

QUALITATIVE ANALYSIS

Charcoal Cavity Test :

Observation		Inference
Incrustation or Residue	Metallic bead	
Yellow when hot, white when cold	None	Zn^{2+}
Brown when hot, yellow when cold	Grey bead which marks the paper	Pb^{2+}
No characteristic residue	Red beads or scales	Cu^{2+}
White residue which glows on heating	None	$\text{Ba}^{2+}, \text{Ca}^{2+}, \text{Mg}^{2+}$
Black	None	Nothing definite—generally coloured salt

Cobalt Nitrate Test :

S.No.	Metal	Colour of the mass
1.	Zinc	Green
2.	Aluminium	Blue
3.	Magnesium	Pink
4.	Tin	Bluish - green

Flame test :

Colour of Flame	Inference
Crimson Red / Carmine Red	Lithium
Golden yellow	Sodium
Violet/Lilac	Potassium
Brick red	Calcium
Crimson	Strontium
Apple Green/Yellowish Green	Barium
Green with a Blue centre/Greenish Blue	Copper

Borax Bead test :

Metal	Colour in oxidising flame		Colour in reducing flame	
	When Hot	When Cold	When Hot	When Cold
Copper	Green	Blue	Colourless	Brown red
Iron	Brown yellow	Pale yellow/Yellow	Bottle green	Bottle green
Chromium	Yellow	Green	Green	Green
Cobalt	Blue	Blue	Blue	Blue
Manganese	Violet/Amethyst	Red/Amethyst	Grey/Colourless	Grey/Colourless
Nickel	Violet	Brown/Reddish brown	Grey	Grey

Analysis of ANIONS (Acidic Radicals) :

(a) DILUTE SULPHURIC ACID/DILUTE HYDROCHLORIC ACID GROUP :

1. CARBONATE ION (CO_3^{2-}) :

- Dilute H_2SO_4 test : A colourless odourless gas is evolved with brisk effervescence.
$$\text{CaCO}_3 + \text{H}_2\text{SO}_4 \longrightarrow \text{CaSO}_4 + \text{H}_2\text{O} + \text{CO}_2 \uparrow$$
- Lime water/Baryta water ($\text{Ba}(\text{OH})_2$) test :
$$\text{CO}_2 + \text{Ca}(\text{OH})_2 \longrightarrow \text{CaCO}_3 \downarrow (\text{milky}) + \text{H}_2\text{O}$$

$$\text{CaCO}_3 + \text{CO}_2 + \text{H}_2\text{O} \longrightarrow \text{Ca}(\text{HCO}_3)_2 (\text{soluble}) \xrightarrow{\Delta} \text{CaCO}_3 \downarrow + \text{H}_2\text{O} + \text{CO}_2$$

2. SULPHITE ION (SO_3^{2-}) :

- Dilute H_2SO_4 test :
$$\text{CaSO}_3 + \text{H}_2\text{SO}_4 \longrightarrow \text{CaSO}_4 + \text{H}_2\text{O} + \text{SO}_2 \uparrow$$
; SO_2 has suffocating odour of burning sulphur.
- Acidified potassium dichromate test : The filter paper dipped in acidified $\text{K}_2\text{Cr}_2\text{O}_7$ turns green.
$$\text{Cr}_2\text{O}_7^{2-} + 2\text{H}^+ + 3\text{SO}_2 \longrightarrow 2\text{Cr}^{3+} (\text{green}) + 3\text{SO}_4^{2-} + \text{H}_2\text{O}.$$
- Barium chloride/Strontium chloride solution :
$$\text{SO}_3^{2-} + \text{Ba}^{2+}/\text{Sr}^{2+} \longrightarrow \text{BaSO}_3/\text{SrSO}_3 \downarrow (\text{white}).$$

 White precipitate dissolves in dilute HCl.
$$\text{BaSO}_3 \downarrow + 2\text{H}^+ \longrightarrow \text{Ba}^{2+} + \text{SO}_2 \uparrow + \text{H}_2\text{O}.$$

3. SULPHIDE ION (S^{2-}) :

- Dilute H_2SO_4 test : Pungent smelling gas like that of rotten egg is obtained.
$$\text{S}^{2-} + 2\text{H}^+ \longrightarrow \text{H}_2\text{S} \uparrow$$
- Lead acetate test : $(\text{CH}_3\text{COO})_2\text{Pb} + \text{H}_2\text{S} \longrightarrow \text{PbS} \downarrow (\text{black}) + 2\text{CH}_3\text{COOH}.$
- Sodium nitroprusside test : Purple coloration is obtained.
$$\text{S}^{2-} + [\text{Fe}(\text{CN})_5(\text{NO})]^{2-} \longrightarrow [\text{Fe}(\text{CN})_5\text{NOS}]^{4-} (\text{violet}).$$
- Cadmium carbonate suspension/ Cadmium acetate solution :
$$\text{Na}_2\text{S} + \text{CdCO}_3 \longrightarrow \text{CdS} \downarrow (\text{Yellow}) + \text{Na}_2\text{CO}_3$$

4. NITRITE ION (NO_2^-) :

- Dilute H_2SO_4 test :
$$\text{NO}_2^- + \text{H}^+ \longrightarrow \text{HNO}_2 ; (2\text{HNO}_2 \longrightarrow \text{H}_2\text{O} + \text{N}_2\text{O}_3);$$

$$3\text{HNO}_2 \longrightarrow \text{HNO}_3 + 2\text{NO} + \text{H}_2\text{O} ; 2\text{NO} + \text{O}_2 \longrightarrow 2\text{NO}_2 \uparrow$$
- Starch iodide test :
$$2\text{NO}_2^- + 3\text{I}^- + 4\text{CH}_3\text{COOH} \longrightarrow \text{I}_3^- + 2\text{NO} \uparrow + 4\text{CH}_3\text{COO}^- + 2\text{H}_2\text{O}$$

$$\text{Starch} + \text{I}_3^- \longrightarrow \text{Blue (starch iodine adsorption complex)}$$

5. ACETATE ION (CH_3COO^-)

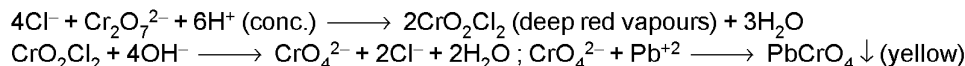
- Dilute H_2SO_4 test : $(\text{CH}_3\text{COO})_2\text{Ca} + \text{H}_2\text{SO}_4 \longrightarrow 2\text{CH}_3\text{COOH}$ (vinegar like smell) + CaSO_4
- Neutral ferric chloride test :
$$6\text{CH}_3\text{COO}^- + 3\text{Fe}^{3+} + 2\text{H}_2\text{O} \longrightarrow [\text{Fe}_3(\text{OH})_2(\text{CH}_3\text{COO})_6]^+ (\text{deep red/ blood red colouration}) + 2\text{H}^+$$

$$[\text{Fe}_3(\text{OH})_2(\text{CH}_3\text{COO})_6]^+ + 4\text{H}_2\text{O} \xrightarrow{\text{Boil}} 3\text{Fe}(\text{OH})_2\text{CH}_3\text{COO} \downarrow (\text{brownish red}) + 3\text{CH}_3\text{COOH} + \text{H}^+$$

(b) CONC. H_2SO_4 GROUP :

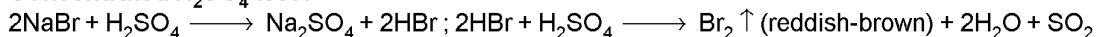
1. CHLORIDE ION (Cl^-) :

- Concentrated H_2SO_4 test : $\text{Cl}^- + \text{H}_2\text{SO}_4 \longrightarrow \text{HCl}$ (colourless pungent smelling gas) + HSO_4^-
- $\text{NH}_4\text{OH} + \text{HCl} \longrightarrow \text{NH}_4\text{Cl} \uparrow$ (white fumes) + $\text{H}_2\text{O}.$
- Silver nitrate test : $\text{Cl}^- + \text{Ag}^+ \longrightarrow \text{AgCl} \downarrow (\text{white})$
 White precipitate is soluble in aqueous ammonia and precipitate reappears with HNO_3 .
$$\text{AgCl} + 2\text{NH}_4\text{OH} \longrightarrow [\text{Ag}(\text{NH}_3)_2]\text{Cl} (\text{Soluble}) + 2\text{H}_2\text{O} ; [\text{Ag}(\text{NH}_3)_2]\text{Cl} + 2\text{H}^+ \longrightarrow \text{AgCl} \downarrow + 2\text{NH}_4^+.$$
- Chromyl chloride test :



2. BROMIDE ION (Br^-) :

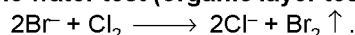
- **Concentrated H_2SO_4 test :**



- **Silver nitrate test :** $\text{NaBr} + \text{AgNO}_3 \longrightarrow \text{AgBr} \downarrow (\text{pale yellow}) + \text{NaNO}_3$

☞ Yellow precipitate is partially soluble in dilute aqueous ammonia but readily dissolves in concentrated ammonia solution. $\text{AgBr} + 2\text{NH}_4\text{OH} \longrightarrow [\text{Ag}(\text{NH}_3)_2] \text{Br} + \text{H}_2\text{O}$

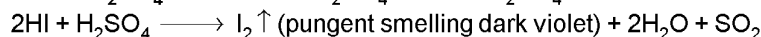
- **Chlorine water test (organic layer test) :**



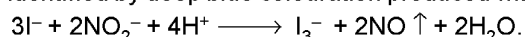
$\text{Br}_2 + \text{CHCl}_3 / \text{CCl}_4 \longrightarrow \text{Br}_2$ dissolve to give reddish brown colour in organic layer.

3. IODIDE ION (I^-) :

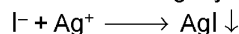
- **Concentrated H_2SO_4 test :** $2\text{NaI} + \text{H}_2\text{SO}_4 \longrightarrow \text{Na}_2\text{SO}_4 + 2\text{HI}$



- **Starch paper test :** Iodides are readily oxidised in acid solution to free iodine; the free iodine may than be identified by deep blue colouration produced with starch solution.

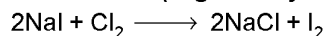


- **Silver nitrate test :** Bright yellow precipitate is formed.



☞ Bright yellow precipitate is insoluble in dilute aqueous ammonia but is partially soluble in concentrated ammonia solution.

- **Chlorine water test (organic layer test) :**



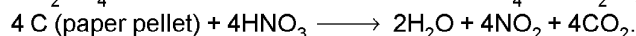
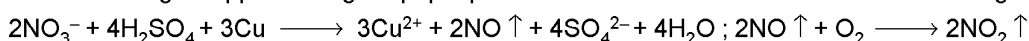
$\text{I}_2 + \text{CHCl}_3 \longrightarrow \text{I}_2$ dissolves to give violet colour in organic layer.

4. NITRATE ION (NO_3^-) :

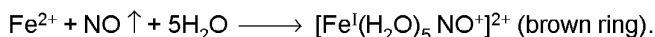
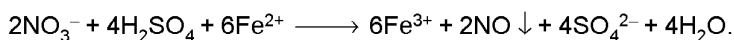
- **Concentrated H_2SO_4 test :** Pungent smelling reddish brown vapours are evolved.



☞ Addition of bright copper turnings or paper pellets intensifies the evolution of reddish brown gas.



- **Brown ring test :**



3. Miscellaneous Group :

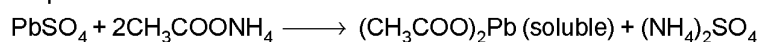
1. SULPHATE ION (SO_4^{2-}) :

- **Barium chloride test :** $\text{Na}_2\text{SO}_4 + \text{BaCl}_2 \longrightarrow \text{BaSO}_4 \downarrow (\text{white}) + 2\text{NaCl}$

☞ White precipitate is insoluble in warm dil. HNO_3 as well as HCl but moderately soluble in boiling concentrated hydrochloric acid.

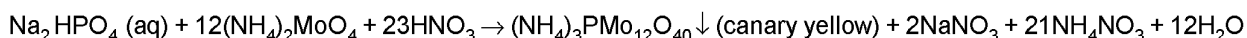
- **Lead acetate test :** $\text{Na}_2\text{SO}_4 + (\text{CH}_3\text{COO})_2\text{Pb} \longrightarrow \text{PbSO}_4 \downarrow (\text{White}) + 2\text{CH}_3\text{COONa}$

☞ White precipitate soluble in excess of hot ammonium acetate.



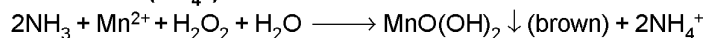
2. PHOSPHATE ION (PO_4^{3-}) :

- **Ammonium molybdate test :**

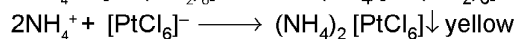
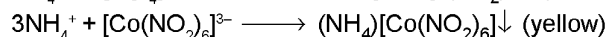


ANALYSIS OF CATIONS

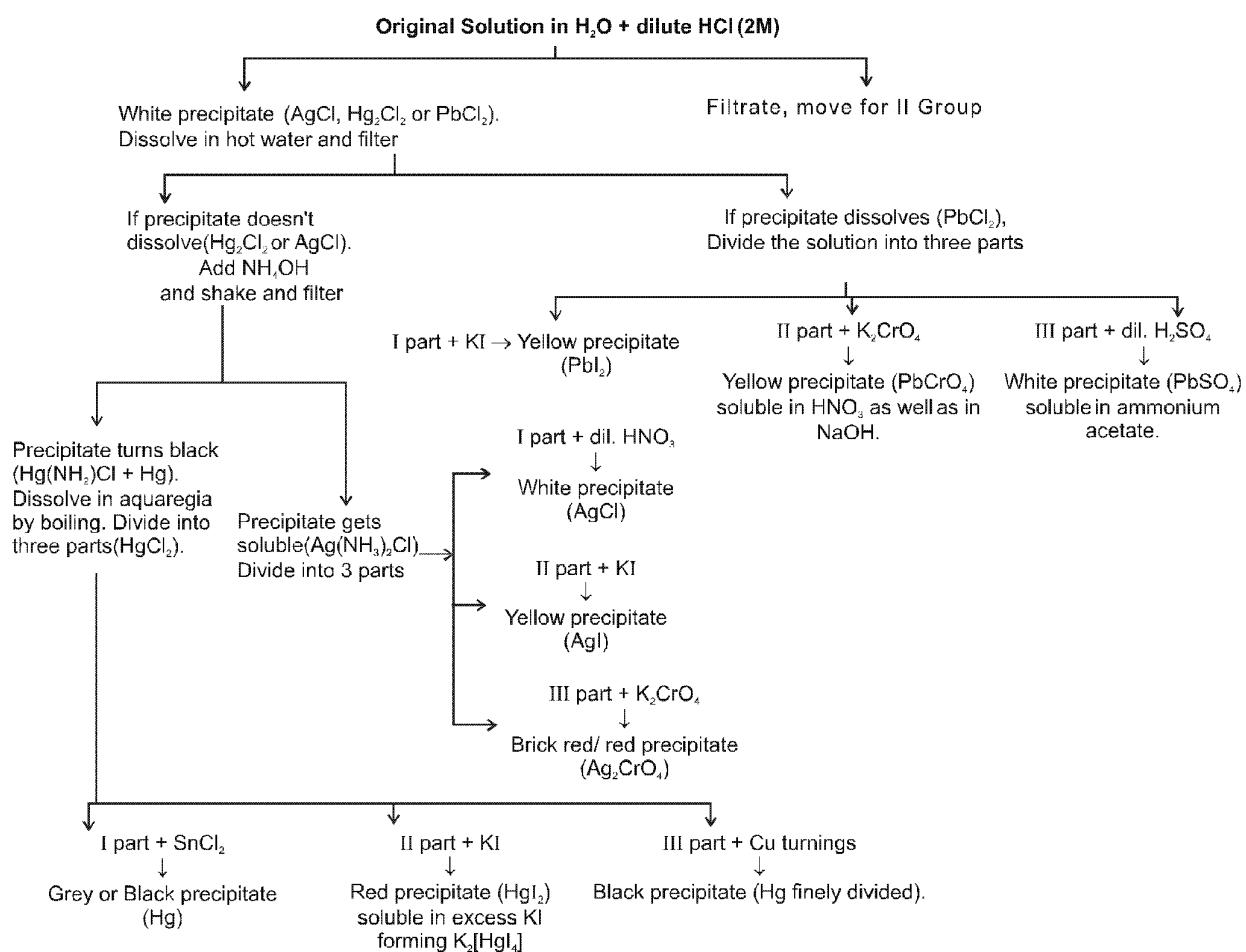
1. AMMONIUM ION (NH_4^+) :



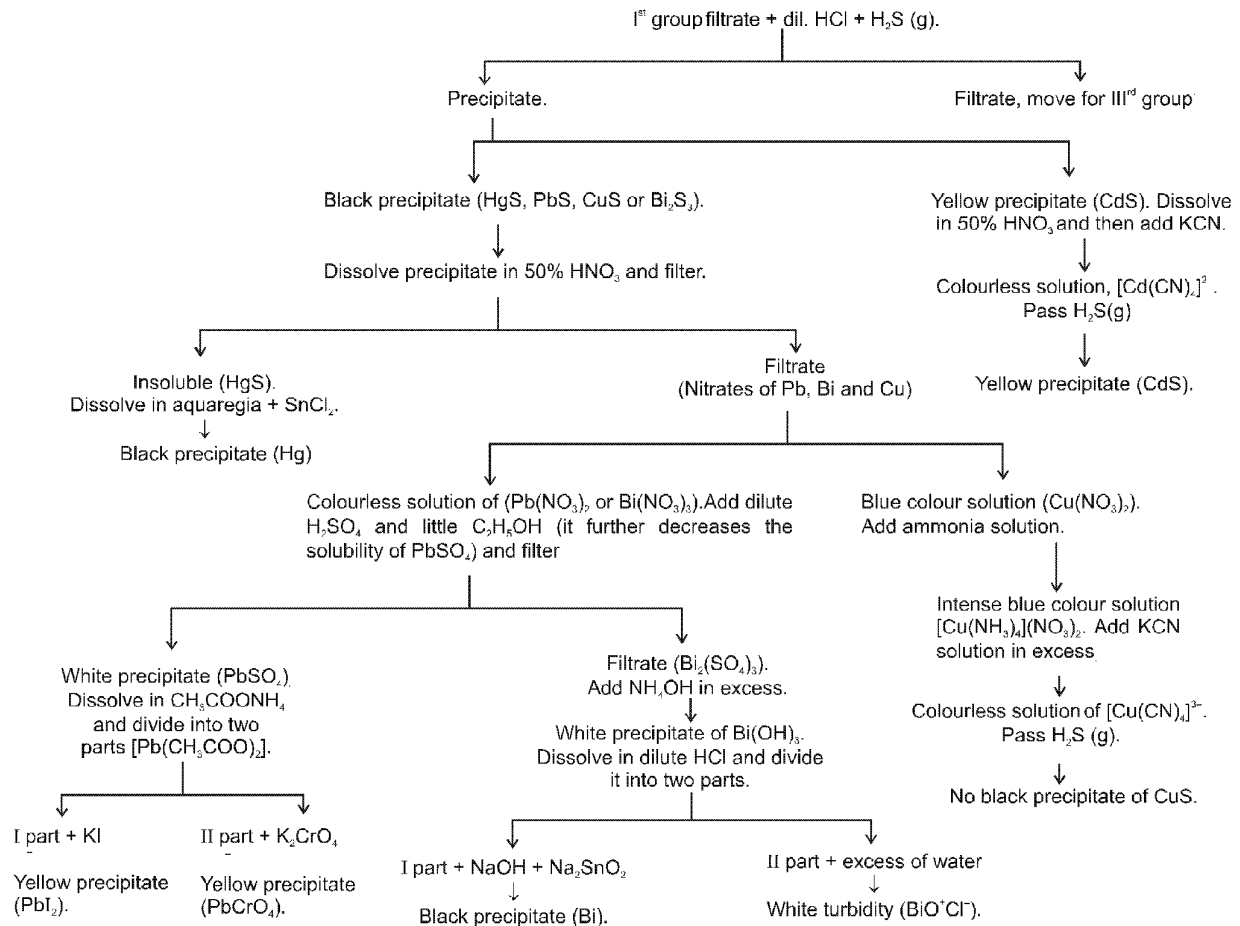
Nessler's reagent (Alkaline solution of potassium tetraiodomercurate(II)) :



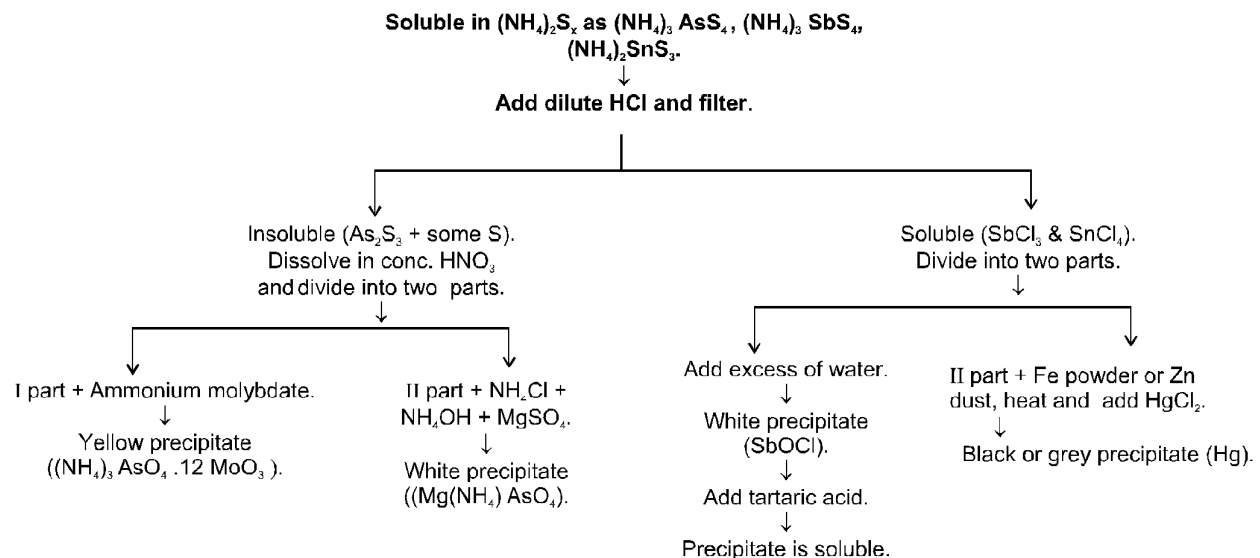
Ist GROUP (Pb^{2+} , Hg_2^{2+} , Ag^+) :



IIA Group (Hg^{2+} , Pb^{2+} , Bi^{3+} , Cu^{2+} , Cd^{2+})

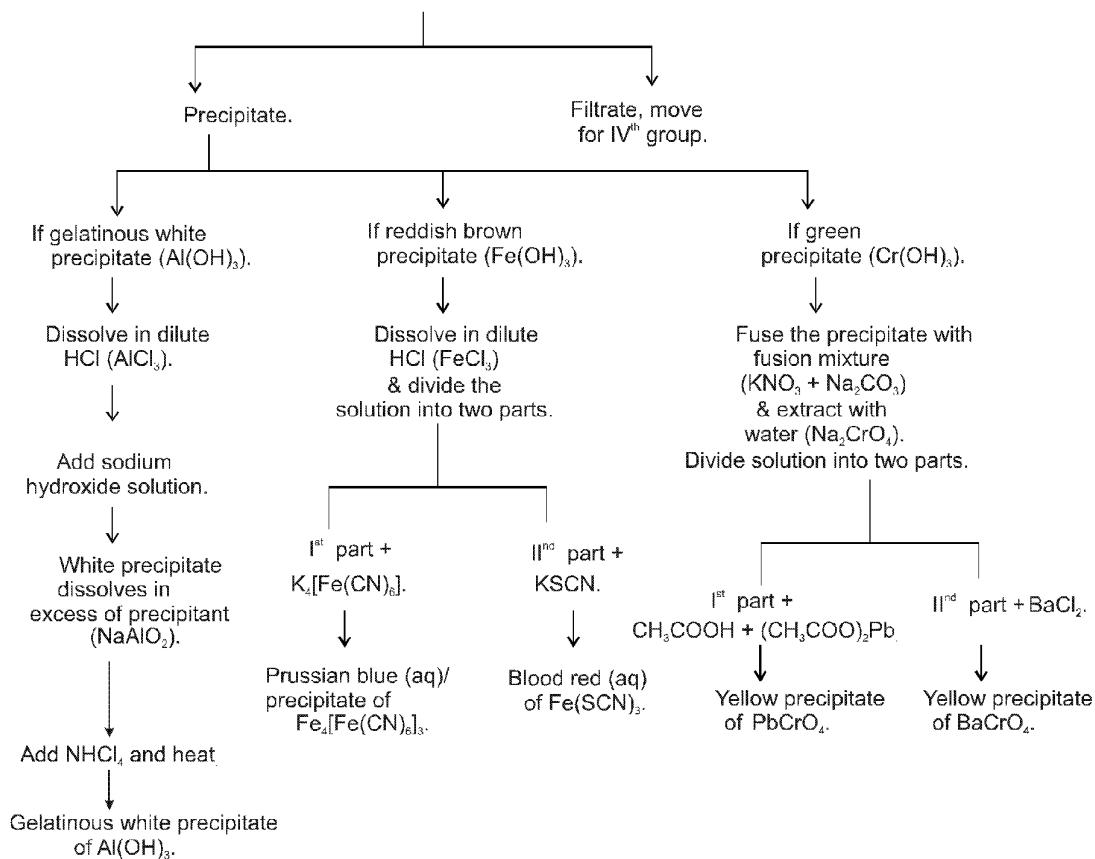


IIB Group (As^{3+} , Sb^{3+} , Sn^{2+} , Sn^{4+})



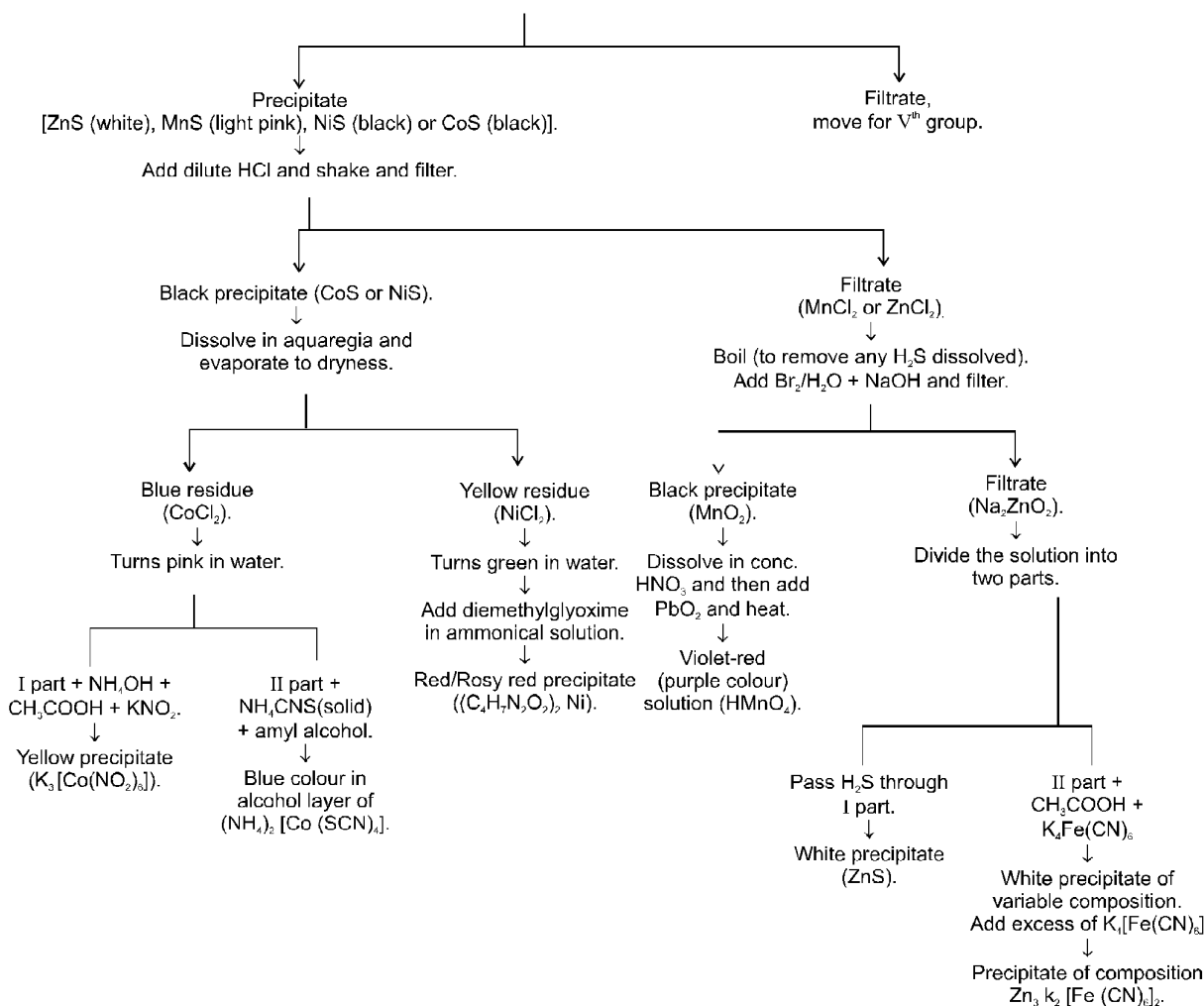
IIIrd Group (Al^{+3} , Cr^{+3} , Fe^{+3})

II Group Filtrate $\xrightarrow{\text{Boil off}}$ $\text{H}_2\text{S} \uparrow$ then add conc. HNO_3 (1-2) drops + NH_4Cl (solid) + NH_4OH



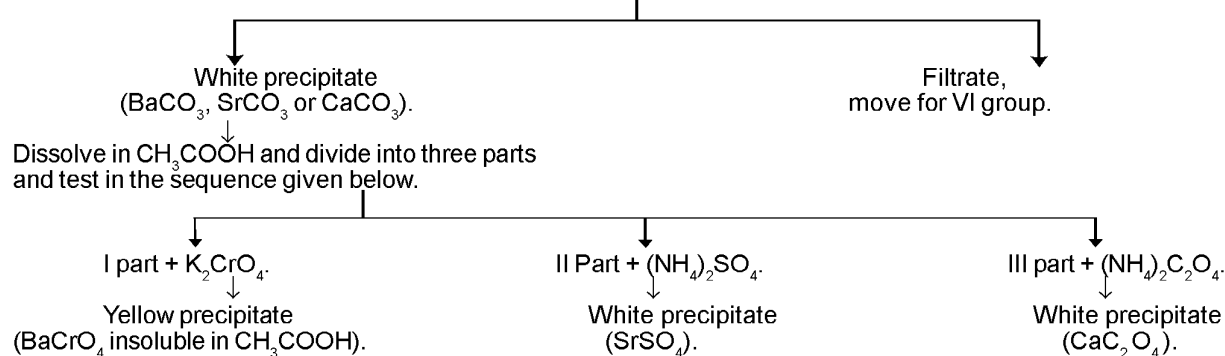
IVth GROUP (Zn^{2+} , Mn^{2+} , Ni^{2+} , Co^{2+}) :

III Group filtrate + NH_4OH (excess) & NH_4Cl , then pass H_2S



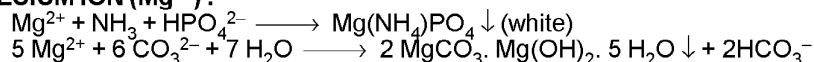
Vth Group (Ba^{2+} , Sr^{2+} , Ca^{2+}) :

IV Group filtrate $\longrightarrow$ Boil off H_2S then add $(\text{NH}_4)_2\text{CO}_3$ (aq), NH_4OH & NH_4Cl (s)



VIth GROUP :

MAGNESIUM ION (Mg^{2+}) :



Titan Yellow (a water soluble yellow dyestuff) : It is adsorbed by $\text{Mg}(\text{OH})_2$ producing a deep red colour or precipitate.