Qualitative Analysis

List of Different Coloured Salts

	Salts	Colour
1)	Copper Salts	Bluish Green
2)	Nickel Salts	Greenish Blue
3)	Chromium Salts	Dark green
4)	Cobalt Salts	Pinkish or Purple
5)	Manganese Salts	Light Pink
6)	Ferrous Salts	Light green
7)	Ferric Salts	Pale yellow

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Action of Heat (Colour of Residue)

	Colour	Residue
1)	Yellow (hot) & white (cold)	ZnO
2)	Reddish brown (hot) & yellow (cold)	PbO
3)	Black (hot) & Red (cold)	HgO, Pb_3O_4
4)	Black (hot) & Red Brown (cold)	Fe_2O_3
5)	Decrepitation	$Pb(NO_3)_2$, NaCl
6)	White Sublimate	Ammonium Salts

Gases

	Gas	Colour	Odour
1)	O_2	Colourless	Odourless
2)	CO_2	Colourless	Odourless
3)	N_2	Colourless	Odourless
4)	NH_3	Colourless	Odour (Pungent
5)	SO_2	Colourless	Odour (")
6)	HCl	Colourless	Odour
7)	H_2S	Colourless	Odour
8)	NO_2	Coloured (Brown)	Pungent
9)	Br_2	Colored (Reddish Brown)	Pungent
10)	I_2	Colored (Violet)	
11)	Cl_2	Colored (greenish yellow)	Pungent
12)	H_2S	Colourless	Rotten Egg
13)	H_2	Colourless	Odourless
14)	NO	Colourless	Odourless
15)	N_2O	Colourless	"
16)	N_2O_5		"

Flame Test

	Metals	Colour
1)	Li	Crimson Red
2)	Na	Golden Yellow
3)	K	Violet / Lilac
4)	Ca	Brick red
5)	Sr	Crimson ~~Green~~ Red
6)	Ba	Apple Green
7)	Rb	Violet
8)	Cs	Blue

Identification of Basic Radicals

White ppt:-

Group	Reagent	Basic Radicals	PPt	
I	Dil. HCl	Ag^+	$AgCl$	Chloride insoluble in cold dil HCl
		Pb^{2+}	$PbCl_2$	
		Hg_2^{2+}	Hg_2Cl_2	
III	NH_4OH in presence of NH_4Cl	Al^{3+}	$Al(OH)_3$	Insoluble in NH_4OH
IV	H_2S in presence of NH_4OH	Zn^{2+}	ZnS (Greenish white)	Sulphides are insoluble in NH_4OH
V	$(NH_4)_2CO_3$ in presence of NH_4OH	Ba^{2+}	$BaCO_3$	Carbonates are insoluble
		Sr^{2+}	$SrCO_3$	
		Ca^{2+}	$CaCO_3$	
VI	Na_2HPO_4	Mg^{2+}	$Mg(NH_4)PO_4$	

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Black ppt:-

Group	Reagent	Basic Radicle	Ppt		
II	H_2S in presence of dil. HCl	Hg^{2+} Pb^{2+} Bi^{3+} Cu^{2+}	HgS PbS Bi_2S_3 CuS	IIA	Sulphides insoluble in dil. HCl
IV	H_2S in presence of NH_4OH	Co^{2+} Ni^{2+}	CoS NiS		Sulphides are insoluble in NH_4OH

Yellow ppt:-

Group	Reagent	Basic Radicals	Ppt		
II	H_2S in presence of dil. HCl	Cd^{2+} As^{3+} Sn^{+4}	CdS As_2S_3 SnS_2	IIA IIB	Sulphides insoluble in dil. HCl

Orange ppt:-

Group	Reagent	Basic Radicals	Ppt		
II	H_2S in presence of dil HCl	Sb^{3+}	Sb_2S_3	IIB	Sulphides insoluble in dil. HCl

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Brown Ppt:-

Group	Reagent	Basic Radicals	Ppt	
II	H_2S in presence of dil. HCl	Sn^{2+}	SnS IIB	Sulphides insoluble in dil. HCl
III	NH_4OH in presence of NH_4Cl	Fe^{3+}	$Fe(OH)_3$	Insoluble in NH_4OH
IV	H_2S in presence of NH_4OH	Mn^{+2}	MnS (buff)	Sulphides are insoluble in NH_4OH

Green ppt:-

Group	Reagent	Basic Radicals	Ppt	
III	NH_4OH in presence of NH_4Cl	Cr^{3+}	$Cr(OH)_3$	Insoluble in NH_4OH

No ppt:-

Group	Reagent	Basic Radical	Gas evolved
Zero	NaOH	NH_4^+	NH_3

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Borax Bead Test

	Metal	Colour of the bead in Oxidizing Flame		Reducing Flame	
		Hot	Cold	Hot	Cold
1)	Copper	Green	Blue	Colourless	Brown-Red
2)	Iron	Brown Yellow	Pale-yellow	Bottle Green	Bottle Green
3)	Chromium	Green	Green	Green	Green
4)	Cobalt	Blue	Blue	Blue	Blue
5)	Manganese	Violet	Amethyst Red	Grey	Grey
6)	Nickel	Violet	Brown	Grey	Grey

$Cu(OH)_2 + H_2SO_4 \longrightarrow CuSO_4 + H_2O$

$CuSO_4$

Cu^{+2} — Cation — Basic Radical (comes from base)

SO_4^{2-} — Anion — Acidic Radical (comes from acid)

Acidic Radical

~~Class A~~

Reagent

Case A — Category A: dil Acid ⟶ gas

Case B — " B: conc. Acid / Δ ⟶ gas

" C: Individual ⟶ gas

Category A :-

CH_3COO^-, CO_3^{2-}, SO_3^{2-}, S^{2-}, NO_2^-, $S_2O_3^{--}$ (Not in JEE)

Category B :-

Cl^-, Br^-, I^-, NO_3^-, $C_2O_4^{2-}$, F^-, ClO_3^-

Not in JEE

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Category C:-

SO_4^{2-}, PO_4^{3-}
(Not in JEE)

Class A:-

1) CO_3^{2-} (Carbonate ion)

$CO_3^{2-} \xrightarrow{H^+} H_2CO_3 \longrightarrow H_2O + CO_2 \uparrow$

H_2CO_3: Unstable Thermodynamically

CO_2: Colourless, Odourless

- $Ba(OH)_2$ (Baryta water) → $BaCO_{3(s)}\downarrow$ White ppt.
  - CO_2 (Excess) → $Ba(HCO_3)_2$ White ppt. Dissolves
    - Δ → $BaCO_3\downarrow$ White ppt. reappear
- $Ca(OH)_2$ (Slake Lime or Lime water) → $CaCO_{3(s)}\downarrow$ Milky White ppt
  - CO_2 Excess → $Ca(HCO_3)_2$ colourless, Milky white ppt. disappear
    - Δ → $CaCO_3\downarrow$ Milky white ppt reappear

$HgCl_2$ Test :- $Na_2CO_3 + 4HgCl_2 + 3H_2O \rightarrow \underset{\text{Reddish Brown}}{Hg_4Cl_2O_3 \cdot 3HgO}$

CO_2 (Oxidizing agent) $\xrightarrow{KMnO_4}$ NO reaction

$\xrightarrow{K_2Cr_2O_7}$ NO reaction

$CO_3^{2-} \xrightarrow{Ag^+} Ag_2CO_3\downarrow$ (White ppt)

- $\xrightarrow{\Delta} Ag_2O\downarrow + CO_2$ (Black)
- $\xrightarrow[NH_3]{HNO_3}$ Dissolves (Brown / Yellow when excess Benzene)

$\xrightarrow{Fe^{+2}} FeCO_3\downarrow$ (white)

$\xrightarrow{Cu^{+2}} CuCO_3\downarrow$ (Blue / green)

$\xrightarrow{Ni^{+2}} NiCO_3\downarrow$ (Green)

$\xrightarrow{Mg^{+2}} MgCO_3\downarrow$ (white)

$\xrightarrow{Ca^{+2}} CaCO_3\downarrow$ (white)

$\xrightarrow{Sn^{+2}} SnCO_3\downarrow$ (white)

$\xrightarrow{Ba^{+2}} BaCO_3\downarrow$ (white)

$\xrightarrow{Hg^{+2}} HgCO_3 \cdot 3HgO\downarrow$ (Brown Red)

$\xrightarrow{Hg_2^{+2}} Hg_2CO_3\downarrow$ (yellow)

- $MgCO_3$: ~~(Magnesite)~~
- $FeCO_3$
- $CaCO_3 \cdot MgCO_3$

Excess of CO_3^{2-} ions act as a buffer in acidic medium

→ Do not react with cold sol^n in acid. They must be finely powdered & warm.

Mercurous Nitrous Test :- $Na_2CO_3 + Hg_2(NO_3)_2 \rightarrow Hg_2CO_3$ (yellow ppt) $+ NaNO_3$

CO_3^{2-} $\xrightarrow[\text{Phenolphthalein}]{H^+/H_2O}$ $CO_2\uparrow$, Pink colour disappears.

The pink colour initially was because of salt of carbonate like Na_2CO_3 (pink) but now $H_2O + CO_2$ is formed

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- Na_2CO_3 & all alkali metals except Li do not decompose on heating
- $Al_2(CO_3)_2$ does not ~~exist~~ exist
- $PbCO_3$ with dil. acid will give reaction initially, after some time protective layer formed
- All carbonates, except alkali metals and ammonium, are insoluble in water
- Any acid more acidic than H_2CO_3 will be able to dissolve CO_3^{2-} as ppt, especially on heating.

Lead Acetate Test: $Pb(CH_3COO)_2 + Na_2CO_3 \longrightarrow PbCO_3 + Na(CH_3COO)$ (white)

(ii) **SO_3^{2-} (Sulphite)**

$SO_3^{2-} \xrightarrow{H^+} H_2SO_3 \longrightarrow H_2O + SO_2\uparrow$ (Colourless, Burning Sulphur odour)

SO_2 + $Ca(OH)_2$ → $CaSO_3\downarrow$ White ppt
- SO_3^{2-} Excess → $Ca(HSO_3)_2$ White ppt. disappear
- Δ → $CaSO_3$ White ppt. reappear

SO_2 + $Ba(OH)_2$ → $BaSO_3\downarrow$ White ppt
- SO_3^{2-} (Excess) → $Ba(HSO_3)_2$ White ppt. disappear
- Δ → $BaSO_3$ White ppt reappear

SO_2:- Pungent smell of burning sulphur

$SO_2 \xrightarrow[(KMnO_4)\ \text{Dark Purple}]{MnO_4^-} SO_4^{2-} + Mn^{+2}$ (Colourless)

$\xrightarrow[(\text{Orange})]{K_2Cr_2O_7}\ SO_4^{2-} + Cr^{+3}$ (Green)

$SO_2 \xrightarrow[Ba(OH)_2]{Ca(OH)_2} CaSO_3\downarrow$, $BaSO_3\downarrow$ white ppt.

On Standing / HNO_3 / O_2 / H_2O_2 / Br_2, H_2O

$BaSO_4\downarrow$ white ppt $\xrightarrow{\text{dil. HCl}}$ No reaction

- $SO_3^{2-} + K_2Cr_2O_7 + H_2SO_4 \rightarrow K_2SO_4 + H_2O + Cr_2(SO_4)_3$
  (Orange) (Green Soln)
- $SO_3^{2-} + KMnO_4 + H_2SO_4 \rightarrow K_2SO_4 + MnSO_4 + H_2O$
  (Purple) (Colourless)
- $SO_2 + IO_3^- + H_2O \longrightarrow I_2\uparrow + SO_4^{2-} + H^+$
  (Violet)
  $\xrightarrow{\text{Starch}}$ Blue

SO_3^{2-} $\xrightarrow{Ag^+}$ $Ag(SO_3)^-$ $\xrightarrow{Ag^+}$ $Ag_2(SO_3)\downarrow$

Sulphite Argantate (White Crystalline ppt.)

$\xrightarrow{SO_3^{2-}}$ $Ag(SO_3)^-$

$\xrightarrow{Ba^{+2}}$ $BaSO_3\downarrow$ (white)

$\xrightarrow{MnO_4^-}$ $MnSO_4$ (Colourless sol^n)

$\xrightarrow{Cr_2O_7^{2-}}$ $Cr_2(SO_4)_3$ (green sol^n)

$\xrightarrow{Pb^{+2}}$ $PbSO_3\downarrow$ (white) $\xrightarrow[Boil]{O_2}$ $PbSO_4$ (White)

$\xrightarrow{Ca^{+2}}$ $CaSO_3\downarrow$ (milky white)

$\xrightarrow{H_2O_2}$ SO_4^{2-}

$\xrightarrow{H_2O}$ $HSO_3^- + OH^-$

$\xrightarrow{Zn/H_2SO_4}$ $H_2S + Zn^{+2}$

(Colourless Rotten egg smell)

- $Ag(SO_3)^- \xrightarrow[Boil]{\Delta} Ag\downarrow + SO_4^{--} + SO_2$

$Ag_2SO_3 + H_2O \xrightarrow[Boil]{\Delta} Ag\downarrow + SO_4^{--} + 2H^+$

(Grey Silver)

$Ag_2SO_3 \xrightarrow{NH_3}$ Dissolve

$\because [[Ag(NH_3)_2]_2SO_3$

More things written after coloured compound

S^{2-} (Sulphide)

$S^{2-} \xrightarrow{H^+} H_2S$ (Colourless, rotten egg smell)

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

(Consider Na_2S was added) (Purple soln)

(* H_2S does not give this test)

$Ag^+ \longrightarrow Ag_2S\downarrow$ (Black)

(Insoluble in cold but soluble in hot dil. HNO_3)

$Hg^{+2} \longrightarrow HgS\downarrow$ (Black)

$Cd^{+2} \longrightarrow CdS\downarrow$ (Yellow)

$Pb^{+2} \longrightarrow PbS\downarrow$ (Black)

$Ba^{+2} \longrightarrow$ NO reaction

More things written after coloured compounds

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Names of Common Compounds

1) CaH_2 - ~~Hydrolith~~ Hydrolith
2) $Na_2CO_3 . 10H_2O$ - Washing soda
3) Na_2CO_3 - soda ash
4) $Na_2SO_4 . 10H_2O$ - glauber's salt
5) $CaSO_4 . 2H_2O$ - gypsum
6) $CaSO_4 . 1/2 H_2O$ - P.O.P
7) $MgSO_4 . 7H_2O$ - epsom salt
8) $CaNCN$ - Nitrolim
9) $B_3N_3H_6$ - Borazine / Borazone / Inorg. Benzene
10) $2CaO . 3B_2O_3$ - Colemanite (Boron ore)
11) SiC - Carborundum
12) Na_2SiO_3 - Water glass
13) ~~Pb_3O_4~~ $= PbO_2 . 2PbO$ - Red Lead
14) SnO_2 - Cassiterite
15) CCl_4 - Pyrene
16) PbO - Litharge
17) PbS - Galena
18) CaF_2 - Fluorospar / Fluorite
19) $COCl_2$ - Phosgene
20) $[SiO_4]^{4-}$ - Orthosilicate ion
21) $[Si_2O_7]^{6-}$ - Pyrosilicate ion
22) $[SiO_3]_n^{2n-}$ - Cyclic silicate ion
23) $CO + H_2$ = Water gas / syn gas
24) $CO + N_2$ = Producer gas
25) $Ca(H_2PO_4)_2$ - Superphosphate of lime
26) $Ca(H_2PO_4)_2 + CaSO_4 + H_2O$ - Triple superphosphate of lime
27) $CH_3(CH_2)_{16}COO^-Na^+$ - Sodium Stearate
28) $CH_3(CH_2)_{11}SO_4^-Na^+$ - Sodium Lauryl sulphate
29) CCl_3NO_2 - Tear gas
30) aq. $NaOCl$ - Bleach

31) $2PbCO_3 . Pb(OH)_2$:- White lead
32) $CuSO_4 . 5H_2O$ - Blue Vitriol
33) Epsom Salt - $MgSO_4 . 7H_2O$
34) Glauber's Salt :- $Na_2SO_4 . 10H_2O$
35) $FeSO_4 . 7H_2O$ - Green Vitriol

Colours of Compounds

Brown

1) Ag_2CrO_4 - Red Brown
2) $Fe(CN)_3$ - Reddish Brown
3) $Fe[Fe(CN)_6]$ - Brown
4) $MnO . (OH)_2$ - "
5) $Co(CN)_2$ - Reddish Brown
6) Ag_2O - Brown
7) KI_3 - Dark "
8) $Fe_2O_3 . xH_2O$ - "
9) NO_2 - "
10) $[Fe(H_2O)_5NO]^{+2}$ - Brown (ring test)
11) $NH_2 - HgO . HgI$ - Brown
(Iodide of Million's base)

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12) SnS - Brown ppt.
13) $Fe(OH)_3$ - " "
14) MnS - Buff colored

Red

1) Hg_2CrO_4 - Red
2) HgI_2 - Scarlet Red
3) $NiDMG$ - Red
4) Cu_2O - Red (Due to charge transfer)
5) $[Fe(CNS)(H_2O)_5]^{+2}$ - Blood Red soln
6) Li_3N - Ruby Red
7) $Xe^+PtF_6^-$ - Red
8) $O_2^+PtF_6^-$ - Red
9) $3MgO.MgCO_3$ - Brick Red

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White

1) $AgCl$ - White ppt. (Soluble in NH_4OH)
2) $PbCl_2$ - " "
3) Hg_2Cl_2 - " "
4) $Al(OH)_3$ - " "
5) ZnS - " Greenish white ppt.
6) $BaCO_3$ - White ppt.
7) $SrCO_3$ - " "
8) $CaCO_3$ - " "
9) $Mg(NH_4)PO_4$ - " "
10) $CuCN$ - White
11) $CuSCN$ - "
12) $Cd(OH)_2$ - "
13) $Mn(OH)_2$ - "
14) $Zn_3[Fe(CN)_6]_2$ - White
15) $Ca[Fe(CN)_6]$ - "
16) $MgCO_3 . Mg(OH)_2 . 5H_2O$ - White
17) $BiOCl$ - White
18) ~~$BiOI$ - Orange~~
19) $SbOCl$ - White
20) $BiO.OH$ - Yellowish White
21) $Pb(OH)_2$ - White
22) $Bi(OH)_3$ - "
23) $Sn(OH)_2$ - "
24) $K_2Ca[Fe(CN)_6]$ - White
25) CuI - White
26) $Zn(OH)_2$ - "
27) $Ag_4[Fe(CN)_6]$ - White
28) Cu_2I_2 - White ppt.

Black

1) HgS - Black ppt.
2) PbS - " "
3) Bi_2S_3 - " "
4) CuS - " "
5) CoS - " "
6) NiS - " "
7) $Cu(SCN)_2$ - Black
8) PbO_2 - "
9) Hg_2O - "
10) BiI_3 - "
11) FeS - "
12) Ni_2O_3 - "

Green

1) $Cr(OH)_3$ – Green ppt.
2) Hg_2I_2 – Green
3) CrO – "
4) FeO – "
5) $Ni(OH)_2$ – "
6) $Ni(CN)_2$ – "
7) $ZnK[Co(CN)_6]$ – Ficamann's Green
8) $CuCl_2 \cdot 2H_2O$ – Green

Yellow

1) CdS – Yellow ppt.
2) As_2S_3 – " "
3) SnS_2 – " "
4) $Cu(CN)_2$ – Yellow
5) PbI_2 – "
6) $[Fe(CN)_6]^{+3}$ – Yellow
7) Fe_2O_3 – "
8) $K_3[Co(NO_2)_6]$ – Yellow
9) $[Ni(CN)_4]^{-2}$ – "
10) HgO – "
11) Hg_2CO_3 – "

(2) $HgSO_4$ - Yellow
(3) $HgSO_4 . 2HgO$ - Yellow
(4) $BaCl$ - "
(5) $AgBr$ - " (sparingly soluble in NH_4OH)
(6) $AgCl$ - " (insoluble in NH_4OH)
(7) PCl_5 - Yellowish Powder
(8) $K_4[Fe(CN)_6]$ - Yellow
(9) $2HgO . HgSO_4$ - "
20) $[CuCl_4]^{2-}$ - "
21) K_2O - Pale Yellow

Blue

1) $Cu(OH)_2$ - Blue
2) CuO - Blue (Borax Bead)
3) CoO - " (" ")
4) $[Co(SCN)_4]^{2-}$ - Blue
5) Anhydrous Co^{+2} salts - Blue
5) Co bead - Blue (Borax Bead)
6) $[Cu(NH_3)_4]^{+2}$ - Deep Blue
7) N_2O_3 - Blue
8) $Fe_4[Fe(CN)_6]_3$ - Prussian Blue
(Test for Nitrogen)
9)

Pink

1) $Mn(NH_4)PO_4$ - Pink
2) Hydrated Co^{+2} salts - Pink
3)

Orange

1) BiOCl - Orange
2) $[BiI_4]^-$ - Orange
3) KO_2 - Orange
4) $Ag_3[Fe(CN)_6]$ - Orange

Colourless

1) $Ag(NH_3)_2^+ Cl^-$ - colourless
2) N_2O_4 - "
3) PCl_3 - oily colourless

S↓ :- This does not mean ppt of S
It means Colloidal Sulphur

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Sulphite (SO_3^{2-})

Alts:- Dil. sol^n of triphenyl methane dye stuffs such as & malachite green are decolourised by neutral sulphate

SO_2 also decolourise Fischsen sol^n but reac^n is not quite complete

Sodium Nitroprusside, Zinc ~~Pkro~~ Sulphate Test

$$ZnSO_4 + Na_2Fe(CN)_5(NO) \longrightarrow ZnFe(CN)_5NO$$

Zinc Nitroprusside
Salmon Coloured

Sulphide (S^{2-})

Lead Acetate Test

$$H_2S + (CH_3COO)_2Pb \longrightarrow PbS\downarrow + CH_3COOH$$

(black)

S^{-2} is yielded from Na_2S which exists as $Na_2S.9H_2O$

$$H_2S + MnO_4^- + H^+ \longrightarrow Mn^{+2} + S\downarrow + H_2O$$

(Colloidal Sulphur)

$$H_2S + Cr_2O_7^{2-} + H^+ \longrightarrow Cr^{+3} + S\downarrow + H_2O$$

$$H_2S + I_3^- \longrightarrow I^- + S\downarrow + H^+$$

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Note:- $H_2S + Na_2[Fe(CN)_5NO] \longrightarrow$ No reacⁿ

$Na_2S + Na_2[Fe(CN)_5NO] \longrightarrow N_4[Fe(CN)_5NOS]$
purple

AIITS **Methylene Blue Test**

N-N dimethyl para phenyl diamine is the reagent.
Reagent is converted by $FeCl_3$ & H_2S in strongly acidic ~~medium~~ solⁿ into water soluble dyestuff methylene blue

AIITS **Catalyses of Iodine Azide reacⁿ Test**

$$N_3^- + I_3^- \longrightarrow \text{No Reacⁿ}$$

$$N_3^- + I_3^- \xrightarrow[\text{Traces}]{S^{-2}} I^- + N_2\uparrow$$
(Catalyst)

Nitrites

i) Dil. Acid

$$NO_2^- + H^+ \longrightarrow \underset{\text{(pale blue)}}{HNO_2} \longrightarrow HNO_3 + NO\uparrow + H_2O$$

$$NO + O_2 \longrightarrow NO_2\uparrow$$
(colourless odourless) (Brown Gas & Pungent)

$\longrightarrow$

NO_2^- —— Ag^+ → $Ag(NO_2)\downarrow$ (white crystalline ppt.)

$\xrightarrow{CH_3COOH}$ HNO_2

$\xrightarrow{*NH_2-\overset{O}{\overset{\|}{C}}-NH_2}$ $CO_2 + N_2 + H_2O$

(Urea)

$\xrightarrow{*NH_2-\overset{S}{\overset{\|}{C}}-NH_2}$ $HSCN + N_2\uparrow$

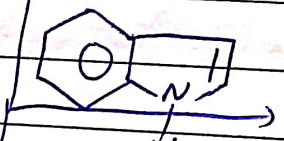
(Thiourea)

$\xrightarrow{FeCl_3}$ ~~$Fe(SCN)_3$~~ $[Fe(SCN)_6]^{3-}$ or $Fe(SCN)_3$

(Blood red)

$\xrightarrow[(H^+)]{KMnO_4}$ $Mn^{+2} + H_2O + NaNO_3$

$\xrightarrow{[H]}$ NH_3



$\longrightarrow$ Red (Nitroso Indole)

(Indole Test)

$\xrightarrow{KI/CH_3COOH}$ $I_3^- + NO\uparrow + CH_3COO^-$

$\xrightarrow[\text{Excess}]{NH_4Cl}$ $N_2\uparrow$

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

Starch + $I_2 \longrightarrow$ Blue

Brown Ring Test

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

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

$Fe^{+2} + SO_4^{-2} + NO \uparrow \longrightarrow [Fe(H_2O)_5NO]SO_4$ or $Fe(NO)SO_4$
($FeSO_4$)

Brown coloured solⁿ

* Here Fe has +1 oxidation state
O " −2 " "
N " +3 " "
(Latest research, Fe has +3)

Sulphamic Acid :- $OH.SO_2.NH_2$: only acid to exist as solid at room temp.

$OH.SO_2.NH_2 + HNO_2 \longrightarrow N_2 + H_2SO_4 + H_2O$

No ~~nitrate~~ nitrate is formed in this reacⁿ, it is an amazing method for complete removal of ~~nitrate~~ nitrate. Traces of nitrite are formed with NH_4Cl, urea, thiourea.

* Both NO_2^- & NO_3^- give brown ring test

* $[Fe(H_2O)_5NO]SO_4$ IUPAC Name :-
Penta aqua Nitrosylium iron (I) sulphate
* This brown ring complex is paramagnetic with 3 unpaired e^-.

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Griess - Ilosvay Test

Sulphanilic Acid - 1 Naphthylamine : Reagent

Reagent + HNO_2 ⟶ Red

Acetate (CH_3COO^-)

(i) Dil. Acid

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

Vinegar like smell

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

Reddish Brown Sol^n

$\longrightarrow [Fe_3(OH)_2(CH_3COO)_6]^+$

(iii) Esterification

Thiosulphate ($S_2O_3^{2-}$)

(i) Dil. Acid: $S_2O_3^{2-} + H^+ \longrightarrow S\downarrow + SO_2\uparrow + H_2O$

(ii) Iodine Sol^n :- $I_2 + 2S_2O_3^{2-} \longrightarrow 2I^- + S_4O_6^{2-}$
(Decolourises)

(iii) $BaCl_2$ Sol^n :-

$S_2O_3^{2-} + Ba^{+2} \longrightarrow BaS_2O_3\downarrow$ (white)
$S_2O_3^{2-} + Ca^{+2} \longrightarrow CaS_2O_3$ (no ppt.)

(iv) $AgNO_3$ Sol^n :-

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

$Ag_2S_2O_3\downarrow + H_2O \longrightarrow Ag_2S\downarrow + 2H^+ + SO_4^{2-}$
(black)

$S_2O_3^{2-}$ —— $Ni(OH)_3(NO)_2$ $[Ni(OH)_3]S_2O_3 + NO_3^-$

$\xrightarrow[FeCl_3]{Fe^{+3}}$ $Na[Fe(S_2O_3)_2]$ (Purple) $\rightarrow$ $Fe^{+2} + S_4O_6^{2-}$

$\xrightarrow{Ag^+}$ $Ag_2S_2O_3\downarrow$ (white) $\xrightarrow{H_2O}$ $Ag_2S\downarrow$ (Black)

$\xrightarrow{Pb^{+2}}$ PbS_2O_3 (white) $\xrightarrow{H_2O}$ $PbS\downarrow$ (Black)

$\xrightarrow{Bi^{+3}}$ $Bi_2(S_2O_3)_3\downarrow$ (white ppt)

$\xrightarrow{Na_2S_2O_3}$ $Na_3[Bi(S_2O_3)]$ $\xrightarrow{\Delta}$ $Bi_2S_3\downarrow$ (Black)

$\xrightarrow{Air}$ $Bi_2S_3\downarrow$ (Black)

$Na_2S_2O_3.5H_2O$ → Only Thiosulphate To have water of crystallization.

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Conc. Acid :-

(1) Chloride (Cl^-)

(i) Conc. Acid: $Cl^- + H^+ \longrightarrow HCl\uparrow \xrightarrow{NH_4OH} NH_4Cl$ (white fumes)

$HCl\uparrow$ | litmus → Red

$Cl^- \xrightarrow{MnO_2/H^+} Cl_2\uparrow$

Yellow Green

$Cl^- \xrightarrow{AgNO_3} AgCl\downarrow$ (white) $\xrightarrow[\text{or } NH_4OH]{NH_3} [Ag(NH_3)_2]^+$ Soluble

$Cl^- \xrightarrow{Pb^{+2}} PbCl_2\downarrow$ (white)

Soluble in hot water

Chromyl Chloride Test : (CrO_2Cl_2)

$K_2Cr_2O_7 + 4NaCl + 6H_2SO_4 \longrightarrow$

$2KHSO_4 + 4NaHSO_4 + 2CrO_2Cl_2\uparrow + 3H_2O$

Orange-Red Fumes

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

(Yellow Soln)

$Na_2CrO_4 + (CH_3COO)_2Pb \longrightarrow PbCrO_4\downarrow + 2CH_3COONa$

Yellow ppt.

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Q:- Odour of Br_2 Gas ?

→

Exceptions to Chromyl Chloride test :-

(Do not give " " ")

Ag^+, Cu^{2+}, Hg_2^{+2}, Sn^{+4}, Pb^{+4}

Gives red ppt

Generally ionic chloride give chromyl chloride test.

② Bromide (Br^-)

(i) Conc. H_2SO_4

$$Br^- + H^+ \longrightarrow HBr$$

$$HBr + H^+ \xrightarrow{H_2SO_4} H_2O + SO_2\uparrow + Br_2\uparrow$$

(Reddish Brown)

- $KBr + MnO_2 + H_2SO_4 \longrightarrow Br_2\uparrow + K_2SO_4 + MnSO_4 + 2H_2O$
- $Br^- + Ag^+ \longrightarrow AgBr\downarrow$ (pale yellow)
- $AgBr + 2NH_4OH \longrightarrow [Ag(NH_3)_2]Br + 2H_2O$

ppt Dissolve

- $Br^- + Pb^{+2} \longrightarrow$ $PbBr_2 \downarrow$ (white crystalline)

** $KBr + Cl_2 \longrightarrow KCl + Br_2$

~~$Br_2 + CHCl_3$~~

$Br_2 + CHCl_3 \longrightarrow$ Orange Red Colour

$KBr + K_2Cr_2O_7 + 7H_2SO_4 \longrightarrow 3Br_2\uparrow + Cr_2(SO_4)_3 + 4K_2SO_4 + 7H_2O$ (yellow brown soln)

Q. Why Br^- & I^- does not give the Chromyl Chloride Test?

→

(3) Iodide (I^-)

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

** $I^- + Ag^+ \longrightarrow AgI$ Yellow Curdy ppt.

(Formation of complex $[Ag(NH_3)_2]I$ is very less)

** $I^- + Pb^{+2} \longrightarrow PbI_2 \downarrow$ Yellow curdy ppt.

Soluble in hot water forming a colourless soln & golden yellow plates on cooling

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

$I_2 + CHCl_3 \rightarrow$ Violet Coloured Layer

- $I^- + Cu^{+2} \rightarrow CuI + I_2$ (Brown ppt.)

$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$ (White ppt.)

- $I^- + HgCl_2 \rightarrow HgI_2\downarrow + 2Cl^-$ (Scarlet Red)

$HgI_2 + KI \rightarrow K_2[HgI_4] \rightarrow$ Nessler's Reagent

(ppt. dissolves)

(4) Nitrate (NO_3^-)

(i) Conc. H_2SO_4

$NO_3^- + H_2SO_4 \rightarrow NO_2\uparrow + O_2 + SO_4^{2-} + H_2O$ (Brown)

(ii) Brown Ring Test

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

$Fe^{+2} + NO \longrightarrow [Fe(H_2O)_5NO]^{+2}$

Brown Ring

On shaking & warming brown colour disappears, NO_2 is evolved yellow sol^n of Fe^{+3} ions exist.

Action of Heat

- All nitrates give Metal Oxide $+ O_2 + NO_2$ on heating

Exceptions to this :-

eg: $NaNO_3 \longrightarrow NaNO_2 + O_2 \uparrow$

$NH_4NO_3 \longrightarrow N_2O \uparrow + 2H_2O$

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

- eg:- $Pb(NO_3)_2 \longrightarrow PbO + NO_2 \uparrow + O_2 \uparrow$

Class B

(1) Sulphate Ion (SO_4^{2-})

All sulphates except Ba, Pb, Sr are soluble in water.
Ca, Hg(II) salts are slightly soluble.

(i) **$BaCl_2$ Sol^n :-**

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

(ii) Hg (I) Nitrates

$SO_4^{-2} + 3Hg^{+2} + 2H_2O \longrightarrow HgSO_4 \cdot 2HgO$ + 4H
(Yellow ppt.)

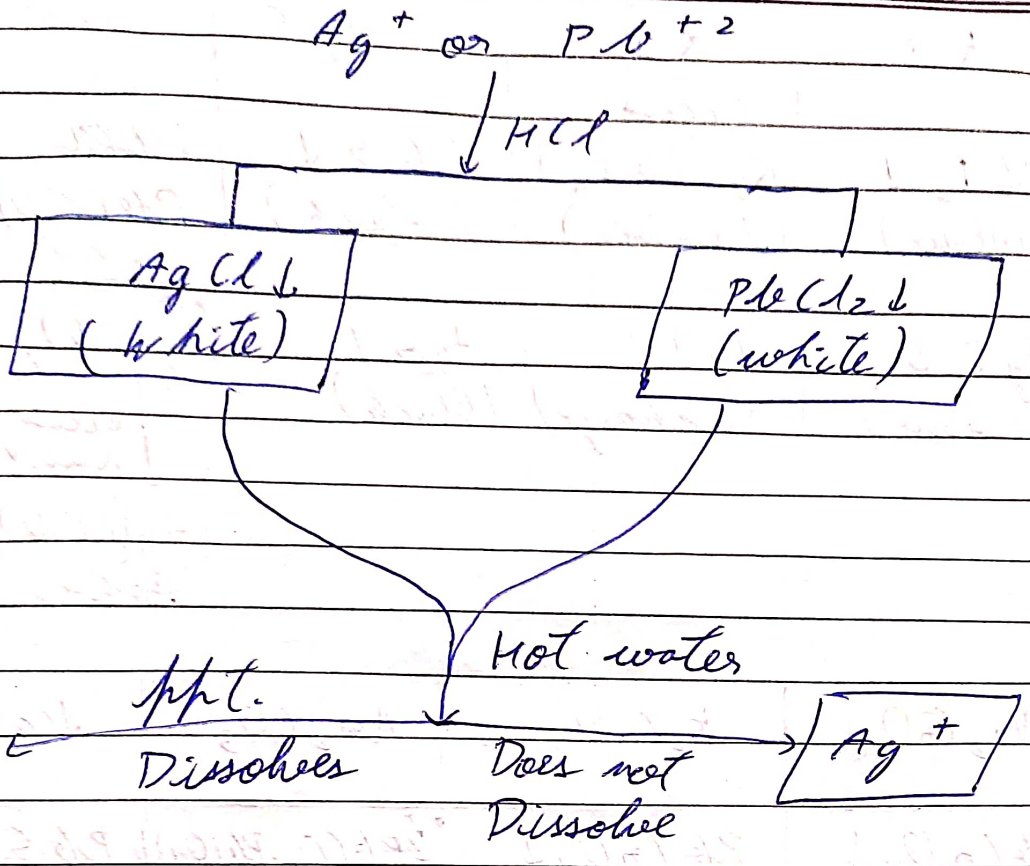
Cations

Gp I

Radicals Ag^+, Pb^{+2}, Hg_2^{+2} (Mercurous) X (Not in syllabus)
चाँदी, हीरा, पारा

Gp Reagent:- HCl

Ag^+ or Pb^{+2}
↓ HCl



	NH_4OH Ammonia Sol^n (limited)	NH_4OH (excess)	NaOH (limited)	NaOH (excess)
Pb^{+2}	$Pb(OH)_2$↓ (white)	No change (Same as limited)	$Pb(OH)_2$↓ white	Na_2PbO_2 Sodium Plumbate (dissolves)
Ag^+	$Ag(OH) \rightarrow Ag_2O$↓ (Insoluble) (Brown)	$[Ag(NH_3)_2]^{+2}$ ppt. dissolves	$Ag(OH) \rightarrow Ag_2O$↓ (Brown)	No change (Same as limited)

	KI	KI excess	H_2S	NaCN
Pb^{+2}	$PbI_2 \downarrow$ (Yellow)	$K_2[PbI_4]$ (dissolves)	$PbS \downarrow$ (black)	$Pb(CN)_2 \downarrow$ (white)
Ag^+	$AgI \downarrow$ (Yellow)	$AgI \downarrow$ (No change)	$Ag_2S \downarrow$ (black)	$Ag(CN) \downarrow$ (white) $\xrightarrow{\text{excess NaCN}}$ $[Ag(CN)_2]^-$ (dissolves)

	Na_2CrO_4	K_2CrO_4	Na_2CO_3	$Na_2S_2O_3$
Pb^{+2}	$PbCrO_4 \downarrow$ (Yellow)	$PbCrO_4 \downarrow$ (Yellow)	$2PbCO_3 \cdot Pb(OH)_2 \downarrow$ White lead (Basic lead carbonate)	$PbS_2O_3 \downarrow$ (white) $\xrightarrow{H_2O}$ $PbS \downarrow$ (black) $\xrightarrow{\text{excess } Na_2S_2O_3}$ $[Pb(S_2O_3)_2]^{2-}$ (clear)
Ag^+	$Ag_2CrO_4 \downarrow$ (Brick red)	$Ag_2CrO_4 \downarrow$ (Brick Red)	$Ag_2CO_3 \downarrow$ (yellowish white) $\xrightarrow{H_2O/\Delta}$ $Ag_2O \downarrow$ (Brown/Black)	$Ag_2S_2O_3 \downarrow$ (white) $\xrightarrow{H_2O/\Delta}$ $Ag_2S \downarrow$ (black) $\xrightarrow{\text{excess } Na_2S_2O_3}$ $[Ag(S_2O_3)_2]^{-3}$ (clear sol^n)

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Grp II

II-A: Hg^{+2}, Pb^{+2}, Cu^{+2}, Cd^{+2}, Bi^{+3}

II-B: As^{+3}, Sb^{+3}, Sn^{+2}, Sn^{+4}

Grp Reagent :- H_2S/ dil. Acid

K_{sp} of Grp II elements is very less so we require low conc. of S^{2-}

Ppt. of grp II — Yellow Ammonium Sulphide $(NH_4)_2S$

- II-A → Does not dissolve
- II-B → Dissolve

Grp II

H_2S/dil HCl

II A

- $HgS\downarrow$ Black
- $PbS\downarrow$ Black
- $Bi_2S_3\downarrow$ Black
- $CuS\downarrow$ Black
- $CdS\downarrow$ Yellow

II-B

- $As_2S_3\downarrow$ Yellow
- $Sb_2S_3\downarrow$ Orange
- $SnS\downarrow$ Brown
- $SnS_2\downarrow$ Yellow

Soluble in Y.A-S:- $(NH_4)_2S$

Naturally occuring Bi_2S_3 is Brown (crystalline) however when prepared as precipitate in lab it is Black in colour

Some Reac^{n}:-

- $CuS + K_4[Fe(CN)_6] \rightarrow Cu_2[Fe(CN)_6]\downarrow$
  Chocolate Brown ppt.

- $CuS \xrightarrow{KCN} Cu(CN)_2 \xrightarrow{KCN} CuKCN\downarrow + (CN)_2\uparrow$
  Yellow White Cyanogen

  $CuKCN \xrightarrow{KCN\ Excess} K_3[Cu(CN)_4] \xleftarrow{H_2S}$ No Reac^{n}
  Colourless Sol^{n}

- $Cu^{+2} + KSCN \rightarrow Cu(SCN)_2\downarrow$
  Black
  $Cu(SCN)_2 \xrightarrow{KSCN\ excess} Cu(SCN)\downarrow + (SCN)_2\uparrow$
  White Thiocyanogen

- $Cu^{+2} + K_3[Fe(CN)_6] \rightarrow Cu_3[Fe(CN)_6]_2\downarrow + KI$
  (Green ppt.)

- $Cd^{+2} + K_4[Fe(CN)_6] \rightarrow Cd_2[Fe(CN)_6]\downarrow$
  (Bluish white)

- $Hg^{+2} + Co(SCN)_2 \rightarrow Co[Hg(SNC)_4]$
  Blue Crystalline ppt.

- $SnCl_2 + HgCl_2 \rightarrow SnCl_4 + Hg_2Cl_2\downarrow$
  (white)

Q:- Why Pb^{+2} is in Gp I & Gp II?

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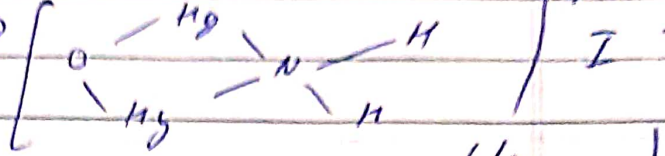
- $SnCl_2 + Hg_2Cl_2 \rightarrow SnCl_4 + 2Hg\downarrow$ (black)

- $K_2[HgI_4] + NH_3 \longrightarrow$  I^- (brown)

Nessler's Reagent

Iodide salt of Millon's ~~Blue~~ Base

	NH_4OH	Excess NH_4OH	NaOH	Excess NaOH	KI
Hg^{+2}	$Hg(NH_2)OH\downarrow$ (White)	No change	HgO ↓ (Brown / Black)	No change	$HgI_2\downarrow$ (Scarlet red)
Pb^{+2}	$Pb(OH)_2$ (White)	No change	$Pb(OH)_2$ (White)	Na_2PbO_2 (Soluble)	$PbI_2\downarrow$ (yellow)
Bi^{+3}	$Bi(OH)_3$ (White) (Soluble in dil HCl)	No change	$Bi(OH)_3$ (White)	No change	$BiI_3\downarrow$ (Black) $\xrightarrow{H_2O}$ $BiOI\downarrow$ (Orange ppt.)
Cu^{+2}	$Cu(OH)_2\downarrow$ Blue	$[Cu(NH_3)_4]^{+2}$ (Deep blue sol^n)	$Cu(OH)_2\downarrow$ $\xrightarrow{\Delta}$ CuO ↓ (Black)	No change	$Cu_2I_2\downarrow$ (White)

	Excess KI	dil. HNO_3	dil. H_2SO_4	Na_2CrO_4	$NaCO_3$	$Na_2S_2O_3$	NaCN
Hg^{+2}	$K_2(HgI_4)$ Nessler's Reagent	NO reac^n	$HgSO_4$ (white)		Hg_2CO_3 (yellow)		
Pb^{+2}	$K_2[PbI_4]$ (Dissolves)	$Pb(NO_3)_2$ Sol^n	$PbSO_4$ (white)				
Bi^{+3}	$[Bi^-I_4]^-$ (Orange)	$Bi(NO_3)_3$ Sol^n	$Bi_2(SO_4)_3$ Sol^n				
Cu^{+2}	Cu_2I_2	$Cu(NO_3)_2$ Sol^n	$CuSO_4$ Blue Sol^n				

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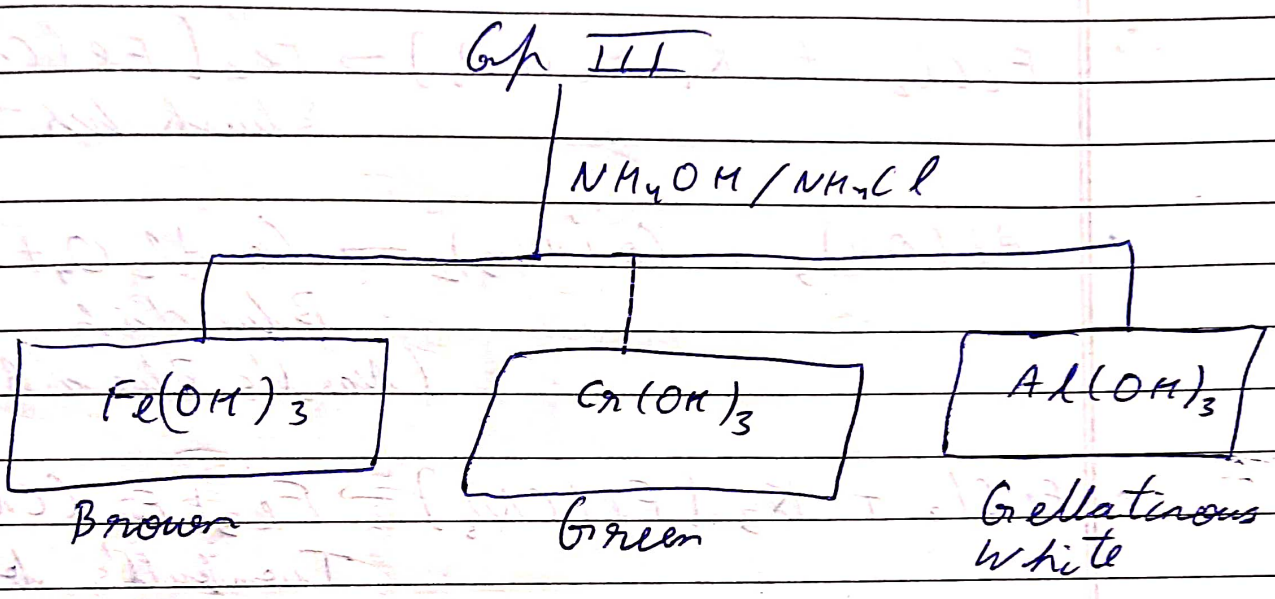
Grp III → Fe^{+3}, Cr^{+3}, Al^{+3}

Grp Reagent:- NH_4OH/NH_4Cl

K_{sp} of hydroxides is less ∴ we need less conc. of OH^-. Moreover high conc. of OH^- will precipitate Grp IV cation also.



Reacⁿ:-

Cr^{+3}:- $Cr(OH)_3 + OH^- \rightleftharpoons [Cr(OH)_4]^-$

$2[Cr(OH)_4]^- + 2H_2O_2 + 2OH^- \rightarrow CrO_4^- + 4H_2O$
(Yellow)

Fe^{+3}:- $Fe^{+3} + H_2S \rightarrow 2Fe^{+3} + S\downarrow + 2H^+$

* $FeCl_3 + 3KSCN \rightarrow Fe(SCN)_3 + KCl$
(Blood red)

* $FeCl_3 + CH_3COOH \rightarrow Fe(CH_3COO)_3$
(Blood red)

→

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$FeCl_3 + K_4[Fe(CN)_6] \rightarrow Fe_4[Fe(CN)_6]_3$
or $KFe[Fe(CN)_6]$
Ferri Ferro Cyanide
(Prussian Blue)

$FeCl_3 + K_3[Fe(CN)_6] \rightarrow Fe[Fe(CN)_6]$
(Brown Complex)

$FeCl_2 + K_4[Fe(CN)_6] \rightarrow Fe_2[Fe(CN)_6]$
Bluish white ppt.

$Al(OH)_3 + Co(NO_3)_2 \rightarrow CoAl_2O_4 + NO_2\uparrow + O_2\uparrow + H_2O$
Blue Ash
(Nard's Blue ash Test)

$FeCl_2 + K_3[Fe(CN)_6] \rightarrow Fe_3[Fe(CN)_6]_2$
Turnbull's blue

$Fe^{+3}Cl_3 + K_4[Fe^{+2}(CN)_6] \rightarrow Fe_4^{+3}[Fe^{+2}(CN)_6]_3$
(Prussian Blue)
(Ferri Ferro Cyanide)

$Fe^{+2}Cl_2 + K_4[Fe^{+2}(CN)_6] \rightarrow Fe_2^{+2}[Fe(CN)_6]$
(Bluish white ppt.)

$Fe^{+3}Cl_3 + K_3[Fe^{+3}(CN)_6] \rightarrow Fe^{+3}[Fe^{+3}(CN)_6]$ (Brown soln)

$Fe^{+2}Cl_2 + K_3[Fe^{+3}(CN)_6] \rightarrow Fe_3^{+2}[Fe^{+3}(CN)_6]_2$
(Turnbull's Blue)

	NH_4OH	NH_4OH (excess)	$NaOH$	$NaOH$ (excess)	$NaCN$ / KCN	Excess KCN	$(NH_4)_2S$	CH_3COONa
Fe^{+3}	$Fe(OH)_3\downarrow$ Brown (Reddish)	No Change	$Fe(OH)_3\downarrow$ Brown	No change	$Fe[Fe(CN)_6]_3\downarrow$ Reddish Brown	$Na_3[Fe(CN)_6]$ Yellow Solⁿ	$FeS\downarrow$ (Brown) + $S\downarrow$	$Fe(CH_3COO)_3$ Bleed Red Solⁿ
Al^{+3}	$Al(OH)_3\downarrow$ White (Gelatanous)	No Change	$Al(OH)_3\downarrow$ White	$Na[Al(OH)_4]$ Sodium Meta Aluminate	No reacⁿ	No reacⁿ	$Al(OH)_3\downarrow$	$Al(OH)_6(CH_3COO$ (White)
Cr^{+3}	$Cr(OH)_3\downarrow$ Green	$[Cr(NH_3)_4]^{+3}$ Dissolves	$Cr(OH)_3\downarrow$ (Green)	$Na(Cr(OH)_4)$ Sodium meta Chromate	No reacⁿ	No reacⁿ	$Cr(OH)_3\downarrow$	No Reacⁿ

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$\therefore Zn^{+2} + KNH_2 \longrightarrow Zn(NH_2)_2$ (amphoteric, insoluble) $\xrightarrow{\text{excess } KNH_2}$ $K_2Zn(NH_2)_4$ (Soluble in NH_3)

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Group IV

Mn^{+2}, Co^{+2}, Zn^{+2}, Ni^{+2}

Reagent :- $H_2S/NH_4OH/NH_4Cl$

	Zn^{+2}	Mn^{+2}
NaOH	$Zn(OH)_2\downarrow$ (white)	$Mn(OH)_2\downarrow$ (Pink) $\xrightarrow{\text{boil}}$ MnO_2 (Black/Brown)
Excess NaOH	Na_2ZnO_2 (Soluble)	
H_2S	ZnS↓ Dirty White	MnS↓ Buff / Pink

- $Zn^{+2} + 2K_4[Fe(CN)_6] \longrightarrow Zn_2[Fe(CN)_6] + 6K^+$ (white)
  n factor = 3
  or $K_2Zn_3[Fe(CN)_6]_2$

- $Zn^{+2} + (NH_4)_2[Hg(SCN)_4]$
  $\downarrow Cu^{+2}$
  $Zn[Hg(SCN)_4]\downarrow + Cu[Hg(SCN)_4]\downarrow$
  Violet ppt. | But $Zn[Hg(SCN)_4]$ is white ppt.

- $Mn(OH)_2 + O_2 \longrightarrow MnO_2\downarrow$ (Black)

- $MnO_2 + PbO_2 + HNO_3 \longrightarrow Mn^{+3} + Pb(NO_3)_2 + H_2O$
  (Purple) ($HMnO_4$)

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Group II

Ba^{+2}, Sr^{+2}, Ca^{+2}

$Ba^{+2}, Ca^{+2}, Sr^{+2} \xrightarrow{(NH_4)_2CO_3} BaCO_3, SrCO_3, CaCO_3$
white ppt.

$Ba^{+2} + K_2CrO_4 \longrightarrow BaCrO_4\downarrow$
(yellow)

$(NH_4)_2C_2O_4$

$BaC_2O_4\downarrow + 2NH_4^+$
(white)

CH_3COOH → Dissolves

Mineral Acid → Dissolves

CH_3COOH → Insoluble

$BaSO_4\downarrow$
(white)

$Ba^{+2} + (NH_4)_2SO_4 \longrightarrow BaSO_4\downarrow$ (white) $\xrightarrow{\text{Mineral Acid}}$ R No Reacn

Group 0: NH_4^+

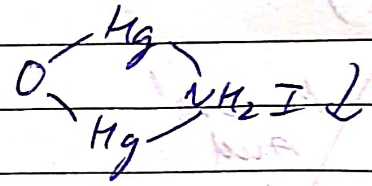
$NH_4Cl + NaOH \rightarrow NaCl + NH_3\uparrow + H_2O$

$NH_3 + HCl \rightarrow NH_4Cl$ (white fumes)

$CuSO_4 + NH_3 \rightarrow [Cu(NH_3)_4]SO_4$
Deep Blue

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

$NH_4Cl + K_2HgI_4 + KOH \rightarrow$
Nessler's Reagent



Brown ppt.

$+ 7KI + 2H_2O$

Gp 6 Mg^{+2}, Na^+, K^+

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

ppt. readily soluble in NH_4OH, but not in H_2O

$Mg^{+2} + (NH_4)_2HPO_4 + NH_4OH$
$\downarrow NH_4Cl$
$Mg(NH_4)PO_4\downarrow + 2NH_4^+$
(white)

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Exceptions of Chromyl Chloride Test

Ag^{+}, Cu_2^{+2}, Hg_2^{+2}, Sn^{+4}, Pb^{+4}

Amphoteric Oxides

ZnO, Al_2O_3, BeO, Cr_2O_3, Ga_2O_3, PbO, SnO