**Qualitative Analysis of Organic Compounds:**

This is used to detect nitrogen, halogen and sulphur present in organic compound.

**a) Sodium Extract:** Aqueous solution containing soluble sodium salt of the elements *i.e* NaCl, $Na_2S$ and NaCNS formed by fusion of compound with sodium metal.

**b) Formation of Sodium Extract:** It is a two-step process

**Step 1:** Organic compounds are fused with dry sodium in a fusion-tube

**Step 2:** Fused mass after extraction with water is boiled and filtered.

**c) Use of Sodium Extract:** Sodium extract (S.E.) is used to detect elements (other than C and H) and the tests are given in the table.

| Element | Sodium Extract (S.E.) | Confirmed Test |
|---|---|---|
| Nitrogen | Na + C + N +Δ→ NaCl | S.E.+ $FeSO_4$ +NaOH, boil and cool<br>+<br>$FeCl_3$ + conc. HCl → Blue/ green colour<br>**Reactions Involved**:<br>$2NaCN+FeSO_4 \rightarrow Fe(CN)_2+Na_2SO_4$<br>$Fe(CN)_2+4NaCN \rightarrow Na_4[Fe(CN)_6]$<br>Sodium Ferrocyanide<br>$3Na_4[Fe(CN)_6]+4FeCl_3 \xrightarrow{HCl} Fe_4[Fe(CN)_6]_3+12NaCl$<br>Ferric Ferrocyanide<br>Prussian Blue |
| Sulphur | 2Na + S → $Na_2S$ | (i) S.E. + sodium nitroprusside → Violet Colour<br>(ii) S.E + $CH_3CO_2H$ + $(CH_3CO_2)_2Pb$ → black ppt.<br>**Reactions Involved:**<br>(i) $Na_2S + Na_2[Fe(CN)_3NO] \rightarrow Na_4[Fe(CN)_5NOS]$<br>(Sodium Nitroprusside) (Violet Coloure)<br>(ii) $Na_2S + (CH_3COO)_2Pb \xrightarrow{CH_3COOH} PbS\downarrow + 2CH_3COONa$<br>(Black ppt) |
| Halogen | Na +X + Δ→ NaX<br>(X = Cl, Br, I) | S.E. + $HNO_3$+$AgNO_3$→ |

| | | |
|---|---|---|
| | | (i) White ppt soluble in aq $NH_3$ confirms Cl.<br><br>(ii) Pale yellow ppt partially soluble in aq. $NH_3$ confirms Br.<br><br>(iii) Yellow ppt insoluble in aq. $NH_3$ confirms I.<br><br>**Reactions Involved:**<br><br>$NaX + AgNO3 \xrightarrow{HNO_3} AgX$<br><br>$AgCl + 3NH_3(aq.) \rightarrow [Ag(NH_3)_2]Cl$<br>White ppt Soluble<br><br>$AgBr + 3NH_3(aq.) \rightarrow [Ag(NH_3)_2]Br$<br>Pale Yellow ppt Partially Soluble<br><br>$AgI + 3NH_3(aq.) \rightarrow Insoluble$<br>Yellow ppt |
| Nitrogen and sulphur together | Na+ C + N + S+ Δ→ NaCNS<br><br>with excess of Na the thiocyanate formed decomposes into cyanide and sulphide.<br><br>NaCNS + 2Na → NaCN +$Na_2S$ | As in test for nitrogen; instead of green or blue colour, blood red colouration confirms presence of N and S both.<br><br>**Reactions Involved:**<br><br>$3NaCN_5 + Cl_3 \rightarrow Fe(SCN)_3$ or $[Fe(SCN)]Cl_2 + 3NaCl$<br>Ferric sulphurcyanide<br>(Blood Red Colour) |

**Qualitative Analysis of Inorganic Salts:**

**1. Physical Examination of Salts/Mixture**

| Observation | Inference |
|---|---|
| 1. Substance is coloured | |
| i) Blue | Copper salt |
| ii) Dark green | Chromium salt |
| iii) Green | Salts of Fe(II), Ni, Cu or Cr |
| iv) Light yellow or brown | Salts of Fe(III) |
| v) Dark brown | $PbO_2$,$Bi_2S_3$ |
| vi) Light pink | Salts of Mn |
| vii) Pink | Salts of Co |
| viii) Red | HgO, $HgI_2$,$Pb_3O_4$ |
| ix) Orange red | $Sb_2S_3$ |
| 2. Substance is deliquescent | $CaCl_2$,$ZnCl_2$,$MgCl_2$, $MnCl_2$, nitrites, nitrates |
| 3. Substance is heavy | Salts of Pb, Hg and Ba |
| 4. Substance is light | Carbonates of Bi, Mg, Al, Zn, Ca, Sr |

**2. Effect of Heating:**

| Observation | Inference |
|---|---|
| 1. Substance melts | Salts of alkali metals and salts having water of crystallisation. |
| 2. Substance decripitates (crackling noise) | NaCl, KI, $Pb(NO_3)_2$ and $Ba(NO_3)_2$ |
| 3. Substance swells (due to loss of water of crystallisation) | Alums, borates and phosphates |
| 4. The substance sublimes and the colour of sublimate is | |
| i) White | $HgCl_2$, $Hg_2Cl_2$,$NH_4X$, $AlCl_3$, $As_2O_3$, $Sb_2O_3$ |
| ii) Yellow | $As_2S_3$ and $HgI_2$ (turns red when rubbed with glass rod). |
| iii) Blue black and violet vapours | Iodides |
| 5. A residue (generally oxide) is left and its colour is | |
| i) Yellow (hot) and white (cold) | ZnO |
| ii) Reddish brown (hot); yellow (cold) | PbO |
| iii) Black (hot); Red (cold) | HgO, $Pb_3O_4$ |
| iv) Black (hot); Red brown (cold) | $Fe_2O_3$ |
| 6. Gas is evolved | |
| (A) Colourless and odourless | |
| i) $O_2$ - rekindles a glowing splinter | Alkali nitrates ($2KNO_3 \rightarrow 2KNO_2 + O_2$) |

| | |
|---|---|
| ii) $CO_2$ - turns lime water milky | Carbonates and oxalates ($CaCO_3 \rightarrow CaO + CO_2$) |
| iii) $N_2$ | Ammonium nitrite ($NH_4NO_2 \rightarrow N_2 + 2H_2O$) |
| (B) Colourless gas with odour | |
| i) $NH_3$ - Turns red litmus blue and mercurous nitrate paper black | Ammonium salts $(NH_4)_2SO_4 \rightarrow NH_4HSO_4 + NH_3$ |
| ii) $SO_2$ - Smell of burning sulphur, turns acidified $K_2Cr_2O_7$ paper green | Sulphites and thiosulphates<br>$CaSO_3 \rightarrow CaO + SO_2$ |
| iii) HCl - Pungent smell, white fumes with ammonia | Hydrated chlorides<br>$CaCl_2.6H_2O \rightarrow Ca(OH)_2 + 4H_2O + 2HCl$ |
| iv) $H_2S$ - smell of rotten eggs, turns lead acetate paper black | Sulphides<br>$Na_2S + 2H_2O \rightarrow 2NaOH + H_2S$ |
| (C) Coloured gas | |
| i) $NO_2$ - Brown, turns starch iodide paper blue | Nitrites and nitrates of heavy metals<br>$2Cu(NO_3)_2 \rightarrow 2CuO + 4NO_2 + O_2$ |
| ii) $Br_2$ - Reddish brown | Bromides<br>$2CdBr_2 + O_2 \rightarrow 2CdO + 2Br_2$ |
| (A) Turns starch paper yellow | |
| (B) turns starch iodide paper blue | |
| iii) $I_2$ - Violet, turns starch paper blue | Iodides<br>$2CdI_2 + O_2 \rightarrow 2CdO + 2I_2$ |
| iv) $Cl_2$ - Greenish yellow | Chlorides |
| (A) bleaches moist litmus paper | $CuCl_2 + H_2O \rightarrow CuO + 2HCl$<br>$CuO + 2HCl \rightarrow Cu + H_2O + Cl_2$ |
| (B) bleaches indigo solution | |
| (C) turns starch iodide paper blue | |

**3. Flame test:**

| **Metals** | **Colour** |
|---|---|
| Li | crimson red |
| Na | golden yellow |
| K | Violet |
| Ca | Brick red |
| Sr | Crimson |

| | |
|---|---|
| Ba | apple green |

**Test for Anions:**

1. Carbonate ($CO_3^{2-}$)

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

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

The gas gives turbidity with lime water and baryta water.

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

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

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

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

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

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

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

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

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

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 happen if the mix is boiled, due to the formation of silver oxide

$Ag_2CO_3 \downarrow \rightarrow Ag_2O \downarrow + CO_2$

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

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

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

The gas has a suffocating odour of burning sulphur.

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

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

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

iv) ***Barium chloride or Strontium chloride solution:*** Gives white ppt. of barium or strontium sulphite.

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

i) ***Dil. HCl or Dil. $H_2SO_4$:*** A colourless gas smelling of rotten eggs ($H_2S$) is evolved.

$S^{2-} + 2H^+ \rightarrow H_2S$

ii) The gas turns lead acetate paper black

iii) Gives yellow ppt. with $CdCO_3$

$Na_2S + CdCO_3 \rightarrow CdS^- + Na_2CO_3$

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

$S^{2-} + 2Ag^+ \rightarrow Ag_2S^-$

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 yields 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

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

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

iii) Turns acidified KI - starch paper blue

$2KI + 2NO_2 \rightarrow 2KNO_2 + I_2$

Starch + $I_2$ $\rightarrow$ 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 is formed, due to the formation of $[FeNO]SO_4$ at the junction of the two liquids.

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

i) ***Dilute Sulphuric Acid :*** Smell of vinegar is observed.

$CH_3COO^- + H^+ \rightarrow CH_3COOH$

The following test is performed with the aqueous salt solution.

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

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

Brown colour

**6. Thiosulphates**

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

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

$S_2O_3^{2-} + 2Ag^+ \rightarrow Ag_2S_2O_3^-$

The ppt. is unstable, turning dark on standing, when silver sulphide is formed.

$Ag_2S_2O_3^- + H_2O \rightarrow Ag_2S + H_2SO_4$

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

$S_2O_3^{2-} + Pb^{2+} \rightarrow PbS_2O_3^{-}$

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

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

**7. Chloride ($Cl^-$)**

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

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

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 near the mouth of test tube.

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

v) ***Chromyl chloride test:*** When a salt 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.

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

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.

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

***Yellow solution***

$Na_2CrO_4 + (CH_3COO)_2 Pb \rightarrow 2CH_3COONa + PbCrO_4^{-}$ (yellow ppt.)

**8. Bromide ($Br^-$)**

i) ***Conc. $H_2SO_4$ :*** Gives reddish brown vapours of bromine accompanying the hydrogen bromide.

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.

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

The following tests are performed with the aqueous salt solution.

iii) ***Silver nitrate solution:*** 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. $HNO_3$.

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

**9. Iodide ($I^-$)**

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

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

**10. Nitrate ($NO_3^-$)**

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

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

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

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

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

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

**11. Sulphate ($SO_4^{2-}$)**

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.

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

**12. Chromate $CrO_4^{2-}$ and Dichromate ($Cr_2O$)**

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

$CrO + Ba^{2+} \rightarrow BaCrO_4^-$

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

$Cr_2O + 2Ba^{2+} + H_2O \quad 2\ BaCrO_4^- + 2H^+$

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 insoluble in acetic acid.

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

**13. Permanganate MnO**

i) Hydrogen peroxide : It decolourises acidified potassium permanganate solution

$2MnO_4^- + 5H_2O_2 + 6H^+$ ¾¾® $5O_2 + 2Mn^{2+} + 8H_2O$.

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

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

**Test For Cations:**

| **Group** | **Group reagent** | **Ions** | **Colour & ppt.** |
|---|---|---|---|
| Group I | dil HCl | $Pb^{2+}$, $Hg^+$, $Ag^+$ | $PbCl_2$, $Hg_2Cl_2$, AgCl - white |
| Group II<br>Group II A | $H_2S$ in dil HCl | $Hg^{2+}$, $Cu^{2+}$, $Bi^{3+}$, $Cd^{2+}$ | Yellow-CdS,$As_2S_3$,<br>$As_2S_5$ , $SnS_2$<br>Black - HgS, CuS, PbS |
| Group II B | | $As^{3+}$, $As^{5+}$, $Sb^{3+}$, $Sb^{5+}$, $Sn^{2+}$, $Sn^{4+}$ | Orange - $Sb_2S_3$, $Sb_2S_5$<br>Brown - $Bi_2S_3$ ,SnS |

| | | | |
|---|---|---|---|
| Group III A | $NH_4OH$ in presence of $NH_4Cl$ | $Fe^{3+}$, $Al^{3+}$, $Cr^{3+}$ | $Fe(OH)_3$, $Al(OH)_3$,$Cr(OH)_3$<br>Brown White Green |
| GroupIII B | $H_2S$ in presence of $NH_3$ & $NH_4Cl$ or $(NH_4)_2S$. | $Ni^{2+}$, $Co^{+2}$, $Mn^{+2}$, $Zn^{2+}$ | ZnS - white or grey,<br>Black - CoS, NiS<br>MnS - Buff (light pink) |
| Group IV | $(NH_4)_2CO_3$ in presence of $NH_4Cl$ & $NH_4OH$. | $Ba^{+2}$, $Sr^{2+}$, $Ca^{+2}$ | $BaCO_3$, $SrCO_3$,<br>$CaCO_3$ - white |
| Group V | No common group reagent. | $Mg^{+2}$, $Na^{+}$, $K^{+}$, $NH_4^{+}$ | ¾ |

**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 NaO

(B) $PbCl_2 + 2KI \rightarrow PbI_2 + 2KCl$

(Yellow)

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

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

$AgCl + 2NH_4OH \rightarrow Ag(NH_3)_2Cl + 2H_2O$

$Hg_2Cl_2 + 2NH_4OH \rightarrow H_2NHgCl + Hg + NH_4Cl + 2H_2O$

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 a white precipitate turning black.

$2Hg^{+2} + SnCl_2 \rightarrow Sn^{+4} + Hg_2Cl_2$

White

$Hg_2Cl_2 + SnCl_2 \rightarrow SnCl_4 + 2Hg$

Black

ii) $Cu^{+2}$ ions in solution give 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.

$BiCl_3 + H_2O \rightarrow BiOCl + 2HCl$

White ppt.

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

$2BiCl_3 + 3Na_2SnO_2 \rightarrow 2Bi^{-} + 3Na_2SnO_3 + 6NaCl + 3H_2O$

black

iv) $Cd^{+2}$ ions in solution, with NaOH give a white precipitate.

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

white

With ammonium hydroxide, $Cd^{2+}$ ions give a white precipitate which dissolves in excess.

$Cd^{2+} + 4NH_4OH \rightarrow [Cd(NH_3)_4](OH)_2 + 2H_2O$

**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 molybdate and $HNO_3$ on heating.

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

Yellow ppt.

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

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

$SbCl_3 + H_2O \rightarrow SbOCl + 2HCl$

White

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

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

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

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

$Fe(OH)_3$ is insoluble in NaOH

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

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 ($Ni^{2+}$, $Co^{2+}$, $Mn^{2+}$, $Zn^{+2}$)**

1. $Ni^{+2}$ 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.

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

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

Apple green colour

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

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

Black ppt.

2. $Zn^{+2}$ ions in solution give white precipitate with NaOH, which dissolve in excess of NaOH.

3. $Mn^{+2}$ ions in solution give pink precipitate with NaOH turning black or brown on heating.

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

$Ba^{+2}$ ions in solution give

(A) Yellow precipitate with $K_2CrO_4$

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

Yellow

(B) White precipitate with $(NH_4)_2SO_4$

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

$Ca^{+2}$ ions give white precipitate with $(NH_4)_2\ C_2O_4$ only.

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

All ammonium salts on heating with alkali say NaOH give a colourless gas with a pungent smell ($NH_3$)

(A) Gas evolved gives white fumes with HCl

(B) Paper soaked in $CuSO_4$ solution, is turned deep blue by $NH_3$ due to complex formation

(C) With $Hg_2\,(NO_3)_2$ , a black colour is obtained

$Hg_2(NO_3)_2 + 2NH_3 \rightarrow Hg + Hg(NH_2)NO_3^- + NH_4NO_3$

black

(D) With Nesslers reagent (alkaline solution of potassium tetraiodomercurate(II) ), a brown ppt. is obtained

Potassium salts give yellow ppt. with sodium cobalt nitrite

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

$Mg^{2+}$ gives white ppt. of magnesium hydroxide with sodium hydroxide