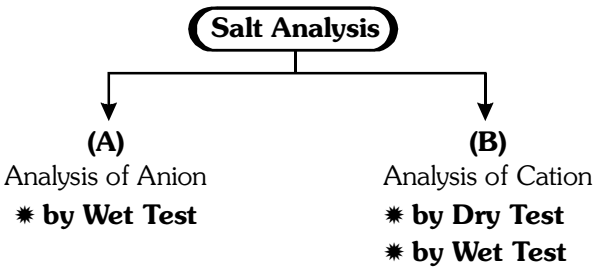
CHAPTER 8

SALT ANALYSIS

Definition :

The branch of chemical analysis which aims to find out the constituents of a mixture of compound is known as Qualitative Analysis.

The identification of a substances usually involves its conversion into a new substance possessing characteristic properties with the help of one or more substance of known composition. The substance which is used to bring about such change is called a Reagent.



ANALYSIS OF ACIDIC RADICAL
Classification of acidic radical

Class - A (Form volatile product with acid)	Class - B (Does not form volatile product with acid)
Sub group-I : (Form volatile product with dil. HCl / dil. H_2SO_4) $CO_3^{2-}, HCO_3^-, SO_3^{2-}, HSO_3^-, S_2O_3^{2-}, S^{2-}, CH_3COO^-, NO_2^-$	**Sub group-I :** (Detected by precipitation reaction) $SO_4^{2-}, PO_4^{3-}, AsO_3^{3-}, AsO_4^{3-}$
Sub group-II : (Form volatile product with conc. H_2SO_4) $F^-, Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, C_2O_4^{2-}$ + sub group-I	**Sub group-II :** (Detected by redox reaction) $CrO_4^{2-}, Cr_2O_7^{2-}, MnO_4^-$

⇒ CO_2 is colourless, odourless gas evolved with brisk effevesence, Detected by lime water test.

⇒ SO_2 is colourless, Suffocating gas with burning sulphur odour. Detected by lime water test or by passing in $Cr_2O_7^{2-}/H^+$ solution.

⇒ H_2S is a colourless gas with rotten egg odour.

⇒ CH_3COOH has colourless fumes having vinegar odour.

⇒ NO_2/Br_2 is brown gas.

⇒ I_2 is violet gas.

LIME WATER / BARYTA WATER TEST :

When CO_2 is passed in lime water or baryta water then white turbidity (milky appearance) is formed due to the formation of soluble carbonate but when excess of CO_2 is passed then white turbidity disappeared due to formation of soluble bicarbonate.

$$CO_2\uparrow + Ca^{2+} + 2OH^- \longrightarrow \underset{\text{White turbidity}}{CaCO_3\downarrow} + H_2O$$

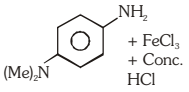
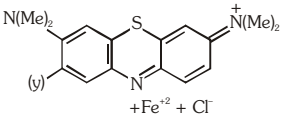
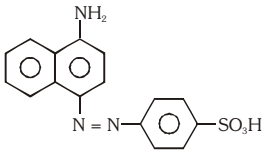
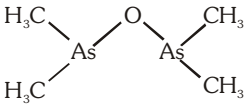
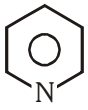
$$CaCO_3\downarrow + CO_2\uparrow + H_2O \longrightarrow \underset{\text{Soluble}}{Ca(HCO_3)_2}$$

Note : SO_2 also gives similar observation.

Acidic Radical Table

	dil. H_2SO_4	Conc. H_2SO_4	$CaCl_2$	$BaCl_2$	$HgCl_2$	$AgNO_3$	$Pb(OAc)_2$	MnO_4^- / H^+
CO_3^{2-}	$CO_2\uparrow$	$CO_2\uparrow$	$CaCO_3\downarrow$ white	$BaCO_3\downarrow$ white	$HgCO_3.3HgO\downarrow$ Reddish brown	$Ag_2CO_3\downarrow$	$PbCO_3.2Pb(OH)_2\downarrow$	—
$\Delta + HCO_3^-$	$CO_2\uparrow$	$CO_2\uparrow$	$CaCO_3\downarrow$	$BaCO_3\downarrow$	$HgCO_3.3HgO\downarrow$ Reddish brown	$Ag_2CO_3\downarrow$	$PbCO_3.2Pb(OH)_2\downarrow$	—
SO_3^{2-}	$SO_2\uparrow$	$SO_2\uparrow$	$CaSO_3\downarrow$ white	$BaSO_3\downarrow$ white	—	$Ag_2SO_3\downarrow$ white	$PbSO_3\downarrow$ white	SO_4^{2-}
$S_2O_3^{2-}$	$SO_2\uparrow + S\downarrow$	$SO_2\uparrow$	—	$BaS_2O_3\downarrow$ white	$HgS_2O_3\downarrow$ white	$Ag_2S_2O_3\downarrow$ white	$PbS_2O_3\downarrow$ white	$SO_4^{2-} + S\downarrow$
S^{2-}	$H_2S\uparrow$	$S\downarrow + SO_2\uparrow$	—	$BaS\downarrow$ black	$HgS\downarrow$ black	$Ag_2S\downarrow$ black	$PbS\downarrow$ black	$S\downarrow$
NO_2^-	$NO_2\uparrow$	$NO_2\uparrow$	—	—	—	$AgNO_2\downarrow$	—	NO_3^-
CH_3COO^-	$CH_3COOH\uparrow$	$CH_3COOH + SO_2\uparrow$	—	—	—	—	—	—
I^-		$I_2\uparrow$ violet	—	—	$HgI_2\downarrow$ scarlet red	$AgI\downarrow$ yellow	$PbI_2\downarrow$ dark yellow	$I_2\uparrow$
Cl^-		$HCl\uparrow$	—	—	—	$AgCl\downarrow$ white	$PbCl_2\downarrow$ white	$Cl_2\uparrow$
Br^-		$Br_2\uparrow$ brown	—	—	—	$AgBr\downarrow$ pale yellow	$PbBr_2\downarrow$ white	$Br_2\uparrow$
$C_2O_4^{2-}$	—	$CO_2\uparrow + CO\uparrow$	$CaC_2O_4\downarrow$ white	$BaC_2O_4\downarrow$ white	—	$Ag_2C_2O_4\downarrow$ white	—	$CO_2\uparrow$
BO_2^-	—	$H_3BO_3\uparrow$	$Ca(BO_2)\downarrow$ white	$Ba(BO_2)\downarrow$ white	—	$AgBO_2\downarrow$ white	—	—
NO_3^-	—	$NO_2\uparrow$	—	—	—	—	—	—
SO_4^{2-}	—	—	$CaSO_4\downarrow$ white	$BaSO_4\downarrow$ curdy white ppt	$HgSO_4.2HgO\downarrow$ yellow	—	$PbSO_4\downarrow$ white	—
PO_4^{3-}	—	—	$CaHPO_4\downarrow$ white	$BaHPO_4\downarrow$ white	—	$Ag_3PO_4\downarrow$ yellow	—	—
CrO_4^{2-}	—	—	—	$BaCrO_4\downarrow$ yellow	—	$Ag_2CrO_4\downarrow$ brick red	$PbCrO_4\downarrow$ yellow	—

SPECIFIC REACTION OF ACIDIC RADICAL

Anion	Reaction Name /with	Reagent	Product	Observation
S^{2-}	Sodium Nitro Prusside	$Na_2[Fe(CN)_5NO]$	$Na_4[(Fe(CN)_5NOS]$	Purple Complex
S^{2-}	Methylene blue Test			Methylene Blue
NO_2^-	Gries Illosavay Test	(i) Sulphanilic acid (ii) 1, napthyl Amine		Red Azo dye
NO_2^-	Brown Ring Test	$FeSO_4$+dil.H_2SO_4	$[Fe(H_2O)_5NO]SO_4$	Brown Ring
CH_3COO^-	Cacodyl Test	As_2O_3		Nauseating odour
CH_3COO^-	$FeCl_3$ Sol^n	$FeCl_3+H_2O \xrightarrow{\text{boil}}$	$[Fe_3(OH)_2(CH_3OO)_6]^+$ ↓ boil $Fe(OH)_2(CH_3COO)$	Blood Red solution ↓ boiling Reddish Brown ppt.
NO_3^-	Brown Ring test	$FeSO_4$+Conc.H_2SO_4	$[Fe(H_2O)_5NO]SO_4$	Brown Ring
$C_2O_4^{2-}$	Mn^{+2} + NaOH	$NaOH + Mn^{+2} \xrightarrow[\text{air}]{\Delta}$	$[Mn(C_2O_4)_3]^{3-}$	Red Complex
Br^-	Layer Test	Cl_2 Water + CCl_4	Br_2+ CCl_4	Red layer
I^-	Layer Test	Cl_2 Water + CCl_4	I_2 + CCl_4	Violet Layer
I^-	$HgCl_2$	$HgCl_2$	HgI_2	Red/yellow
Cl^-	Chromyl Chloride Test	(i) $K_2Cr_2O_7$(s) + conc.H_2SO_4 (ii) NaOH (iii) $Pb(CH_3COO)_2$ + CH_3COOH	CrO_2Cl_2 ↓ CrO_4^{2-} ↓ $PbCrO_4$	Reddish brown Vapour ↓ Yellow Solution ↓ Yellow PPt.
BO_3^{3-}	Green Flame Test	Conc. H_2SO_4 + R OH + Δ(Flame)	$B(OR)_3$	Green edge flame
BO_3^{3-}	Modified Green Flame Test	CaF_2 + Conc. H_2SO_4 + Δ	$BF_3\uparrow$ + $Ca(HSO_4)_2$	Green flame
PO_4^{3-}	Ammonium molybdate	$(NH_4)_2MoO_4$ + dill HNO_3 + 30 – 40° C	$(NH_4)_3PO_4.12MoO_3$	Canary yellow ppt.
CrO_4^{2-} /Cr_2O_7	Acidic Solution of H_2O_2 + pyridine	$H_2O_2 + H^+ +$ 	CrO_5	Blue Solution

BASIC RADICAL ANALYSIS

Dry test of cation :

Flame test : used for s-block cation (except Be^{+2}, Mg^{+2})

Cation :	Li^+	Na^+	K^+	Ca^{+2}	Sr^{+2}	Ba^{+2}	Cu^{+2}
Observation : (Naked eye)	Caramine red	Golden yellow	Lilac	Brick Red	Crimson Red	Apple green	Green flame
Cobalt glass :		flame disappear	crimson red	Light Green	Purple	Bluish green	Green flame

Borax bead test :

⇒ Used for coloured cation (d-block cation)

⇒ Given salt heated on borax bead than metal metaborate are form.

⇒ Metal metaborate on heating show characteristic bead colour.

	Oxidizing flame		**Reducing flame**	
	Hot	Cold	Hot	Cold
Mn	Violet	Amethyst	Colourless	Colourless
Cr	Yellow	Green	Green	Green
Fe	Yellowish brown	Yellow	Green	Green
Co	Blue	Blue	Blue	Blue
Ni	Violet	Brown	Grey	Grey
Cu	Green	Blue	Colourless	Opaque red

Charcol cavity test :

Heat salt with Na_2CO_3 in charcoal cavity

Zn^{+2} In hot yellow and in cold white residue.

Pb^{+2} Yellow residue in hot and grey metal in cold.

As^{+3} White residue with garlic odour.

Cd^{+2} Brown residue.

If white residue is obtain then add. $Co(NO_3)_2$ and heat.

Zn^{+2}	ZnO.CoO	Rinmann's Green
Al^{+3}	$Al_2.O_3$	Thenard Blue
Mg^{+2}	MgO.CoO	Pink residue
Sn^{+2}	SnO.CoO	Bluish residue

Classification of Basic Radical

Group	**Basic Radical**	**Reagent used**	**Precipitate form**
Group-I	Pb^{+2}, Hg_2^{+2}	dil HCl	$\underbrace{AgCl \quad PbCl_2 \quad Hg_2Cl_2}_{\text{white ppt.}}$
Group-II	Cu^{+2}, Pb^{+2}, Hg^{+2}, Cd^{+2}, Bi^{+3}	H_2S+dil. HCl	$\underbrace{Cu_2S, PbS, HgS}_{\text{Black}}, \underbrace{CdS, Bi_2S_3}_{\text{yellow black}}$
	Sn^{+2},Sn^{+4},As^{+3},As^{+5},Sb^{+3},Sb^{+5}		$\underbrace{SnS}_{\text{brown}} \quad \underbrace{SnS_2 \quad As_2S_3\, As_2S_5}_{\text{yellow}} \quad \underbrace{Sb_2S_3 Sb_2S_5}_{\text{orange}}$ brown
Group-III	Cr^{+3}, Al^{+3}, Fe^{+3}	$NH_4OH + NH_4Cl$	$Al(OH)_3$, gelatinous white; $Fe(OH)_3$, reddish brown; $Cr(OH)_3$ green
Group-IV	Zn^{+2}, Mn^{+2}, Ni^{+2}, Co^{+2}	$H_2S + NH_4OH$	$\underbrace{ZnS}_{\text{white}} \quad \underbrace{MnS}_{\text{buff}} \quad \underbrace{NiS \quad CoS}_{\text{black}}$
Group-V	Ca^{+2}, Sr^{+2}, Ba^{+2}	$(NH_4)_2CO_3 + NH_4OH$	$\underbrace{CaCO_3, SrCO_3, BaCO_3}_{\text{white}}$

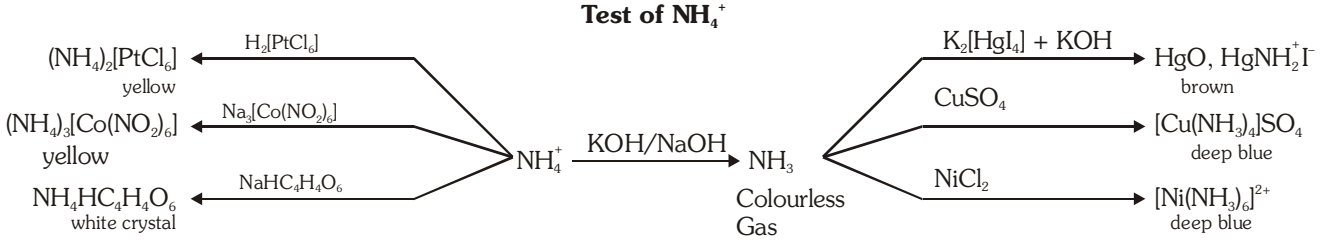
Test of Basic Radical

	Ag^{+}	Hg_2^{2+}	Pb^{2+}	Cu^{+2}	Hg^{+2}	Cd^{+2}	Al^{+3}	Cr^{+3}	Fe^{+3}	Fe^{+2}	Zn^{+2}	Mn^{+2}	Ni^{+2}	Co^{+2}
KI	AgI Yellow	Hg_2I_2 Green	PbI_2 Yellow	$CuI + I_3^-$ White solution	HgI_2 Scarlet Red	——	——	——	$FeI_2 + I_3^-$ yellowish brown sol.	——	——	——	——	——
ex KI	——	$Hg + [HgI_4]^{2-}$ Black	$[PbI_4]^{2-}$ soluble complex	——	$[HgI_4]^{2-}$ Solution	——	——	——	——	——	——	——	——	——
KCN	$AgCN$ White	$Hg + Hg(CN)_2$ Black	$Pb(CN)_2$ White	$CuCN + (CN)_2\uparrow$ White	——	$Cd(CN)_2$ White	——	——	$Fe(CN)_3$ Brown	$Fe(CN)_2$ yellowish brown	$Zn(CN)_2$ White	$Mn(CN)_2.Mn(OH)_2$ Pink	$Ni(CN)_2$ green	$Co(CN)_2$ Reddish Brown
ex KCN	$[Ag(CN)_2]^-$	——	——	$K_3[Cu(CN)_4]$ soluble complex	——	$[Cd(CN)_4]^{2-}$	——	——	$K_3[Fe(CN)_6]$ Yellow	$K_4[Fe(CN)_6]$ Pale yellow	——	——	$K_2[Ni(CN)_4]$ Soluble complex	$[Co(CN)_6]^{-4}$ Brown Solution
NaOH	Ag_2O Bbrown	Hg_2O Black	$Pb(OH)_2$ White	$Cu(OH)_2$ Pale Blue	HgO yellow	$Cd(OH)_2$ White	$Al(OH)_3$ Gelatinous white	$Cr(OH)_3$ Green	$Fe(OH)_3$ Reddish Brown ppt.	$Fe(OH)_2$ Dirty Green	$Zn(OH)_2$ White	$Mn(OH)_2$ Pink	$Ni(OH)_2$ Green	$Co(OH)Cl$ Blue
ex NaOH	——	——	$Na_2[Pb(OH)_4]$ soluble complex	——	——	——	$Na[Al(OH)_4]$ soluble complex	$Na[Cr(OH)_4]$ Yellow	——	——	$Na_2[Zn(OH)_4]$	——	——	$Co(OH)_2$ pink
NH_4OH	Ag_2O Brown	$Hg + HgO.HgNH_2^+ NO_3^-$ black white	$Pb(OH)_2$ White	$Cu(OH)_2$ Pale Blue	$HgO.HgNH_2^+Cl^-$ White	$Cd(OH)_2$ White	$Al(OH)_3$ Gelatinous white	$Cr(OH)_3$ Green	$Fe(OH)_3$ Reddish Brown ppt.	$Fe(OH)_2$ Dirty Green	$Zn(OH)_2$ White	$Mn(OH)_2$	$Ni(OH)_2$ Green	$Co(OH)Cl$ Blue
ex NH_4OH	$[Ag(NH_3)_2]^+$	——	——	$[Cu(NH_3)_4]^{2+}$ Deep blue.	——	$[Cd(NH_3)_4]^{2+}$	——	$[Cr(NH_3)_6]^{3+}$ Pink/voilet	——	——	$[Zn(NH_3)_4]^{2+}$ White	——	$Ni[(NH_3)_6]^{2+}$ Deep blue	$[Co(NH_3)_6]^{2+}$ Yellow
H_2S/*$(NH_4)_2S$	Ag_2S Black	$\underbrace{Hg + HgS}_{\text{black}}$	PbS Black	CuS Black	HgS Black	CdS Yellow	$Al(OH)_3$ Gelatinous white	$Cr(OH)_3$ Green	$FeS + S$ Black yellow	FeS Black	ZnS White	MnS Pink	NiS Black	CoS Black
K_2CrO_4	Ag_2CrO_4 Red	Hg_2CrO_4 Red	$PbCrO_4$ Yellow	——	——	——	——	——	——	——	——	——	——	——
$Na_2S_2O_3$	$Ag_2S_2O_3$ White	——	PbS_2O_3 White	$Cu_2S_2O_3$ White	HgS_2O_3 White	——	——	——	Fe^{+2} Green solution					
$K_4[Fe(CN)_6]$	$Ag_4[Fe(CN)_6]$ White	——	——	$Cu_2[Fe(CN)_6]$ Brown	——	$Cd_2[Fe(CN)_6]$	——	——	$Fe_4[Fe(CN)_6]_3$ Prussian blue	$K_2Fe[Fe(CN)_6]$ White	$K_2Zn_3[Fe(CN)_6]$ White	$Mn_2[Fe(CN)_6]$ White	$Ni_2[Fe(CN)_6]$ Light green	$Co_2[Fe(CN)_6]$ Green
$K_3[Fe(CN)_6]$	——	——	——	$Cu_3[Fe(CN)_6]$ Green	——	——	——	——	$Fe[Fe(CN_6)]$ Brown	$Fe_3[Fe(CN_6)]_2$ Turnbull's blue	——	——	——	——

Other important reaction of basic radical

Basic radical	Reagent	Product	Observation
Fe^{+3}	SCN^-	$[Fe(H_2O)_5(SCN)]^{2+}$	Blood red colouration
Ni^{+2}	dmg / NH_4^+	$[Ni(dmg)_2]$	Rosy red complex
Co^{+2}	KNO_2	$K_3[Co(NO_2)_6]$	Yellow ppt
Hg^{+2}	$SnCl_2$(ex)	Hg	Grey / black
K^+	$HClO_4$	$KClO_4$	White ppt

Test of NH_4^+



IMPORTANT NOTES