Page No.
Date : / /

Qualitative analysis

$Cu(OH)_2 + H_2SO_4 \longrightarrow CuSO_4$ → anion from acid ⇒ acidic radical.

Cation from base ⇒ basic radical.

Classification of anions

but in lab comes in conc

- class A →
  - I dil acid: HCl / H_2SO_4 : CO_3^{2-}, SO_3^{2-}, S^{2-}, NO_2^-, CH_3COO^- (conc radical), $S_2O_3^{2-}$ (out of syllabus)
  - II conc acid: HCl / H_2SO_4 : Cl^-, Br^-, I^-, NO_3^- { F^-, $C_2O_4^{2-}$ } (ClO_3^-)
- class B → SO_4^{2-}, PO_4^{3-} (extra)

II) are conjugate bases of strong acids ∴ are weak bases and have low affinity for H^+, and are reacted with conc acid.

(CLASS A, (I))

1) CO_3^{2-} : Carbonate

Reagent: dil HCl / dil H_2SO_4 → H^+

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

(H_2CO_3: thermodynamically unstable)

(CO_2: colorless, odorless)

Confirmatory: $CO_2 + Ca(OH)_2 \longrightarrow CaCO_3\downarrow$

($Ca(OH)_2$: lime water; ($CaCO_3$: milky white color appears)

$CaCO_3 + CO_2$ (excess) $\longrightarrow Ca(HCO_3)_2$

milky white color disappears

∴ overall:

$CO_3^{2-} \xrightarrow{H^+} H_2CO_3$ (unstable) $\longrightarrow H_2O + CO_2\uparrow$ (lime water in side tube) → $CaCO_3$ (milky white)

$CaCO_3$ (milky white) $\xleftarrow{\Delta} Ca(HCO_3)_2 \xleftarrow{CO_2}$ (excess)

milky white reappears

Page No.
Date : / /

Instead of $Ca(OH)_2$, $Ba(OH)_2$ can also be used

$CO_2 \xrightarrow[\text{Baryta water}]{Ba(OH)_2}$ $BaCO_3\downarrow$ (milky white) $\xrightarrow[\text{excess}]{CO_2}$ $Ba(HCO_3)_2$ (white dissapears) $\xrightarrow{\Delta}$ $BaCO_3\downarrow$ (white reappears)

- $CO_3^{2-} \xrightarrow{Ag^+} Ag_2CO_3\downarrow$ white ppt
  - $\xrightarrow{HNO_3}$ dissolves
  - $\xrightarrow{NH_3}$ dissolves
  - Yellow / Brown soln
  - $\xrightarrow{HPh/H_2O}$ $CO_2\uparrow$ [Pink color changes to colorless]
  - $\xrightarrow{\Delta}$ $Ag_2O\downarrow + CO_2\uparrow$ Black ppt
  - ppt becomes brown yellow on adding excess reagent owing to the formation of Ag_2O

- $CO_3^{2-} + 4Hg^{2+} + 3H_2O \longrightarrow \underbrace{Hg_4O_3CO_3\downarrow}_{\text{reddish brown}} + 6H^+$
  - Test for $HgCl_2$
  - $= 3HgO \cdot HgCO_3$

- Excess of CO_3^{2-} acts as buffer in acidic medium.
  - ⟶ Some neutral carbonates
  1) Siderite ($FeCO_3$) ; 2) Magnesite ($MgCO_3$)
  3) Dolomite [$(Ca, Mg)CO_3$ i.e $CaCO_3 \cdot MgCO_3$]

  These do not react with cold soln with acid. They must be powdered and soln must be warmed

- Na_2CO_3 is thermally stable
- $Al_2(CO_3)_2$ does not exist
- $PbCO_3$ with dil acid (HCl/H_2SO_4) will gone rxn initially (effervescence observed) Then protective layer is formed, stopping further rxn
- All normal carbonates, except that of alkali metals and NH_4^+ are insoluble in water.

Page No.
Date : / /

- $Na_2CO_3 \cdot 10H_2O$ ← crystals

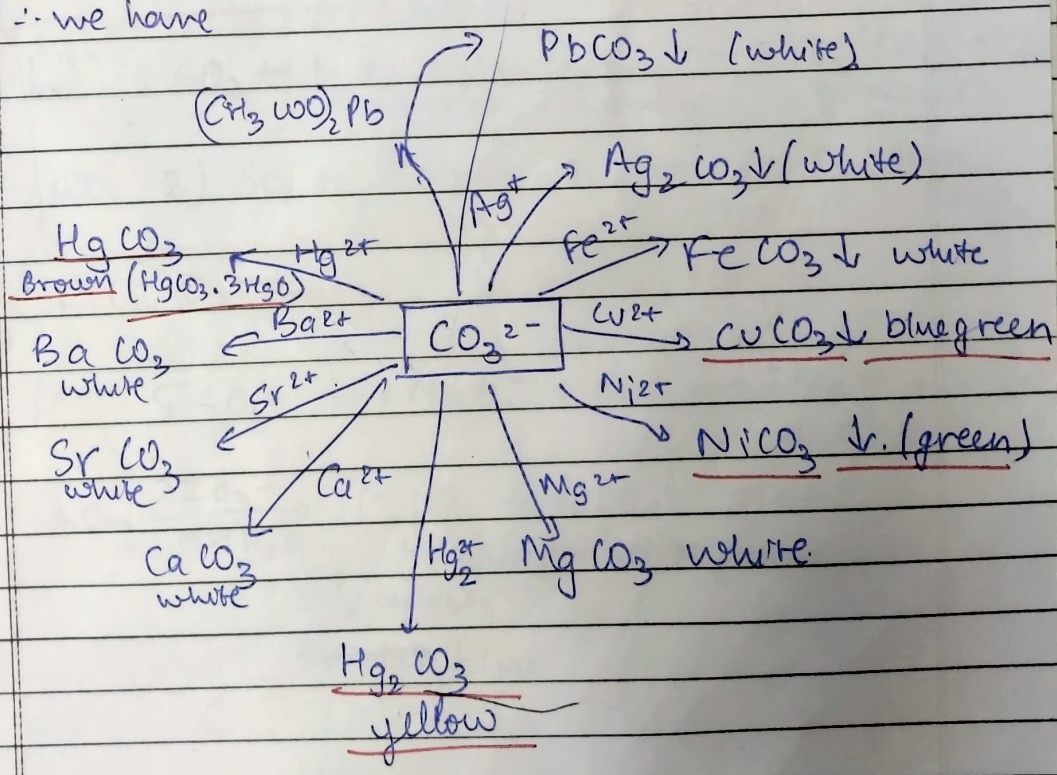
- $CaCO_3 + CO_2 + H_2O \longrightarrow Ca^{2+} + 2HCO_3^-$
Any acid which is stronger than H_2CO_3 will displace it especially on warming. Thus even acetic acid will decompose CO_3^{2-} but H_2BO_3 and HCN will not.
⟹ white ppt dissolves in any acid stronger than H_2CO_3 except HCN, H_3BO_3

Test for $Hg_2(NO_3)_2$

$$Na_2CO_3 + Hg_2(NO_3)_2 \longrightarrow \underset{\text{Yellow ppt}}{Hg_2CO_3\downarrow} + 2NaNO_3$$

$$(CH_3COO)_2Pb + CO_3^{2-} \longrightarrow \underset{\text{White ppt}}{PbCO_3\downarrow} + 2CH_3COO^-$$

∴ we have



(as H_2SO_3)

Page No.
Date : / /

2) SO_3^{2-} : Sulphite

$SO_3^{2-} \xrightarrow{H^+}$ H_2SO_3 unstable $\longrightarrow H_2O + SO_2\uparrow$
- colorless
- pungent

$SO_2 \xrightarrow{Ca(OH)_2 \text{ or } Ba(OH)_2}$ $CaSO_3/BaSO_3$ white ppt

$CaSO_3/BaSO_3 \xleftarrow{\Delta}$ White ppt $\xleftarrow{\text{excess } SO_2}$ disappears $Ca(HSO_3)_2$, $Ba(HSO_3)_2$

white ppt reappears

→ To differentiate b/w CO_2, SO_2 :

1) ~~Smell~~ smell of gas released

2) SO_2 can act as both OA & RA but CO_2 is only an O.A.

So : $CO_2 \xrightarrow{KMnO_4 \text{ or } K_2Cr_2O_7}$ No rxn

but

1) $SO_2 \xrightarrow[H_2SO_4]{K_2Cr_2O_7}$ green color

Rxn : $SO_2 + K_2Cr_2O_7 + H_2SO_4 \longrightarrow Cr_2(SO_4)_3 + KSO_4$
(Acidified pot. dichromate; green soln)

~~So~~ 2) $SO_2 + KMnO_4/H^+ \longrightarrow Mn^{2+}$ from $MnSO_4$
(Pink soln)

$K_2Cr_2O_7$: Orange, $KMnO_4$: Purple

Rxn : $5SO_3^{2-} + 2MnO_4^- + 6H^+ \longrightarrow 2Mn^{2+} + 3H_2O + 5SO_4^{2-}$

$SO_2 \xrightarrow[+4H_2O]{2IO_3^-} (I_2) + 5SO_4^{2-} + 8H^+$
↳ blue / violet vapours
↓ starch
~~violet~~ blue

$Ag_2SO_3 \downarrow \xrightarrow{\Delta} Ag \downarrow$
white → grey

$BaSO_3$ dissolves in dil HCl
$BaSO_4$ does not

Page No.
Date : / /

out

SO_3^{2-} rxns same as SO_2 rxns

written RA in notes?

$HSO_3^- + OH^-$

$SO_4^{2-} + H_2O$

H_2O_2 (as OA) | H_2O

• $[AgSO_3]^-$: sulphito argentate ion, no charge, Zn^{2+} ion or metallic

Ag^+ • on excess Ag^+, Ag_2SO_3 formed (white crystalline

$CaSO_3 \downarrow$ (White) ← Ca^{2+}

SO_3^{2-}

$Ba^{2+} \rightarrow BaSO_3 \downarrow$, White ppt

Zn/H_2SO_4 → $Zn^{2+} + H_2S \uparrow$

Pb^{2+} → $PbSO_3 \downarrow$ White ppt

MnO_4^- → Mn^{2+} (pink)

$Cr_2O_7^{2-}$ → green, $Cr_2(SO_4)_3$

Ag^+

• $AgSO_3^- \xrightarrow{Ag^+} [Ag_2SO_3] \xrightarrow{SO_3^{2-}} AgSO_3^- \xrightarrow{boil} Ag \downarrow + SO_4^{2-} + SO_2$

grey

White crystalline ppt → $\xrightarrow{H_2O/\Delta} Ag \downarrow + SO_4^{2-} + 2H^+$

Ag_2SO_3 dissolves in ammonia, (C.N of Ag is 2)

$(Ag_2SO_3 + NH_3 \rightarrow [Ag(NH_3)_2]^+)$

Pb^{2+}

• $PbSO_3 \xrightarrow{O_2} PbSO_4$ (white ppt)

• $BaSO_3 \xrightarrow{O_2}$ (i.e on standing, rxn with O_2) $BaSO_4$ (white ppt) : Diff b/w $BaSO_3$ & $BaSO_4$

$BaSO_3 \xrightarrow{dil\ HCl} BaSO_4$ No rxn

$BaSO_3 \xrightarrow{dil\ HCl}$ Dissolves + $SO_2 \uparrow$

$BaSO_3 \xrightarrow[\text{or } Br_2 \text{ water}\ /\ \text{or } H_2O_2]{HNO_3 \text{ (conc)}} BaSO_4$

Ans. Fuchsin test:

Dil soln of triphenyl methane dye stuffs such as fuchsin & malachyte green, are immediately discolored by neutral sulphite. SO_2 also decolorizes fuchsin soln but rxn is not quite complete

Sod. Nitroprussiol test, $ZnSO_4$ test

$Na_2[Fe(CN)_5NO]$, red colored.

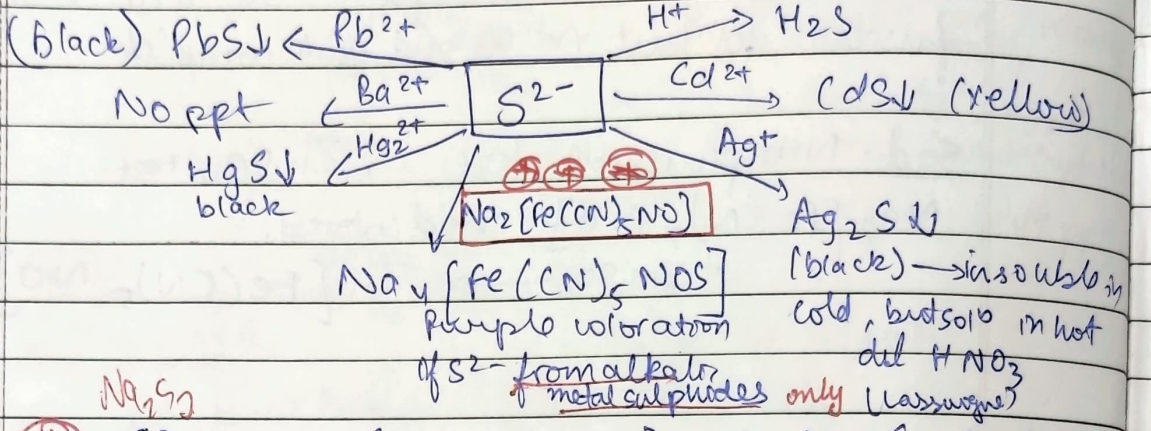
$+ ZnSO_4 \longrightarrow Zn[Fe(CN)_5NO]$

Page No.
Date : / /

3) Sulphide (S^{2-})

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

$H_2S \xrightarrow{(CH_3COO)_2Pb}$ Black ppt $PbS\downarrow + CH_3COOH$



Na_2S_2

$S^{2-} + Na_2[Fe(CN)_5NO] \longrightarrow Na_4[Fe(CN)_5NOS]$ (red color) → (purple color)

- $Na_2S \cdot 9H_2O \longrightarrow$ Sod. sulphide
- $MnO_4^- + H_2S \xrightarrow{H^+} S\downarrow + Mn^{2+}$ (acidic medium) (good RA) ppt in colloidal form
- $Cr_2O_7^{2-} + H_2S \longrightarrow Cr^{3+} + S\downarrow$
- $I_3^- + H_2S \longrightarrow I^- + H^+ + S\downarrow$

- $H_2S + Na_2[Fe(CN)_5NO] \longrightarrow$ No rxn but
  $K_2S/Na_2S \longrightarrow Na_2[Fe(CN)_5NO] \longrightarrow$ Purple

In nitroprusside test
- transient purple color in presence of alkali
- No rxn with H_2S and free gases

- Spot test : violet color (rxn with H_2S when it was put on filter paper with alkali)

- O_2 in liquid form is pale yellow

Page No.
Date : / /

Methylene Blue Test

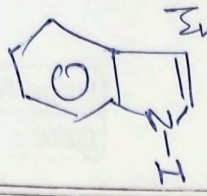
N,N Dimethyl p-phenylene diamine on rxn with $FeCl_3$ & H_2S in strongly acidic soln into water soluble dye stuff methylene blue.
& $Fe^{3+} \longrightarrow Fe^{2+}$

Catalysis of Iodine Azide rxn test

Iodyne : I_3^- , Azide : N_3^-

$N_3^- + I_3^- \xrightarrow{S^{2-}(\text{Trace})} I^- + N_2 \uparrow$.

But no rxn without S^{2-}, which acts as a catalyst



$FeCl_3$: brown

Page No.
Date : / /

4) NO_2^- : Nitrite

$NO_2^- \xrightarrow{H^+} HNO_2 \xrightarrow{\text{Disprop}} HNO_3 + NO\uparrow + H_2O$

$HNO_2 \rightarrow N_2\uparrow$

$HNO_3 \downarrow O_2$

$NO_2\uparrow$ (brown)

Red color ← Indole ← NH_4Cl (excess) p-block

$K_2SO_4 + MnSO_4 \leftarrow KMnO_4 / H_2SO_4 + H_2O + NaNO_3$

NO_2^-

$KI / CH_3COOH \rightarrow I_3^- + NO\uparrow + CH_3COO^-$

$Ag^+ \rightarrow AgNO_2\downarrow$ (white crystalline)

NH_2CSNH_2 (thiourea) → $HSCN + N_2$ → $FeCl_3$ (brown) → $Fe(SCN)_3$ (Blood red)

NH_2CONH_2 (Urea) → $CO_2\uparrow + N_2\uparrow + H_2$

$[H]$ (Reduction) → NH_3

$CH_3COOH \rightarrow HNO_2 + CH_3COO^-$

- $NO_2^- + KI \longrightarrow I_2\uparrow + KNO_2$
  (starch: blue color)

- Brown ring test

$NO + FeSO_4 \longrightarrow [Fe(H_2O)_5NO]SO_4$

IUPAC NAME: Penta-aqua nitrosylium iron(I) sulphate.

Oxidation state of Fe: 1, Coord no of Fe: 6

magnetic moment = $\sqrt{15}$

- Sulphamic acid : $OH \cdot SO_2 \cdot NH_2$

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

No nitrate is formed in this rxn. It is an excellent method for complete removal of NO_3^-. Trace of NO_3^- are formed with NH_4Cl, urea, thiourea

5)

AIIS

- Griess - Ilosvay test
  or sulphanilic -1- naphthyl amine reagent
  HNO_2 ⋯⟶ red
  This rxn depends on the diazonium of the reagent.

5) CH_3COO^- (acetate)

- $CH_3COO^- + H^+ \longrightarrow CH_3COOH$ (vinegar smell)
- $CH_3COO^- + FeCl_3 \longrightarrow$ deep red coloration
  (neutral)

$$[Fe_3(OH)_2(CH_3COO)_5]^+ \xrightarrow{\text{Boiling}} (CH_3COO)_3Fe$$

Brick red or reddish-brown sol^n.

Amphoteric Oxides: ZnO, Al_2O_3, BeO, Cr_2O_3, also As, Sb, V_2O_5
जनाब अली ने "बेकार" Ga_2O_3 गाया PbO, PbO_2 पंजाबी SnO, SnO_2 song.

Page No.
Date : / /

CLASS A(II) → As_2O_3 Sb_2O_3 V_2O_5 As सब बेकार है

Conc acid

① Cl^-, chloride

$Cl^- \xrightarrow{H^+} HCl(g)\uparrow \xrightarrow{NH_4OH} NH_4Cl$ → Dense white fumes
↳ wet blue litmus → red

$Cl^- \xrightarrow{MnO_2/H^+} Cl_2\uparrow + Mn^{2+} + 2SO_4^{2-} + 2H_2O$

MnO_2: Catalyst, increases intensity of gas released.

Confirmatory: yellowish green colour is obtained.

- $Cl^- \xrightarrow{AgNO_3}$ $AgCl\downarrow$ White ppt $\xrightarrow[\text{Ammonia soln}]{NH_3}$ $[Ag(NH_3)_2]^+$ or NH_4OH (excess)

AgI does not dissolve in $AgNO_3$

- $Cl^- \xrightarrow{Pb^{2+}} PbCl_2\downarrow$ White $\xrightarrow{\Delta}$ Soluble in hot water

V.V Imp

- **CHROMYL CHLORIDE TEST**

i) $K_2Cr_2O_7 + HNaCl + 6H_2SO_4 \longrightarrow 2KHSO_4 + 2NaHSO_4 + 2CrO_2Cl_2\uparrow + H_2O$
Chromyl chloride: orange red fumes

ii) $CrO_2Cl_2 + 2NaOH \longrightarrow Na_2CrO_4 + 2HCl$
(Yellow soln)

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

- Ionic chlorides give this test but covalent chlorides do not give this test.
- F^-, Br^-, I^- do not give this test
- Ag^+, (Cu_2^{2+}, Hg_2^{2+}), Sn^{2+}, Pb^{2+} → other chlorides do not give this test

आज क्यों होगा दूसरा पल ... Sann Rub.

$PbBr_2$ is white

Acidic Metal oxides: Mn_2O_7, CrO_3

Neutral Non metal oxides: CO, NO, N_2O

Page No.
Date: / /

(2) Br^-, Bromide

- $Br^- + H^+ \longrightarrow HBr \xrightarrow{H_2SO_4} Br_2\uparrow + SO_2 + H_2O$ (colorless; Br_2: reddish brown)
- $KBr + MnO_2 + H_2SO_4 \longrightarrow Br_2 + K_2SO_4 + MnSO_4 + H_2O$
- $Br^- + Ag^+ \longrightarrow AgBr\downarrow$ (Pale yellow) $\xrightarrow{NH_3\ soln} [Ag(NH_3)_2]^+$ dissolves
- $Pb^{2+} + 2Br^- \longrightarrow PbBr_2\downarrow$ (White crystalline.)
- $KBr + K_2Cr_2O_7 + H_2SO_4 \longrightarrow Br_2 + Cr_2(SO_4)_3 + K_2SO_4 + 7H_2O$ (Br_2: brown; $Cr_2(SO_4)_3$: green)
- $KBr + Cl_2(water) \longrightarrow KCl + Br_2$
  - $\downarrow CHCl_3$ or CCl_4
  - orange – red color (layer)

(3) I^-, Iodide

- $I^- + H_2SO_4 \longrightarrow HI \xrightarrow{H_2SO_4} I_2\uparrow + SO_2$ (violet vapours)
- $I^- + AgNO_3 \longrightarrow AgI$ (yellow curdy ppt) $\xrightarrow{NH_3\ soln}$ slightly sol^b (does not dissolve)
- $I^- + Pb^{2+} \longrightarrow PbI_2$ (yellow)
- $I^- + Cr_2O_7^{2-} + H^+ \longrightarrow I_2 + Cr_2(SO_4)_3 + K_2SO_4$
- $I^- + Cl_2 \longrightarrow Cl^- + I_2 \xrightarrow{CHCl_3}$ Violet colored layer (on walls)
- $I_2 + \text{hypo soln}\ (S_2O_3^{2-}) \longrightarrow S_4O_6^{2-} + I^-$
- $2I^- + 2Cu^{2+} \longrightarrow Cu_2I_2 + I_2$
- $I^- + HgCl_2 \longrightarrow HgI_2$ (Scarlet color)

$HgI_2 \xrightarrow[\text{excess}]{I^-} K_2HgI_4$ (Nessler's reagent)

Page No.
Date : / /

(4) NO_3^- : Nitrate

- $NO_3^- + H_2SO_4 \longrightarrow NO_2\uparrow + O_2 + SO_4^{2-} + H_2O$
  (brown)
- $NO_3^- + H_2SO_4 + Fe^{2+} \longrightarrow Fe^{3+} + NO\uparrow + SO_4^{2-} + H_2O$
  ($\downarrow Fe^{2+}$)
  $[Fe(H_2O)_5NO]SO_4$ brown ring
- $NaNO_3 \xrightarrow{\Delta} NaNO_2 + 1/2\ O_2$
  $AgNO_3 \xrightarrow{\Delta} Ag + NO_2 + O_2$
  $PbNO_3 \xrightarrow{\Delta} PbO + NO_2 + O_2$
  $NH_4NO_3 \xrightarrow{\Delta} N_2O + 2H_2O$
  $NH_4NO_2 \xrightarrow{\Delta} N_2\uparrow + 2H_2O\uparrow$
- $NaNO_3 + H_2SO_4 \longrightarrow NaHSO_4 + HNO_3$
- $4HNO_3 \longrightarrow 4NO_2\uparrow + O_2\uparrow + 2H_2O$

CLASS B

- SO_4^{2-}: Sulphate

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

2) $Hg^{2+} + SO_4^{2-} \longrightarrow HgSO_4 \cdot 2HgO\downarrow$
   yellow ppt

- PO_4^{3-} : Phosphate

Salt + Nitric acid + Amm molybdate

$MoO_4^- + 2HNO_3 \longrightarrow H_2MoO_4 + NO_3^-$

$H_2MoO_4 \longrightarrow MoO_3 + H_2O$

$(NH_4)_3PO_4 + 12MoO_3 + 6H_2O \longrightarrow (NH_4)_3PO_4 \cdot 12MoO_3 \cdot 6H_2O$
Amm phospho molybdate
(yellow ppt)

Page No.
Date : / /

BASIC RADICALS

- For formation of coordination compound, ligand must be present in excess
- coordination no. of a metal x dentate nature

Group 1 :

Radicals: Ag^+ (आज) Hg_2^{2+} (होगा) Pb^{2+} (प्रभात) — × not in syllabus

आज Pab

Reagent: HCl

$AgCl\downarrow$ (White) — hot water → does not dissolve

$PbCl_2\downarrow$ (white) — hot water → dissolves

- Ligand in NH_4OH is NH_3 $(NH_3 \cdot H_2O)$
- ⭐ $Ag_2S_2O_3$ → white ppt used in fixing negatives of photos

→ CN's of:

Ag → 2 Fe → 6 Ni → 4/6 Co → 6

Cu → 4 Cr → 6 Hg → 4, Bi : 4

Complexes

Ag^+ : $[Ag(NH_3)_2]^{+}$, $[Ag(CN)_2]^{-}$, $[Ag(S_2O_3)_2]^{3-}$ (all soluble)

Hg^{2+} : $K_2[HgI_4]$ (Nessler's rgt), $Co[Hg(SCN)_4]$ (Blue crystalline) ↓

Bi^{3+} : BiI_4^- (orange)

Cu^{2+} : $K_3[Cu(CN)_4]$ (colorless), $[Cu(NH_3)_4]^{2+}$ (Deep blue soln, dissolves with Fe^{2+})

Ferrocyanides: Fe^{2+} : $Cu_2[Fe(CN)_6]\downarrow$ (chocolate brown), $Fe_2[Fe(CN)_6]\downarrow$ (Bluish white with Fe^{3+}), $Fe_4[Fe(CN)_6]_3$ (Prussian blue with Fe^{3+})

Ferricyanides Fe^{3+} : $Cu_3[Fe(CN)_6]_2\downarrow$ (Green), $Fe[Fe(CN)_6]\downarrow$ (Brown ppt), $Fe_3[Fe(CN)_6]_2\downarrow$ (Turnbull's blue with Fe^{2+})

	NH_4OH (Ammonia solⁿ)	NH_4OH (excess)	$NaOH$	$NaOH$ (excess)	KI	KI (excess)	H_2S	Na_2CrO_4 / K_2CrO_4	$NaCN$	$Na_2S_2O_3$	Na_2CO_3
Pb^{2+}	$Pb(OH)_2\downarrow$ White	No change i.e white ppt of $Pb(OH)_2$	$Pb(OH)_2\downarrow$ White	Na_2PbO_2 Sodium Plumbate i.e dissolves ppt (Amphot)	$PbI_2\downarrow$ Yellow ppt	$K_2[PbI_4]$ ppt dissolves	$PbS\downarrow$ black	$PbCrO_4\downarrow$ Yellow	$Pb(CN)_2$ white ↓excess No change	PbS_2O_3 ↓white H_2O $PbS\downarrow$ Black	$2PbCO_3 \cdot Pb(OH)_2$ ↓white ppt White lead
Ag^+	$AgOH$ ↓ $Ag_2O\downarrow$ (brown)	ppt dissolves i.e coordinate compound formed $[Ag(NH_3)_2]^+$	$AgOH$ ↓ $Ag_2O\downarrow$ (brown)	$Ag_2O\downarrow$ (no change)	$AgI\downarrow$ Yellow curdy	$AgI\downarrow$ No change	$Ag_2S\downarrow$ black	Ag_2CrO_4 Brick red	$AgCN$ white ↓excess dissolves as $[Ag(CN)_2]^-$	$Ag_2S_2O_3$ white ↓H_2O/Δ $Ag_2S\downarrow$ (black) ↓excess $Na_2S_2O_3$ $[Ag(S_2O_3)_2]^{3-}$	$Ag_2CO_3\downarrow$ Yellowish white ↓boil $Ag_2O\downarrow$ (brown)

Page No.
Date : / /

Page No.
Date : / /

careful ↑ extra ↑

Group 2: → IIA : Hg^{2+}, Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}

हीरो Punjab के कुत्ते बीमार

→ IIB : As^{3+}, Sb^{3+}, Sn^{2+}, Sn^{4+}

extra आज सब सन्नाटा है सन्नाटा.

Reagent : H_2S / dil acidic

→ K_{sp} of group 2 ppt is very low so we need more conc of S^{2-},

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

$HCl \longrightarrow H^+ + Cl^-$, due to H^+, rx^n goes back by common ion effect

ppt of group II

yellow Ammonium Sulphate

IIA — Does not dissolve

IIB — Dissolves

(*) Pb^{2+} is present in both group I and group 2 as $PbCl_2$ is very soluble, so if Pb^{2+} remains unppted in test of grp I, it ppts as sulphide

Grp II:

IIA

HgS ↓ (Black)

PbS ↓ (Black)

? Bi_2S_3 ↓ Black / Brown

CuS ↓ Black

CdS ↓ Yellow

IIB

As_2S_3 ↓ Yellow

Sb_2S_3 ↓ Orange

SnS_2 ↓ Yellow

SnS ↓ Brown

Bi_2S_3 : naturally occuring crystals are brown.

: lab ppt is black

	NH_4OH	NH_4OH (excess)	NaOH	NaOH (excess)	KI	KI (excess)	dil HNO_3	dil H_2SO_4
Hg^{2+}	$HgNH_2OH\downarrow$ White ppt	No change ($HgNH_2OH\downarrow$)	$HgO\downarrow$ Brown black	No change ($HgO\downarrow$)	$HgI_2\downarrow$ Scarlet red	$K_2[HgI_4]$ Nessler's reagent	No rxn	$HgSO_4\downarrow$ White
Bi^{3+}	$Bi(OH)_3\downarrow$ White	No change	$Bi(OH)_3\downarrow$ White	No change	$BiI_3\downarrow$ (Black) $\xrightarrow{H_2O}$ $BiOI\downarrow$ (orange ppt) Incomplete hydrolysis	BiI_4^- orange	$Bi(NO_3)_3$	$Bi_2(SO_4)_3$ soln
Cu^{2+}	$Cu(OH)_2\downarrow$ Blue ppt	$Cu(NH_3)_4^{2+}$ deep blue soln i.e ppt dissolves	$Cu(OH)_2\downarrow$ Blue ppt $\xrightarrow{\Delta}$ $CuO\downarrow$ Black	No change	$CuI_2\downarrow$ White	$Cu_2I_2\downarrow + I_3^-$ white	$Cu(NO_3)_2$	$CuSO_4$ blue soln
Pb^{2+}							$Pb(NO_3)_2$	

Page No.
Date: / /

Page No.
Date : / /

Cu^{2+} :

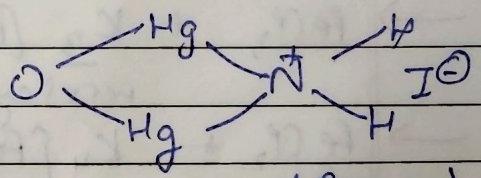
- $CuS + K_4[Fe(CN)_6] \longrightarrow Cu_2[Fe(CN)_6]\downarrow$ (Chocolate brown ppt)
- $CuS \xrightarrow{KCN} Cu(CN)_2\downarrow$ (Yellow ppt) $\xrightarrow[\text{Reduction}]{KCN} CuCN\downarrow$ (White) $+ (CN)_2\uparrow$ (cyanogen)
  - $CuCN \xrightarrow{\text{Reduction}} K_3[Cu(CN)_4]$ (colorless) $\Rightarrow Cu^+$
  - KCN (excess)
  - $K_3[Cu(CN)_4] \xrightarrow{H_2S}$ No rx^n
- Confirmatory
  - $Cu^{2+} + KSCN \longrightarrow \underbrace{Cu(SCN)_2\downarrow}_{\text{Black}} \xrightarrow[\text{Reduction}]{KSCN \text{ (excess)}} Cu(SCN)\downarrow$ (White) $+ (SCN)_2$ (Thiocyanogen)
  - $Cu^{2+} + K_3[Fe(CN)_6] \longrightarrow Cu_3[Fe(CN)_6]_2\downarrow$ (Green) $+ KI$
  - $CuS + K_4[Fe(CN)_6] \longrightarrow Cu_2[Fe(CN)_6]\downarrow$ (Chocolate brown)

School conf: $CuSO_4 + NH_3 \longrightarrow [Cu(NH_3)_4]SO_4 \xrightarrow{CH_3COOH} \xrightarrow{K_4Fe(CN)_6} Cu_2[Fe(CN)_6]$ (choco brown)

Hg^{2+}

- $SnCl_2 + HgCl_2 \longrightarrow SnCl_4 + Hg_2Cl_2\downarrow$ (White)
- $SnCl_2 + Hg_2Cl_2 \longrightarrow SnCl_4 + 2Hg\downarrow$ (Black)
- $Hg^{2+} + Co(SCN)_2 \longrightarrow Co[Hg(SCN)_4]\downarrow$ (Blue crystalline)

Imp:

$K_2[HgI_4] + NH_3 \longrightarrow$ 

Messber's rgt

(Brown)

Iodide salt of Million's base

$H_2N \cdot Hg \cdot O \cdot HgI$

H_2O_2 in basic medium use CH₃COOH (NO)
H_2O_2 in acidic medium use PA
generally

Page No.
Date : / /

Group III: Fe^{3+}, Cr^{3+}, Al^{3+}
फेरस क्रोम अलम

Group reagent: NH_4OH | NH_4Cl

- $Fe(OH)_3\downarrow$ Brown
- $Cr(OH)_3\downarrow$ Green
- $Al(OH)_3\downarrow$ Gelatinous white

Low K_{sp} of hydroxides so excess of NH_4Cl required (otherwise gp 4 ppt)

$NH_4OH \rightleftharpoons NH_4^+ + OH^-$

$NH_4Cl \longrightarrow NH_4^+ + Cl^-$

NH_4^+ → common ion

Cr^{3+}

$Cr(OH)_3 + OH^- \longrightarrow [Cr(OH)_4]^-$

$2[Cr(OH)_4]^- + 2H_2O_2 + 2OH^- \longrightarrow 2CrO_4^{2-} + 8H_2O$

YELLOW

Fe^{3+}

Add dil HCl to ppt

$Fe^{3+} + H_2S \longrightarrow 2Fe^{2+} + S\downarrow + 2H^+$

$FeCl_3 + 3KSCN \longrightarrow Fe(SCN)_3 + KCl$
or NH_4SCN — Blood red

~~or $KFe[Fe(CN)_6]$~~

$FeCl_3 + K_4[Fe(CN)_6] \longrightarrow Fe_4[Fe(CN)_6]_3$
Ferrocyanide — Prussian blue — Ferric ferrocyanide

or $KFe[Fe(CN)_6]$

$FeCl_3 + K_3[Fe(CN)_6] \longrightarrow Fe[Fe(CN)_6]$
Ferricyanide — Brown ppt

$FeCl_2 + K_4[Fe(CN)_6] \longrightarrow Fe_2[Fe(CN)_6] + KCl$
Blurish white ppt

$FeCl_2 + K_3[Fe(CN)_6] \longrightarrow Fe_3[Fe(CN)_6]_2$
Turnbull's blue — Ferro ferricyanide

Al^{3+}

$Al(OH)_3 + Co(NO_3)_2 \longrightarrow CoAl_2O_4 + NO_2\uparrow + O_2\uparrow + H_2O$

Cobalt blue — Blue ash (____ Blue Ash Test)?

Page No.
Date : / /

Blue lake test:-

$Al(OH)_3$ + blue litmus + HCl → red

add NH_4OH → blue lake in colorless medium

For Chromium.

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

$$2Na^+CrO_4^{2-} + 2H_2O_2 + 2H^+ \longrightarrow \underset{\text{Dark blue}}{CrO_5}\downarrow + 3H_2O + 2Na^+$$

Chromic peroxide.

	NH_4OH	excess NH_4OH	NaOH	excess NaOH	KCN/NaCN	excess KCN/NaCN	$(NH_4)_2S$	CH_3COONa
Fe^{3+}	$Fe(OH)_3\downarrow$ Brown	No change (No complex)	$Fe(OH)_3\downarrow$	No change	$Fe(CN)_3\downarrow$ Reddish Brown	$Na_3[Fe(CN)_6]$ Yellow soln	$Fe_2S_3\downarrow + S\downarrow$ Brown	$Fe(CH_3COO)_3$ Blood red soln
Al^{3+}	$Al(OH)_3\downarrow$ Gelatinous white	No change	$Al(OH)_3\downarrow$	$Na[Al(OH)_4]$ Sodium meta aluminate i.e ppt is dissolved	No rxn	No rxn	$Al(OH)_3\downarrow$	$(CH_3COO)Al(OH)_2\downarrow$ White
Cr^{3+}	$Cr(OH)_3\downarrow$ green	$[Cr(NH_3)_6]^{3+}$	$Cr(OH)_3\downarrow$	$Na[Cr(OH)_4]$ Sodium meta chromate	No rxn	No rxn	$Cr(OH)_3$	No rxn

Page No.
Date : / /

$CoCl_2 + H_2O \longrightarrow [Co(H_2O)_6]Cl_2$ → pink

$[Co(H_2O)_6]Cl_2 + HCl_{conc} \longrightarrow H_2[CoCl_4]$ → blue

Page No.
Date : / /

Group IV : Mn^{2+}, Co^{2+}, Zn^{2+}, Ni^{2+}
मान को जाना नहीं

reagent : H_2S/NH_4OH : High Ksp

	NaOH	excess NaOH	H_2S
Zn^{2+}	$Zn(OH)_2\downarrow$ White	Na_2ZnO_2 Soluble	$ZnS\downarrow$ Dirty white
Mn^{2+}	$Mn(OH)_2\downarrow$ (Pink) $\xrightarrow[H_2O]{Br_2}$ $MnO(OH)_2$ or MnO_2 Black/Brown	$MnS + HCl \rightarrow Mn^{2+}$ $\xrightarrow{NaOH}$ $Mn(OH)_2$	• $MnS\downarrow$ Pink/buff colored

$ZnS + HCl \longrightarrow Zn^{2+} + H_2S$

- $3\,Zn^{2+} + 2K_4[Fe(CN)_6] \longrightarrow Zn_3K_2[Fe(CN)_6]_2 + 6K^+$

n factor = 3 (6 cations displaced from 2 moles)

- $Zn^{2+} + (NH_4)_2[Hg(SCN)_4] \xrightarrow{Cu^{2+}} Zn[Hg(SCN)_4]\downarrow$ violet ppt

- To differentiate b/w ZnS & MnS, add _____ ?

- BO_3^- test, green edged flame is observed on heating salt with conc H_2SO_4 & CH_3OH.
Green color is of $(CH_3O)_3B$: Trimethyl borate.

Page No.
Date : / /

Group 5 : Ba^{2+} , Sr^{2+} , Ca^{2+}

B , S , C

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

$\downarrow (NH_4)_2CO_3$

Grp reagent : $(NH_4)_2CO_3 + NH_4OH + NH_4Cl$

$BaCO_3 \downarrow$, $CaCO_3 \downarrow$ (white) $\xrightarrow{CH_3COOH} (CH_3COO)_2Ba$ —

- $Ba^{2+} + K_2CrO_4 \longrightarrow BaCrO_4 \downarrow + 2NH_4^+$

  yellow

  CH_3COOH → insoluble ; Mineral acid → soluble

- $Sr^{2+} + (NH_4)_2SO_4 \longrightarrow BaSO_4 \downarrow + 2NH_4^+$ (or $SrSO_4$.)

  $+Ba^{2+}$

  white

  CH_3COOH → No rxn ; Mineral acid → No rxn

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

  white

  CH_3COOH → dissolves ; Mineral acid → dissolves

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

  white

  CH_3COOH → No rxn ; Mineral acid → dissolves

  Crimson red

That's why proved $Ba \longrightarrow Sr \longrightarrow Ca$.

↓ Grassy green ; ↓ Brick red

Page No.
Date : / /

Group 0 :

→ $NH_4^+ + NaOH \longrightarrow NaCl + NH_3 \uparrow + H_2O$

Ammoniacal smell, colorless, pungent

Bring glass rod dipped in HCl conc in contact

$NH_3 + HCl \longrightarrow NH_4Cl \uparrow$

dense white fumes

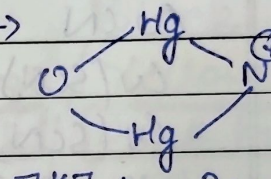
→ $CuSO_4 + HNH_3 \longrightarrow [Cu(NH_3)_4]SO_4$

Deep blue

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

Black

→ $NH_4Cl + 2K_2HgI_4 + 2KOH \longrightarrow$



$+ 7KI + 2H_2O$

Nessler's reagent : Alkaline sol^n of potassium tetraiodomercurate (II)

Mg^{2+} : salt + NH_4Cl + NH_4OH + excess $(NH_4)_2HPO_4$ → White ppt

$MgCl_2 + NH_4OH + (NH_4)_2HPO_4 \longrightarrow Mg(NH_4)PO_4 \downarrow + 2NH_4Cl + H_2O$

Page No.
Date : / /

- List of different colored salts:

Salts	Color
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

Ag_2CrO_4	Red Brown
$Cu(CN)_2$	Yellow
$CuCN$	White
$Cu(SCN)_2$	Black
$Cu(SCN)$	White
Hg_2CrO_4	Red
Hg_2I_2	Yellow / Green
HgI_2	Scarlet Red
PbI_2	Yellow
$Cu(OH)_2$	Blue
$Cd(OH)_2$	White
$Fe(CN)_3$	Reddish Brown
$[Fe(CN)_6]^{3-}$	Yellow
$Fe[Fe(CN)_6]$	Brown
$Mn(NH_4)PO_4$	Pink
$Mn(OH)_2$	White
$MnO \cdot (OH)_2$	Brown
$Zn_3[Fe(CN)_6]_2$	White
$Ca[Fe(CN)_6]$	White
$MgCO_3 \cdot Mg(OH)_2 \cdot 5H_2O$	White
$BiOCl$	White

Page No.
Date : / /

Salts	Color
$BiOI$	Orange
$SbOCl$	White
$Co(CN)_2$	Reddish Brown
$K_3[Co(NO_2)_6]$	Yellow
$[Co(SCN)_4]^{2-}$	Blue
$Ni(OH)_2$	Green
$Ni(CN)_2$	Green.
Ni ——	Red
$[Ni(CN)_4]^{2-}$	Yellow
$BiO \cdot OH$	Yellow/White
PbO_2	Black
Hg_2O	Black
HgO	Orange / Yellow
Ag_2O	Black / Dark brown
$Pb(OH)_2$	White
Hg_2CO_3	Yellow
$HgSO_4$	Yellow
BiI_3	Black
$[BiI_4]^-$	Orange
Cu_2O	Red (charge transfer)
$Bi(OH)_3$	White
$Sn(OH)_2$	White
$[Fe(SCN)(H_2O)_5]^{2+}$	Blood Red Sol^n
FeS	Black
$K_2Ca[Fe(CN)_6]$	White
Hydrated Co^{2+} salts	Pink
Anhydrous Co^{2+} salts	Blue
Ni_2O_3	Black
$HgSO_4 \cdot 2HgO$	Yellow
$BrCl$	Yellow

Page No.
Date : / /

Salt	Color
Li_3N	Ruby Red
K_2O	Pale yellow
KO_2	Orange

Page No.
Date : / /

Gases :

	Gas	color	odor
1)	O_2	Colorless	Odorless
2)	CO_2	—	—
3)	N_2	—	—
4)	NH_3	—	(Ammoniacal) Pungent
5)	SO_2	—	Pungent
6)	HCl	—	Pungent (biting)
7)	H_2S	—	Rotten egg
8)	NO_2	Brown	pungent
9)	Br_2	Reddish brown	Pungent
10)	I_2	Colored (violet)	
11)	Cl_2	Greenish yellow	Pungent
12)	NO	colorless	odorless
13)	N_2O	Colorless	Odorless
14)	N_2O_5	"	"

Flame tests

Some volatile salts impart characteristic color to a non-luminous flame. The chlorides of metals are more volatile as compared to other salts. The metal chlorides volatilize and its thermal ionization takes place:

$NaCl \rightleftharpoons Na^+ + Cl^-$

$CaCl_2 \rightleftharpoons Ca^{2+} + 2Cl^-$

Some cations impart a characteristic color to the flame as the electrons in them absorb energy from the flame, jump to higher energy levels, and while returning, clean energy in the form of visible light

Page No.
Date : / /

	Metal	Color
1)	Li	(Vibrant) Crimson red
2)	Na	Golden yellow
3)	K	Violet / Lilac
4)	Ca	(Orangish) Brick red
5)	Sr	(Vibrant) Crimson red
6)	Ba	Apple Green
7)	Rb	Violet
8)	Cs	Blue.

Page No.
Date : / /

Borax bead tests

On heating Borax, we get a colorless glassy bead consisting of sodium metaborate & Boric anhydride

$Na_2B_4O_7 \cdot 10H_2O \xrightarrow{\Delta} Na_2B_4O_7 \xrightarrow{\Delta} \underbrace{2NaBO_2 + B_2O_3}_{\text{Glassy bead}}$

On heating with a colored salt, the glassy bead forms a colored metaborate in oxidizing flame

The metaborates have different characteristic colors. However in reducing flame, the colors may be different due to different reactions.

Metal	Bead color.			
	Oxidizing Flame		Reducing flame	
	Hot	Cold	Hot	Cold
	$CuCl_2 \leftarrow Cu^{2+} \rightarrow CuSO_4$		$Cu_2Cl_2 \leftarrow Cu^{+} \rightarrow Cu_2O$	
1) Copper	Green	Blue	Colorless	Brown-Red opaque
	$\leftarrow Fe^{3+} \rightarrow$		$FeCl_2 \leftarrow Fe^{2+} \rightarrow$	
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	Amethyst ? / Violet	Grey / Colorless	Grey
6) Nickel	Violet	Brown	Grey	Grey

Page No.
Date : / /

Important chemicals (involved in reactions)

Name	color
$CaCO_3$	Milky white
$Ca(HCO_3)$	Colorless sol^n
$BaCO_3$	Milky white
$Ba(HCO_3)_2$	Colorless sol^n
Ag_2CO_3	White ppt
Ag_2O	Black ppt
$Hg_4O_3CO_3$ or $3HgO \cdot HgCO_3$	Reddish brown
Hg_2CO_3	Yellow
$PbCO_3$	White
$FeCO_3$	White
$CuCO_3$	Blue green
$NiCO_3$	green
$MgCO_3$, $SrCO_3$	White
$CaSO_3$, $BaSO_3$	White
$Ca(HSO_3)_2$, $Ba(HSO_3)_2$	Colorless sol^n
$Cr_2(SO_4)_3$ (Cr^{3+})	Green sol^n
$MnSO_4$ (Mn^{2+})	Pink sol^n
$K_2Cr_2O_7$	Orange
$KMnO_4$	Purple
Ag_2SO_3	White crystalline
$PbSO_3$	White ppt
☆ $BaSO_3$	White, sol^b in HCl.
☆ $BaSO_4$	White, insol^b in HCl
CdS	Yellow
$AgNO_3$	White crystalline
$AgCl$	White ppt
☆ $AgBr$	Pale yellow
☆ AgI	Yellow curdy
☆ CrO_2Cl_2	Orange-red fumes
Na_2CrO_4	Yellow sol^n
☆ HgI_2	Scarlet color

Page No.
Date : / /

Name	Color
$Pb(OH)_2$	White
Na_2PbO_2	Colorless
PbI_2	Yellow ↓
$K_2[PbI_4]$	Colorless
$Pb(CN)_2$	White
$PbCrO_4$	Yellow
PbS_2O_3	White
PbS	black
$2PbCO_3.Pb(OH)_2$	White (White lead)
Ag_2O	Black
Ag_2CrO_4	Brick red
$AgCN$	White
$Ag_2S_2O_3$	White
Ag_2CO_3	Yellowish white
$HgNH_2OH$	White ppt
HgO	Brown-black
$HgSO_4$	White
$Bi(OH)_3$	White ↓
BiI_3	White
$BiOI$	Orange ppt
$Bi_2(SO_4)_3$	Sol^n
$Cu(CN)_2$	Yellow ppt
$Cu(SCN)_2$	Black
Hg_2Cl_2	White
$Cu(OH)_2$	Blue
CuO	Black
Cu_2I_2	White
$CoAl_2O_4$	Blue Ash
$Fe(OH)_2$	Brown
$Fe(CN)_2$	Reddish Brown

Page No.
Date : / /

Name	Color.
FeS	Brown
$Fe(CH_3COO)_3$	Blood red
$Al(OH)_3$	Gelatinous white
$CH_3COOAl(OH)_2$	White
$Mn(OH)_2$	Pink
MnS	Buff

COMPLEXES

	Name	Color.
Used in	Acidic radical tests ↓.	
SO_3^{2-}	$[AgSO_3^-]$	Colorless
S^{2-}	$Na_2[Fe(CN)_5NO]$	Red.
S^{2-}	$Na_4[Fe(CN)_5NOS]$	Purple.
NO_2^-, NO_3^-	$[Fe NO(H_2O)_5]SO_4$	Brown ring
I^-	K_2HgI_4	
Ag	$[Ag(NH_3)_2]^{+}$, $[Ag(CN)_2]^{-}$, $[Ag(S_2O_3)_2]^{3-}$	Soluble.
Hg	K_2HgI_4	Nessler's reagent
	$Co[Hg(SCN)_4]^{2-}$	Blue crystalline
Bi	BiI_4^-	Orange
Cu	$K_3[Cu(CN)_4]$	Colorless
	$[Cu(NH_3)_4]^{2+}$	Deep blue
	$Cu_2[Fe(CN)_6]$	Chocolate brown
	$Cu_3[Fe(CN)_6]_2$	Green

Page No.
Date : / /

Used in	Name	Color
	Ferrocyanides: → Fe^{3+}	
Fe	$Fe_2[Fe(CN)_6]$ (Fe^{2+})	Bluish white
	$Fe_4[Fe(CN)_6]_3$ (Fe^{3+})	Prussian blue.
	Ferricyanides → Fe^{2+}	
	$Fe[Fe(CN)_6]$ → Fe^{3+}	Brown ppt
	$Fe_3[Fe(CN)_6]_2$ → Fe^{2+}	Turnbull's blue
	$Na_3[Fe(CN)_6]$ → Fe^{3+}	Yellow soln
Al	$Na[Al(OH)_4]$	Soln
Cr	$Na[Cr(OH)_4]$	Soln
Zn	$Zn[Hg(SCN)_2]$	Violet ppt
	$Zn_3K_2[Fe(CN)_6]_2$	Soln