CHAPTER

16 Salt Analysis

INTRODUCTION

Qualitative analysis involves the detection of cation(s) and anion(s) of a salt or a mixture of salts.

Preliminary Test

1. Physical appearance (smell):

Table: 1

Take a pinch of the salt between your fingers and rub with a drop of water	
Smell	**Inference**
Ammoniacal smell	NH_4^+
Vinegar like smell	CH_3COO^-
Smell like that of rotten eggs	S^{2-}

2. Dry Heating Test:

This test is performed by heating a small amount of mixture in a dry test tube. Quite valuable information can be generated by carefully performing and noting the observations here. On heating, some salts undergo decomposition thus evolving the gases or may undergo characteristic changes in the colour of residue.

3. Flame test:

Table: 2

Colour of Flame	Inference
Crimson Red / Carmine Red	Lithium
Golden yellow	Sodium
Violet/Lilac	Potassium
Brick red	Calcium
Crimson	Strontium
Apple Green/Yellowish Green	Barium
Green with a Blue centre/Greenish Blue	Copper

4. Borax Bead test:

On heating, borax forms a colourless glassy bead of $NaBO_2$ and B_2O_3.

$$Na_2B_4O_7.10H_2O \xrightarrow{\Delta} Na_2B_4O_7 \xrightarrow{\Delta} 2NaBO_2 + B_2O_3$$

On heating with a coloured salt , the glassy bead forms a coloured metaborate in oxidising flame.

For example, In oxidising flame, copper salts give blue bead.

$CuSO_4 \longrightarrow CuO + SO_3$; $CuO + B_2O_3 \longrightarrow Cu(BO_2)_2$ (blue bead)

5. Solubility Chart:

Table: 3

S. No.	Anion	Solubility / Exception
1.	CO_3^{2-}	Except carbonates of alkali metals and of ammonium, all other normal carbonates are insoluble.
2.	SO_3^{2-}	Only the sulphites of the alkali metals and of ammonium are water soluble. The sulphite of other metals are either sparingly soluble or insoluble.
3.	S^{2-}	The acid, normal and polysulphide of alkali metals are soluble in water. The normal sulphides of most other metals are insoluble, those of the alkaline earths are sparingly soluble, but are gradually changed by contact with water into soluble hydrogen sulphides.
4.	NO_2^- , NO_3^-	Almost all nitrites and nitrates are soluble in water. $AgNO_2$ is sparingly soluble. Nitrates of mercury and bismuth give basic salts on treatment with water. These are soluble in dilute nitric acid.
5.	CH_3COO^-	Acetates are water soluble except Ag(I) and Hg(II) acetates which are sparingly soluble.
6.	Cl^-	Most chlorides are soluble in water. $PbCl_2$ (sparingly soluble in cold but readily soluble in boiling water), Hg_2Cl_2, AgCl, CuCl, BiOCl, SbOCl and Hg_2OCl_2 are insoluble in water.
7.	Br^-	Silver, mercury(I) and copper(I), bromides are insoluble. Lead bromide is sparingly soluble in cold but more soluble in boiling water. All other bromides are soluble in water.
8.	I^-	Silver, mercury(I), mercury(II), copper(I), lead and bismuth(III) iodides are the least soluble in water.
9.	SO_4^{2-}	The sulphates of barium, silver lead are insoluble in water, those of calcium and mercury(II) are slightly soluble. Some basic sulphates of mercury, bismuth and chromium are also insoluble, but these dissolve in dilute hydrochloric or nitric acid.
10.	PO_4^{3-}	The phosphate of the alkali metals, with the exception of lithium and ammonium, are soluble in water ; the primary phosphate of the alkaline earth metals are soluble. All the phosphates of the other metals and also the secondary and tertiary phosphate of the alkaline earth metals are sparingly soluble or insoluble in water.

Analysis of ANIONS (Acidic Radicals)

Analysis of anions (acidic radicals) can be broadly divided into two groups.

(A) GROUP 'A' RADICALS: It involves those anions which are characterised by volatile products by reaction with HCl/ H_2SO_4. It is further subdivided into two groups as given below.

(a) Dilute Sulphuric acid/Dilute Hydrochloric acid: The anions of this group liberate gases or acid vapours with dilute sulphuric acid/hydrochloric acid.

Table: 4

Observation	Inference	
	Gas	Radical
Effervescence with the evolution of a colourless and odourless gas which turns lime water milky	CO_2	CO_3^{2-}
Evolution of colourless gas having smell of rotten egg which turns lead acetate paper black.	H_2S	S^{2-}
Colourless gas having suffocating odour (like burning sulphur) which turns acidified $K_2Cr_2O_7$ paper green.	SO_2	SO_3^{2-}
Evolution of reddish brown pungent smelling gas which turns **(i)** $FeSO_4$ solution brownish-black and **(ii)** wet starch –iodide paper blue.	NO_2	NO_2^-
Colourless gas having smell of vinegar.	HAc(g)	CH_3COO^-
No peculiar gas is evolved.	–	All above are absent

(b) Concentrated Sulphuric acid group: The anions of this group liberate acid vapours or gases with conc. H_2SO_4.

Table: 5

Observation	Inference	
	Gas	Radical
Colourless gas with pungent smell which gives dense white fumes with a glass rod dipped in NH_4OH.	HCl	Cl^-
Reddish brown gas with pungent smell, intensity of reddish brown fumes increases on addition of a pinch of solid MnO_2. Also, it turns starch paper, orange red.	Br_2	Br^-
Evolution of violet vapours which turns starch paper, blue.	I_2	I^-
Evolution of reddish brown fumes which intensifies on addition of copper turnings or bits of filter paper. Starch iodide paper develops a blue–black spot due to the formation of a I_2–starch complex. (NO_2 liberated acts as oxidising agent).	NO_2	NO_3^-

(B) GROUP 'B' RADICALS: Anions of this group do not give acid vapours or gases with dilute as well as concentrated H_2SO_4 but are characterised by their specific reactions in solutions. This group is further sub divided into two groups based on the type of the reactions.

(a) Oxidation and reduction in solutions: CrO_4^{2-}, $Cr_2O_7^{2-}$ etc.

(b) Precipitation reactions: These are given by SO_4^{2-}, PO_4^{3-} etc.

Observation	Inference
W.E. or S.E. + $BaCl_2$(aq) ⟶ White precipitate, insoluble in dil. HCl and HNO_3	SO_4^{2-}
W.E or S.E + conc. HNO_3 (1–2 mL) + ammonium molybdate and boil → Canary yellow precipitate	PO_4^{3-}

Classification of Cations

Cations are classified into five groups on the basis of their behaviour with some reagents.

Table: 6

Group	Group Reagent	Ions	Colour and Ppt.
Group I	dil. HCl	Pb^{2+} , Hg^{+}, Ag^{+}	$PbCl_2$, Hg_2Cl_2, AgCl-White Cds, As_2S_3, As_2S_5, SnS_2 -Yellow
Group II A Group II B	H_2S in dil. HCl	Hg^{2+}, Cu^{2+}, Bi^{3+}, Cd^{2+} As^{3+}, As^{5+}, Sb^{3+}, Sb^{5+}, Sn^{2+}, Sn^{4+}	HgS, CuS,Pbs, Bi_2S_3 - Black Sb_2S_3, Sb_2S_5 - Orange; SnS - Brown
Group III	NH_4OH in presence of NH_4Cl	Fe^{3+}, Al^{3+}, Cr^{3+}	$Fe(OH)_3$ - Brown; $Al(OH)_3$ - White; $Cr(OH)_3$ - Green
Group IV	H_2S in presence of NH_3 and NH_4Cl or $(NH_4)S$	Ni^{2+}, Co^{+2}, Mn^{+2}, Zn^{+2}	ZnS - White or grey; CoS, NiS - Black; MnS - Buff (light pink)
Group V	$(NH_4)_2CO_3$ in presence of NH_4Cl and NH_4OH	Ba^{+2}, Sr^{+2}, Ca^{+2}	$BaCO_3$, $SrCO_3$, $CaCO_3$ - White
Group VI	No common group reagent	Mg^{2+}, Na^{+}, K^{+}	$Mg(NH_4)PO_4$ - White