$  ions.  
 (B) It gives a white precipitate of mixed salt with  $\text{Ca}^{2+}$  ions.  
 (C) It in excess gives a bluish white/white precipitate with  $\text{Zn}^{2+}$ .  
 (D) It develops a deep red colouration with  $\text{Fe}^{3+}$ .

## PART - IV : COMPREHENSION

Read the following passage carefully and answer the questions.

### Comprehension # 1

Aqueous solution of 'A'  $\xrightarrow{\text{H}_2\text{S (g)}}$  Black precipitate 'B', soluble in 50%  $\text{HNO}_3$  forming 'C'.

$\downarrow$   
 $\text{NH}_3$  solution

White precipitate dissolves in hydrochloric acid but on dilution with water again white turbidity appears 'E'.

$\downarrow$   
 Alkaline  $\text{Na}_2\text{SnO}_2$

Black precipitate 'D'

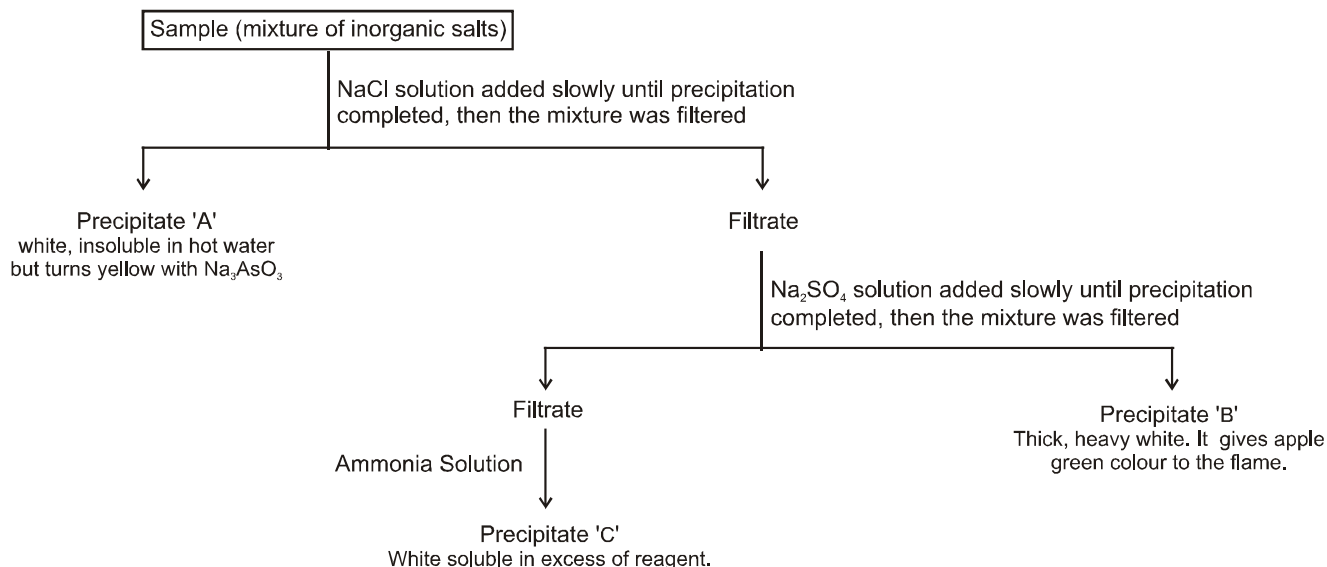
Moreover, the salt 'A' on heating with solid  $\text{K}_2\text{Cr}_2\text{O}_7$  and concentrated  $\text{H}_2\text{SO}_4$  produces deep red vapours which dissolve in sodium hydroxide solution forming a yellow solution. This yellow solution gives yellow precipitate with  $\text{Ba}(\text{NO}_3)_2$  solution.

On the basis of the aforesaid characteristic informations answer the following questions :

1. Acidified solution of 'A', on treatment with KI gives black precipitate 'F' which dissolves in excess of reagent forming the coloured compound 'G'. The chemical composition of 'F' and 'G' are respectively :  
 (A)  $\text{HgI}_2$  and  $[\text{HgI}_4]^{2-}$  (B)  $\text{PbI}_2$  and  $[\text{PbI}_4]^{2-}$  (C)  $\text{BiI}_3$  and  $[\text{BiI}_4]^-$  (D)  $\text{CuI}$  and  $\text{CuI}_2$ .
2. The black precipitate 'F' on heating with water produces :  
 (A)  $\text{Hg}(\text{OH})_2$  (B)  $\text{BiOI}$  (C)  $\text{BiO.OH}$  (D)  $\text{CuO.OH}$
3. Select the correct statement.  
 (A) Aqueous solution of 'A' reacts with  $\text{AgNO}_3$  solution to give white precipitate which turns into yellow on treatment with sodium arsenite.  
 (B) Aqueous solution of 'A' produces white precipitate with sodium hydroxide which turns into yellowish-white on boiling.  
 (C) White turbidity 'E' is soluble in dilute mineral acids.  
 (D) All of these.

**Comprehension # 2**

A student was given a sample of colourless solution containing three cations and was asked to identify the cations. Student carried out a series of reactions as given below.



4. Precipitates 'A', 'B' and 'C' are respectively :  
 (A)  $\text{Al}(\text{OH})_3$ ,  $\text{BaSO}_4$  and  $\text{AgCl}$  (B)  $\text{AgCl}$ ,  $\text{BaSO}_4$  and  $\text{Zn}(\text{OH})_2$   
 (C)  $\text{AgCl}$ ,  $\text{Ca}(\text{OH})_2$  and  $\text{ZnSO}_4$  (D)  $\text{ZnCl}_2$ ,  $\text{BaSO}_4$  and  $\text{Al}(\text{OH})_3$
5. White precipitate 'A' is not soluble in :  
 (A)  $\text{NH}_3$  (B) dilute  $\text{HCl}$  (C)  $\text{KCN}$  (D)  $\text{Na}_2\text{S}_2\text{O}_3$
6. Which of the following statement is correct ?  
 (A) Precipitate 'C' forms Rinmann's green in  $\text{Co}(\text{NO}_3)_2$  test.  
 (B) Precipitate 'B' is appreciably soluble in boiling concentrated  $\text{H}_2\text{SO}_4$ .  
 (C) Precipitate (A) on exposure to sunlight or ultraviolet radiations turns black.  
 (D) All of these.

**Comprehension # 3**

Answer Q.7, Q.8 and Q.9 by appropriately matching the information given in the three columns of the following table.

In Column-1 cation are given while in Column-2 reagent are given which is used for test and in Column-3 observation are given. [Consider each solution to be aqueous unless stated.]					
Column-1		Column-2		Column-3	
(I)	$\text{Bi}^{3+}$	(i)	$\text{NH}_3$	(P)	Black / white precipitate is obtained.
(II)	$\text{Cu}^{2+}$	(ii)	$\text{KI}$	(Q)	Blue / Brown precipitate is obtained.
(III)	$\text{Fe}^{3+}$	(iii)	$\text{KCN}$	(R)	Form soluble complex in excess reagent.
(IV)	$\text{Zn}^{2+}$	(iv)	$\text{K}_4[\text{Fe}(\text{CN})_6]$	(S)	Redox reaction take place.

7. The only incorrect combination is:  
 (A) (I) (ii) (P) (B) (II) (ii) (S) (C) (II) (ii) (R) (D) (III) (iii) (R)
8. The only correct combination is:  
 (A) (II) (ii) (R) (B) (III) (ii) (Q) (C) (III) (i) (R) (D) (II) (iii) (S)
9. The only incorrect combination is:  
 (A) (III) (iv) (Q) (B) (IV) (ii) (P) (C) (I) (i) (P) (D) (IV) (i) (R)



## Exercise-3

\* Marked Questions may have more than one correct option.

### PART - I : JEE (ADVANCED) / IIT-JEE PROBLEMS (PREVIOUS YEARS)

- A metal nitrate reacts with KI to give a black precipitate which on addition of excess of KI is converted into orange colour solution. The cation of the metal nitrate is : **[JEE - 2005, 3/84]**  
 (A)  $\text{Hg}^{2+}$  (B)  $\text{Bi}^{3+}$  (C)  $\text{Pb}^{2+}$  (D)  $\text{Cu}^+$
- In the given reaction sequence, Identify (A) and (B).  

$$\text{Fe}^{3+} \xrightarrow[\text{(Excess)}]{\text{SCN}^-} \underset{\text{Blood red}}{\text{A}} \xrightarrow[\text{(excess)}]{\text{F}^-} \text{colourless(B)}$$
 (a) Write the IUPAC name of (A) and (B).  
 (b) Find out the spin only magnetic moment of B. **[JEE 2005, 4/144]**
- A white precipitate is obtained when a solution is diluted with  $\text{H}_2\text{O}$  and boiled. On addition of excess  $\text{NH}_4\text{Cl}/\text{NH}_4\text{OH}$ , the volume of precipitate decreases leaving behind a white gelatinous precipitate. Identify the precipitate which dissolves in ammonia solution or  $\text{NH}_4\text{Cl}$ . **[JEE 2006, 3/184]**  
 (A)  $\text{Al}(\text{OH})_3$  (B)  $\text{Zn}(\text{OH})_2$  (C)  $\text{Mg}(\text{OH})_2$  (D)  $\text{Ca}(\text{OH})_2$
- In blue solution of copper sulphate excess of KCN is added then solution becomes colourless due to the formation of : **[JEE 2006, 3/184]**  
 (A)  $[\text{Cu}(\text{CN})_4]^{2-}$  (B)  $\text{Cu}^{2+}$  get reduced to form  $[\text{Cu}(\text{CN})_4]^{3-}$   
 (C)  $\text{Cu}(\text{CN})_2$  (D)  $\text{CuCN}$
- $\text{MgSO}_4 + \text{NH}_4\text{OH} + \text{Na}_2\text{HPO}_4 \longrightarrow$  white crystalline precipitate. The formula of crystalline precipitate is: **[JEE 2006, 3/184]**  
 (A)  $\text{MgCl}_2 \cdot \text{MgSO}_4$  (B)  $\text{MgSO}_4$  (C)  $\text{Mg}(\text{NH}_4)\text{PO}_4$  (D)  $\text{Mg}(\text{PO}_4)_2$
- A solution of a metal ion when treated with KI gives a red precipitate which dissolves in excess KI to give a colourless solution. Moreover, the solution of metal ion on treatment with a solution of cobalt(II) thiocyanate gives rise to a deep blue crystalline precipitate. The metal ion is : **[JEE - 2007, 3/162]**  
 (A)  $\text{Pb}^{2+}$  (B)  $\text{Hg}^{2+}$  (C)  $\text{Cu}^{2+}$  (D)  $\text{Co}^{2+}$
- \* A solution of colourless salt **H** on boiling with excess NaOH produces a non-flammable gas. The gas evolution ceases after some time. On addition of Zn dust to the same solution, the gas evolution restarts. The colourless salt(s) **H** is (are) : **[JEE 2008, 4/163]**  
 (A)  $\text{NH}_4\text{NO}_3$  (B)  $\text{NH}_4\text{NO}_2$  (C)  $\text{NH}_4\text{Cl}$  (D)  $(\text{NH}_4)_2\text{SO}_4$

#### Paragraph for Question Nos. 8 to 10

p-Amino-N, N-dimethylaniline is added to a strongly acidic solution of **X**. The resulting solution is treated with a few drops of aqueous solution of **Y** to yield blue coloration due to the formation of methylene blue. Treatment of the aqueous solution of **Y** with the reagent potassium hexacyanoferrate(II) leads to the formation of an intense blue precipitate. The precipitate dissolves on excess addition of the reagent. Similarly, treatment of the solution of **Y** with the solution of potassium hexacyanoferrate(III) leads to a brown coloration due to the formation of **Z**.

- The compound **X** is : **[JEE 2009, 4/160]**  
 (A)  $\text{NaNO}_3$  (B)  $\text{NaCl}$  (C)  $\text{Na}_2\text{SO}_4$  (D)  $\text{Na}_2\text{S}$
- The compound **Y** is : **[JEE 2009, 4/160]**  
 (A)  $\text{MgCl}_2$  (B)  $\text{FeCl}_2$  (C)  $\text{FeCl}_3$  (D)  $\text{ZnCl}_2$
- The compound **Z** is : **[JEE 2009, 4/160]**  
 (A)  $\text{Mg}_2[\text{Fe}(\text{CN})_6]$  (B)  $\text{Fe}[\text{Fe}(\text{CN})_6]$  (C)  $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$  (D)  $\text{K}_2\text{Zn}_3[\text{Fe}(\text{CN})_6]_2$



## Paragraph for Question Nos. 11 to 13

When a metal rod **M** is dipped into an aqueous colourless concentrated solution of compound **N** the solution turns light blue. Addition of aqueous  $\text{NaCl}$  to the blue solution gives a white precipitate **O**. Addition of aqueous  $\text{NH}_3$  dissolves **O** and gives an intense blue solution.

11. The metal rod **M** is : [JEE 2011, 3/180]  
 (A) Fe (B) Cu (C) Ni (D) Co
12. The compound **N** is : [JEE 2011, 3/180]  
 (A)  $\text{AgNO}_3$  (B)  $\text{Zn(NO}_3)_2$  (C)  $\text{Al(NO}_3)_3$  (D)  $\text{Pb(NO}_3)_2$
13. The final solution contains [JEE 2011, 3/180]  
 (A)  $[\text{Pb(NH}_3)_4]^{2+}$  and  $[\text{CoCl}_4]^{2-}$  (B)  $[\text{Al(NH}_3)_4]^{3+}$  and  $[\text{Cu(NH}_3)_4]^{2+}$   
 (C)  $[\text{Ag(NH}_3)_2]^+$  and  $[\text{Cu(NH}_3)_4]^{2+}$  (D)  $[\text{Ag(NH}_3)_2]^+$  and  $[\text{Ni(NH}_3)_6]^{2+}$
14. Passing  $\text{H}_2\text{S}$  gas into a mixture of  $\text{Mn}^{2+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Cu}^{2+}$  and  $\text{Hg}^{2+}$  ions in an acidified aqueous solution precipitates: [JEE 2011, 3/180]  
 (A)  $\text{CuS}$  and  $\text{HgS}$  (B)  $\text{MnS}$  and  $\text{CuS}$  (C)  $\text{MnS}$  and  $\text{NiS}$  (D)  $\text{NiS}$  and  $\text{HgS}$
- 15.\* The equilibrium,  $2\text{Cu}^I \rightleftharpoons \text{Cu}^0 + \text{Cu}^{II}$  in aqueous medium at  $25^\circ\text{C}$  shifts towards the left in the presence of : [JEE 2011, 4/180]  
 (A)  $\text{NO}_3^-$  (B)  $\text{Cl}^-$  (C)  $\text{SCN}^-$  (D)  $\text{CN}^-$
- 16.\* For the given aqueous reaction which of the statement(s) is (are) true ? [JEE 2012, 4/136]  
 excess  $\text{KI} + \text{K}_3[\text{Fe(CN)}_6] \xrightarrow{\text{dilute H}_2\text{SO}_4} \text{brownish-yellow solution}$   
 $\downarrow \text{ZnSO}_4$   
 (white precipitate + brownish-yellow filtrate)  
 $\downarrow \text{Na}_2\text{S}_2\text{O}_3$   
 colourless solution
- (A) The first reaction is a redox reaction  
 (B) White precipitate is  $\text{Zn}_3[\text{Fe(CN)}_6]_2$   
 (C) Addition of filtrate to starch solution gives blue colour.  
 (D) White precipitate is soluble in  $\text{NaOH}$  solution
17. Upon treatment with ammoniacal  $\text{H}_2\text{S}$ , the metal ion that precipitates as a sulphide is : [JEE(Advanced) 2013, 2/120]  
 (A)  $\text{Fe(III)}$  (B)  $\text{Al(III)}$  (C)  $\text{Mg(II)}$  (D)  $\text{Zn(II)}$

## Paragraph for Question 18 and 19

An aqueous solution of a mixture of two inorganic salts, when treated with dilute  $\text{HCl}$ , gave a precipitate (**P**) and a filtrate (**Q**). The precipitate **P** was found to dissolve in hot water. The filtrate (**Q**) remained unchanged, when treated with  $\text{H}_2\text{S}$  in a dilute mineral acid medium. However, it gave a precipitate (**R**) with  $\text{H}_2\text{S}$  in an ammoniacal medium. The precipitate **R** gave a coloured solution (**S**), when treated with  $\text{H}_2\text{O}_2$  in an aqueous  $\text{NaOH}$  medium.

18. The precipitate **P** contains [JEE(Advanced) 2013, 3/120]  
 (A)  $\text{Pb}^{2+}$  (B)  $\text{Hg}_2^{2+}$  (C)  $\text{Ag}^+$  (D)  $\text{Hg}^{2+}$
19. The coloured solution **S** contains [JEE(Advanced) 2013, 3/120]  
 (A)  $\text{Fe}_2(\text{SO}_4)_3$  (B)  $\text{CuSO}_4$  (C)  $\text{ZnSO}_4$  (D)  $\text{Na}_2\text{CrO}_4$
20. Among  $\text{PbS}$ ,  $\text{CuS}$ ,  $\text{HgS}$ ,  $\text{MnS}$ ,  $\text{Ag}_2\text{S}$ ,  $\text{NiS}$ ,  $\text{CoS}$ ,  $\text{Bi}_2\text{S}_3$  and  $\text{SnS}_2$ , the total number of **BLACK** coloured sulphides is : [JEE(Advanced) 2014, 3/120]



- 21.\* The pair(s) of ions where BOTH the ions are precipitated upon passing  $\text{H}_2\text{S}$  gas in presence of dilute  $\text{HCl}$ , is(are) [JEE(Advanced) 2015, 4/168]  
 (A)  $\text{Ba}^{2+}$ ,  $\text{Zn}^{2+}$  (B)  $\text{Bi}^{3+}$ ,  $\text{Fe}^{3+}$  (C)  $\text{Cu}^{2+}$ ,  $\text{Pb}^{2+}$  (D)  $\text{Hg}^{2+}$ ,  $\text{Bi}^{3+}$
22. In the following reaction sequence in aqueous solution, the species X, Y and Z, respectively, are [JEE(Advanced) 2016, 4/120]
- $$\text{S}_2\text{O}_3^{2-} \xrightarrow{\text{Ag}^+} \text{X} \xrightarrow{\text{Ag}^+} \text{Y} \xrightarrow{\text{with time}} \text{Y}$$
- Clear solution                      white precipitate                      black precipitate
- (A)  $[\text{Ag}(\text{S}_2\text{O}_3)_2]^{3-}$ ,  $\text{Ag}_2\text{S}_2\text{O}_3$ ,  $\text{Ag}_2\text{S}$  (B)  $[\text{Ag}(\text{S}_2\text{O}_3)_3]^{5-}$ ,  $\text{Ag}_2\text{SO}_3$ ,  $\text{Ag}_2\text{S}$   
 (C)  $[\text{Ag}(\text{SO}_3)_2]^{3-}$ ,  $\text{Ag}_2\text{S}_2\text{O}_3$ ,  $\text{Ag}$  (D)  $[\text{Ag}(\text{SO}_3)_3]^{3-}$ ,  $\text{Ag}_2\text{SO}_4$ ,  $\text{Ag}_2\text{S}$
- 23.\* The correct option(s) to distinguish nitrate salts of  $\text{Mn}^{2+}$  and  $\text{Cu}^{2+}$  taken separately is (are) [JEE(Advanced) 2018, 4/120]  
 (A)  $\text{Mn}^{2+}$  show the characteristic green colour in the flame test  
 (B) Only  $\text{Cu}^{2+}$  show the formation of precipitate by passing  $\text{H}_2\text{S}$  in acidic medium  
 (C) Only  $\text{Mn}^{2+}$  show the formation of precipitate by passing  $\text{H}_2\text{S}$  in faintly basic medium  
 (D)  $\text{Cu}^{2+}/\text{Cu}$  has higher reduction potential than  $\text{Mn}^{2+}/\text{Mn}$  (measured under similar conditions)

## PART - II : JEE (MAIN) / AIEEE PROBLEMS (PREVIOUS YEARS)

### JEE(MAIN) OFFLINE PROBLEMS

1. Which one of the following statement is correct ? [AIEEE 2003, 3/225]  
 (1) From a mixed precipitate of  $\text{AgCl}$  and  $\text{AgI}$ , ammonia solution dissolves only  $\text{AgCl}$ .  
 (2) Ferric ions gave a deep green precipitate on adding potassium ferrocyanide solution.  
 (3) On boiling a solution having  $\text{K}^+$ ,  $\text{Ca}^{2+}$  and  $\text{HCO}_3^-$  ions we get a precipitate of  $\text{K}_2\text{Ca}(\text{CO}_3)_2$ .  
 (4) Manganese salts give a violet borax bead test in the reducing flame .
2. A red solid is insoluble in water. However it becomes soluble if some  $\text{KI}$  is added to water. Heating the red solid in a test tube results in liberation of some violet coloured fumes and droplets of a metal appear on the cooler parts of the test tube. The red solid is : [AIEEE 2003, 3/225]  
 (1)  $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$  (2)  $\text{HgI}_2$  (3)  $\text{HgO}$  (4)  $\text{Pb}_3\text{O}_4$ .
3. Which of the following compounds is **not** colored yellow ? [JEE(Main) 2015, 4/120]  
 (1)  $\text{Zn}_2[\text{Fe}(\text{CN})_6]$  (2)  $\text{K}_3[\text{Co}(\text{NO}_2)_6]$   
 (3)  $(\text{NH}_4)_3[\text{As}(\text{Mo}_3\text{O}_{10})_4]$  (4)  $\text{BaCrO}_4$
4. Sodium salt of an organic acid 'X' produces effervescence with conc.  $\text{H}_2\text{SO}_4$ . 'X' reacts with the acidified aqueous  $\text{CaCl}_2$  solution to give a white precipitate which decolourises acidic solution of  $\text{KMnO}_4$ . 'X' is: [JEE(Main) 2017, 4/120]  
 (1)  $\text{HCOONa}$  (2)  $\text{CH}_3\text{COONa}$  (3)  $\text{Na}_2\text{C}_2\text{O}_4$  (4)  $\text{C}_6\text{H}_5\text{COONa}$

### JEE(MAIN) ONLINE PROBLEMS

1. The cation that will not be precipitated by  $\text{H}_2\text{S}$  in the presence of dil  $\text{HCl}$  is: [JEE(Main) 2015 Online (10-04-15), 4/120]  
 (1)  $\text{Pb}^{2+}$  (2)  $\text{As}^{3+}$  (3)  $\text{Co}^{2+}$  (4)  $\text{Cu}^{2+}$
2. An aqueous solution of a salt X turns blood red on treatment with  $\text{SCN}^-$  and blue on treatment with  $\text{K}_4[\text{Fe}(\text{CN})_6]$ . X also gives a positive chromyl chloride test. The salt X is : [JEE(Main) 2015 Online (10-04-15), 4/120]  
 (1)  $\text{CuCl}_2$  (2)  $\text{Cu}(\text{NO}_3)_2$  (3)  $\text{FeCl}_3$  (4)  $\text{Fe}(\text{NO}_3)_3$



3. When concentrated HCl is added to an aqueous solution of  $\text{CoCl}_2$ , its colour changes from reddish pink to deep blue. Which complex ion gives blue colour in this reaction?  
[JEE(Main) 2015 Online (11-04-15), 4/120]  
(1)  $[\text{CoCl}_4]^{2-}$  (2)  $[\text{CoCl}_6]^{3-}$  (3)  $[\text{CoCl}_6]^{4-}$  (4)  $[\text{Co}(\text{H}_2\text{O})_6]^{2+}$
4. A pink coloured salt turns blue on heating. The presence of which cation is most likely ?  
[JEE(Main) 2015 Online (11-04-15), 4/120]  
(1)  $\text{Co}^{2+}$  (2)  $\text{Cu}^{2+}$  (3)  $\text{Zn}^{2+}$  (4)  $\text{Fe}^{2+}$
5. A solution containing a group-IV cation gives a precipitate on passing  $\text{H}_2\text{S}$ . A solution of this precipitate in dil. HCl produces a white precipitate with NaOH solution and bluish-white precipitate with basic potassium ferrocyanide. The cation is :  
[JEE(Main) 2017 Online (08-04-17), 4/120]  
(1)  $\text{Mn}^{2+}$  (2)  $\text{Zn}^{2+}$  (3)  $\text{Co}^{2+}$  (4)  $\text{Ni}^{2+}$
6. The **incorrect** statement is :  
[JEE(Main) 2018 Online (16-04-18), 4/120]  
(1)  $\text{Cu}^{2+}$  ion gives chocolate coloured precipitate with potassium ferrocyanide solution.  
(2)  $\text{Cu}^{2+}$  and  $\text{Ni}^{2+}$  ions give black precipitate with  $\text{H}_2\text{S}$  in presence of HCl solution.  
(3) Ferric ion gives blood red colour with potassium thiocyanate.  
(4)  $\text{Cu}^{2+}$  salts give red coloured borax bead test in reducing flame.

## EXERCISE - 1

## PART - I

- A-1.**  $\text{PbCl}_2$  is soluble in hot water and it also dissolves in concentrated HCl and KCl solutions forming soluble complex. ;  $\text{PbCl}_2 + 2\text{HCl} \longrightarrow \text{H}_2\text{PbCl}_4$  (soluble complex).
- A-2.**  $\text{Pb}^{2+} + \text{H}_2\text{S}$  (atmospheric)  $\longrightarrow \text{PbS} \downarrow$  (black) +  $2\text{H}^+$ .
- A-3.**  $\text{PbCl}_2 + 2\text{KI} \longrightarrow \text{PbI}_2 \downarrow$  (yellow) +  $2\text{KCl}$  ;  $\text{PbCl}_2 + \text{H}_2\text{S} \longrightarrow \text{PbS} \downarrow$  (Black)  
 $\text{PbI}_2 + \text{KI}(\text{Conc.}) \rightleftharpoons \text{K}_2(\text{PbI}_4)$  (aq)  
yellow precipitate of  $\text{PbI}_2$  dissolves in excess  $\text{KI}(\text{conc.})$  and give  $\text{PbI}_4^{2-}$ , ppt reappears on dilution.
- A-4.**  $\text{Hg}_2\text{Cl}_2 + 2 \text{NH}_4\text{OH} \longrightarrow \underbrace{\text{HgNH}_2\text{Cl} \downarrow}_{\text{black}} + \text{Hg} \downarrow (\text{black}) + \text{NH}_4\text{Cl} + 2 \text{H}_2\text{O}$   
Disproportionation reaction.
- A-5.**  $\text{Hg}_2^{2+} + 2\text{OH}^- \longrightarrow \text{Hg}_2\text{O} \downarrow$  (black) +  $\text{H}_2\text{O}$   
 $\text{Hg}_2\text{O} \downarrow \longrightarrow \text{HgO} \downarrow + \text{Hg} \downarrow$  (grey) ; Disproportionation reaction.
- A-6.**  $\text{Hg}_2^{2+} + 2\text{I}^- \longrightarrow \text{Hg}_2\text{I}_2 \downarrow$   
green  
 $\text{Hg}_2\text{I}_2 + \text{I}^\ominus \longrightarrow [\text{HgI}_4]^{2-} + \text{Hg} \downarrow$   
(excess) (Soluble ion) black
- A-7.**  $\text{AgI} \downarrow + 2\text{CN}^- \longrightarrow [\text{Ag}(\text{CN})_2]^- + \text{I}^-$ ,  $\text{AgI} \downarrow + 2\text{S}_2\text{O}_3^{2-} \longrightarrow [\text{Ag}(\text{S}_2\text{O}_3)_2]^{3-} + \text{I}^-$   
for formation of soluble complex
- A-8.** (A) is  $\text{AgBr}$  (present in photographic plate)  
 $\text{AgBr} + 2\text{Na}_2\text{S}_2\text{O}_3 \longrightarrow \text{Na}_3[\text{Ag}(\text{S}_2\text{O}_3)_2] + \text{NaBr}$   
soluble  
(B)  
 $\downarrow \Delta$   
 $[\text{Ag}(\text{NH}_3)_2\text{Cl}] \xleftarrow{\text{NH}_3} \text{AgCl} \xleftarrow{\text{HCl}+\text{HNO}_3} \text{Ag}_2\text{S}$   
(E) (D) (C)
- B-1.** With  $\text{Na}_2\text{S}$ , along with 2nd group cations, some cations of higher groups i.e., III<sup>rd</sup> and IV<sup>th</sup> groups may be precipitated because the higher concentration of  $\text{S}^{2-}$  ions is obtained according to following reaction.  
 $\text{Na}_2\text{S} \rightleftharpoons 2 \text{Na}^+ + \text{S}^{2-}$   
To precipitate II<sup>nd</sup> group cations lower concentration of  $\text{S}^{2-}$  ions is required (because of low  $K_{\text{sp}}$  of II<sup>nd</sup> group sulphides) and this can be obtained easily by  $\text{H}_2\text{S}$  in presence of dilute HCl.  
 $\text{H}_2\text{S} \rightleftharpoons 2 \text{H}^+ + \text{S}^{2-}$  ;  $\text{HCl} \rightleftharpoons \text{H}^+ + \text{Cl}^-$   
Due to common ion effect the ionisation of  $\text{H}_2\text{S}$  is suppressed and the concentration of  $\text{S}^{2-}$  ions obtained is just sufficient to precipitate the cations of II<sup>nd</sup> group.
- B-2.** Yes,  $\text{Hg}^{2+} + 2\text{OH}^- \longrightarrow \text{HgO} \downarrow$  +  $\text{H}_2\text{O}$   
yellow  
 $\text{Hg}_2^{2+} + 2\text{OH}^- \longrightarrow \text{Hg}_2\text{O} \downarrow$  +  $\text{H}_2\text{O}$   
black
- B-3.** It turns yellowish–white owing to the formation of  $\text{BiO.OH} \downarrow$ .  
 $\text{Bi}(\text{OH})_3 \longrightarrow \text{BiO.OH} \downarrow + \text{H}_2\text{O}$
- B-4.** (A) :  $\text{CuSO}_4$  (B) :  $\text{BaSO}_4$  (C) : HCl (D) : ( $\text{Cu}_2\text{I}_2 + \text{I}_3^-$ )  
(E) ( $\text{Cu}_2\text{I}_2 + \text{I}^- + \text{S}_4\text{O}_6^{2-}$ ) (F)  $\text{Cu}_2[\text{Fe}(\text{CN})_6]$





- C-1.** Presence of  $\text{Sb}^{3+}$  or  $\text{Bi}^{3+}$ , their chloride hydrolyse to oxychlorides in presence of excess of water.  
 $\text{BiCl}_3 + \text{H}_2\text{O} \longrightarrow \text{BiOCl} + 2\text{HCl}$   
 $\text{SbCl}_3 + \text{H}_2\text{O} \longrightarrow \text{SbOCl} + 2\text{HCl}$
- C-2.**  $\text{HNO}_3$  is a powerful oxidising solution. Causing confusion with  $\text{CdS}$ ,  $\text{As}_2\text{S}_3$  (both yellow ppt). Colloidal solution can not be filtered causing unnecessary trouble.
- C-3.**  $\text{AsCl}_3 (\text{x}) + 3\text{H}_2\text{S} \xrightarrow{\text{H}^+} \text{As}_2\text{S}_3 \downarrow (\text{yellow}) + 6\text{HCl}$   
 $3\text{As}_2\text{S}_3 + 28\text{HNO}_3 + 4\text{H}_2\text{O} \longrightarrow 6\text{H}_3\text{AsO}_4 (\text{y}) + 18\text{H} + 9\text{SO}_4^{2-} + 28\text{NO} \uparrow$   
 $\text{H}_3\text{AsO}_4 (\text{y}) + 12\text{NH}_4\text{MoO}_4 + 21\text{HNO}_3 \longrightarrow (\text{NH}_4)_3\text{AsO}_4 \cdot 12\text{MoO}_3 \downarrow (\text{yellow}) + 21\text{NH}_4\text{NO}_3 + 12\text{H}_2\text{O}$
- C-4.** (A) is  $\text{SnCl}_2$
- D-1.**  $\text{Fe}^{2+}$  salt are oxidised to  $\text{Fe}^{3+}$  salt by boiling with conc.  $\text{HNO}_3$ , before adding  $\text{NH}_4\text{Cl}$  and  $\text{NH}_4\text{OH}$ , otherwise  $\text{Fe}^{2+}$  would not be precipitated in group III.
- D-2.** Only  $\text{Fe(II)}$  salts give soluble red iron(II) dimethylglyoxime in ammonical solution.
- D-3.** (i) White precipitate,  $\text{K}_2\text{Fe}[\text{Fe(CN)}_6]$  and (ii) Pale blue precipitate.
- E-1.**  $\text{Mn}^{2+} + 2\text{NH}_3 + 2\text{H}_2\text{O} \rightleftharpoons \text{Mn(OH)}_2 \downarrow (\text{white}) + \text{NH}_4^+$ .  
 In presence of ammonium salts, the reaction proceeds in backward direction.
- E-2.**  $\text{Zn}^{2+} + 2\text{NH}_3 + 2\text{H}_2\text{O} \rightleftharpoons \text{Zn(OH)}_2 \downarrow + 2\text{NH}_4^+$   
 It is due to the lowering of  $\text{OH}^-$  ion concentration because of common ion effect of  $\text{NH}_4^+$  to such a value that the  $K_{\text{sp}}$  of  $\text{Zn(OH)}_2$  is not attained.
- E-3.**  $\rightarrow \text{Zn}^{2+} + [\text{Hg(SCN)}_4]^{2-} \longrightarrow \text{Zn}[\text{Hg(SCN)}_4] \downarrow$   
 (white)  
 $\rightarrow \text{Cu}^{2+} + [\text{Hg(SCN)}_4]^{2-} \longrightarrow \text{Cu}[\text{Hg(SCN)}_4]$   
 \* In the presence of the copper ions, the copper complex Co-precipitated with that of zinc complex and colour become violet
- E-4.** (A) :  $\text{Zn(NO}_3)_2$  (B) :  $\text{NO}_2$  (C) :  $\text{ZnO}$  (D) :  $\text{ZnS}$
- F-1.**  $\text{Hg}_2\text{ONH}_2\text{I}$  or  $\text{O} \begin{cases} \text{HgNH}_2 \\ \text{HgI} \end{cases}$  or  $\text{Hg} \begin{cases} \text{NH}_2 \\ \text{I} \end{cases} \cdot \text{HgO}$
- F-2.** A yellow precipitate of ammonium cobaltinitrite is formed.  
 $3\text{NH}_4^+ + \text{Na}_3[\text{Co(NO}_2)_6] \longrightarrow (\text{NH}_4)_3[\text{Co(NO}_2)_6] \downarrow (\text{yellow}) + 3\text{Na}^+$
- F-3.**  $\text{Mg}^{2+}$  ions will also be precipitated.
- F-4.**  $\text{Sr}^{2+} + \text{NH}_4^+ + \text{SO}_4^{2-} \longrightarrow \text{SrSO}_4 \downarrow (\text{white}) + \text{NH}_4^+$   
 $\text{Ca}^{2+} + 2\text{NH}_4^+ + 2\text{SO}_4^{2-} \longrightarrow (\text{NH}_4)_2[\text{Ca(SO}_4)_2] (\text{soluble complex}).$
- F-5.** White precipitate is obtained.  
 $\text{Ca}^{2+} + 2\text{K}^+ + [\text{Fe(CN)}_6]^{4-} \longrightarrow \text{K}_2\text{Ca}[\text{Fe(CN)}_6] \downarrow$

## PART - II

- |                 |                 |                 |                 |                 |
|-----------------|-----------------|-----------------|-----------------|-----------------|
| <b>A-1.</b> (C) | <b>A-2.</b> (B) | <b>A-3.</b> (C) | <b>A-4.</b> (B) | <b>A-5.</b> (C) |
| <b>A-6.</b> (A) | <b>B-1.</b> (C) | <b>B-2.</b> (C) | <b>B-3.</b> (A) | <b>B-4.</b> (C) |
| <b>B-5.</b> (A) | <b>B-6.</b> (D) | <b>B-7.</b> (C) | <b>B-8.</b> (B) | <b>B-9.</b> (D) |
| <b>C-1.</b> (D) | <b>C-2.</b> (B) | <b>D-1.</b> (D) | <b>D-2.</b> (B) | <b>D-3.</b> (B) |
| <b>D-4.</b> (B) | <b>D-5.</b> (C) | <b>E-1.</b> (A) | <b>E-2.</b> (C) | <b>E-3.</b> (B) |
| <b>E-4.</b> (D) | <b>E-5.</b> (A) | <b>E-6.</b> (D) | <b>F-1.</b> (D) | <b>F-2.</b> (C) |
| <b>F-3.</b> (C) | <b>F-4.</b> (B) | <b>F-5.</b> (C) | <b>F-6.</b> (C) | <b>F-7.</b> (C) |

## PART - III

1. (A - p,q,r ; B - r,s ; C - p,q,r,s,t ; D - p,s)      2. (A - p,q ; B - p,s ; C - s ; D - p,r)





## EXERCISE - 2

### PART - I

- |         |         |         |         |         |
|---------|---------|---------|---------|---------|
| 1. (D)  | 2. (A)  | 3. (B)  | 4. (C)  | 5. (D)  |
| 6. (D)  | 7. (D)  | 8. (B)  | 9. (D)  | 10. (D) |
| 11. (C) | 12. (D) | 13. (C) | 14. (B) | 15. (A) |
| 16. (C) | 17. (C) |         |         |         |

### PART - II

- |  |                 |       |                                      |
|--|-----------------|-------|--------------------------------------|
| 1. 3 ( $\text{Hg}_2^{2+}$ , $\text{Pb}^{2+}$ , $\text{Ag}^+$ ) | 2. 4            | 3. 4  | 4. 2                                 |
| 5. 3 (a, b, c)   | 6. 3 (I, IV, V) | 7. 20 | 8. $a = 6$ ; $b = 3$ ( $a + b = 9$ ) |
| 9. 5 (i), (ii), (iv), (v), (vi)                                |                 |       |                                      |

### PART - III

- |           |          |          |         |           |
|-----------|----------|----------|---------|-----------|
| 1. (ABCD) | 2. (ABC) | 3. (CD)  | 4. (BC) | 5. (ABCD) |
| 6. (ABCD) | 7. (ABC) | 8. (ACD) | 9. (AC) | 10. (AD)  |
| 11. (ABC) |          |          |         |           |

### PART - IV

- |        |        |        |        |        |
|--------|--------|--------|--------|--------|
| 1. (C) | 2. (B) | 3. (D) | 4. (B) | 5. (B) |
| 6. (D) | 7. (C) | 8. (D) | 9. (B) |        |

## EXERCISE - 3

### PART - I

- |   |         |            |            |          |
|---|---------|------------|------------|----------|
| 1. (B)  |         |            |            |          |
| 2. (a) (A) = Pentaquathiocyanato-S-iron(III) ; (B) = Hexafluoridoferrate(III) (b) 5.93 B.M. |         |            |            |          |
| 3. (B)  | 4. (B)  | 5. (C)     | 6. (B)     | 7.* (AB) |
| 8. (D)  | 9. (C)  | 10. (B)    | 11. (B)    | 12. (A)  |
| 13. (C)   | 14. (A) | 15.* (BCD) | 16.* (ACD) | 17. (D)  |
| 18. (A)   | 19. (D) | 20. 7      | 21.* (CD)  | 22. (A)  |
| 23.* (BD)   |         |            |            |          |

### PART - II

### JEE(MAIN) OFFLINE PROBLEMS

- |        |        |        |        |
|--------|--------|--------|--------|
| 1. (1) | 2. (2) | 3. (1) | 4. (3) |
|--------|--------|--------|--------|

### JEE(MAIN) ONLINE PROBLEMS

- |        |        |        |        |        |
|--------|--------|--------|--------|--------|
| 1. (3) | 2. (3) | 3. (1) | 4. (1) | 5. (2) |
| 6. (2) |        |        |        |        |



## Additional Problems for Self Practice (APSP)

**This Section is not meant for classroom discussion. It is being given to promote self-study and self testing amongst the Resonance students.**

### PART - I : PRACTICE TEST-1 (IIT-JEE (MAIN Pattern))

Max. Time : 1 Hr.

Max. Marks : 120

#### Important Instructions

1. The test is of **1 hour** duration.
2. The Test Booklet consists of **30** questions. The maximum marks are **120**.
3. Each question is allotted **4 (four)** marks for correct response.
4. Candidates will be awarded marks as stated above in Instructions No. 3 for correct response of each question.  $\frac{1}{4}$  (**one fourth**) marks will be deducted for indicating incorrect response of each question. No deduction from the total score will be made if no response is indicated for an item in the answer sheet.
5. There is only one correct response for each question. Filling up more than one response in any question will be treated as wrong response and marks for wrong response will be deducted accordingly as per instructions 4 above.

1. Identify the compound which turns black with ammonia solution.  
 (1) Lead chloride (2) Mercurous chloride  
 (3) Mercuric chloride (4) Silver chloride
2. A white crystalline substance dissolves in water. On passing  $H_2S$  in this solution, a black precipitate is obtained. The black precipitate dissolves completely in hot  $HNO_3$ . On adding a few drops of concentrated  $H_2SO_4$ , a white precipitate is obtained which is soluble in ammonium acetate. The white precipitate is that of:  
 (1)  $BaSO_4$  (2)  $SrSO_4$  (3)  $PbSO_4$  (4)  $Ag_2SO_4$
3. The composition of golden spangles is :  
 (1)  $PbCrO_4$  (2)  $PbI_2$  (3)  $As_2S_3$  (4)  $BaCrO_4$
4. In which of the following solvents,  $AgBr$  will have the highest solubility ?  
 (1)  $10^{-3}$  M  $NaBr$  (2)  $10^{-3}$  M  $NH_4OH$  (3) Pure water (4)  $10^{-3}$  M  $HBr$
5. Which one among the following pairs of ions can not be separated by passing  $H_2S$  gas in presence of dilute hydrochloric acid?  
 (1)  $Cd^{2+}$ ,  $Sn^{2+}$  (2)  $Al^{3+}$ ,  $Hg^{2+}$  (3)  $Zn^{2+}$ ,  $Cu^{2+}$  (4)  $Ni^{2+}$ ,  $Bi^{3+}$
6. Which of the following is not precipitated as sulphide by passing  $H_2S$  in the presence of dilute  $HCl$  ?  
 (1) Copper (2) Arsenic (3) Cadmium (4) none of these
7. Which of the following metal cation is reduced from its higher oxidation state (+2) to (+1) by both  $KI$  solution and excess of  $KCN$  solution ?  
 (1)  $Zn^{2+}$  (2)  $Hg^{2+}$  (3)  $Cu^{2+}$  (4) None
8. Which of the following reagents give an orange coloured soluble complex when dissolved in excess with  $Bi^{3+}$  ions ?  
 (1) Ammonia solution (excess).  
 (2) Dilution in water  
 (3) Potassium iodide solution.  
 (4) Freshly prepared 0.125 M alkaline sodium tetrahydroxidoantimonate (II) solution.
9. Which of the following ions on reaction with  $NaOH$  and subsequent heating produce black ppt.  
 (1)  $Cu^{+2}$  (2)  $Zn^{+2}$  (3)  $Al^{+3}$  (4)  $Pb^{+2}$
10.  $FeCl_3 + K_3[Fe(CN)_6] + H_2O_2 \longrightarrow$  Precipitate. The colour of the precipitate is :  
 (1) sky blue (2) brown (3) prussian blue (4) white



11.  $\text{CrO}_4^{2-} + \text{H}^+ + \text{H}_2\text{O}_2 \xrightarrow{\text{ether}} \text{X} + \text{H}_2\text{O}$   
Identify the correct statement with respect to X.  
(1) It is an acid anhydride of chromic acid.  
(2) It is a red colour compound which can be extracted easily into the ethereal phase.  
(3) It is chromium peroxide which produces blue colouration in ethereal layer on gentle shaking.  
(4) It is  $\text{Cr}_2\text{O}_3$  which is used as a green pigment.
12. White precipitate of  $\text{Mn}(\text{OH})_2$  on heating with  $\text{PbO}_2$  and concentrated  $\text{HNO}_3$  gives red-violet (purple) colour due to the formation of :  
(1)  $\text{HMnO}_4$  (2)  $\text{Mn}_2\text{O}_7$  (3)  $\text{MnO}(\text{OH})_2$  (4)  $\text{PbMnO}_4$
13.  $\text{Zn}(\text{OH})_2$  precipitate is soluble in :  
(1) excess of sodium hydroxide (2) excess of ammonia solution  
(3) solutions of ammonium salts (4) all of these
14. Select the correct statement with respect to  $\text{Ca}^{2+}$  ions.  
(1)  $\text{K}_2\text{CrO}_4$  gives white precipitate in the presence of acetic acid.  
(2) Potassium hexacyanidoferrate (II) solution gives white precipitate.  
(3) It gives lilac colour in Bunsen flame.  
(4) Prolonged passage of carbon dioxide gas through its aqueous solution produces white precipitate.
15. A mixture of two salts is not water soluble but dissolves completely in dilute  $\text{HCl}$  to form a colourless solution. The mixture could be :  
(1)  $\text{AgNO}_3$  and  $\text{KBr}$  (2)  $\text{BaCO}_3$  and  $\text{ZnS}$   
(3)  $\text{FeSO}_4$  and  $\text{Na}_2\text{CO}_3$  (4)  $\text{Mn}(\text{NO}_3)_2$  and  $\text{MgSO}_4$
16. The reagents,  $\text{NH}_4\text{Cl}$  and aqueous  $\text{NH}_3$  will precipitate :  
(1)  $\text{Ca}^{2+}$  (2)  $\text{Al}^{3+}$  (3)  $\text{Mg}^{2+}$  (4)  $\text{Zn}^{2+}$
17. In the precipitation of the iron group in qualitative analysis, ammonium chloride is added before adding ammonium hydroxide to :  
(1) decrease concentration of  $\text{OH}^-$  ions (2) prevent interference by phosphate ions  
(3) increase concentration of  $\text{Cl}^-$  ions (4) increase concentration of  $\text{NH}_4^+$  ions
18.  $\text{Fe}^{2+}$  does not give prussian blue colour with  $\text{K}_4[\text{Fe}(\text{CN})_6]$  but on its reaction with (X), prussian blue colour appears (X) can be :  
(1)  $\text{MnO}_4^-/\text{H}^+$  (2)  $\text{Zn}/\text{NaOH}$  (3)  $\text{NH}_3$  (aq) (4) all true
19. Select the correct statement with respect to  $\text{Fe}^{3+}$  ions.  
(1) Iron (III) ions react with  $\text{H}_2\text{S}$  in acidic solution to give a black precipitate of  $\text{Fe}_2\text{S}_3$ .  
(2) Iron (III) ions react with ammonium sulphide to give the black precipitate of  $\text{Fe}_2\text{S}_3$ .  
(3) Iron (III) ions react with ammonium thiocyanate solution to produce deep red colouration.  
(4) All of these
20. Which of the following cation does not give red colour precipitate/solution with dimethylglyoxime (DMG) in alkaline solution ?  
(1)  $\text{Zn}^{2+}$  (2)  $\text{Ni}^{2+}$  (3)  $\text{Fe}^{2+}$  (4) both (1) and (3)
21. A suspension containing insoluble substances  $\text{ZnS}$ ,  $\text{MnS}$ ,  $\text{HgS}$ ,  $\text{Ag}_2\text{S}$  and  $\text{FeS}$ , is treated with 2N  $\text{HCl}$ . On filtering, the filtrate contains appreciable amounts of which one of the following?  
(1) Zinc and mercury (2) Silver and iron  
(3) Manganese and mercury (4) Zinc, manganese and iron
22. Potassium chromate  $\text{K}_2\text{CrO}_4$  is NOT used to identify.  
(1)  $\text{Pb}^{+2}$  (2)  $\text{Ba}^{+2}$  (3)  $\text{Ag}^+$  (4)  $\text{Ca}^{+2}$
23. When  $\text{H}_2\text{S}$  gas is passed through  $\text{HCl}$  containing aqueous solution of  $\text{CuCl}_2$ ,  $\text{HgCl}_2$ ,  $\text{BiCl}_3$ , and  $\text{CaCl}_2$  it does not precipitate out :  
(1)  $\text{CuS}$  (2)  $\text{HgS}$  (3)  $\text{Bi}_2\text{S}_3$  (4)  $\text{CaS}$
24.  $\text{AgI}$  is soluble in  $\text{NaCN}$  due to formation of :  
(1)  $\text{Na}[\text{Ag}(\text{CN})_2]$  (2)  $\text{Ag}(\text{CN})_2$  (3)  $\text{Na}_2[\text{Ag}(\text{CN})_3]$  (4)  $\text{Na}_2[\text{Ag}(\text{CN})_2]$



25.  $\text{Cu}^{2+}$  and  $\text{Ag}^{+}$  are both present in the same solution. To precipitate one of the ions and leave the other in solution, which reagent should be added :  
 (1)  $\text{H}_2\text{S}$  (aq) (2)  $\text{HCl}$  (aq) (3)  $\text{HNO}_3$  (aq) (4)  $\text{NH}_4\text{NO}_3$  (aq)
26. Aqueous (A) +  $\text{K}_2\text{CrO}_4 \longrightarrow$  (B)  $\xrightarrow{\text{aq. NH}_3}$  (C)  
 (Red ppt.) (soluble)  
 A is :  
 (1)  $\text{AgNO}_3$  (2)  $\text{Pb}(\text{NO}_3)_2$  (3)  $\text{Hg}_2(\text{NO}_3)_2$  (4)  $\text{Ca}(\text{NO}_3)_2$
27. The ion most difficult to remove as a precipitate is :  
 (1)  $\text{Ag}^{+}$  (2)  $\text{NH}_4^{+}$  (3)  $\text{Fe}^{3+}$  (4)  $\text{Cu}^{2+}$
28.  $\text{CuSO}_4$  reacts with  $\text{NH}_4\text{OH}$  to give deep blue complex of :  
 (1)  $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4$  (2)  $[\text{Cu}(\text{NH}_3)_4](\text{OH})_2$   
 (3) Both (1) and (2) (4) none of these
29. Thenard blue is :  
 (1)  $\text{Cu}(\text{NH}_3)_4\text{SO}_4$  (2)  $\text{CoAl}_2\text{O}_4$   
 (3)  $\text{K}_2\text{Fe}[\text{Fe}(\text{CN})_6]$  (4)  $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$
30. Among the species A ( $\text{CrCl}_3$ ), B ( $\text{CuS}$ ), C ( $\text{AlCl}_3$ ), D ( $\text{ZnCl}_2$ ), which will be soluble in excess of  $\text{NaOH}$  ?  
 (1) A, C and D (2) C and D only (3) B and C only (4) A and D only

### Practice Test-1 (IIT-JEE (Main Pattern))

#### OBJECTIVE RESPONSE SHEET (ORS)

Que.	1	2	3	4	5	6	7	8	9	10
Ans.										
Que.	11	12	13	14	15	16	17	18	19	20
Ans.										
Que.	21	22	23	24	25	26	27	28	29	30
Ans.										

### PART - II : NATIONAL STANDARD EXAMINATION IN CHEMISTRY (NSEC) STAGE-I

1. A 0.1 M solution of certain cation will precipitate with 0.1 M solutions of all these anions  $\text{OH}^{-}$ ,  $\text{CO}_3^{2-}$  &  $\text{SO}_4^{2-}$ . This description is true for the cation. [NSEC-2000]  
 (A)  $\text{Fe}^{2+}$  (B)  $\text{Mg}^{2+}$  (C)  $\text{Ba}^{2+}$  (D)  $\text{Pb}^{2+}$
2. A solution containing  $\text{Co}^{2+}$ ,  $\text{Zn}^{2+}$  and  $\text{Al}^{3+}$  is mixed with an excess of  $\text{KSCN}$  solution. The resulting solution besides the unreacted ions, should contain [NSEC-2003]  
 (A)  $[\text{Co}(\text{SCN})_6]^{4-}$  (B)  $[\text{Zn}(\text{NCS})_6]^{2-}$  (C)  $\text{Al}(\text{SCN})_3$  (D)  $\text{Zn}(\text{SCN})_2$
3. The blue pigment prussian blue is an iron complex with formula [NSEC-2003]  
 (A)  $\text{K}_4[\text{Fe}(\text{CN})_6]$  (B)  $\text{K}_2[\text{Fe}(\text{CN})_4(\text{NH}_3)_2]$   
 (C)  $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$  (D)  $\text{Na}_2[\text{Fe}(\text{CN})_5\text{NO}]$
4. When  $\text{H}_2\text{S}$  is passed through a solution containing  $\text{Cu}^{2+}$ ,  $\text{Cd}^{2+}$  and an excess of cyanide ions, cadmium sulphide precipitates while copper ions remain in solution. This is because [NSEC-2003]  
 (A)  $\text{Cu}^{2+}$  forms a stable complex with cyanide while  $\text{Cd}^{2+}$  does not  
 (B)  $\text{Cu}^{2+}$  forms a more stable complex with cyanide than  $\text{Cd}^{2+}$   
 (C)  $\text{Cu}^{2+}$  does not form a sulphide  
 (D) both  $\text{CdS}$  and  $\text{CuS}$  are formed, but  $\text{CuS}$  is soluble.



5. Generation of a blue colour which is not due to metal ammonia complex formation is seen when [NSEC-2003]  
 (A) sodium is dissolved in liquid ammonia  
 (B) copper (II) sulphate is reacted with ammonium hydroxide  
 (C) cobalt (II) chloride is reacted with ammonium hydroxide  
 (D) formaldehyde is reacted with ammonium hydroxide.
6. There is a mixture of Cu(II) chloride and Fe (II) sulphate. The best way to separate the metal ions from this mixture in qualitative analysis is by treating it with [NSEC-2003]  
 (A) hydrogen sulphide in mild acidic medium, where only Cu(II) sulphide will be precipitated  
 (B) ammonium hydroxide buffer, where only Fe(II) hydroxide will be precipitated  
 (C) hydrogen sulphide in mild acidic medium, where only Fe(II) sulphide will be precipitated  
 (D) ammonium hydroxide buffer, where only Cu(II) hydroxide will be precipitated.
7. The precipitate of AgCl dissolves in [NSEC-2004]  
 (A) conc.  $\text{HNO}_3$  (B) excess of HCl (C) dilute  $\text{H}_2\text{SO}_4$  (D) aq. ammonia.
8. Colour of the bead in borax bead test is mainly due to the formation of [NSEC-2005]  
 (A) metal oxides (B) boron oxide  
 (C) metal metaborates (D) elemental boron.
9. The metal that dissolves in liquid ammonia giving dark blue coloured solution is [NSEC-2005]  
 (A) Sn (B) Pb (C) Na (D) Ag.
10. Aqueous solutions having equimolar quantities of  $\text{Pb}(\text{NO}_3)_2$ ,  $\text{AgNO}_3$ ,  $\text{AgSO}_4$ ,  $\text{BaCl}_2$  and  $\text{K}_2\text{CrO}_4$  are allowed to react and the reaction mixture is then filtered. Which ions in the filtrate in appreciable quantity? [NSEC-2007]  
 (A)  $\text{Pb}^{2+}$ ,  $\text{Ag}^+$ ,  $\text{Ba}^{2+}$ ,  $\text{K}^+$ ,  $\text{NO}_3^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{CrO}_4^{2-}$ ,  $\text{Cl}^-$  (B)  $\text{Ba}^{2+}$ ,  $\text{K}^+$ ,  $\text{NO}_3^-$ ,  $\text{CrO}_4^{2-}$   
 (C)  $\text{Pb}^{2+}$ ,  $\text{Ba}^{2+}$ ,  $\text{K}^+$ ,  $\text{NO}_3^-$ ,  $\text{CrO}_4^{2-}$  (D)  $\text{K}^+$ ,  $\text{NO}_3^-$
11. 1 mL of concentrated aqueous ammonia is added dropwise to 1 mL of a dilute aqueous solution of Cu(II). What observations can be made during this process? [NSEC-2008]  
 (A) The colorless Cu(II) nitrate solution turns blue and yields a dark blue precipitate  
 (B) The colorless copper (II) nitrate solution yields a white precipitate which turns dark blue upon standing.  
 (C) The light blue copper (II) nitrate solution yields a white precipitate which redissolves to form a dark blue solution.  
 (D) The light blue copper (II) nitrate solution turns dark
12. Two white solids, lead (II) chloride and silver chloride can be distinguished from each other by - [NSEC-2008]  
 (A) adding cold water to each : the silver chloride will dissolve.  
 (B) adding hot water to each : the lead (II) chloride will dissolve.  
 (C) adding sodium chloride solution to each : the lead (II) chloride will become warm and release chlorine gas.  
 (D) adding zinc chloride solution to each : the silver chloride will change to metallic silver.
13.  $\text{CuSO}_4$  reacts with KCN to form water insoluble CuCN. This insoluble precipitate dissolves in excess of KCN, due to formation of the following complex [NSEC-2008]  
 (A)  $\text{K}_2[\text{Cu}(\text{CN})_4]$  (B)  $\text{K}_3[\text{Cu}(\text{CN})_4]$  (C)  $\text{Cu}(\text{CN})_2$  (D)  $\text{Cu}[\text{KCu}(\text{CN})_4]$
14.  $\text{MgSO}_4$  on reaction with  $\text{NH}_4\text{OH}$  and  $\text{Na}_2\text{HPO}_4$  forms a white crystalline precipitate. The formula of the precipitate is - [NSEC-2009]  
 (A)  $\text{Mg}(\text{NH}_4)\text{PO}_4$  (B)  $\text{Mg}_3(\text{PO}_4)_2$  (C)  $\text{MgCl}_2 \cdot \text{MgSO}_4$  (D)  $\text{MgSO}_4$
15. The pair of cations which **cannot** be separated by  $\text{H}_2\text{S}$  in a 0.3N acid solution is - [NSEC-2011]  
 (A)  $\text{Al}^{+++}$ ,  $\text{Hg}^{++}$  (B)  $\text{Bi}^{+++}$ ,  $\text{Pb}^{++}$  (C)  $\text{Zn}^{++}$ ,  $\text{Cu}^{++}$  (D)  $\text{Ni}^{++}$ ,  $\text{Cd}^{++}$
16. An aqueous solution of a salt 'X' gives white precipitate with dilute  $\text{H}_2\text{SO}_4$ . The same solution with a few drops of aq. KI gives golden yellow precipitate which dissolves on heating. The salt 'X' is : [NSEC-2012]  
 (A)  $\text{Ba}(\text{NO}_3)_2$  (B)  $\text{Sr}(\text{NO}_3)_2$  (C)  $\text{Pb}(\text{NO}_3)_2$  (D)  $\text{Zn}(\text{NO}_3)_2$



17. A cold aqueous solution of  $\text{PbCl}_2$  gives golden yellow precipitate on addition of [NSEC-2013]  
(A) KCl solution (B) KI solution (C) NaCl solution (D)  $\text{K}_2\text{SO}_4$  solution
18. The ions which give black precipitates on passing  $\text{H}_2\text{S}$  gas in acidic medium are [NSEC-2013]  
(A)  $\text{Al}^{3+}$  and  $\text{Ni}^{2+}$  (B)  $\text{Ni}^{2+}$  and  $\text{Co}^{2+}$  (C)  $\text{Cu}^{2+}$  and  $\text{Bi}^{3+}$  (D)  $\text{Zn}^{2+}$  and  $\text{Mn}^{2+}$
19. The colorless salt that gives white precipitate with  $\text{BaCl}_2$  in aqueous HCl is [NSEC-2014]  
(A)  $\text{K}_2\text{SO}_4$  (B)  $\text{K}_2\text{SO}_3$  (C)  $\text{KNO}_3$  (D) KBr
20. Certain combinations of cations and anions lead to the formation of colored salts in solid state even though each of these ions with other counter ions may produce colorless salts. This phenomenon is due to temporary charge transfer between the two ions. Out of the following the salt that can exhibit this behavior is [NSEC-2015]  
(A)  $\text{SnCl}_2$  (B)  $\text{SnCl}_4$  (C)  $\text{SnBr}_2$  (D)  $\text{SnI}_4$
21. Metallic copper dissolves in [NSEC-2015]  
(A) dilute HCl (B) Concentrated HCl (C) aqueous KCN (D) pure ammonia
22. Cyanide ion is a very good complexing agent and also functions as a reducing agent. Hence may cyanide complexes of metals are known. Addition of an aqueous solution of KCN to a solution of copper sulphate yields a white precipitate which is soluble in excess of aqueous KCN to form the complex : [NSEC-2016]  
(A)  $[\text{Cu}(\text{CN})_4]^{1-}$  (B)  $[\text{Cu}(\text{CN})_4]^{2-}$  (C)  $[\text{Cu}(\text{CN})_4]^{3-}$  (D)  $[\text{Cu}(\text{CN})_4]^{4-}$
23. Passing  $\text{H}_2\text{S}$  gas into a mixture of  $\text{Mn}^{2+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Cu}^{2+}$  and  $\text{Hg}^{2+}$  in an acidified aqueous solution precipitates. [NSEC-2016]  
(A) CuS and HgS (B) MnS and CuS (C) MnS and NiS (D) NiS and HgS

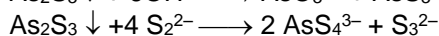
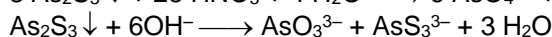
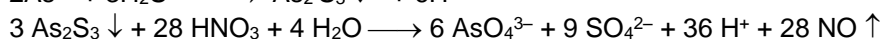
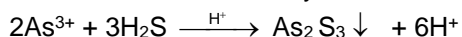
## PART - III : HIGH LEVEL PROBLEMS (HLP)

### THEORY

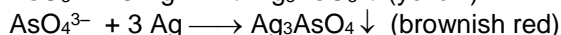
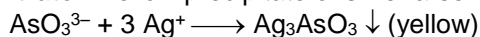
#### IIB Group ( $\text{As}^{3+}$ , $\text{Sb}^{3+}$ , $\text{Sn}^{2+}$ , $\text{Sn}^{4+}$ ) (Not in JEE advance syllabus)

##### 1. ARSENIC ION ( $\text{As}^{3+}$ ) :

- **Precipitation with  $\text{H}_2\text{S}$  in acidic medium** : Yellow precipitate is formed which is soluble in warm concentrated nitric acid, sodiumhydroxide solution and yellow ammonium sulphide.

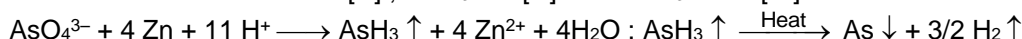
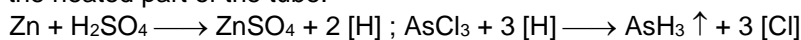


- **Silver nitrate** : Yellow precipitate of silver arsenite in neutral solution is formed with  $\text{AsO}_3^{3-}$  ions.



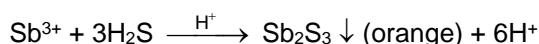
The precipitate is soluble in both nitric acid and ammonia.

- **Marsh's test** : This test is based on the fact that all soluble compounds of arsenic are reduced by 'nascent' hydrogen in acid solution to arsine ( $\text{AsH}_3$ ), a colourless, extremely poisonous gas with a garlic-like odour. If the gas, mixed with hydrogen, is passed through a heated glass tube, it is decomposed into hydrogen and metallic arsenic, which is deposited as a brownish-black 'mirror' just beyond the heated part of the tube.



##### 2. ANTIMONY ION ( $\text{Sb}^{3+}$ ) :

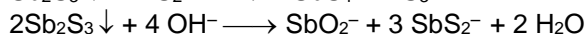
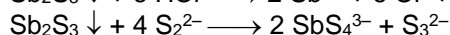
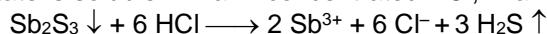
- **Precipitation with  $\text{H}_2\text{S}$  in acidic medium** : A orange red precipitate is formed from mildly acidic solutions.



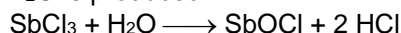




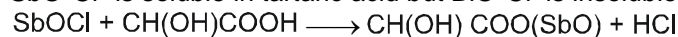
Precipitate is soluble in warm concentrated HCl, in ammonium polysulphide and in alkali hydroxides.



- **Dilution with water** : When water is poured in a solution of soluble  $\text{SbCl}_3$ , a white precipitate of antimonyl chloride ( $\text{SbOCl}$ ) is formed, soluble in HCl. With a large excess of water, the hydrated oxide  $\text{Sb}_2\text{O}_3 \cdot x\text{H}_2\text{O}$  is produced.



☞  $\text{SbO}^+\text{Cl}^-$  is soluble in tartaric acid but  $\text{BiO}^+\text{Cl}^-$  is insoluble in tartaric acid.



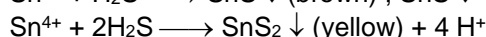
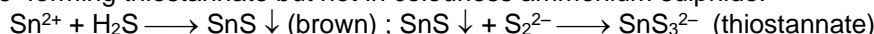
Antimonyl tartrate (soluble)

- **Sodium hydroxide or Ammonia solution** : White precipitate of hydrate of antimony (III) oxide  $\text{Sb}_2\text{O}_3 \cdot x\text{H}_2\text{O}$  is soluble in concentrated (5M) solution of caustic alkalies forming antimonites.  
 $2 \text{Sb}^{3+} + 6 \text{OH}^- \longrightarrow \text{Sb}_2\text{O}_3 \downarrow + 3 \text{H}_2\text{O}$  ;  $\text{Sb}_2\text{O}_3 + 2 \text{OH}^- \longrightarrow 2 \text{SbO}_2^- + \text{H}_2\text{O}$
- **Potassium iodide solution** : Yellow colouration is obtained owing to the formation of a complex salt.  
 $\text{Sb}^{3+} + 6 \text{I}^- \longrightarrow [\text{SbI}_6]^{3-}$
- **Reduction with zinc or tin** :  $\text{Sb}^{3+}$  ions give black precipitate of metal.  
 $2 \text{Sb}^{3+} + 3 \text{Zn} \longrightarrow 2 \text{Sb} \downarrow + 3 \text{Zn}^{2+}$  ;  $2 \text{Sb}^{3+} + 3 \text{Sn} \longrightarrow 2 \text{Sb} \downarrow + 3 \text{Sn}^{2+}$

### 3. TIN (II) ION ( $\text{Sn}^{2+}$ ) AND TIN (IV) ION ( $\text{Sn}^{4+}$ ) :

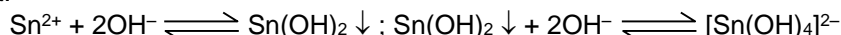
- **Precipitation with  $\text{H}_2\text{S}$  in acidic medium** :

Brown precipitate is obtained with  $\text{Sn}^{2+}$  which is soluble in concentrated HCl and yellow ammonium sulphide forming thiostannate but not in colourless ammonium sulphide.



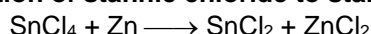
Precipitate is soluble in concentrated HCl (difference from  $\text{As}^{3+}$  and  $\text{Hg}^{2+}$ ) and in alkali hydroxide, and also in ammonium sulphide and yellow ammonium sulphide.

- **Sodium hydroxide solution**: White precipitate of  $\text{Sn}(\text{OH})_2$  is formed which is soluble in excess of reagent.

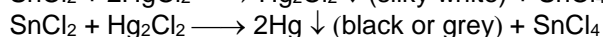


☞ With ammonia solution, white tin (II) hydroxide is precipitated, which cannot be dissolved in excess ammonia.

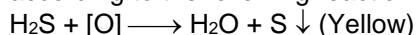
- **Reduction of stannic chloride to stannous chloride by iron filling or granulated zinc** :



- **Mercuric chloride solution** :



☞  $\text{HNO}_3$  is not used because it acts as an oxidising agent and in solution it oxidises  $\text{H}_2\text{S}$  to S according to the following reaction.



## SUBJECTIVE QUESTIONS

1. What happens when diammine silver (I) reacts with hydrazine sulphate ?
2. Does mercuric sulphide dissolve in sodium sulphide solution (of 2M) ?
3. What happens when black precipitate of  $\text{HgS}$  is dissolved in aquaregia ?
4. Is there any reaction other than cyanide reaction which can be used for the differentiation of  $\text{Cu}^{2+}$  and  $\text{Cd}^{2+}$  ions?
5. Which basic radical is tested with the help of alkaline sodium stannite solution ?
6. Does tartaric acid can be used to distinguish  $\text{SbOCl}$  and  $\text{BiOCl}$  ?
7. Why use of excess cobalt nitrate solution should be avoided in the dry test of aluminium compounds ?

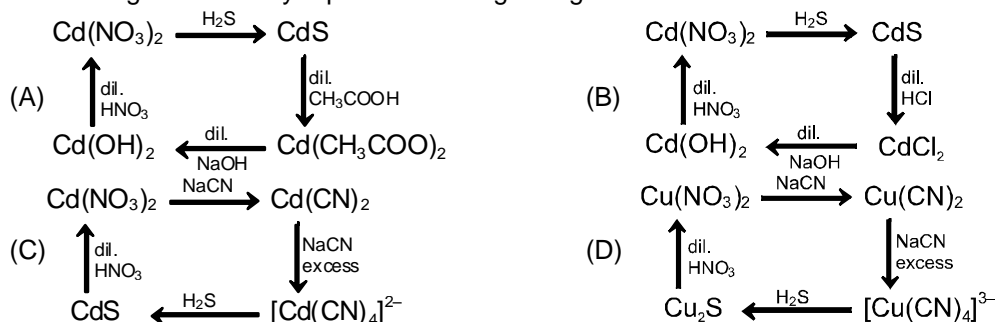








20. Which diagram correctly represents change for given nitrate solution.



21. In regards to  $\text{Sn}^{2+}$  and  $\text{Sn}^{4+}$  which statement is incorrect -  
 (A)  $\text{Sn}^{2+}$  sulphides is black while  $\text{Sn}^{4+}$  sulphide is golden yellow.  
 (B)  $\text{Sn}^{2+}$  sulphides is Brown while  $\text{Sn}^{4+}$  sulphide is golden yellow.  
 (C) Both sulphides dissolve in HCl.  
 (D) Both chloride does not react with  $\text{HgCl}_2$ .
22.  $\text{SnCl}_2$  solution, when treated with excess of KOH on heating produces  
 (A)  $\text{K}_2\text{SnO}_2$  (B)  $\text{K}_2\text{SnO}_3$  (C)  $\text{K}_4\text{SnO}_4$  (D)  $\text{K}_3\text{SnO}_3$
23. Intense blue precipitate of  $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$  and potassium hydroxide solution when mixed gives :  
 (A)  $\text{K}_2\text{Fe}[\text{Fe}(\text{CN})_6]$  - white precipitate (B)  $\text{Fe}(\text{OH})_3$  - reddish-brown precipitate  
 (C)  $\text{Fe}(\text{CN})_3$  - reddish-brown precipitate (D)  $\text{KFe}[\text{Fe}(\text{CN})_6]$  - Turnbull's blue
24. Turnbull's blue is a .....  
 (A) ferricyanide (B) ferrous ferricyanide  
 (C) ferrous cyanide (D) ferri ferrocyanide
25. A metal salt cobalt form brown solution with excess of KCN solution. This brown solution turns yellow when boiled for a longer time in air due to formation of :  
 (A)  $\text{Co}(\text{CN})_2$  (B)  $\text{K}_4[\text{Co}(\text{CN})_6]$  (C)  $\text{K}_3[\text{Co}(\text{CN})_6]$  (D)  $\text{K}_2[\text{Co}(\text{CN})_6]$
26. CoS (black) obtained in group IV of salt analysis is dissolved in aqua regia and is treated with an excess of  $\text{NaHCO}_3$  and then  $\text{Br}_2$  water. An apple green coloured stable complex is formed. It is :  
 (A) sodium cobaltocarbonate (B) sodium cobaltibromide  
 (C) sodium cobaltcarbonate (D) sodium cobaltobromide
27. Orange coloured sodium cobaltinitrite  $\text{Na}_3[\text{Co}(\text{NO}_2)_6]$  is used for the detection of  $\text{K}^+$  ions which gives ..... ppt. due to the formation of Pot. Sod. Cobaltinitrite  $\text{K}_2\text{Na}[\text{Co}(\text{NO}_2)_6]$   
 (A) White (B) Orange (C) Yellow (D) Brown
28.  $\text{NiCl}_2 + \text{KCN} \xrightarrow{\text{excess}} \text{Yellow colour solution} \xrightarrow{\text{NaOH} + \text{Br}_2 \text{ water}} \text{"X" ppt}$   
 Colour of precipitate of "X" is :  
 (A) green (B) black (C) yellow (D) Reddish Brown
29. The presence of magnesium is confirmed in the qualitative analysis by :  
 (A) titan yellow solution + 2M NaOH solution (B) disodium hydrogen phosphate +  $\text{NH}_4\text{Cl}$  +  $\text{NH}_3$  (aq.)  
 (C) magneson(I) reagent (D) all of these
30. To a solution of a substance, gradual addition of ammonium hydroxide results in a brownish black precipitate which does not dissolve in excess of  $\text{NH}_4\text{OH}$ . However, when KI (not in excess) is added to the original solution, a green precipitate is formed. The solution contained :  
 (A) Lead salt (B) Silver salt (C) Mercurous salt (D) Copper salt.
31. Which of following is soluble in yellow ammonium sulphide ?  
 (A) CdS (B) CuS (C) SnS (D) PbS



32. A mixture of chlorides of cadmium, chromium, iron and aluminium was dissolved in water acidified with HCl and hydrogen sulphide gas was passed for sufficient time. It was filtered, boiled and a few drops of nitric acid were added while boiling. To this solution ammonium chloride and sodium hydroxide were added in excess of filtered. The filtrate shall give test for :  
 (A) sodium and iron ion (B) sodium, chromium and aluminium ion  
 (C) aluminium and iron ion (D) sodium, iron, cadmium and aluminium ion.
33. Which one of the following cations will give a green coloured ash when a piece of filter paper dipped in a solution containing its salt and  $\text{Co}(\text{NO}_3)_2$  is burned ?  
 (A)  $\text{Cu}^{2+}$  (B)  $\text{Mg}^{2+}$  (C)  $\text{Al}^{3+}$  (D)  $\text{Zn}^{2+}$
34. To avoid the precipitation of hydroxides of  $\text{Ni}^{2+}$ ,  $\text{Co}^{2+}$ ,  $\text{Mn}^{2+}$  along with those of the third group cations, the solutions should be :  
 (A) heated with few drops of concentrated  $\text{HNO}_3$ .  
 (B) boiled with excess of ammonium chloride.  
 (C) concentrated to small volume.  
 (D) none of these.
35. A metal M and its compound can give the following observable changes in a sequence of reactions,  

$$\text{M} \xrightarrow[\text{HNO}_3]{\text{very dilute}} \left[ \begin{array}{c} \text{Colourless solution} \\ \text{and no gas is evolved} \end{array} \right] \xrightarrow[\text{NaOH}]{\text{aqueous}} \left[ \begin{array}{c} \text{White} \\ \text{precipitate} \end{array} \right] \xrightarrow[\text{NaOH(aq.)}]{\text{excess}} \left[ \begin{array}{c} \text{Colourless} \\ \text{solution} \end{array} \right] \xrightarrow{\text{H}_2\text{S} / \text{OH}^-} \left[ \begin{array}{c} \text{White} \\ \text{precipitate} \end{array} \right]$$
  
 The metal M can be :  
 (A) Mg (B) Pb (C) Zn (D) Sn
36. Identify the correct order of solubility of  $\text{Na}_2\text{S}$ ,  $\text{CuS}$  and  $\text{ZnS}$  in aqueous medium. [JEE 2002, 3/150]  
 (A)  $\text{CuS} > \text{ZnS} > \text{Na}_2\text{S}$  (B)  $\text{ZnS} > \text{Na}_2\text{S} < \text{CuS}$  (C)  $\text{Na}_2\text{S} > \text{CuS} > \text{ZnS}$  (D)  $\text{Na}_2\text{S} > \text{ZnS} > \text{CuS}$

### SINGLE AND DOUBLE VALUE INTEGER TYPE

37. When a metal rod M is dipped into a aqueous, colourless conc. solution of compound N, which is a nitrate of metal 'P', the solution turns light blue. Addition of aqueous. NaCl to the blue solution given a white ppt 'O'. Addition of aqueous  $\text{NH}_3$ , dissolve 'O' and give an deep blue solution. The final solution contains  $[\text{M}(\text{NH}_3)_x]^{n+}$  and  $[\text{P}(\text{NH}_3)_y]^{m+}$ . (M) & (N) both belongs to same groups in periodic table. Calculate the value of  $x + y + n + m$  ?
38.  $\text{Sn}^{n+} + \text{H}_2\text{S} \xrightarrow{\text{dil. HCl}} \text{(A) Yellow ppt.}$   
 If yellow ppt of (A) has "p" number of atom (per molecule). Then what is the value of  $(p + n)$ .
39.  $\text{Na}_2\text{CrO}_4 + \text{dil. H}_2\text{SO}_4 \longrightarrow \text{Na}_2\text{SO}_4 + \text{H}_2\text{CrO}_4$   
 $\text{H}_2\text{CrO}_4 + 2\text{H}_2\text{O}_2 \xrightarrow{\text{amyl alcohol}} \text{'A' (blue colouration)} + \text{H}_2\text{O}$   
 then find a + b, if  
 a = number of O – O bonds in "A"  
 b = number of Cr – O  $\sigma$ (sigma) bonds in "A"
40.  $\text{NaBiO}_3 + \text{Mn}(\text{NO}_3)_2 + \text{HNO}_3 \longrightarrow \text{Product}$   
 Sum of oxidation number of Bi, N and Mn in products
41. Solution of  $\text{AsO}_4^{3-}$  ion containing considerable excess of  $\text{HNO}_3$  on boiling with Ammonium molybdate test gives a yellow crystalline precipitate (X). Number of oxygen atom present in per molecule of precipitated (X) are :
42.  $\text{As}^{3+} + \text{H}_2\text{S} \xrightarrow{\text{dil. HCl}} \text{"yellow ppt of A"}$   
 $\text{A} + \text{yellow ammonium sulphide} \longrightarrow \text{C} + \text{D}$   
 How many different type of oxidation states of sulphur are possible in "C" and "D".



## ONE OR MORE THAN ONE OPTIONS CORRECT TYPE

43. Which of the following statement(s) is/are correct ?  
 (A) Yellow precipitated of silver arsenite is soluble in both nitric acid and ammonia.  
 (B) Potassium cyanide when added in very small quantity to copper sulphate solution, produces first yellow precipitate which quickly converts in to white precipitate.  
 (C) Black precipitate of  $\text{BiI}_3$  turns orange on heating with water.  
 (D) White precipitate of  $\text{Bi}(\text{OH})_3$  turns yellowish brown, when boiled.
44.  $\text{Cu}^{2+}$  ions give white precipitate with :  
 (A) potassium iodide solution.  
 (B) potassium thiocyanate and saturated solution of  $\text{SO}_2$ .  
 (C) excess of potassium cyanide solution.  
 (D) potassium hydroxide solution.
45. Ammonium molybdate is used to detect the radical :  
 (A)  $\text{PO}_4^{3-}$  (B)  $\text{AsO}_4^{3-}$  (C)  $\text{Cu}^{2+}$  (D)  $\text{Ag}^+$
46. Which of the following process result in a prussian blue ppt ?  
 (A)  $\text{Fe}^{2+} + [\text{Fe}(\text{CN})_6]^{3-} \rightarrow$  (B)  $\text{Fe}^{3+} + [\text{Fe}(\text{CN})_6]^{4-} \rightarrow$   
 (C)  $\text{Fe}^{3+} + [\text{Fe}(\text{CN})_6]^{3-} \rightarrow$  (D)  $\text{Fe}^{3+} + [\text{Fe}(\text{CN})_6]^{3-} \rightarrow \text{P} \xrightarrow{\text{SnCl}_2}$
47. Which of the following statement(s) is /are false ?  
 (A)  $\text{Fe}^{3+}$  gives red precipitate with dimethyl glyoxime in alkaline solution.  
 (B)  $\text{Cu}^{2+}$  ion with potassium iodide solution gives a dirty brownish white precipitate which turns white on adding hypo solution.  
 (C) A filter paper soaked in mercurous nitrate turns black in contact with ammonia gas.  
 (D)  $\text{Ag}_2\text{O}$  does not dissolve in nitric acid as well as ammonia solution.
48. Which of the following statements is/are correct ?  
 (A) An aqueous solution of  $\text{Co}(\text{II})$  thiocyanate (10% freshly prepared) and mercuric nitrate solution taken in equal volumes on stirring the wall of the vessel with a glass rod produce deep-blue precipitate.  
 (B) White precipitate of  $\text{Al}(\text{OH})_3$  is soluble in sodium hydroxide as well as in ammonia solution.  
 (C) Green precipitate of  $\text{Cr}(\text{OH})_3$  readily dissolves in excess of sodium hydroxide forming a green solution.  
 (D) Chromium (III) salts give green coloured borax bead in both oxidising and reducing flame.
49.  $\text{Co}^{2+} + \text{KCN}$  (not in excess)  $\longrightarrow$  precipitate.  
 Select the correct statement(s) with respect to the precipitate.  
 (A) It is yellow in colour.  
 (B) It is reddish-brown in colour.  
 (C) It dissolves in excess of the reagent forming a brown solution.  
 (D) It is obtained when brown solution (option (C)) is acidified with dilute  $\text{HCl}$  in the cold.
50. Which of the following sulphides do not dissolve in 50%  $\text{HNO}_3$  but dissolve in aquaregia ?  
 (A)  $\text{CoS}$  (B)  $\text{NiS}$  (C)  $\text{CuS}$  (D)  $\text{HgS}$
51.  $\text{Ni} + \text{H}_2\text{SO}_4$  (hot and concentrated)  $\longrightarrow \text{X}(\text{g})$ .  
 The liberated gas (select the correct statement(s)) :  
 (A) develops blue colour spots on the filter paper moistened with potassium iodate and starch solution.  
 (B) turns acidified  $\text{K}_2\text{Cr}_2\text{O}_7$  solution green.  
 (C) produces black precipitate with lead acetate solution.  
 (D) reacts with  $\text{Cl}_2$  water to produce an acid which gives white fumes with ammonia.
52. Select the incorrect statement(s).  
 (A) Ammonium ions produce yellow colour solution with sodium hexanitrito-N-cobaltate (III).  
 (B) Ammonia gas develops a brown colour on filter paper moistened with a solution of  $\text{MnCl}_2$  and  $\text{H}_2\text{O}_2$ .  
 (C) Ammonium ions produce white precipitate with saturated sodium hydrogen tartrate solution.  
 (D) Ammonium salts in presence of sodium hydroxide solution produces red precipitate with 4-nitrobenzene diazonium chloride reagent.



## PART - IV : PRACTICE TEST-2 (IIT-JEE (ADVANCED Pattern))

Max. Time : 1 Hr.

Max. Marks : 66

### Important Instructions

#### A. General :

- The test is of 1 hour duration.
- The Test Booklet consists of 22 questions. The maximum marks are 66.

#### B. Question Paper Format :

- Each part consists of five sections.
- Section-1 contains 7 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which ONE is correct.
- Section-2 contains 5 multiple choice questions. Each question has four choices (A), (B), (C) and (D) out of which ONE OR MORE THAN ONE are correct.
- Section-3 contains 6 questions. The answer to each of the questions is a single-digit integer, ranging from 0 to 9 (both inclusive).
- Section-4 contains 1 paragraphs each describing theory, experiment and data etc. 3 questions relate to paragraph. Each question pertaining to a particular passage should have only one correct answer among the four given choices (A), (B), (C) and (D).
- Section-5 contains 1 multiple choice questions. Question has two lists (list-1 : P, Q, R and S; List-2 : 1, 2, 3 and 4). The options for the correct match are provided as (A), (B), (C) and (D) out of which ONLY ONE is correct.

#### C. Marking Scheme :

- For each question in Section-1, 4 and 5 you will be awarded 3 marks if you darken the bubble corresponding to the correct answer and zero mark if no bubble is darkened. In all other cases, minus one (– 1) mark will be awarded.
- For each question in Section-2, you will be awarded 3 marks. If you darken all the bubble(s) corresponding to the correct answer(s) and zero mark. If no bubbles are darkened. No negative marks will be answered for incorrect answer in this section.
- For each question in Section-3, you will be awarded 3 marks if you darken only the bubble corresponding to the correct answer and zero mark if no bubble is darkened. No negative marks will be awarded for incorrect answer in this section.

### SECTION-1 : (Only One option correct Type)

**This section contains 7 multiple choice questions. Each questions has four choices (A), (B), (C) and (D) out of which Only ONE option is correct.**

- A solution containing  $\text{SCN}^-$  ions can be used to test one or more out of :  $\text{Fe}^{3+}$ ,  $\text{Co}^{2+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Ag}^+$  and  $\text{Hg}^{2+}$ .  
 (A)  $\text{Fe}^{3+}$  and  $\text{Co}^{2+}$  only (B)  $\text{Co}^{2+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Ag}^+$  and  $\text{Hg}^{2+}$   
 (C)  $\text{Fe}^{3+}$ ,  $\text{Cu}^{2+}$ ,  $\text{Co}^{2+}$  and  $\text{Hg}^{2+}$  (D) all
- A blue colouration (in solution or precipitate) is not obtained when :  
 (A) ammonium hydroxide dissolves in copper sulphate.  
 (B) cobalt chloride reacts with  $\text{NH}_4\text{SCN}$  in presence of amyl alcohol.  
 (C) ferric chloride reacts with sodium ferrocyanide.  
 (D) aqueous ammonia reacts with white precipitate of silver (I) chloride.
- A metal nitrate solution reacts with dilute hydrochloric acid to give a white precipitate which is soluble in concentrated potassium chloride. White precipitate on passing of hydrogen sulphide gas is converted into black precipitate. The black precipitate on boiling with hydrogen peroxide (3%) is converted again to a white precipitate which is soluble in ammonium acetate. The cation of the metal nitrate is :  
 (A)  $\text{Pb}^{2+}$  (B)  $\text{Ag}^+$  (C)  $\text{Hg}^{2+}$  (D)  $\text{Bi}^{3+}$
- A metal nitrate solution does not give white precipitate with concentrated hydrochloric acid but on dilution with water produces a white precipitate. The metal nitrate solution with  $\text{K}_2\text{CrO}_4$  and  $\text{Na}_2\text{HPO}_4$  reagents gives red and yellow precipitates respectively which are soluble in ammonia solution. The cation of the metal nitrate is :  
 (A)  $\text{Pb}^{2+}$  (B)  $\text{Ag}^+$  (C)  $\text{Cu}^{2+}$  (D)  $\text{Bi}^{3+}$



5. Which of the following pairs comprise the red precipitates ?  
 (A)  $\text{Ag}_2\text{CrO}_4$  and  $\text{Hg}_2\text{CrO}_4$  (B)  $\text{HgI}_2$  and  $\text{Ni}(\text{dmg})_2$   
 (C)  $\text{BiOI}$  and  $\text{Cu}_2[\text{Fe}(\text{CN})_6]$  (D) (A) and (B) both
6. A coloured solution of an inorganic salt reacts with potassium thiocyanate to give first a black precipitate, which slowly turns white. The salt solution also gives black precipitate with  $\text{H}_2\text{S}$  gas in slightly acidic medium. The black precipitate dissolves in potassium cyanide forming a colourless solution. The basic radical present in the inorganic salt is :  
 (A)  $\text{Bi}^{3+}$  (B)  $\text{Cu}^{2+}$  (C)  $\text{Hg}^{2+}$  (D) None
7. Select the incorrect statement.  
 (A) Marsh's test involves the reduction of soluble arsenic compound to arsine by nascent hydrogen in acidic solution and its subsequent decomposition into hydrogen and metallic arsenic as a brownish-black mirror on heating in a glass tube mixed with hydrogen.  
 (B) Ammonical silver nitrate gives metallic silver mirror with saturated solution of hydrazine sulphate.  
 (C) Red precipitate of silver (I) chromate is soluble in dilute nitric acid and ammonia solution.  
 (D) None of these

### Section-2 : (One or More than one options correct Type)

This section contains 5 multipole choice questions. Each questions has four choices (A), (B), (C) and (D) out of which ONE or MORE THAN ONE are correct.

8. The following can be used to regulate the concentration of  $\text{OH}^-$  ions for the scheme of basic radical analysis (III group).  
 (A)  $\text{NH}_4\text{NO}_3$  (B)  $\text{NH}_4\text{Cl}$  (C)  $(\text{NH}_4)_2\text{SO}_4$  (D)  $(\text{NH}_4)_2\text{CO}_3$
9. White precipitate of  $\text{PbSO}_4$  gets dissolved in :  
 (A) concentrated  $\text{H}_2\text{SO}_4$  on heating (B) concentrated  $\text{NaOH}$   
 (C)  $(\text{NH}_4)_2\text{CO}_3$  (D) dilute  $\text{HNO}_3$
10. Select the correct statement(s).  
 (A) In group III,  $\text{Fe}^{3+}$  and  $\text{Cr}^{3+}$  can be differentiated by increasing  $\text{NH}_4^+$  ion concentration  
 (B) In V<sup>th</sup> group,  $\text{Na}_2\text{CO}_3$  is added to precipitate out only the carbonates of  $\text{Ba}^{2+}$ ,  $\text{Sr}^{2+}$  and  $\text{Ca}^{2+}$ .  
 (C) Like brown ring test, diphenylamine test is given only by salts containing  $\text{NO}_3^-$ .  
 (D) Sodium chloride on heating with aqueous solution of  $\text{K}_2\text{Cr}_2\text{O}_7$  and concentrated  $\text{H}_2\text{SO}_4$  produces deep red vapours.
11. Which of the following statement(s) is/are not correct ?  
 (A) Nickel salts give rosy red precipitate with dimethyl glyoxime in excess of  $\text{NH}_4\text{OH}$ .  
 (B) Fe (III) salts give red colour with potassium sulphocyanide.  
 (C) In nitroprusside, the iron and NO exist as Fe(III) and NO.  
 (D) Mn (II) salts give white precipitate with  $\text{NaOH}$  which turns brown on adding  $\text{Br}_2$  water.
12. Potassium ferrocyanide is used for testing  
 (A)  $\text{Cu}^{2+}$  and  $\text{Zn}^{2+}$  (B)  $\text{Fe}^{3+}$  and  $\text{Ca}^{2+}$  (C)  $\text{Ag}^+$  and  $\text{Zn}^{2+}$  (D)  $\text{Cd}^{2+}$  and  $\text{Cu}^{2+}$

### Section-3 : (One Integer Value Correct Type.)

This section contains 6 questions. Each question, when worked out will result in one integer from 0 to 9 (both inclusive)

13. How many of the following pairs of ions can be separated by  $\text{H}_2\text{S}$  in dilute  $\text{HCl}$  ?  
 $\text{Bi}^{3+}$  and  $\text{Sn}^{4+}$ ,  $\text{Al}^{3+}$  and  $\text{Hg}^{2+}$ ,  $\text{Cd}^{2+}$  and  $\text{Zn}^{2+}$ ,  $\text{Fe}^{3+}$  and  $\text{Cu}^{2+}$ ,  $\text{As}^{3+}$  and  $\text{Sb}^{3+}$
14. In how many of the following reactions, one of the product is obtained as a yellow precipitate ?  
 $\text{Ba}^{2+}(\text{aq}) + \text{CrO}_4^{2-}(\text{aq}) \longrightarrow \text{product}$   
 $\text{Ag}^+(\text{aq}) + \text{Br}^-(\text{aq}) \longrightarrow \text{product}$   
 $\text{Pb}^{2+}(\text{aq}) + \text{I}^-(\text{aq}) \longrightarrow \text{product}$   
 $\text{NH}_4^+(\text{aq}) + [\text{PtCl}_6]^{2-}(\text{aq}) \longrightarrow \text{product}$



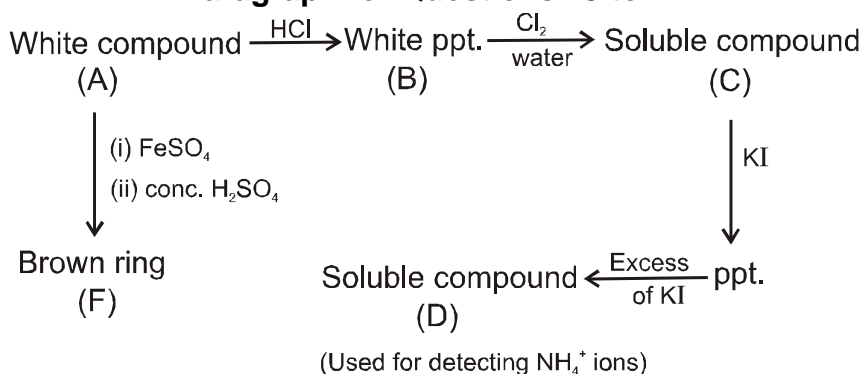


15. In how many of the following cases solubility of salt is greater in acidic solution than in pure water?
- |                       |                                   |                     |
|-----------------------|-----------------------------------|---------------------|
| AgCl,                 | AgCN,                             | MnS,                |
| Zn(OH) <sub>2</sub> , | Ag <sub>3</sub> PO <sub>4</sub> , | AgNO <sub>2</sub> , |
| Al(OH) <sub>3</sub> , | CH <sub>3</sub> COOAg,            | BaSO <sub>3</sub>   |
16. How many statements are correct ?
- Like CO<sub>3</sub><sup>2-</sup>, SO<sub>3</sub><sup>2-</sup> also gives test with lime water.
  - In the test of NO<sub>3</sub><sup>-</sup>, brown ring is formed due to the formation of [Fe (H<sub>2</sub>O)<sub>5</sub> NO]<sup>2+</sup>.
  - Aqueous solution of Ag<sup>+</sup> ions gives brick red/red precipitate with K<sub>2</sub>CrO<sub>4</sub>.
  - Lead salts turn black on prolonged exposure in a chemical laboratory.
  - In analysis of group II<sup>nd</sup> cations, H<sub>2</sub>S gas is passed in presence of hydrochloric acid to enhance the concentration of S<sup>2-</sup> ions.
  - Aqueous solution of Cu<sup>2+</sup> ions forms a green complex with K<sub>4</sub>[Fe(CN)<sub>6</sub>].
17. How many of the following reaction result in the formation of colored precipitate (not white).
- HgCl<sub>2</sub> + SnCl<sub>2</sub> (excess)  $\longrightarrow$
  - HgCl<sub>2</sub> + KI  $\longrightarrow$
  - Pb(NO<sub>3</sub>)<sub>2</sub> + KCl  $\longrightarrow$
  - NH<sub>4</sub>Cl + NO<sub>2</sub><sup>-</sup> + Co<sup>3+</sup>  $\longrightarrow$
  - Ni<sup>2+</sup> +  $\begin{matrix} \text{H}_3\text{C} & & \text{CH}_3 \\ & \diagdown & / \\ & \text{C} = \text{C} \\ & / & \diagdown \\ \text{HO}-\text{N} & & \text{N}-\text{OH} \end{matrix}$  + NH<sub>4</sub>OH  $\longrightarrow$
  - K<sub>2</sub>CrO<sub>4</sub> + Hg<sub>2</sub><sup>2+</sup>  $\longrightarrow$
  - Hg<sup>2+</sup> + Co<sup>2+</sup> + SCN<sup>-</sup>  $\longrightarrow$
  - Cu<sup>2+</sup> + I<sup>-</sup>  $\longrightarrow$
  - Cd<sup>2+</sup> + CN<sup>-</sup>  $\longrightarrow$
  - K<sub>2</sub>Cr<sub>2</sub>O<sub>7</sub> + conc. H<sub>2</sub>SO<sub>4</sub> + Cl<sub>2</sub>  $\longrightarrow$  A  $\xrightarrow[\text{NaOH}]{\text{aq.}}$  B  $\xrightarrow{\text{Pb}^{2+}}$  ?
18. Which of the following sulphides are not black in colour.  
PbS, CdS, As<sub>2</sub>S<sub>3</sub>, Sb<sub>2</sub>S<sub>3</sub>, SnS, CoS, HgS, ZnS, MnS.

#### SECTION-4 : Comprehension Type (Only One options correct)

This section contains 1 paragraphs, each describing theory, experiments, data etc. 3 questions relate to the paragraph. Each question has only one correct answer among the four given options (A), (B), (C) and (D)

#### Paragraph for Questions 19 to 21



19. Compound (A) is :  
(A) Hgl<sub>2</sub> (B) K<sub>2</sub>Hgl<sub>4</sub> (C) Hg(NO<sub>3</sub>)<sub>2</sub> (D) Hg<sub>2</sub>(NO<sub>3</sub>)<sub>2</sub>
20. (D) + (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>  $\longrightarrow$  brown ppt. (G). Hence, compound (G) is :  
in basic medium  
(A) Hgl<sub>2</sub> (B) NH<sub>4</sub>I (C) HgO.Hg(NH<sub>2</sub>)I (D) Hg(NH<sub>2</sub>)I
21. White ppt. (B) + NH<sub>3</sub>  $\longrightarrow$  Black ppt. (H). Hence, (H) is due to the formation of :  
in basic medium  
(A) Hg(NH<sub>2</sub>)Cl (B) Hg (C) Hg(NH<sub>2</sub>)Cl + Hg (D) Hg(NH<sub>2</sub>)<sub>2</sub>



**SECTION-5 : Matching List Type (Only One options correct)**

This section contains 1 questions, each having two matching lists. Choices for the correct combination of elements from List-I and List-II are given as options (A), (B), (C) and (D) out of which one is correct.

22. Match the reactions/reaction conditions listed in column-I with the characteristics/ precipitate colour of the reaction products listed in column-II.

	Column I		Column II
(P)	$2\text{NiS} + 2\text{HNO}_3 + 6\text{HCl} \xrightarrow[\text{extract with water}]{\Delta}$	(1)	Black precipitate & its chloride imparts greenish blue flame.
(Q)	$\text{CoCl}_2 + 4\text{NH}_4 \text{CNS} \xrightarrow{\text{amyl alcohol}}$	(2)	Blue colour in organic layer.
(R)	$\text{CuCl}_2 + \text{NaOH} \xrightarrow{\Delta}$	(3)	White precipitate soluble in ammonium acetate.
(S)	$\text{Sr}(\text{CH}_3\text{COO})_2 + (\text{NH}_4)_2 \text{C}_2\text{O}_4 \longrightarrow$	(4)	Green colour solution.
(T)	$\text{H}_2\text{SO}_4 + \text{PbCl}_2 \longrightarrow$	(5)	Yellow precipitate soluble in NaOH.
(U)	$\text{Na}_2\text{CrO}_4 + (\text{CH}_3\text{OO})_2 \text{Pb} \longrightarrow$	(6)	Scarlet / red precipitate.
(V)	$\text{HgCl}_2 + \text{KI} \text{ (Not in excess)} \longrightarrow$	(7)	White precipitate & its chloride imparts crimson flame.

Code :

	P	Q	R	S	T	U	V
(A)	1	3	2	4	7	6	5
(B)	3	2	7	6	5	4	1
(C)	4	2	1	7	3	5	6
(D)	7	3	5	6	4	2	1

**Practice Test-2 ((IIT-JEE (ADVANCED Pattern))****OBJECTIVE RESPONSE SHEET (ORS)**

Que.	1	2	3	4	5	6	7	8	9	10
Ans.										
Que.	11	12	13	14	15	16	17	18	19	20
Ans.										
Que.	21	22								
Ans.										



# APSP Answers

## PART - I

1.	(2)	2.	(3)	3.	(2)	4.	(2)	5.	(1)
6.	(4)	7.	(3)	8.	(3)	9.	(1)	10.	(3)
11.	(3)	12.	(1)	13.	(4)	14.	(2)	15.	(2)
16.	(2)	17.	(1)	18.	(1)	19.	(3)	20.	(1)
21.	(4)	22.	(4)	23.	(4)	24.	(1)	25.	(2)
26.	(1)	27.	(2)	28.	(1)	29.	(2)	30.	(1)

## PART - II

1.	(D)	2.	(C)	3.	(C)	4.	(B)	5.	(A)
6.	(A)	7.	(D)	8.	(B)	9.	(C)	10.	(D)
11.	(C)	12.	(B)	13.	(B)	14.	(A)	15.	(B)
16.	(C)	17.	(B)	18.	(C)	19.	(A)	20.	(D)
21.	(C)	22.	(C)	23.	(A)				

## PART - III

- $4[\text{Ag}(\text{NH}_3)_2]^+ + \text{H}_2\text{N}-\text{NH}_2 \cdot \text{H}_2\text{SO}_4 \rightarrow 4\text{Ag}\downarrow + \text{N}_2\uparrow + 6\text{NH}_4^+ + 2\text{NH}_3 + \text{SO}_4^{2-}$
- Yes, forming a soluble complex.  

$$\text{HgS} + \text{S}^{2-} \longrightarrow [\text{HgS}_2]^{2-}$$
- $3\text{HgS} + 6\text{HCl} + 2\text{HNO}_3 \longrightarrow 3\text{HgCl}_2 + 3\text{S}\downarrow + 2\text{NO}\uparrow + 4\text{H}_2\text{O}$
- Yes. By the reaction of ammonia according to the following reactions.  

$$\text{Cu}^{2+} + 4\text{NH}_3 \longrightarrow [\text{Cu}(\text{NH}_3)_4]^{2+} \text{ (deep blue solution).}$$

$$\text{Cd}^{2+} + 4\text{NH}_3 \longrightarrow [\text{Cd}(\text{NH}_3)_4]^{2+} \text{ (colourless solution).}$$
- $\text{Bi}^{3+}$  ;  $\text{Bi}^{3+} + 3\text{OH}^- \longrightarrow \text{Bi}(\text{OH})_3 \downarrow$  ;  $2\text{Bi}(\text{OH})_3 \downarrow + 3[\text{Sn}(\text{OH})_4]^{2-} \longrightarrow 2\text{Bi} \downarrow \text{ (black)} + 3[\text{Sn}(\text{OH})_6]^{2-}$ .
- Yes :  $\text{SbOCl}$  is soluble in tartaric acid but  $\text{BiOCl}$  is insoluble in tartaric acid.
- $2\text{Al}_2\text{O}_3 + 2\text{Co}^{2+} + 4\text{NO}_3^- \longrightarrow 2\text{CoAl}_2\text{O}_4 \text{ (thenard blue)} + 4\text{NO}_2\uparrow + \text{O}_2\uparrow$   
 In case of excess of  $\text{Co}(\text{NO}_3)_2$ ,  $\text{CoAl}_2\text{O}_3$  will produce black cobalt oxide ( $\text{Co}_3\text{O}_4$ ), which will mask the blue colour.
- Ferrous and stannous ( $\text{Fe}^{2+}$  and  $\text{Sn}^{2+}$ ) both act as reducing agents and decolourize acidic  $\text{KMnO}_4$ .  

$$\text{MnO}_4^- + 5\text{Fe}^{2+} + 8\text{H}^+ \longrightarrow 5\text{Fe}^{3+} + \text{Mn}^{2+} + 4\text{H}_2\text{O}.$$
- Reddish-violet colouration is obtained owing to the formation of  $\text{MnO}_4^-$ .  

$$2\text{Mn}^{2+} + 5\text{S}_2\text{O}_8^{2-} + 8\text{H}_2\text{O} \longrightarrow \text{MnO}_4^- + 10\text{SO}_4^{2-} + 16\text{H}^+$$

$$\text{AgNO}_3 \text{ acts as catalyst.}$$
- $\text{Ni}^{2+}$  gives black ppt ( $\text{Ni}_2\text{O}_3$ ) with  $\text{NaHCO}_3$  and bromine water on heating. Where as  $\text{Co}^{2+}$  gives green coloured solution.  

$$\text{NiCl}_2 + 2\text{NaHCO}_3 \longrightarrow \text{NiCO}_3 + 2\text{NaCl} + \text{H}_2\text{O}$$

$$2\text{NiCO}_3 + [\text{O}] \longrightarrow \text{Ni}_2\text{O}_3 \downarrow \text{ (Black)} + 2\text{CO}_2$$
- (A), (B), (C) and (D) are  $\text{HgI}_2$ ,  $\text{KI}$ ,  $\text{HgS}$  and  $\text{Hg}$  respectively.



12. (X) =  $\text{NH}_4\text{Cl}$ , (A) =  $\text{CrO}_2\text{Cl}_2$ , (B) =  $\text{Na}_2\text{CrO}_4$ , (C) =  $\text{PbCrO}_4$ , (D) =  $\text{NH}_2\text{HgO}(\text{HgI})$
13. Because  $\text{CaSO}_4$  precipitate form a complex with  $(\text{NH}_4)_2\text{SO}_4$  which is water soluble  
 $\text{CaSO}_4 + (\text{NH}_4)_2\text{SO}_4 \longrightarrow (\text{NH}_4)_2\text{Ca}(\text{SO}_4)_2$  (soluble)
14. (A) :  $\text{CaC}_2\text{O}_4$  (B) :  $\text{CaO}$  (C) :  $\text{CO}$  (D) :  $\text{CO}_2$
15. (B) 16. (C) 17. (C) 18. (A) 19. (A)
20. (C) 21. (A) 22. (A) 23. (B) 24. (B)
25. (C) 26. (C) 27. (C) 28. (B) 29. (D)
30. (C) 31. (C) 32. (B) 33. (D) 34. (B)
35. (C) 36. (D) 37. 9 38. 7
39.  $a + b = 2 + 5 = 7$  40.  $7 + 3 + 5 = 15$  41. 40 42. 3
43. (ABC) 44. (AB) 45. (AB) 46. (ABD) 47. (AD)
48. (ACD) 49. (BCD) 50. (ABD) 51. (ABD) 52. (AD)

## PART - IV

1. (D) 2. (D) 3. (A) 4. (B) 5. (D)
6. (B) 7. (D) 8. (AB) 9. (AB) 10. (A)
11. (C) 12. (ABCD) 13. 3 14. 4 15. 8
16. 4 17. 07 18. 6 19. (D) 20. (C)
21. (C) 22. (C)

## APSP Solutions

## PART - I

1.  $\text{Hg}_2\text{Cl}_2 + 2\text{NH}_3 \longrightarrow \text{Hg} \begin{matrix} \text{Cl} \\ \text{NH}_2 \end{matrix} \downarrow \text{(white)} + \text{Hg} \downarrow \text{(black)} + \text{NH}_4\text{Cl}$   
Black
2. The white precipitate obtained with  $\text{H}_2\text{SO}_4$  is that of  $\text{PbSO}_4$ . The white crystalline substance may be that of  $\text{Pb}(\text{NO}_3)_2$ .  
 $\text{Pb}^{2+} + \text{S}^{2-} \longrightarrow \text{PbS} \downarrow \text{(black)} ; 3\text{PbS} \downarrow + 8\text{HNO}_3 \longrightarrow 3\text{Pb}^{2+} + 6\text{NO}_3^- + 3\text{S} \downarrow + 2\text{NO} + 4\text{H}_2\text{O}$   
 $\text{Pb}^{2+} + \text{SO}_4^{2-} \longrightarrow \text{PbSO}_4 \downarrow \text{(white)}$   
 $\text{PbSO}_4 + 2\text{CH}_3\text{COONH}_4 \longrightarrow (\text{NH}_4)_2[\text{Pb}(\text{CH}_3\text{COO})_4] + (\text{NH}_4)_2\text{SO}_4$   
 $\text{BaS}$  and  $\text{SrS}$  are not precipitated.  $\text{Ag}_2\text{SO}_4$  is white precipitate but does not dissolve in ammonium acetate.
3.  $\text{PbI}_2$  is yellow (known as golden spangles).
4.  $\text{AgBr}$  has the highest solubility in  $10^{-3} \text{ M NH}_4\text{OH}$   
 $\text{AgBr}$  dissolves in all other solvents poorly.
5. Both  $\text{Cd}^{2+}$  and  $\text{Sn}^{2+}$  are precipitated as yellow sulphides in the presence of dilute  $\text{HCl}$ .
6.  $\text{Cd}^{2+} + \text{H}_2\text{S} \longrightarrow \text{CdS} \downarrow + 2\text{H}^+$ , reaction is reversible; if the concentration of strong acid in the solution is above  $0.5 \text{ M}$ , precipitation is incomplete. Concentrated acid dissolves the precipitate for the same reason.



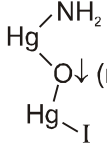
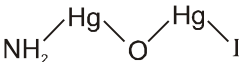


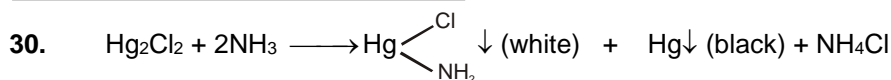
22. (1)  $\text{Pb}^{+2} + \text{CrO}_4^{-2} \longrightarrow \text{PbCrO}_4$  (yellow ppt)  
 (2)  $\text{Ba}^{+2} + \text{CrO}_4^{-2} \longrightarrow \text{BaCrO}_4$  (Yellow ppt)  
 (3)  $\text{Ag}^{\oplus} + \text{CrO}_4^{-2} \longrightarrow \text{Ag}_2\text{CrO}_4$  (Brick like red ppt)  
 (4)  $\text{Ca}^{+2} + \text{CrO}_4^{-2} \longrightarrow \text{CaCrO}_4$  (soluble)
23. CaS belongs to V<sup>th</sup> group and precipitate by H<sub>2</sub>S in presence of NH<sub>4</sub>OH and NH<sub>4</sub>Cl
24.  $\text{AgI} + \text{NaCN} \longrightarrow \text{Na}[\text{Ag}(\text{CN})_2]$  (soluble)
25. (1)  $\text{Cu}^{2+} + \text{H}_2\text{S} \longrightarrow \text{CuS}$  (ppt.)  
 $\text{Ag}^{2+} + \text{H}_2\text{S} \longrightarrow \text{Ag}_2\text{S}$  (ppt.)  
 (2)  $\text{Cu}^{2+} + \text{HCl} \longrightarrow \text{CuCl}_2$  (soluble)  
 $\text{Ag}^{2+} + \text{HCl} \longrightarrow \text{AgCl}$  (ppt.)  
 with HNO<sub>3</sub> and NH<sub>4</sub>NO<sub>3</sub> both Ag<sup>+</sup> and Cu<sup>2+</sup> form soluble compound.
26.  $2\text{Ag}^+ + \text{CrO}_4^{2-} \rightarrow \underset{\text{(red ppt.)}}{\text{Ag}_2\text{CrO}_4} \downarrow \xrightarrow{\text{NH}_3} \underset{\text{(Soluble)}}{[\text{Ag}(\text{NH}_3)_2]^+} + \text{CrO}_4^{2-}$
27. Because NH<sub>4</sub><sup>+</sup> form soluble compounds.
28.  $\text{CuSO}_4 + \text{NH}_4\text{OH} \longrightarrow [\text{Cu}(\text{NH}_3)_4]\text{SO}_4 + \text{H}_2\text{O}$
29.  $2\text{Al}_2\text{O}_3 + 2\text{Co}^{+2} + 4\text{NO}_3^- \longrightarrow 2\text{CoAl}_2\text{O}_4$  (thenard blue) + 4NO<sub>2</sub> + O<sub>2</sub>
30.  $\text{CrCl}_3 + \text{NaOH} \longrightarrow \text{Cr}(\text{OH})_3 \downarrow \xrightleftharpoons{\text{OH}^-} [\text{Cr}(\text{OH})_4]^-$  (soluble)  
 $\text{AlCl}_3 + \text{NaOH} \longrightarrow \text{Al}(\text{OH})_3 \downarrow \xrightleftharpoons{\text{OH}^-} [\text{Al}(\text{OH})_4]^-$  (soluble)  
 $\text{ZnCl}_2 + \text{NaOH} \longrightarrow \text{Zn}(\text{OH})_2 \downarrow \xrightleftharpoons{\text{OH}^-} [\text{Zn}(\text{OH})_4]^{2-}$  (soluble)  
 $\text{CuCl}_2 + \text{NaOH} \longrightarrow \text{Cu}(\text{OH})_2 \downarrow \xrightleftharpoons{\text{OH}^-}$  (not soluble in excess NaOH)

### PART - III

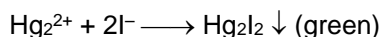
11. (A) + (B) → lilac colour in flame. So one of the cation may be K<sup>+</sup>.
- (a) (A) + (B)  $\xrightarrow{\text{H}_2\text{S (g)}}$  (C) black precipitate.  
 (b) (C)  $\xrightarrow[\text{in aqua regia}]{\text{soluble}}$  soluble  $\xrightarrow{\text{Evaporation}}$  Residue  $\xrightarrow{\text{SnCl}_2}$  Greyish black precipitate (D).  
 (A) + (B)  $\xrightarrow{\text{NH}_4\text{OH}}$  brown precipitate. So second cation may be Hg<sup>2+</sup>.
- (i) Sodium carbonate extract of salt  $\xrightarrow{\text{CCl}_4/\text{FeCl}_3}$  violet colour.  
 (ii) Sodium extract of salt  $\xrightarrow{\text{AgNO}_3}$  yellow precipitate  $\xrightarrow{\text{NH}_3}$  soluble.  
 So the anion may be I<sup>-</sup>.
- (a)  $\text{HgI}_2 + \text{H}_2\text{S} \longrightarrow \text{HgS (C)} \downarrow \text{ (black)} + 2\text{HI}$ .  
 (b)  $3\text{HgS} + 6\text{HCl} + 2\text{HNO}_3 \longrightarrow 3\text{HgCl}_2 + 2\text{NO} + 4\text{H}_2\text{O} + \text{S}$ .  
 $\text{HgCl}_2 + \text{SnCl}_2 \longrightarrow \text{Hg} \downarrow \text{ (D) (greyish black)} + \text{SnCl}_4$ .  
 $2\text{KI (B)} + \text{HgI}_2 \text{ (A)} \longrightarrow \text{K}_2[\text{HgI}_4]$  (colourless).  
 $2\text{K}_2[\text{HgI}_4] + \text{NH}_3 + 3\text{KOH} \longrightarrow [\text{HgOHg}(\text{NH}_2)\text{I}] \downarrow \text{ (brown)}$ .  
 Sodium carbonate extract of salt contains NaI.  
 $2\text{NaI} + 2\text{Fe}^{3+} \xrightarrow{\text{CCl}_4} \text{I}_2 \text{ (violet)} + 2\text{Na}^+ + 2\text{Fe}^{2+}$ .  
 I<sub>2</sub> dissolves in CCl<sub>4</sub> giving violet colour solution.  
 $\text{AgNO}_3 + \text{NaI} \longrightarrow \text{AgI} \downarrow \text{ (yellow)} + \text{NaNO}_3$ .  
 AgI is insoluble in ammonia solution.
- So, (A), (B), (C) and (D) are HgI<sub>2</sub>, KI, HgS and Hg respectively.



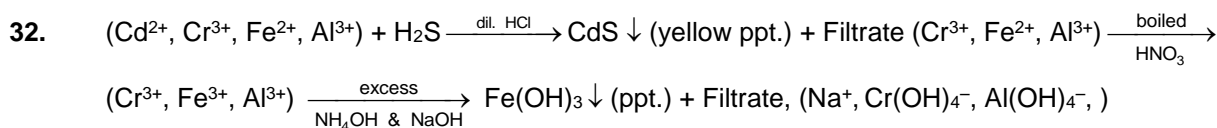
12.  $4\text{Cl}^- + \text{Cr}_2\text{O}_7^{2-} + 6\text{H}^+ \longrightarrow 2\text{CrO}_2\text{Cl}_2$  (A)(deep red) +  $3\text{H}_2\text{O}$   
 $\text{CrO}_2\text{Cl}_2 + 4\text{OH}^- \longrightarrow \text{CrO}_4^{2-}$  (B)(yellow solution) +  $2\text{Cl}^- + 2\text{H}_2\text{O}$   
 $\text{CrO}_4^{2-} + \text{Pb}^{2+} \longrightarrow \text{PbCrO}_4 \downarrow$  (C)(yellow)  
 $\text{NH}_4\text{Cl} + \text{NaOH} \longrightarrow \text{NaCl} + \text{NH}_3 + \text{H}_2\text{O}$   
 $\text{NH}_3 + \text{K}_2\text{HgI}_4 + \text{H}_2\text{O} \longrightarrow$   (reddish brown) (D) +  $4\text{KI} + 3\text{HI}$
- So, (X) =  $\text{NH}_4\text{Cl}$ , (A) =  $\text{CrO}_2\text{Cl}_2$ , (B) =  $\text{Na}_2\text{CrO}_4$ , (C) =  $\text{PbCrO}_4$ , (D) = 
15. aquaregia is  $\text{HNO}_3 + \text{HCl}$   
 1 : 3  
 $3\text{Hg}_2\text{Cl}_2 + 2\text{HNO}_3 + 6\text{HCl} \longrightarrow 6\text{HgCl}_2 + 2\text{NO} + 4\text{H}_2\text{O}$
16.  $\text{Ag}_2\text{CO}_3 \xrightarrow{\Delta} \text{Ag}_2\text{O} \downarrow + \text{CO}_2$   
 unstable brown ppt  $\xrightarrow{>300^\circ\text{C}}$  Ag  $\downarrow$  black ppt
17. (A)  $\text{Hg}^{2+} + \text{Co}^{2+} + 4\text{SCN}^- \longrightarrow \text{Co}[\text{Hg}(\text{SCN})_4] \downarrow$  (deep blue) ;  
 (B)  $2\text{Hg}^{2+} + \text{Sn}^{2+} + 2\text{Cl}^- \longrightarrow \text{Hg}_2\text{Cl}_2 \downarrow$  (white) +  $\text{Sn}^{4+}$  ;  $\text{Hg}_2\text{Cl}_2 + \text{Sn}^{2+} \longrightarrow \text{Hg} \downarrow$  (black) +  $\text{Sn}^{4+} + 2\text{Cl}^-$   
 (C)  $2\text{Hg}^{2+} + \text{NO}_3^- + 4\text{NH}_3 + \text{H}_2\text{O} \longrightarrow \text{HgO} \cdot \text{Hg}(\text{NH}_2)\text{NO}_3 \downarrow$  (white)  
 (D) KCN no effect i.e. no reaction.
18.  $\text{PbS}$ ,  $\text{Bi}_2\text{S}_3$  and  $\text{CuS}$  dissolve in dilute  $\text{HNO}_3$  forming nitrates but  $\text{HgS}$  dissolves in aquaregia forming  $\text{HgCl}_2$ .
19.  $\text{Cu}^{2+} + \text{CN}^-$  (excess)  $\longrightarrow [\text{Cu}(\text{CN})_4]^{3-}$  (stable)  $\xrightarrow{\text{H}_2\text{S}}$  No ppt  
 $\text{Cd}^{2+} + \text{CN}^-$  (excess)  $\longrightarrow [\text{Cd}(\text{CN})_4]^{2-}$  (un-stable)  $\xrightarrow{\text{H}_2\text{S}}$   $\text{CdS}$  yellow ppt
21.  $\text{Sn}^{2+}$  chloride react with  $\text{HgCl}_2$  and formed black or grey ppt of Hg  
 $\text{SnCl}_2 + \text{HgCl}_2 \longrightarrow \text{SnCl}_4 + \text{Hg}_2\text{Cl}_2$   
 $\text{SnCl}_2 + \text{HgCl}_2 \longrightarrow \text{SnCl}_4 + 2\text{Hg} \downarrow$  (black grey ppt)  
 $\text{Sn}^{4+}$  does not react with  $\text{HgCl}_2$ . It is first treated with Aluminium foil which reduces  $\text{Sn}^{4+}$  to  $\text{Sn}^{+2}$  (Stannous ion); then it with  $\text{HgCl}_2$   
 $3\text{SnCl}_4 + 2\text{Al} \longrightarrow 2\text{AlCl}_3 + 3\text{SnCl}_2$  (Stannous chloride)
22.  $\text{SnCl}_2 + \text{KOH} \longrightarrow \text{SnO}$   
 $\text{SnO} + \text{KOH}$  (excess)  $\longrightarrow \text{K}_2\text{SnO}_2 + 2\text{H}_2\text{O}$
23.  $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3 + 12\text{OH}^- \longrightarrow 4\text{Fe}(\text{OH})_3$  (reddish brown) +  $3[\text{Fe}(\text{CN})_6]^{4-}$
25.  $\text{Co}^{2+} + \text{CN}^-$  (excess)  $\longrightarrow [\text{Co}(\text{CN})_6]^{4-}$  (Brown solution)  
 $[\text{Co}(\text{CN})_6]^{4-} + \text{O}_2 + 2\text{H}_2\text{O} \longrightarrow [\text{Co}(\text{CN})_6]^{3-}$  (Yellow solution)
26.  $2\text{CoS} + 6\text{HCl} + 2\text{HNO}_3 \longrightarrow 3\text{CoCl}_2 + 2\text{NO} + 3\text{S} + 4\text{H}_2\text{O}$   
 $\text{CoCl}_2 + 6\text{NaHCO}_3 \longrightarrow \text{Na}_4[\text{Co}(\text{CO}_3)_3] + 2\text{NaCl} + 3\text{H}_2\text{O} + 3\text{CO}_2$   
 $2\text{Na}_4[\text{Co}(\text{CO}_3)_3] + \text{Br}_2 \longrightarrow 2\text{Na}_3[\text{Co}(\text{CO}_3)_3] + 2\text{NaBr}$   
 (Green)
28.  $\text{NiCl}_2 + \text{KCN}$  (excess)  $\text{K}_2[\text{Ni}(\text{CN})_4]$   
 $\text{K}_2[\text{Ni}(\text{CN})_4] \xrightarrow{\text{NaOH} + \text{Br}_2 \text{ water}} \text{Ni}_2\text{O}_3 \downarrow + 4\text{NaCNO} + \text{NaBr} + \text{KCNO} + \text{H}_2\text{O}$   
 black
29. (A) titan yellow is absorbed by magnesium hydroxide producing a deep-red colour or precipitate.  
 (B)  $\text{Mg}^{2+} + \text{NH}_3 + \text{HPO}_4^{2-} \longrightarrow \text{Mg}(\text{NH}_4)\text{PO}_4 \downarrow$  (white).  
 (C) Blue lake is formed by the adsorption of reagent on  $\text{Mg}(\text{OH})_2$ .



black

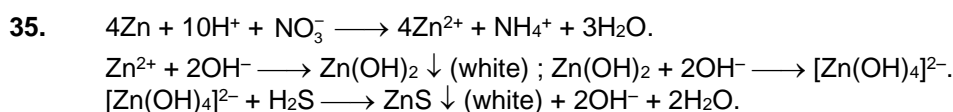


31.  $\text{Sn}^{2+}$  belongs to second B group.



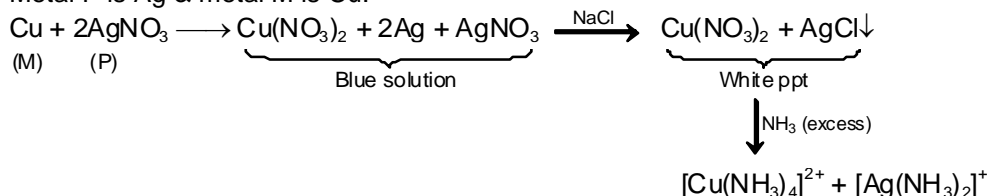
33. The filter paper ash test is substitute for cobalt nitrate charcoal cavity test. Double oxide  $\text{ZnO} \cdot \text{CoO}$  formed is green in colour. It is called Rinmann's green.

34. Function of strong electrolyte  $\text{NH}_4\text{Cl}$  is to suppress the ionisation of  $\text{NH}_4\text{OH}$  so that the concentration of  $\text{OH}^-$  ions in the solution is decreased but it is sufficient to precipitate the third group basic radicals because the solubility product of group III hydroxides is lower than IV, V and VI group hydroxides. The  $\text{Cr}(\text{OH})_3 \downarrow$  is slightly soluble in excess of precipitant, upon boiling the solution,  $\text{Cr}(\text{OH})_3$  is precipitated.

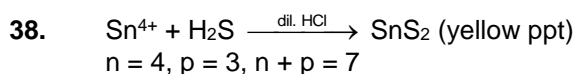


36. Sodium sulphide is water soluble and  $K_{\text{sp}}$  of  $\text{ZnS}$  is higher than that of  $\text{CuS}$ . So correct order is  $\text{Na}_2\text{S} > \text{ZnS} > \text{CuS}$

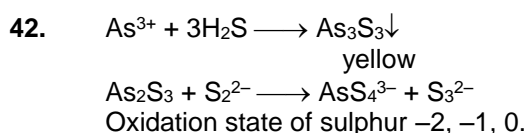
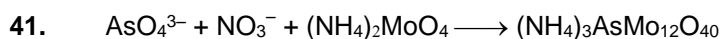
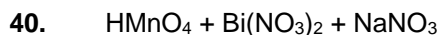
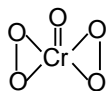
37. Metal P is Ag & metal M is Cu.



$\therefore x = 4, y = 2, m = 1, n = 2$   
 $\therefore x + y + m + n = 4 + 2 + 2 + 1 = 9$



39. A is  $\text{CrO}_5$



43. (A) Correct.  
 (B)  $\text{Cu}^{2+} + 2\text{CN}^- \longrightarrow \text{Cu}(\text{CN})_2 \downarrow \text{(yellow)}$   
 $2\text{Cu}(\text{CN})_2 \downarrow \longrightarrow 2\text{Cu}(\text{CN})_2 \downarrow \text{(white)} + (\text{CN})_2$   
 (C)  $\text{BiI}_3 \downarrow + \text{H}_2\text{O} \xrightarrow{\text{boiled}} \text{BiOI} \downarrow \text{(orange)} + 2\text{HI}$   
 (D)  $\text{Bi}(\text{OH})_3 \downarrow \xrightarrow{\Delta} \text{BiO} \cdot \text{OH} \downarrow \text{(yellowish white)} + \text{H}_2\text{O}$





44. (A)  $2\text{Cu}^{2+} + 4\text{I}^- \longrightarrow \text{CuI (white)} \downarrow + \text{I}_2$   
 (B)  $2\text{Cu}^{2+} + 4\text{SCN}^- + \text{SO}_2 + 2\text{H}_2\text{O} \longrightarrow 2\text{CuSCN} \downarrow \text{ (white)} + 2\text{SCN}^- + \text{SO}_4^{2-} + 4\text{H}^+$   
 (C)  $\text{Cu}^{2+} + 6\text{CN}^- \longrightarrow [\text{Cu}(\text{CN})_4]^{3-} \text{ (soluble complex)} + (\text{CN})_2$   
 (D)  $\text{Cu}^{2+} + 2\text{OH}^- \longrightarrow \text{Cu}(\text{OH})_2 \downarrow \text{ (blue)}$ .
45.  $\therefore \text{PO}_4^{3-}$  and  $\text{AsO}_4^{3-}$  both radical give ammonium molybdate test.
47. (A)  $\text{Fe}^{2+}$  responds to this test but not  $\text{Fe}^{3+}$ ;  $\text{Fe(II)}$  gives soluble red iron(II) dimethylglyoxime in alkaline solution.  
 (D)  $\text{Ag}_2\text{O} \downarrow + 4\text{NH}_3 + \text{H}_2\text{O} \longrightarrow 2[\text{Ag}(\text{NH}_3)_2]^+ + 2\text{OH}^-$   
 $\text{Ag}_2\text{O} \downarrow + 2\text{H}^+ \longrightarrow 2\text{Ag}^+ + \text{H}_2\text{O}$   
 (B) and (C) are correct statements.
48. (A)  $\text{Hg}^{2+} + \text{Co}^{2+} + 4\text{SCN}^- \longrightarrow \text{Co}[\text{Hg}(\text{SCN})_4] \downarrow \text{ (deep blue)}$   
 (B) Soluble in  $\text{NaOH}$  forming  $[\text{Al}(\text{OH})_4]^-$ , not in  $\text{NH}_3$  (aq)  
 (C)  $\text{Cr}(\text{OH})_3 \downarrow \text{ (green)} + \text{OH}^- \rightleftharpoons [\text{Cr}(\text{OH})_4]^- \text{ (green solution)}$   
 (D) Correct statement.
49.  $\text{Co}^{2+} + 2\text{CN}^- \longrightarrow \text{Co}(\text{CN})_2 \downarrow \text{ (reddish - brown) or buff colour}$   
 $\text{Co}(\text{CN})_2 \downarrow + 4\text{CN}^- \text{ (excess)} \longrightarrow [\text{Co}(\text{CN})_6]^{4-} \text{ (brown solution)}$   
 $[\text{Co}(\text{CN})_6]^{4-} + 4\text{H}^+ \longrightarrow \text{Co}(\text{CN})_2 \downarrow + 4\text{HCN}$ .
50.  $\text{CuS}$  dissolves in 50%  $\text{HNO}_3$ ;  $3\text{CuS} + 8\text{HNO}_3 \longrightarrow 3\text{Cu}^{2+} + 6\text{NO}_3^- + 3\text{S} \downarrow + 2\text{NO} + 4\text{H}_2\text{O}$   
 But  $\text{NiS}$ ,  $\text{CoS}$  and  $\text{HgS}$  do not dissolve in 50%  $\text{HNO}_3$  and dissolve in aquaregia forming their chlorides.
51. (A)  $5\text{SO}_2 + 2\text{IO}_3^- + 4\text{H}_2\text{O} \longrightarrow \text{I}_2 + 5\text{SO}_4^{2-} + 8\text{H}^+$ ;  $\text{I}_2 + \text{starch} \longrightarrow \text{blue colour}$ .  
 (B)  $2\text{H}^+ + 3\text{SO}_2 + \text{Cr}_2\text{O}_7^{2-} \longrightarrow 2\text{Cr}^{3+} \text{ (green)} + 3\text{SO}_4^{2-} + \text{H}_2\text{O}$   
 (C)  $\text{Pb}^{2+} + \text{SO}_3^{2-} \longrightarrow \text{PbSO}_3 \downarrow \text{ (white)}$   
 (D)  $\text{SO}_2 + 2\text{H}_2\text{O} + \text{Cl}_2 \longrightarrow \text{H}_2\text{SO}_4 + \text{HCl}$   
 $\text{HCl} + \text{NH}_3 \longrightarrow \text{NH}_4\text{Cl}$   
 $\text{Ni} + \text{H}_2\text{SO}_4 + 2\text{H}^+ \longrightarrow \text{Ni}^{2+} + \text{SO}_2 [\text{X}] + 2\text{H}_2\text{O}$   
 With dilute  $\text{H}_2\text{SO}_4$ , hydrogen gas is liberated.
52. (A)  $3\text{NH}_4^+ + [\text{Co}(\text{NO}_2)_6]^{3-} \longrightarrow (\text{NH}_4)_3[\text{Co}(\text{NO}_2)_6] \downarrow \text{ (yellow)}$   
 (B)  $2\text{NH}_3 + \text{Mn}^{2+} + \text{H}_2\text{O}_2 + \text{H}_2\text{O} \longrightarrow \text{MnO}(\text{OH})_2 \downarrow \text{ (brown)} + 2\text{NH}_4^+$   
 (C)  $\text{NH}_4^+ + \text{HC}_4\text{H}_4\text{O}_6^- \longrightarrow \text{NH}_4\text{HC}_4\text{H}_4\text{O}_6 \downarrow \text{ (white)}$   
 (D)  $\text{O}_2\text{N}-\text{C}_6\text{H}_4-\text{N}=\text{N}-\text{Cl} + \text{NH}_4^+ + 2\text{OH}^- \longrightarrow \text{O}_2\text{N}-\text{C}_6\text{H}_4-\text{N}=\text{NONH}_4 \text{ (red colouration)} + \text{Cl}^- + \text{H}_2\text{O}$

## PART - IV

1.  $\text{CoCl}_2 + 4\text{NH}_4\text{SCN} \xrightarrow{\text{ether}} (\text{NH}_4)_2[\text{Co}(\text{SCN})_4] \text{ (blue colour in ethereal layer)} + 2\text{NH}_4\text{Cl}$ .  
 $\text{Cu}^{2+} + 3\text{SCN}^- \longrightarrow \text{CuSCN} \downarrow \text{ (white)} + (\text{SCN})_2$ .  
 $\text{FeCl}_3 + 3\text{NH}_4\text{SCN} \xrightarrow{\text{ether}} \text{Fe}(\text{SCN})_3 \text{ (blood red colour)} + 3\text{NH}_4\text{Cl}$ .  
 $\text{Ag}^+ + \text{SCN}^- \longrightarrow \text{AgSCN} \downarrow \text{ (white)}$ .  
 $\text{Co}^{2+} + 4\text{SCN}^- + \text{Hg}^{2+} \longrightarrow \text{Co}[\text{Hg}(\text{SCN})_4] \downarrow \text{ (deep blue) or } \text{Hg}[\text{Co}(\text{NCS})_4]$ .
2. (A), (B) and (C) all gives blue colouration in solution or blue precipitate.  
 (D)  $\text{AgCl} \downarrow + 2\text{NH}_3 \longrightarrow [\text{Ag}(\text{NH}_3)_2]^+ \text{Cl}^- \text{ (colourless solution)}$
3.  $\text{Pb}^{2+} + 2\text{Cl}^- \longrightarrow \text{PbCl}_2 \downarrow \text{ (white)} ; \text{PbCl}_2 + 2\text{Cl}^- \longrightarrow [\text{PbCl}_4]^{2-} \text{ (colourless soluble complex)}$   
 $\text{PbCl}_2 \downarrow + \text{H}_2\text{S} \longrightarrow \text{PbS} \downarrow \text{ (black)} + 2\text{HCl}$   
 $\text{PbS} + 4\text{H}_2\text{O}_2 \longrightarrow \text{PbSO}_4 \downarrow \text{ (white)} + 4\text{H}_2\text{O}$   
 $\text{PbSO}_4 \downarrow + 2\text{CH}_3\text{COONH}_4 \longrightarrow (\text{NH}_4)_2\text{SO}_4 + (\text{NH}_4)_2[\text{Pb}(\text{CH}_3\text{COO})_4]$
4.  $\text{Ag}^+ + 2\text{Cl}^- \longrightarrow [\text{AgCl}_2]^- \text{ (soluble complex)} ; \text{Ag}^+ + \text{Cl}^- \text{ (dilute HCl)} \longrightarrow \text{AgCl} \downarrow \text{ (white)}$   
 $2\text{Ag}^+ + \text{CrO}_4^{2-} \longrightarrow \text{Ag}_2\text{CrO}_4 \downarrow \text{ (red)} ; \text{Ag}_2\text{CrO}_4 \downarrow + \text{NH}_3 \longrightarrow 2[\text{Ag}(\text{NH}_3)_2]^+ + \text{CrO}_4^{2-}$   
 $3\text{Ag}^+ + \text{HPO}_4^{2-} \longrightarrow \text{Ag}_3\text{PO}_4 \downarrow \text{ (yellow)} + \text{H}^+ ; \text{Ag}_3\text{PO}_4 \downarrow + 6\text{NH}_3 \longrightarrow [\text{Ag}(\text{NH}_3)_2]^+ + \text{PO}_4^{3-}$



5. (A) Both are red precipitates  
(B)  $\text{Ni}^{2+} + 2\text{dmg} + \text{NH}_4\text{OH} \rightarrow \text{Ni}(\text{dmg})_2 \downarrow$  (red)  
(C)  $\text{BiOI} \downarrow$  (orange) and  $\text{Cu}_2[\text{Fe}(\text{CN})_6] \downarrow$  (brown)
6.  $\text{Cu}^{2+} + 2\text{SCN}^- \rightarrow \text{Cu}(\text{SCN})_2 \downarrow$  (black)  
 $2\text{Cu}(\text{SCN})_2 \rightarrow 2\text{CuSCN} \downarrow$  (white) +  $(\text{SCN})_2$   
 $\text{Cu}^{2+} + \text{H}_2\text{S} \xrightarrow{\text{H}^+} \text{CuS} \downarrow$  (black) +  $2\text{H}^+$   
 $2\text{CuS} \downarrow + 8\text{CN}^- \rightarrow 2[\text{Cu}(\text{CN})_4]^{3-} + \text{S}_2^{2-}$
7. (A)  $\text{As}^{3+} + 3\text{Zn} + 3\text{H}^+ \rightarrow \text{AsH}_3 + 3\text{Zn}^{2+}$ ;  $4\text{AsH}_3 \xrightarrow{\Delta} 4\text{As} \downarrow + 6\text{H}_2$   
 (B)  $4[\text{Ag}(\text{NH}_3)_2]^+ + \text{H}_2\text{N}-\text{NH}_2 \cdot \text{H}_2\text{SO}_4 \rightarrow 4\text{Ag} \downarrow + \text{N}_2 + 6\text{NH}_4^+ + 2\text{NH}_3 + \text{SO}_4^{2-}$   
 (C)  $2\text{Ag}_2\text{CrO}_4 \downarrow + 2\text{H}^+ \rightleftharpoons 4\text{Ag}^+ + \text{Cr}_2\text{O}_7^{2-} + \text{H}_2\text{O}$   
 $\text{Ag}_2\text{CrO}_4 \downarrow + 4\text{NH}_3 \rightleftharpoons 2[\text{Ag}(\text{NH}_3)_2]^+ + \text{CrO}_4^{2-}$   
 So, all statements are correct.
8.  $(\text{NH}_4)_2\text{CO}_3$  and  $(\text{NH}_4)_2\text{SO}_4$  can not be used as they would also precipitate the IV and V<sup>th</sup> group cations.
9. (A)  $\text{PbSO}_4 \downarrow + \text{H}_2\text{SO}_4$  (hot and concentrated)  $\rightarrow \text{Pb}^{2+} + 2\text{HSO}_4^-$  (soluble)  
 (B) It dissolves forming  $\text{Na}_2[\text{Pb}(\text{OH})_4]$  soluble complex.
10. (A)  $\text{Cr}^{3+} + 3\text{NH}_3 + 3\text{H}_2\text{O} \rightleftharpoons \text{Cr}(\text{OH})_3 \downarrow + 3\text{NH}_4^+$   
 The above reaction is reversible. On addition of  $\text{NH}_4^+$ , shifts to backward direction. Thus if excess of  $\text{NH}_4^+$  salt is added, then precipitation of  $\text{Cr}(\text{OH})_3$  will not take place. However, because of very small  $K_{\text{sp}}$  of iron (III) hydroxide complete precipitation will take place even in the presence of ammonium salts. ( $K_{\text{sp}} = 3.8 \times 10^{-38}$ )  
 (B) Concentration of  $\text{CO}_3^{2-}$  provided by  $\text{Na}_2\text{CO}_3$  in aqueous solution is just sufficient to precipitate  $\text{Mg}^{2+}$  ion as  $\text{MgCO}_3$  along with  $\text{Ba}^{2+}$ ,  $\text{Ca}^{2+}$  and  $\text{Sr}^{2+}$  as their carbonates.  
 (C) The oxidising anions like  $\text{MnO}_4^-$ ,  $\text{Cr}_2\text{O}_7^{2-}$ ,  $\text{ClO}_4^-$  etc., also respond to this test.  
 (D)  $\text{K}_2\text{Cr}_2\text{O}_7 + \text{NaCl} + \text{H}_2\text{SO}_4 \rightarrow \text{CrO}_2\text{Cl}_2$
11. Iron and NO exist as Fe(II) and NO<sup>+</sup> respectively.
12. (A)  $\text{Cu}_2[\text{Fe}(\text{CN})_6]$ ;  $\text{K}_2\text{Zn}_3[\text{Fe}(\text{CN})_6]_2$ ; (B)  $\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$ ;  $\text{K}_2\text{Ca}[\text{Fe}(\text{CN})_6]$   
 (C)  $\text{Ag}_4[\text{Fe}(\text{CN})_6]$ ;  $\text{K}_2\text{Zn}_3[\text{Fe}(\text{CN})_6]$ ; (D)  $\text{Cd}_2[\text{Fe}(\text{CN})_6]$ ;  $\text{Cu}_2[\text{Fe}(\text{CN})_6]$
13. (1)  $\text{Al}^{3+}$  and  $\text{Hg}^{2+} \xrightarrow[\text{H}_2\text{S}]{\text{H}^+} \text{HgS} \downarrow$  (black) +  $\text{Al}^{3+}$  (in solution)  
 (2)  $\text{Cu}^{2+}$  and  $\text{Zn}^{2+} \xrightarrow[\text{H}_2\text{S}]{\text{H}^+} \text{CuS} \downarrow$  (black) +  $\text{Zn}^{2+}$  (in solution)  
 (3)  $\text{Cd}^{2+}$  and  $\text{Zn}^{2+} \xrightarrow[\text{H}_2\text{S}]{\text{H}^+} \text{CdS} \downarrow$  (yellow) +  $\text{Zn}^{2+}$  (in solution)
14.  $\text{Ba}^{2+}(\text{aq}) + \text{CrO}_4^{2-}(\text{aq}) \rightarrow \text{BaCrO}_4 \downarrow$  (yellow)  
 $\text{Ag}^+(\text{aq}) + \text{Br}^-(\text{aq}) \rightarrow \text{AgBr} \downarrow$  (yellow)  
 $\text{Pb}^{2+}(\text{aq}) + 2\text{I}^-(\text{aq}) \rightarrow \text{PbI}_2 \downarrow$  (yellow)  
 $2\text{NH}_4^+(\text{aq}) + [\text{PtCl}_6]^{2-}(\text{aq}) \rightarrow (\text{NH}_4)_2[\text{PtCl}_6] \downarrow$  (yellow)
15.  $\text{AgCN}$ ,  $\text{MnS}$ ,  $\text{Ag}_3\text{PO}_4$ ,  $\text{Zn}(\text{OH})_2$ ,  $\text{AgNO}_2$ ,  $\text{FeS}$ ,  $\text{BaSO}_3$ ,  $\text{Al}(\text{OH})_3$ ,  $\text{CH}_3\text{COOAg} \rightarrow$  solubility in acidic solution is greater than that in pure water due to protonation of anion.
16. T T T T F F  
 (i)  $\text{SO}_3^{2-} + \text{Ca}(\text{OH})_2 \rightarrow \text{CaSO}_3 \downarrow$  (white) +  $\text{H}_2\text{O}$   
 $\text{CO}_3^{2-} + \text{Ca}(\text{OH})_2 \rightarrow \text{CaCO}_3 \downarrow$  (white) +  $\text{H}_2\text{O}$   
 (ii)  $\text{FeSO}_4 + \text{NO} + 5\text{H}_2\text{O} \rightarrow [\text{Fe}(\text{H}_2\text{O})_5\text{NO}]^{2+} \text{SO}_4^{2-}$   
 (iii)  $2\text{AgNO}_3 + \text{K}_2\text{CrO}_4 \rightarrow \text{Ag}_2\text{CrO}_4 \downarrow$  (red) +  $2\text{KNO}_3$   
 (iv)  $\text{Pb}^{2+} + \text{H}_2\text{S} \rightarrow \text{PbS} + 2\text{H}^+$   
 (v)  $\text{S}^{2-}$  concentration in presence of dil HCl is sufficient to ppt the II<sup>nd</sup> group cations only. Due to common ion effect ionization of  $\text{H}_2\text{S}$  is suppressed.  
 (iv)  $2\text{Cu}^{2+} + [\text{Fe}(\text{CN})_6]^{4-} \rightarrow \text{Cu}_2[\text{Fe}(\text{CN})_6] \downarrow$  (chocolate brown)



17. (a)  $\text{HgCl}_2 + \text{SnCl}_2 \text{ (excess)} \longrightarrow \text{Hg} + \text{SnCl}_4$   
black precipitated
- (b)  $\text{HgCl}_2 + \text{KI} \longrightarrow \text{K}_2(\text{HgI}_4) \text{ (soluble)}$
- (d)  $\text{NH}_4\text{Cl} + \text{NO}_2^- + \text{Co}^{3+} \longrightarrow (\text{NH}_4)_3 [\text{Co}(\text{NO}_2)_6] \downarrow \text{yellow}$
- (e)  $\text{Ni}^{2+} + \begin{array}{c} \text{H}_3\text{C} \quad \quad \text{CH}_3 \\ \diagdown \quad \diagup \\ \text{C} = \text{C} \\ \diagup \quad \diagdown \\ \text{HO-N} \quad \quad \text{N-OH} \end{array} + \text{NH}_4\text{OH} \longrightarrow \text{Ni(dmg)}_2 \downarrow \text{(red)}$
- (f)  $\text{K}_2\text{Cr}_2\text{O}_7 + \text{conc. H}_2\text{SO}_4 + \text{Cl}_2 \longrightarrow \text{CrO}_2\text{Cl}_2 \xrightarrow[\text{NaOH}]{\text{aq.}} \text{Na}_2\text{CrO}_4 \xrightarrow{\text{Pb}^{2+}} \text{PbCrO}_4$
- (g)  $\text{K}_2\text{CrO}_4 + \text{Hg}_2^{2+} \longrightarrow \text{HgCrO}_4 \text{ (red ppt.)}$
- (h)  $\text{Hg}_2^{2+} + \text{Co}^{2+} + \text{SCN}^- \longrightarrow \text{Co}[\text{Hg}(\text{SCN})_4] \text{ or } \text{Hg}[\text{Co}(\text{NCS})_4] \text{ (deepblue crystalline ppt.)}$
18.  $\text{PbS} \longrightarrow \text{Black}$ ,  $\text{CdS} \longrightarrow \text{yellow}$ ,  $\text{As}_2\text{S}_3 \longrightarrow \text{yellow}$ ,  $\text{Sb}_2\text{S}_3 \longrightarrow \text{Orange}$ ,  $\text{SnS} \longrightarrow \text{Brown}$ ,  $\text{CoS} \longrightarrow \text{Black}$ ,  $\text{HgS} \longrightarrow \text{Black}$ ,  $\text{ZnS} \longrightarrow \text{White}$ ,  $\text{MnS} \longrightarrow \text{Pink}$ .
21.  $\text{Hg}_2(\text{NO}_3)_2 \xrightarrow{\text{HCl}} \text{Hg}_2\text{Cl}_2 \text{ (White ppt.)} \xrightarrow[\text{water}]{\text{Cl}_2} \text{HgCl}_2 \text{ (soluble compound)}$   
(A) (B) (C)
- (A)  $\downarrow \begin{array}{l} \text{(i) FeSO}_4 \\ \text{(ii) conc. H}_2\text{SO}_4 \end{array}$   
Brown ring  
(F)
- (B)  $\downarrow \begin{array}{l} \text{(i) FeSO}_4 \\ \text{(ii) conc. H}_2\text{SO}_4 \end{array}$   
Brown ring  
(F)
- (C)  $\downarrow \text{KI}$   
 $\text{HgI}_2 \text{ (Red ppt.)} \xleftarrow[\text{of KI}]{\text{Excess}} \text{K}_2[\text{HgI}_4] \text{ (soluble compound)} \text{ (D)}$   
(Used for detecting  $\text{NH}_4^+$  ions)
- $\text{K}_2[\text{HgI}_4] + \text{OH}^- + (\text{NH}_4)_2\text{SO}_4 \longrightarrow \text{HgO} \cdot \text{Hg}(\text{NH}_2)\text{I} \text{ (brown ppt)} \text{ (G)}$
- $\text{HgCl}_2 + \text{NH}_3 \longrightarrow \text{Hg}(\text{NH}_2)\text{Cl} + \text{Hg} \text{ (black ppt)} \text{ (H)}$
- $\text{NO}_2^- / \text{NO}_3^- + \text{dil. HCl/con. HCl} \rightarrow \text{NO}$   
 $\Rightarrow \text{Fe}^{2+} \text{NO} + 5\text{H}_2\text{O} \rightarrow [\text{Fe}(\text{H}_2\text{O})_5\text{NO}]^2$
22. (P) Aqueous solutions of nickel (II) salts are green, owing to the colour of the  $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$  complex.
- (Q)  $\text{Co}^{2+} + 4\text{SCN}^- \longrightarrow [\text{Co}(\text{SCN})_4]^{2-}$  (blue colour complex).  
In amyl alcohol or diethyl ether dissolves forming  $\text{H}_2[\text{Co}(\text{SCN})_4]$ .
- (R)  $\text{Cu}^{2+} + 2\text{OH}^- \longrightarrow \text{Cu}(\text{OH})_2 \downarrow \text{(blue)} ; \text{Cu}(\text{OH})_2 \downarrow \xrightarrow{\Delta} \text{CuO} \downarrow \text{(black)} + \text{H}_2\text{O}$ .  
Copper salts imparts greenish blue colour to the Bunsen flame.
- (S)  $\text{Sr}^{2+} + 2\text{C}_2\text{O}_4^{2-} \longrightarrow \text{SrC}_2\text{O}_4 \downarrow \text{(white)}$ .  
Strontium salts imparts crimson colour to the Bunsen burner.
- (T)  $\text{Pb}^{2+} + \text{SO}_4^{2-} \longrightarrow \text{PbSO}_4 \downarrow \text{(white)} ; \text{PbSO}_4 \downarrow + 2\text{CH}_3\text{COONH}_4 \rightarrow (\text{CH}_3\text{COO})_2\text{Pb} + (\text{NH}_4)_2\text{SO}_4$ .
- (U)  $\text{CrO}_4^{2-} + \text{Pb}^{2+} \longrightarrow \text{PbCrO}_4 \downarrow \text{(yellow)} ; \text{PbCrO}_4 \downarrow + 4\text{OH}^- \rightleftharpoons [\text{Pb}(\text{OH})_4]^{2-} + \text{CrO}_4^{2-}$ .
- (V)  $\text{Hg}_2^{2+} + 2\text{I}^- \longrightarrow \text{HgI}_2 \downarrow \text{(scarlet / red)}$ .