SALT ANALYSIS

Principles of qualitative analysis group I to V excluding interfering radicals.

The detection of cations (basic radicals)and anions(acidic radicals) in a salt or in a mixture is known as ***Qualitative Analysis.***

Some Important Observations during Qualitative Analysis

1. List of different coloured salts

Salts	Colour
Copper salts	Bluish green
Nickel salts	Greenish blue
Chromium salts	Dark green
Cobalt salts	Pinkish or purple
Manganese salts	Light pink
Ferrous salts	Light green
Ferric salts	Pale yellow

2. Action of Heat (Colour of Residue)

S. No.	Colour	Residue
i)	Yellow (hot) and white (cold)	ZnO
ii)	Reddish brown (hot) and yellow (cold)	PbO
iii)	Black (hot) and Red (cold)	HgO, Pb_3O_4
iv)	Black (hot) and Red brown (cold)	Fe_2O_3
v)	Decripitation	$Pb(NO_3)_2$, NaCl
vi)	White sublimate	Ammonium salts

3. Gases

S. No.	Nature	Gases
i)	Colourless and odourless gases	O_2, CO_2, N_2
ii)	Colourless gases with odour	NH_3, SO_2, HCl, H_2S
iii)	Coloured gases	NO_2 (brown), Br_2, (reddish brown), I_2 (violet) Cl_2 (greenish yellow)

4. Flame Test

Metals	Colour
Li	crimson red
Na	golden yellow
K	violet
Ca	Brick red
Sr	crimson
Ba	apple green

Classification Of Anions

Methods available for the detection of anions are not as systematic as those used for the detection of cations. Furthermore anions are classified essentially on the basis of process employed.

Class A: Includes anions that are identified by volatile products obtained on treatment with acids.It is further divided into two sub groups.

(i) Gases evolved with dil HCl/ dil H_2SO_4.

(ii) Gases or acid vapours evolved with conc H_2SO_4

Class B: Includes anions that are identified by their reactions in solution. It is subdivided into two groups:

(i) Precipitation reactions

(ii) Oxidation and reduction in solution

Class A (i): Anions which evolve gases on reaction with dil. HCl/dil. H_2SO_4.

It includes - **CO_3^{2-}, SO_3^{2-}, S^{2-}, NO_2^-, CH_3COO^-, $S_2O_3^{2-}$**

1. **Carbonate (CO_3^{2-}) :**

(i) ***Dilute HCl :*** gives effervescence, due to the evolution of carbon dioxide

$$CO_3^{2-} + 2H^+ \longrightarrow CO_2\uparrow + H_2O$$

The gas gives *white turbidity* with *lime water* and *baryta water*

$$CO_2 + Ca^{2+} + 2OH^- \longrightarrow CaCO_3\downarrow + H_2O$$

$$CO_2 + Ba^{2+} + 2OH^- \longrightarrow BaCO_3\downarrow + H_2O$$

On prolonged passage of carbon dioxide in lime water, the turbidity slowly disappears due to the formation of soluble hydrogen carbonate.

$$CaCO_3\downarrow + CO_2 + H_2O \longrightarrow Ca(HCO_3)_2$$

The following tests performed with then aqueous salts solution.

(ii) ***Barium chloride or Calcium chloride solution:*** *White ppt* of barium or Calcium carbonate is obtained, which is soluble in mineral acid.

$$CO_3^{2-} + Ba^{2+} \longrightarrow BaCO_3\downarrow$$

$$CO_3^{2-} + Ca^{2+} \longrightarrow CaCO_3\downarrow$$

(iii) **Silver nitrate solution :** White ppt of silver carbonate is obtained.

$$CO_3^{2-} + 2Ag^+ \longrightarrow Ag_2CO_3\downarrow$$

The ppt so obtained is soluble in nitric acid and in ammonia, the ppt becomes *yellow or brown* on addition of excess reagent and same may also be happened if the mix is boiled, due to the formation of silver oxide

$$Ag_2CO_3\downarrow \longrightarrow Ag_2O\downarrow + CO_2\uparrow$$

2. **Sulphites (SO_3^{2-}):**

(i) ***Dilute HCl or Dilute H_2SO_4 :*** decomposes with the evolution of sulphur dioxide

$$SO_3^{2-} + 2H^+ \longrightarrow SO_2 + H_2O$$

The gas has a *suffocating odour* of burning sulphur.

(ii) ***Acidified potassium dichromate solution:*** The gas turns filter paper moistened with acidified potassium dichromate solution, green due to the formation of Cr^{3+}ions.

$$SO_2 + K_2Cr_2O_7 + H_2SO_4 \longrightarrow K_2SO_4 + \underset{\text{green}}{Cr_2(SO_4)_3} + H_2O$$

(iii) ***Lime water :*** On passing the gas through lime water, a milky ppt is formed.

$$SO_2 + Ca(OH)_2 \longrightarrow \underset{\text{milky}}{CaSO_3\downarrow} + H_2O$$

Precipitate dissolves on prolonged passage of the gas, due to the formation of soluble hydrogen sulphite ions.

$$CaSO_3\downarrow + SO_2 + H_2O \longrightarrow Ca(HSO_3)_2.$$

(iv) **Barium chloride or Strontium chloride solution :** Salt solutions gives *white ppt* of barium or strontium sulphite.

$$SO_3^{2-} + Ba^{2+} \rightarrow BaSO_3 \downarrow$$

$$SO_3^{2-} + Sr^{2+} \rightarrow SrSO_3 \downarrow$$

3. **Sulphide (S^{-2}) :**

(i) **Dil HCl or Dil H_2SO_4 :** A colourless gas with a smell of rotten eggs (H_2S) is evolved

$$S^{2-} + 2H^+ \longrightarrow H_2S\uparrow$$

(ii) The gas turns lead acetate paper *black*

$$(CH_3COO)_2Pb + H_2S \longrightarrow \underset{\text{black}}{PbS\downarrow} + 2CH_3COOH$$

(iii) Salt solution gives yellow *ppt.* with $CdCl_2$

$$Na_2S + CdCl_2 \longrightarrow \underset{\text{yellow}}{CdS\downarrow} + 2NaCl$$

(iv) **Silver nitrate solution :** black ppt. of silver sulphide insoluble in cold but soluble in hot dil nitric acid.

$$S^{2-} + 2Ag^+ \longrightarrow Ag_2S \downarrow$$

(v) **Sodium nitroprusside solution** : Turns sodium nitroprusside solution *purple*

$$Na_2S + Na_2[Fe(CN)_5NO] \rightarrow Na_4[Fe(CN)_5NOS]$$

4. **Nitrites (NO_2^-) :**

(i) ***Dil HCl and Dil. H_2SO_4:*** Adding to solid nitrite in cold yield *pale blue liquid* (due to the presence of free nitrous acid HNO_2 or its anhydride N_2O_3) & the evolution of *brown fumes* of nitrogen dioxide, the latter being largely produced by combination of nitric oxide with the oxygen of the air

$$NO_2^- + H^+ \longrightarrow HNO_2$$

$$2HNO_2 \longrightarrow H_2O + N_2O_3$$

$$3HNO_2 \longrightarrow HNO_3 + 2NO\uparrow + H_2O$$

$$2NO\uparrow + O_2\uparrow \longrightarrow 2NO_2\uparrow$$

Following tests performed with an aqueous salt solution.

(ii) **Silver nitrate solution :** *White* crystalline ppt. is obtained

$$NO_2^- + Ag^+ \rightarrow AgNO_2\downarrow$$

(iii) Turns acidified KI - starch paper *blue*

$$2KI + 2NO_2 \longrightarrow 2KNO_2 + I_2\uparrow$$

Starch + I_2 $\longrightarrow$ Blue Colour

(iv) ***Brown ring test:*** When the nitrite solution is added carefully to a conc. solution of Iron(II) sulphate acidified with dil acetic acid or with dilute sulphuric acid, a ***brown ring***, due to the formation of $[Fe,NO]SO_4$ at the junction of the two liquids.

$$NO_2^- + CH_3COOH \longrightarrow HNO_2 + CH_3COO^-$$

$$3HNO_2 \longrightarrow H_2O + HNO_3 + 2NO\uparrow$$

$$Fe^{2+} + SO_4^{2-} + NO\uparrow \longrightarrow [Fe, NO]SO_4.$$

5. **Acetate (CH_3COO^-) :**

(i) ***Dilute Sulphuric Acid:*** Smell of vinegar

$CH_3COO^- + H^+ \longrightarrow CH_3COOH \uparrow$

(ii) ***Iron (III) Chloride Solution:*** Gives deep - red colouration

$CH_3COONa + FeCl_3 \longrightarrow (CH_3COO)_3Fe + 3NaCl$

Brown colour

6. **Thiosulphates ($S_2O_3^{2-}$):**

(i) **Dil Hydrochloric acid :** Gives sulphur & sulphur di oxide

$S_2O_3^{2-} + 2H^+ \longrightarrow S \downarrow + SO_2\uparrow + H_2O$

(ii) **Iodine Solution :** Decolourise due to formation of tetrathionate ion

$I_2 + 2S_2O_3^{2-} \longrightarrow 2I^- + S_4O_6^{2-}$

(iii) **Barium chloride solution :** White ppt. of barium thiosulphate is formed

$S_2O_3^{2-} + Ba^{2+} \longrightarrow BaS_2O_3 \downarrow$

But no ppt. is obtained with $CaCl_2$ solution.

(iv) **Silver nitrate solution :** Gives white ppt. of silver thiosulphate.

$S_2O_3^{2-} + 2Ag^+ \longrightarrow Ag_2S_2O_3 \downarrow$

The ppt. is unstable, turning dark on standing, due to the formation of silver sulphide.

$Ag_2S_2O_3\downarrow + H_2O \longrightarrow Ag_2S + H_2SO_4$

(v) **Lead acetate or Lead nitrate solution :** Gives white ppt.

$S_2O_3^{2-} + Pb^{2+} \longrightarrow PbS_2O_3 \downarrow$

On boiling it turns black due to the formation of PbS.

$PbS_2O_3 \downarrow + H_2O \longrightarrow PbS \downarrow + 2H^+ + SO_4^{2-}$

Class A(ii): Gases or acid vapours evolved with conc. Sulphuric acid

It includes - Cl^-, Br^-, I^-, NO_3^-.

1. **Chloride (Cl^-) :**

(i) ***Conc. H_2SO_4 :*** decomposes with the evolution of HCl.

$Cl^- + H_2SO_4 \rightarrow HCl + HSO_4^-$

Gas so produced

1. Turns blue litmus paper red

2. Gives *white fumes* of NH_4Cl when a glass rod moistened with ammonia solution is brought to the mouth of test tube.

(ii) ***Manganese dioxide and conc. sulphuric acid*:** When a solid chloride is treated with MnO_2 and conc. H_2SO_4, *yellowish green colour* is obtained.

$MnO_2 + 2H_2SO_4 + 2Cl^- \rightarrow Mn^{2+} + Cl_2\uparrow + 2SO_4^{2-} + 2H_2O$

The following tests are performed with the salt solution.

(iii) ***Silver nitrate solution****: White, curdy ppt.* of AgCl insoluble in water & in dil nitric acid, but soluble in dilute ammonia solution.

$Cl^- + Ag^+ \rightarrow AgCl \downarrow$

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

$Ag(NH_3)_2Cl + 2H^+ \rightarrow AgCl + 2NH_4^+$.

(iv) ***Lead acetate solution****: White ppt.* of lead chloride is formed

$2Cl^- + Pb^{+2} \rightarrow PbCl_2 \downarrow$

(v) **Chromyl chloride test** : When a mix containing chloride ion is heated with $K_2Cr_2O_7$ and conc. H_2SO_4 *orange red fumes* of *chromyl chloride* (CrO_2Cl_2) are formed.

$K_2Cr_2O_7 + 4NaCl + 6H_2SO_4 \rightarrow 2KHSO_4 + 4NaHSO_4 + 2CrO_2Cl_2 \uparrow + 3H_2O$

orange – red fumes

Chlorides of mercury, owing to their slight ionization, do not respond to this test and only partial conversion to CrO_2Cl_2 occurs with the chlorides of lead, silver, antimony and tin.

When chromyl chloride vapours are passed into sodium hydroxide a *yellow solution* of sodium chromate is formed which when treated with lead acetate gives yellow ppt. of lead chromate.

$CrO_2Cl_2 + 2NaOH \longrightarrow Na_2CrO_4 + 2HCl$

Yellow solution

$Na_2CrO_4 + (CH_3COO)_2 Pb \rightarrow 2CH_3COONa + PbCrO_4 \downarrow$

(yellow ppt.)

2. **Bromide (Br^-)**

(i) ***Conc. H_2SO_4 :*** Gives *reddish brown vapours* of bromine.

$2KBr + H_2SO_4 \rightarrow K_2SO_4 + 2HBr$

$2HBr + H_2SO_4 \rightarrow 2H_2O + SO_2 \uparrow + Br_2 \uparrow$

(reddish brown)

(ii) ***Manganese dioxide and conc. sulphuric acid :*** When a mix of solid bromide, MnO_2 and conc. H_2SO_4 is heated reddish brown vapours of bromine are evolved.

$2KBr + MnO_2 + 2H_2SO_4 \rightarrow Br_2 \uparrow + K_2SO_4 + MnSO_4 + 2H_2O$

The following tests are performed with the salt solution.

(iii) ***Silver nitrate solution:*** *A pale yellow ppt.* of silver bromide is obtained. This ppt. is sparingly soluble in dil but readily soluble in conc. ammonia solution and insoluble in dil. HNO_3.

$Br^- + Ag^+ \longrightarrow AgBr$

(iv) ***Lead acetate solution:*** White crystalline ppt. of lead bromide which is soluble in boiling water.

$2Br^- + Pb^{+2} \longrightarrow PbBr_2 \downarrow$

(v) ***Chlorine water:*** When this solution is added to a solution of bromide and chloroform free bromine is liberated, which colours the organic layer *orange – red*.

$2KBr + Cl_2$ (water) $\longrightarrow 2KCl + Br_2$

Br_2 + Chloroform $\longrightarrow$ Orange red colour

(vi) ***Potassium dichromate & conc. H_2SO_4:*** When a mix of solid bromide, $K_2Cr_2O_7$, and conc. H_2SO_4 is heated and passing the evolved vapours into water, a yellowish brown solution is obtained.

$2KBr + K_2Cr_2O_7 + 7H_2SO_4 \rightarrow 3Br_2 \uparrow + Cr_2(SO_4)_3 + 4K_2SO_4 + 7H_2O.$

3. **Iodide (I^-) :**

(i) ***Conc. H_2SO_4 :*** Gives *violet* vapours of iodine

$2I^- + 2H_2SO_4 \longrightarrow I_2 + SO_4^{2-} + 2H_2O + SO_2 \uparrow$

violet vapours

The following tests are performed with the salt solution.

(ii) ***Silver nitrate solution:*** *Yellow, curdy ppt.* of silver iodide AgI, very slightly soluble in conc. ammonia solution and insoluble in dil nitric acid.

$I^- + Ag^+ \longrightarrow AgI$

(iii) ***Lead acetate solution:*** *Yellow, curdy ppt.* of lead iodide soluble in much hot water forming a colourless solution & yielding golden yellow plates *(spangles)* on cooling.

$2I^- + Pb^{2+} \longrightarrow PbI_2\downarrow$

(iv) ***Potassium dichromate & conc. sulphuric acid:*** Iodine is liberated

$6I^- + Cr_2O_7^{2-} + 2H_2SO_4 \longrightarrow 3I_2 \uparrow + 2Cr^{3+} + 7SO_4^{2-} + 7H_2O.$

(v) ***Chlorine water****:* Iodine is liberated, by the dropwise addition of chlorine water to iodide, and on addition of $CHCl_3$ violet coloured organic layer is obtained.

$2I^- + Cl_2 \longrightarrow I_2 + 2Cl^-$

I_2 + chloroform $\longrightarrow$ violet coloured layer.

(vi) ***Copper sulphate solution****:* Gives *brown ppt.* consisting of a mixture of copper (I) iodide & iodine and on additon of hypo solution brown ppt changes to *white ppt*.

$4I^- + 2Cu^{2+} \longrightarrow 2CuI + I_2$

$I_2 + 2S_2O_3^{2-} \longrightarrow 2I^- + S_4O_6^{2-}.$

v(ii) ***Mercury (II) chloride solution:*** Forms *scarlet ppt.* of HgI_2

$2I^- + HgCl_2 \longrightarrow HgI_2 \downarrow + 2Cl^-.$

This ppt. dissolves in excess of KI, forming tetraiodo mercurate (II) complex.

$HgI_2 + 2I^- \longrightarrow [HgI_4]^{2-}$

4. **Nitrate (NO_3^-) :**

(i) ***Conc H_2SO_4 :*** Gives *reddish - brown* vapours of nitrogen dioxide

$4NO_3^- + 2H_2SO_4 \longrightarrow 4NO_2\uparrow + 2SO_4^{2-} + 2H_2O + O_2\uparrow$

The following tests are performed with the salt solution.

(ii) ***Brown ring test*** *:* When a freshly prepared solution of iron (II) sulphate is added to nitrate solution & conc. H_2SO_4 is poured slowly down the side of the test - tube, *a brown ring* is obtained.

$2NO_3^- + 4H_2SO_4 + 6Fe^{2+} \longrightarrow 6Fe^{3+} + 2NO + 4SO_4^- + 4H_2O$

$Fe^{2+} + NO\uparrow \rightarrow [Fe(NO)]^{2+}$

On shaking and warming the mix, the brown colour disappears, nitric oxide is evolved and a yellow solution of Iron(III) ions remains.

Action of heat : The result varies with the metal

1. Nitrates of sodium and potassium evolve oxygen *(test with glowing splint)* & leave solid nitrites (brown fumes with dilute acid)

$2NaNO_3 \longrightarrow 2NaNO_2 + O_2\uparrow.$

2. Ammonium nitrate yields dinitrogen oxide & steam

$NH_4NO_3 \longrightarrow N_2O \uparrow + 2H_2O.$

3. Nitrates of the noble metals leave a residue of the metal and a mix of nitrogen dioxide and oxygen is evolved.

$2AgNO_3 \longrightarrow 2Ag + 2NO_2 \uparrow + O_2\uparrow.$

4. Nitrates of other metals, such as those of lead and copper, evolve oxygen and nitrogen dioxide and leave a residue of the oxide.

$2Pb(NO_3)_2 \longrightarrow 2PbO + 4NO_2\uparrow + O_2\uparrow.$

Class B (i) Precipitation reaction : SO_4^{2-}

(ii) Oxidation and reduction in solution - CrO_4^{2-} ,$Cr_2O_7^{2-}$, MnO_4^-

1. **Sulphate (SO_4^{2-}):**

All sulphates except those of Ba, Pb, Sr are soluble in water. Sulphates of calcium and mercury(II) are slightly soluble. The following tests are performed with the salt solution.

(i) ***Barium chloride solution:*** White ppt. of barium sulphate $BaSO_4$ insoluble in warm dil. hydrochloric acid and in dilute nitric acid, but moderately soluble in boiling, conc. hydrochloric acid.

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

(ii) **Mercury (II) nitrate solution :** Gives yellow ppt. of basic mercury (II) sulphate.

$$SO_4^{2-} + 3Hg^{2+} + 2H_2O \rightarrow HgSO_4.2HgO \downarrow + 4H^+$$

2. **Chromate $CrO_4^{2-}$and Dichromate ($Cr_2O_7^{2-}$) :**

Metallic chromates gives *yellow solution* when dissolved in water. In the presence of H^+ chromates are converted into dichromates (orange-red solution).

$$2CrO_4^{2-} + 2H^+ \rightleftharpoons Cr_2O_7^{2-} + H_2O$$

$$Cr_2O_7^{2-} + 2OH^- \rightleftharpoons 2CrO_4^{2-} + H_2O$$

It may also be expressed as :

$$2CrO_4^{2-} + 2H^+ \rightleftharpoons 2HCrO_4^- \rightleftharpoons Cr_2O_7^{-2} + H_2O$$

(i) ***Barium chloride solution:*** *Pale - yellow ppt.* of barium chromate soluble in dilute mineral acids but insoluble in water and acetic acid.

$$CrO_4^{2-} + Ba^{2+} \longrightarrow BaCrO_4 \downarrow$$

Dichromate ions also gives the same ppt. but due to the formation of strong acid precipitation is partial.

$$Cr_2O_7^{2-} + 2Ba^{2+} + H_2O \rightleftharpoons 2\ BaCrO_4 \downarrow + 2H^+$$

If sodium hydroxide or sodium acetate is added, precipitation becomes quantitative.

(ii) ***Silver nitrate solution:*** *Brownish - red ppt.* of silver chromate Ag_2CrO_4 which is soluble in dil. nitric acid & in ammonia solution, but is insoluble in acetic acid.

$$CrO_4^{2-} + 2Ag^+ \longrightarrow Ag_2CrO_4 \downarrow$$

$$2\ Ag_2CrO_4 + 2H^+ \longrightarrow 4\ Ag^+ + Cr_2O_7^{2-} + H_2O$$

$$Ag_2CrO_4 \downarrow + 4NH_3 \longrightarrow 2[Ag(NH_3)_2]^+ + CrO_4^{2-}$$

$$Ag_2CrO_4 \downarrow + 2Cl^- \longrightarrow 2AgCl + CrO_4^{2-}$$

A reddish brown ppt. of silver dichromate $Ag_2Cr_2O_7$ is formed with a conc. solution of a dichromate.

$$Cr_2O_7^{2-} + 2Ag^+ \longrightarrow Ag_2Cr_2O_7$$

(iii) ***Lead acetate solution:*** *Yellow ppt.* of lead chromate $PbCrO_4$ insoluble in acetic acid, but soluble in dil nitric acid

$$CrO_4^{2-} + Pb^{2+} \longrightarrow PbCrO_4 \downarrow.$$

$$2PbCrO_4 \downarrow + 2H^+ \rightleftharpoons 2Pb^{2+} + Cr_2O_7^{2-} + H_2O.$$

(iv) ***H_2O_2:*** If an acidic solution of a chromate is treated with H_2O_2 a *deep blue solution* of chromium penta oxide is obtained.

$$CrO_4^{2-} + 2H^+ + 2H_2O_2 \longrightarrow CrO_5 + 3H_2O$$

CrO_5 is unstable and it decomposes yielding oxygen and a *green solution* of a Cr^{+3} Salt.

3. **Permanganate MnO_4^- :**

(i) ***Hydrogen peroxide :*** It decolourises acidified potassium permanganate solution

$2MnO_4^- + 5H_2O_2 + 6H^+ \longrightarrow 5O_2\uparrow + 2Mn^{2+} + 8H_2O$.

(ii) Iron (II) sulphate, in the presence of sulphuric acid, reduces permanganate to manganese (II). The solution becomes *yellow* because of the formation of iron (III) ions

$MnO_4^- + 5Fe^{2+} + 8H^+ \longrightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$

(iii) **Action of heat :** On heating, a residue of potassium manganate K_2MnO_4 and black manganese dioxide remains behind. Upon extracting with water and filtering, a green solution of potassium manganate is obtained.

$2KMnO_4 \longrightarrow K_2MnO_4 + MnO_2 + O_2\uparrow$.

Exercise 1: ***(i) How to distinguish between CO_3^{--} and SO_3^{--} ions?***

(ii) A gas turns red litmus paper into blue and forms white fume with HCl, identify the gas

Classification of Cations

For the purpose of systematic qualitative analysis, cations are classified into *five groups* on the basis of their behaviour with some reagents and classification is based on whether a cation reacts with these reagents by the formation of precipitate or not (solubility difference)

Group reagent: Hydrocholoric acid, hydrogen sulphide, ammonium sulphide and ammonium carbonate.

Group	Group Reagent	Ions	Colour & Ppt.
Group I	dil HCl	Pb^{2+}, Hg^+, Ag^+	$PbCl_2$, Hg_2Cl_2, AgCl - white
Group II Group II A	H_2S in dil HCl	Hg^{2+}, Cu^{2+}, Bi^{3+}, Cd^{2+} As^{3+}, As^{5+}, Sb^{3+}, Sb^{5+}, Sn^{2+},	Yellow-CdS, As_2S_3, As_2S_5, SnS_2
Group II B		Sn^{4+}	Black - HgS, CuS, PbS Orange - Sb_2S_3, Sb_2S_5 Brown - Bi_2S_3, SnS
Group III A	NH_4OH in presence of NH_4Cl	Fe^{3+}, Al^{3+}, Cr^{3+}	$Fe(OH)_3$, $Al(OH)_3$, $Cr(OH)_3$ Brown White Green
GroupIII B	H_2S in presence of NH_3 & NH_4Cl or NH_4S.	Ni^{2+}, Co^{+2}, Mn^{+2}, Zn^{+2s}	ZnS - white or grey, Black - CoS, NiS MnS - Buff (light pink)
Group IV	$(NH_4)_2CO_3$ in presence of NH_4Cl & NH_4OH.	Ba^{+2}, Sr^{2+}, Ca^{+2}	$BaCO_3$, $SrCO_3$, $CaCO_3$ - white
Group V	No common group reagent.	Mg^{+2}, Na^+, K^+, NH_4^+	—

Points to Remember

1. Group I radicals (Ag^+, Pb^{+2} Hg_2^{2+}) are precipitated as chlorides because the solubility product of these chlorides (AgCl, $PbCl_2$, Hg_2Cl_2) is less than the solubility products of all other chlorides which remain in solution.

2. Group II radicals are precipitated as sulphides because sulphides of other metals remain in solution because of their high solubility products, HCl acts as a source of H^+ and thus decreases the conc. of S^{2-} due to *common ion effect*. Hence decreased conc. of S^{2-} is only sufficient to precipitate the Group II radicals only.

3. Group III A radicals are precipitated as hydroxides and the NH_4Cl suppresses the ionisation of NH_4OH so that only the group III A radicals are precipitated because of their low solubility product.

   Note:

   (i) Excess of NH_4Cl should be added otherwise manganese will be ppt. as $MnO_2.H_2O$.

   (ii) $(NH_4)_2SO_4$ can't be used in place of NH_4Cl because the SO_4^{2-} will ppt. barium as $BaSO_4$.

   (iii) NH_4NO_3 can't be used in place of NH_4Cl because NO_3^- ions will oxidise Mn^{2+} to Mn^{3+} and thus $Mn(OH)_3$ will be precipitated in III A group.

   (iv) Only $Al(OH)_3$ is soluble in excess of NaOH followed by boiling to form sodium metaluminate while $Fe(OH)_3$ and $Cr(OH)_3$ are insoluble.

4. Ammonium hydroxide increases the ionisation of H_2S by removing H^+ from H_2S as unionised water

   $H_2S \rightleftharpoons 2H^+ + S^{2-}$. $\quad H^+ + OH^- \longrightarrow H_2O$

   Now excess of S^{2-} ions are available and hence the ionic product of hydroxides of Group III B exceed their solubility product and ppt. will be obtained.In case H_2S is passed through a neutral solution, incomplete precipitation will take place due to the formation of HCl which decreases the ionization of H_2S.

   $MnCl_2 + H_2S \longrightarrow MnS + 2HCl$

Identification of Basic Radicals

All confirmatory tests for basic radicals are performed with the salt solution.

1. **Group I (Pb^{2+}, Ag^+, Hg^+)**

   (a) $PbCl_2$ gives a yellow ppt. with K_2CrO_4. The ppt. is insoluble in acetic acid but soluble in NaOH

   $Pb(NO_3)_2 + K_2CrO_4 \rightarrow PbCrO_4\downarrow + 2KNO_3$

   Yellow ppt.

   $PbCrO_4 + 4NaOH \rightarrow Na_2[PbO_2] + Na_2CrO_4 + 2H_2O$

   (b) $Pb(NO_3)_2 + 2KI \rightarrow PbI_2\downarrow + 2KNO_3$

   (Yellow)

   $PbCl_2 + 2KI \text{ (excess)} \rightarrow K_2[PbI_4]$

2. AgCl is soluble in NH_4OH forming a complex while Hg_2Cl_2 forms a *black ppt*. with NH_4OH.

   $AgCl + 2NH_4OH \rightarrow Ag(NH_2)_2Cl + 2H_2O$

   $Hg_2Cl_2 + 2NH_4OH \rightarrow H_2N — Hg — Cl + Hg\downarrow + NH_4Cl + 2H_2O$

   Amino mercuric Chloride

2. **Group II A (Hg^{2+}, Cu^{2+}, Bi^{3+}, Cd^{2+})**

(i) Hg^{+2} ions in solution, on addition of $SnCl_2$, give *white precipitate* turning *black*.

$$2Hg^{+2} + SnCl \rightarrow Sn^{+4} + Hg_2Cl_2 \downarrow$$

White

$$Hg_2Cl_2 + SnCl_2 \rightarrow SnCl_4 + 2Hg \downarrow$$

Black

(ii) Cu^{+2} ions in solution gives a pale blue precipitate which gives a deep blue colour with excess of NH_4OH

$$Cu^{+2} + 4NH_4OH \rightarrow [Cu(NH_3)_4]^{+2} + 4H_2O$$

Deep blue in colour

Cu^{+2} ions give chocolate precipitate with $K_4Fe(CN)_6$.

$$2Cu^{+2} + K_4Fe(CN)_6 \rightarrow Cu_2[Fe(CN)_6] + 4K^+$$

(iii) Bi^{+3} ions in solution of HCl on addition of water give white cloudy precipitate.

$$BiCl_3 + H_2O \longrightarrow BiOCl \downarrow + 2HCl$$

White ppt.

When treated with sodium stannite a black ppt. is obtained.

$$2BiCl_3 + 3Na_2SnO_2 \longrightarrow 2Bi \downarrow + 3Na_2SnO_3 + 6NaCl + 3H_2O$$

black

(iv) Cd^{+2} ions in solution, with ammonium hydroxide gives a white precipitate which dissolves .

$$Cd^{+2} + 2NH_4OH \longrightarrow Cd(OH)_2 \downarrow + 2NH_4^+$$

Yellow

$$Cd(OH)_2 + 4NH_4OH \rightarrow [Cd(NH_3)_4](OH)_2$$

3. **Group II B (As^{3+}, As^{5+}, Sb^{3+}, Sb^{5+}, Sn^{3+}, Sn^{4+})**

(v) As^{+3} ions in solution give *yellow precipitate* with ammonium molybadate and HNO_3.

$$As^{+3} \xrightarrow[\text{Oxidation}]{HNO_3} As^{+5} (\text{as } H_3AsO_4)$$

$$H_3AsO_4 + 12(NH_4)_2MoO_4 + 21HNO_3 \longrightarrow (NH_4)_3 AsMo_{12}O_{40} \downarrow + 21NH_4NO_3 + 12H_2O$$

Yellow ppt.

(vi) Sn^{2+} ions in solution as $SnCl_2$ give white ppt. with $HgCl_2$,which turns black on standing.

$$SnCl_2 + 2HgCl_2 \longrightarrow SnCl_4 + Hg_2Cl_2 \downarrow$$

White

$$Hg_2Cl_2 + SnCl_2 \longrightarrow SnCl_4 + 2Hg \downarrow$$

Black

v(ii) Sb^{+3} ions in solution as $SbCl_3$, on addition of water give white precipitate.

$$SbCl_3 + H_2O \rightarrow SbOCl \downarrow + 2HCI$$

White

4. **Group III A (Al^{3+}, Fe^{3+}, Cr^{3+})**

(i) White precipitate of $Al(OH)_3$ is soluble in NaOH

$Al(OH)_3 + NaOH \rightarrow NaAlO_2 + 2H_2O$

(ii) Precipitate of $Cr(OH)_3$ is soluble in NaOH + Br_2 water and addition of $BaCl_2$ to this solution gives yellow precipitate.

$Br_2 + H_2O \rightarrow 2HBr + (O)$

$2Cr(OH)_3 + 4NaOH + 3(O) \rightarrow 2Na_2CrO_4 + 5H_2O$

$Na_2CrO_4 + BaCl_2 \rightarrow BaCrO_4\downarrow + 2NaCl$

Yellow ppt.

$Fe(OH)_3$ is insoluble in NaOH

(iii) Brown precipitate of $Fe(OH)_3$ is dissolved in HCl and addition of KCNS to this solution gives blood red colour.

$Fe(OH)_3 + 3HCl \rightarrow FeCl_3 + 3H_2O$

$FeCl_3 + 3KCNS \rightarrow Fe(CNS)_3 + 3KCl$

blood red

Also on addition of $K_4Fe(CN)_6$ to this solution, a prussian blue colour is obtained.

$FeCl_3 + 3K_4Fe(CN)_6 \rightarrow Fe_4[Fe(CN)_6]_3 + 12KCl$

prussian blue colour

5. **Group III B (Ni^{2+}, Co^{2+}, Mn^{2+}, Zn^{2+})**

(i) Ni^{+2} and Co^{+2} ions in solution, on addition of $KHCO_3$ and Br_2 water give *apple green colour* if Co^{+2} is present and black precipitate if Ni^{+2} is present.

$CoCl_2 + 6KHCO_3 \rightarrow K_4[Co(CO_3)_3] + 2KCl + 3CO_2\uparrow + 3H_2O$

$2K_4[Co(CO_3)_3] + 2KHCO_3 + [O] \rightarrow 2K_3[Co(CO_3)_3] + 2K_2CO_3 + H_2O$

Apple green colour

$NiCl_2 + 2KHCO_3 \rightarrow NiCO_3 + 2KCl + H_2O + CO_2\uparrow$

$2NiCO_3 + 4NaOH + [O] \rightarrow Ni_2O_3\downarrow + 2Na_2CO_3 + 2H_2O$

Black ppt.

(ii) Zn^{+2} ions in solution give a *white precipitate* with NaOH, which dissolves in excess of NaOH.

$Zn^{+2} + 2NaOH \rightarrow Zn(OH)_2\downarrow + 2Na^+$

White

$Zn(OH)_2 + 2NaOH \rightarrow Na_2ZnO_2 + 2H_2O$

Soluble

(iii) Mn^{+2} ions in solution give *pink precipitate* with NaOH turning *black* or *brown* on heating.

$Mn^{+2} + 2NaOH \longrightarrow Mn(OH)_2 + 2Na^+$

Pink

$Mn(OH)_2 + [O] \xrightarrow{\Delta} MnO_2 + H_2O$

Brown or black

6. **Group IV (Ba^{2+}, Sr^{2+}, Ca^{2+})**

(i) Ba^{+2} ions in solution give

(a) *Yellow precipitate* with K_2CrO_4

$$Ba^{+2} + K_2CrO_4 \rightarrow BaCrO_4\downarrow + 2K^+$$

Yellow

(b) *White precipitate* with $(NH_4)_2SO_4$

$$Ba^{+2} + (NH_4)_2SO_4 \rightarrow BaSO_4\downarrow + 2NH_4^+$$

White

(c) *White precipitate* with $(NH_4)_2C_2O_4$

$$Ba^{+2} + (NH_4)_2C_2O_4 \rightarrow BaC_2O_4\downarrow + 2NH_4^+$$

White

(ii) Sr^{+2} ions give white precipitate with $(NH_4)_2SO_4$ and $(NH_4)_2C_2O_4$

$$Sr^{+2} + (NH_4)_2SO_4 \rightarrow SrSO_4\downarrow + 2NH_4^+$$

White ppt.

$$Sr^{+2} + (NH_4)_2C_2O_4 \rightarrow SrC_2O_4\downarrow + 2NH_4^+$$

White

(iii) Ca^{+2} ions give *white precipitate* with $(NH_4)_2C_2O_4$ only.

$$Ca^{+2} + (NH_4)_2C_2O_4 \rightarrow CaC_2O_4\downarrow + 2NH_4^+$$

White

7. **Group V (NH_4^+, Na^+, K^+, Mg^{+2})**

(i) All ammonium salts on heating with alkali say NaOH give a colourless, pungent smelling gas (NH_3).

$$NH_4Cl + NaOH \longrightarrow NaCl + NH_3\uparrow + H_2O$$

(a) Gas evolved gives white fumes with a rod dipped in conc. HCl

$$NH_3 + HCl \longrightarrow NH_4Cl\uparrow$$

White fumes

(b) Paper soaked in $CuSO_4$ solution, becomes deep blue due to complex formation with NH_3.

$$CuSO_4 + 4NH_3 \longrightarrow [Cu(NH_3)_4]SO_4$$

deep blue

(c) With $Hg_2(NO_3)_2$, *a black colour* is obtained

$$Hg_2(NO_3)_2 + 2NH_3 \longrightarrow Hg\downarrow + Hg(NH_2)NO_3\downarrow + NH_4NO_3$$

black

(d) An aqueous solution of an ammonium gives a brown ppt. with Nessler's reagent(alkaline solution of potassium tetraiodomercurate(II)).

$$NH_4Cl + 2K_2HgI_4 + 3KOH \rightarrow \underset{\text{(Iodide of Millon's base)}}{\underset{\text{(Brown)}}{O(Hg)_2NH_2I}} + 4KI + 2H_2O + 3NaI$$

(ii) Potassium salts give a *yellow ppt.* with sodium cobaltinitrite

$$Na_3[Co(NO_2)_6] + 3KCl \longrightarrow \underset{\text{yellow}}{K_3[Co(NO_2)_6]} + 3NaCl$$

(iii) Sodium salts give a heavy white ppt. with potassium dihydrogen antimonate

$$KH_2SbO_4 + NaCl \longrightarrow \underset{\text{White ppt.}}{NaH_2SbO_4\downarrow} + KCl$$

(iv) Mg^{2+} gives white ppt. of magnesium hydroxide with sodium hydroxide

$$Mg^{2+} + 2NH_3 + 2H_2O \longrightarrow Mg(OH)_2\downarrow + 2NH_4^+$$

The ppt. obtained is sparingly soluble in water but readily soluble in ammonium salt.

Problem 1: An aqueous solution of gas (X) shows the following reactions :-

(i) It turns red litmus blue.

(ii) When added in excess to a copper sulphate solution, a deep blue colour is obtained.

(iii) On addition of $FeCl_3$ solution a brown ppt. soluble in dilute nitric acid is obtained.

Identify (X) and give equations for the reactions at step (ii) & (iii)

Solution: X - NH_3

Reactions :

(i) $CuSO_4 + 4NH_4OH \longrightarrow \underset{\text{deep blue}}{Cu(NH_3)_4SO_4} + H_2O$

(ii) $FeCl_3 + 3NH_4OH \longrightarrow \underset{\text{brown ppt.}}{Fe(OH)_3\downarrow} + 3NH_4Cl$

$$Fe(OH)_3 + 3HNO_3 \longrightarrow \underset{\text{Soluble}}{Fe(NO_3)_3} + 3H_2O$$

Problem 2: An aqueous solution of a gas (X) gives the following reactions:

(i) It decolourizes an acidified $K_2Cr_2O_7$ solution.

(ii) On boiling with H_2O_2 , cooling it and then adding an aqueous solution of $BaCl_2$, a white ppt. insoluble in dilute HCl is obtained.

(iii) On passing H_2S into the solution, turbidity is obtained.

Identify (X) and give equations for the steps (i), (ii), (iii) .

Solution: X - SO_2

Reactions :

(i) $K_2Cr_2O_7 + H_2SO_4 + 3SO_2 \rightarrow K_2SO_4 + Cr_2(SO_3)_3 + H_2O$

(ii) $SO_2 + H_2O_2 \longrightarrow H_2SO_4$

$$H_2SO_4 + BaCl_2 \longrightarrow \underset{\text{white ppt.}}{BaSO_4\downarrow} + 2HCl$$

(iii) $SO_2 + 2H_2S \longrightarrow \underset{\substack{\text{white}\\\text{turbidity}}}{3S\downarrow} + 2H_2O$

Problem 3: A white amorphous powder (A) on strongly heating gives a colourless non-combustible gas (B) and solid (C). The gas (B) turns lime water milky and turbidity disappears with the passage of excess of gas.The solution of (C) in dilute HCl gives a white ppt. with an aqueous solution of $K_4[Fe(CN)_6]$. The solution of (A) in dilute HCl gives a white ppt. (D) on passing H_2S in presence of excess of NH_4OH. Identify (A) to (D) by giving chemical equations.

Solution: (A) - $ZnCO_3$ (B) - CO_2 (C) - ZnO (D) - ZnS

Reactions : (i) $ZnCO_3 \rightarrow ZnO + CO_2$
(A) (C) (B)

(ii) $CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O$
(B) White

$CaCO_3 + H_2O + CO_2 \rightarrow Ca(HCO_3)_2$
Excess Soluble

(iii) $ZnO + 2HCl \rightarrow ZnCl_2 + H_2O$

$2ZnCl_2 + K_4Fe(CN)_6 \rightarrow Zn_2[Fe(CN)_6] + 4KCl$
White ppt.

(iv) $ZnCl_2 + H_2S \rightarrow ZnS + 2HCl$
(D)

Problem 4: A certain compound (X) is used in laboratory for analysis. Its aq. solution gave the following reactions.

(i) On addition to copper sulphate solution, a brown ppt. is obtained which turns white on addition of excess of $Na_2S_2O_3$ solution.

(ii) On addition to Ag^+ ion solution, a yellow ppt. is obtained which is insoluble in NH_4OH. Identify (X), giving reactions

Solution: X - KI

Reactions : (i) $2CuSO_4 + 2KI \longrightarrow 2CuI_2 + K_2SO_4$

$2CuI_2 \longrightarrow Cu_2I_2 + I_2$
white

$I_2 + 2Na_2S_2O_3 \longrightarrow Na_2S_4O_6 + 2NaI$

(ii) $Ag^+ + KI \longrightarrow AgI + K^+$
Yellow ppt.

The white ppt. of Cu_2I_2 is coloured brown due to the presence of I_2. On adding sodium thiosulphate, I_2 is consumed. Therefore the ppt. appears white.

Problem 5: An aqueous solution of inorganic compound (X) gives the following reactions:

(i) With an aq. solution of barium chloride a ppt. insoluble in dil. HCl is obtained.

(ii) Addition of excess of KI gives a brown ppt. which turns white on addition of excess of hypo.

(iii) With an aqueous solution of $K_4[Fe(CN)_6]$ a chocolate coloured ppt. is obtained.

Identify (X) and give equations for the reactions for (i), (ii) and (iii) observations.

Solution: X - $CuSO_4$

Reactions : (i) $CuSO_4 + BaCl_2 \longrightarrow BaSO_4 + CuCl_2$
White ppt.
(insoluble in HC(I)

(ii) $2CuSO_4 + 4KI \longrightarrow 2CuI_2 + 2K_2SO_4$
$\downarrow$
$Cu_2I_2 + I_2$

$I_2 + Na_2S_2O_3 \longrightarrow Na_2S_4O_6 + 2NaI$

(iii) $CuSO_4 + K_4[Fe(CN)_6] \longrightarrow Cu_2[Fe(CN)_6] + 2K_2SO_4$

Chocolate

Coloured ppt.

Problem 6: An aq. solution of an inorganic compound (X) shows the following reactions.

(i) It decolorizes an acidified $KMnO_4$ solution accompanied with evolution of O_2.

(ii) It liberates I_2 from acidified KI solution.

(iii) It gives brown ppt. with alkaline $KMnO_4$ solution with evolution of O_2.

(iv) It is used to restore old oil paintings. Identify (X) and give chemical reactions for the steps (i) to (iv).

Solution: X - H_2O_2

Reactions: (i) $5H_2O_2 + 2KMnO_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 5O_2$

(ii) $H_2O_2 + 2KI + H_2SO_4 \longrightarrow I_2\uparrow + K_2SO_4 + 2H_2O$

(iii) $3H_2O_2 + 2KMnO_4 \longrightarrow 2MnO_2\downarrow + 2KOH + 3O_2 + 2H_2O$

(iv) $4H_2O_2 + PbS \longrightarrow PbSO_4 + 4H_2O$

white

Problem 7: A certain compound (X) shows the following reactions :

(i) When KI is added to an aq. suspension of (X) containing acetic acid, iodine is liberated

(ii) When CO_2 is passed through an aq. suspension of (X) the turbidity transforms to a ppt.

(iii) When a paste of (X) in water is heated with ethyl alcohol a product of anaesthetic use is obtained.

Identify (X) and write down chemical equations for reactions involved in steps (i), (ii) and (iii) .

Solution: X - $CaOCl_2$

Reactions: (i) $CaOCl_2 + 2CH_3COOH \longrightarrow Ca(CH_3COO)_2 + Cl_2 + H_2O$

$2KI + Cl_2 \longrightarrow 2KCl + I_2$

(ii) $CaOCl_2(aq) + CO_2 \longrightarrow CaCO_3 + Cl_2$

white ppt.

(iii) $CaOCl_2 + H_2O \longrightarrow Ca(OH)_2 + Cl_2$

$C_2H_5OH + Cl_2 \longrightarrow CH_3CHO + 2HCl$

$CH_3CHO + 3Cl_2 \longrightarrow CCl_3CHO \xrightarrow{Ca(OH)_2} CHCl_3$

Anaesthetic

Problem 8: An inorganic Lewis acid (X) shows the following reactions :

(i) It fumes in moist air.

(ii) The intensity of fumes increases when a rod dipped in NH_4OH is brought near it.

(iii) An acidic solution of (X) on addition of NH_4Cl and NH_4OH gives a precipitate which dissolves in NaOH solution.

(iv) An acidic solution of (X) does not give a precipitate with H_2S. Identify (X) and give chemical equation for steps (i) to (iii) .

Solution: X - $AlCl_3$

Reactions : (i) $AlCl_3 + 3H_2O \rightarrow Al(OH)_3 + 3HCl\uparrow$

fumes

(ii) $HCl + NH_4OH \rightarrow NH_4Cl\uparrow + H_2O$

White fumes

(iii) $AlCl_3 + 3NH_4OH \rightarrow Al(OH)_3 + 3NH_4Cl$

White ppt.

$Al(OH)_3 + NaOH \rightarrow NaAlO_2 + 2H_2O$

Soluble

Problem 9: (i) A black mineral (A) on treatment with dilute sodium cyanide solution in presence of air gives a clear solution of (B) and (C).

(ii) The solution of (B) on reaction with zinc gives a precipitate of metal (D).

(iii) (D) is dissolved in dil. HNO_3 and the resulting solution gives a white precipitate (E) with dil. HCl.

(iv) (E) on fusion with sodium carbonate gives (D).

(v) (E) dissolves in aqueous solution of ammonia giving a colourless solution of (F). Identify (A) to (F) and give chemical equations for reactions involved in steps (i) to (v).

Solution: (A) - Ag_2S (B) - $NaAg(CN)_2$

(C) - Na_2SO_4 (D) Ag

(E) AgCl (F) - $Ag(NH_3)_2Cl$

Reactions : (i) $Ag_2S + 4NaCN + 2O_2 \rightarrow 2NaAg(CN)_2 + Na_2SO_4$

(A) (B) (C)

(ii) $2NaAg(CN)_2 + Zn \rightarrow Na_2Zn(CN)_4 + 2Ag$

(D)

(iii) $3Ag + 4HNO_3 \rightarrow 3AgNO_3 + NO + 2H_2O$

HCl

(iv) $AgNO_3 \longrightarrow AgCl + HNO_3$

(v) $AgCl + 2NH_3 \rightarrow Ag(NH_3)_2Cl$

(E) (F)

(vi) $4AgCl + 2Na_2CO_3 \rightarrow 4Ag + 4NaCl + 2CO_2 + O_2$

Problem 10: A solid laboratory reagent (A) gives the following reactions.

(i) It imparts green colour to flame.

(ii) Its solution does not give ppt. on passing H_2S.

(iii) When it is heated with $K_2Cr_2O_7$ and conc. H_2SO_4 a red gas is evolved. The gas when passed in aq. NaOH solution turns it yellow. Identify (A) giving chemical reactions.

Solution: A - $BaCl_2$

Reactions : (i) $2BaCl_2 + K_2Cr_2O_7 + 3H_2SO_4 \rightarrow K_2SO_4 + 2CrO_2Cl_2 + 2BaSO_4 + 3H_2O$

red gas

(ii) $CrO_2Cl_2 + 4NaOH \longrightarrow Na_2CrO_4 + 2NaCl + 2H_2O$

yellow solution

Problem 11: *NH_4SCN can be used to test one or more out of Fe^{3+}, Co^{2+}, Cu^{2+}*
(A) Fe^{3+} only (B) Co^{2+}, Cu^{2+} (C) Fe^{3+}, Cu^{2+} (D) All
Solution: **(D)**

Problem 12: *Ag_2S is soluble in NaCN due to formation of*
(A) $Na[Ag(CN)_2]$ (B) $Ag(CN)_2$ (C) $Na_2Ag(CN)_3$ (D) $Na_2[Ag(CN)_2]$
Solution: **(A)**

Problem 13: *There is foul smell in presence of moisture with*
(A) $AlCl_3$ (B) $Al_2(SO_4)_3$ (C) FeS (D) $FeSO_4$
Solution: **(C)**

Problem 14: *$AgNO_3$ on treatment with hypo gives white ppt. changing to black after some time. Black ppt. is*
(A) $Ag_2S_2O_3$ (B) Ag_2SO_4 (C) $Ag_2S_4O_6$ (D) Ag_2S
Solution: **(D)**

Problem 15: *Yellow coloured solution of $FeCl_3$ changes to light green when*
(A) $SnCl_2$ is added (B) Zn is added
(C) H_2S gas is passed (D) Any one of the above is added.
Solution: **(D)**

Problem 16: *$Fe(OH)_3$ and $Cr(OH)_3$ precipitate are separated by*
(A) $[Ag(NH_3)_2]^+$ (B) HCl (C) $NaOH/H_2O_2$ (D) H_2SO_4
Solution: **(C)**

Problem 17: *Evolution of deep red vapours when an inorganic salt is mixed with powdered $K_2Cr_2O_7$ and heated with conc. H_2SO_4 confirms the presence of a*
(A) chloride (B) fluoride (C) borate (D) phosphate
Solution: **(A)**

Problem 18: *Which of the following would enable you to remove SO_4^{2-} ions from a mixture of SO_4^{2-}, $C_2O_4^{2-}$ and Cl^- ions?*
(A) NaOH (B) KOH (C) $Ba(OH)_2$ (D) $BaSO_4$
Solution: **(C)**

Problem 19: *Which of the following sulphates is insoluble in water?*
(A) $CuSO_4$ (B) $CdSO_4$ (C) $PbSO_4$ (D) $Bi(SO_4)_3$
Solution: **(C)**

Problem 20: *A fire work gave bright crimson light. It probably contained a salt of*
(A) Ca (B) Sr (C) Ba (D) Mg
Solution: **(B)**