

# Chapter 23

## Principles Related to Practical Chemistry

### ANALYSIS OF ACIDIC RADICALS

Acidic radicals are categorised into three groups. There is no such scheme which permits the separation of the common anions into major groups. The classification may be studied in two parts :

1. Those involving the identification by volatile products obtained on treatment with acids, and
2. Those dependent upon reactions in solution.

The part (1) is subdivided into

- (i) Gases evolved with dilute HCl or dil  $\text{H}_2\text{SO}_4$  and
- (ii) Gases or vapours evolved with conc.  $\text{H}_2\text{SO}_4$ .

The part (2) is subdivided into

- (i) Precipitation reactions and
- (ii) Oxidation and reduction in solution

### Group Category of Acid Radicals

#### Group I :

Radicals which are detected by dilute  $\text{H}_2\text{SO}_4$  or dilute HCl, by liberating a gas/volatile material

- (i) Carbonate
- (ii) Sulphite
- (iii) Sulphide
- (iv) Nitrite
- (v) Acetate

#### Group II :

Radicals which are detected by concentrated  $\text{H}_2\text{SO}_4$

- (i) Chloride
- (ii) Bromide
- (iii) Iodide
- (iv) Nitrate
- (v) Oxalate

**Group III :**

Radicals which do not give any characteristic gas with dilute and concentrated  $\text{H}_2\text{SO}_4$

- (i) Sulphate
- (ii) Phosphate
- (iii) Borate
- (iv) Fluoride

| Group | Group reagent                                                                                                                                                                            | Group radicals                                                                                                                      | Colour & Observation                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.    | Dil. $\text{H}_2\text{SO}_4$ or dil HCl                                                                                                                                                  | (i) $\text{CO}_3^{2-}$<br>(ii) $\text{SO}_3^{2-}$<br>(iii) $\text{S}^{2-}$<br>(iv) $\text{NO}_2^-$<br>(v) $\text{CH}_3\text{COO}^-$ | Brisk effervescence in cold with evolution of colourless and odourless gas i.e. $\text{CO}_2$<br>Colourless gas with suffocating odour (smell of burning sulphur) i.e. $\text{SO}_2$<br>A colourless gas with smell of rotten eggs i.e. $\text{H}_2\text{S}$<br>A light brown gas i.e. $\text{NO}_2$<br>Colourless vapours with smell of vinegar.                                                                              |
| 2.    | Conc. $\text{H}_2\text{SO}_4$                                                                                                                                                            | (i) $\text{Cl}^-$<br>(ii) $\text{Br}^-$<br>(iii) $\text{I}^-$<br>(iv) $\text{NO}_3^-$<br>(v) $\text{C}_2\text{O}_4^{2-}$            | Colourless gas with pungent smell which fumes in air.<br>Reddish brown fumes which intensify on addition of $\text{MnO}_2$ .<br>Violet pungent fumes evolved which intensify on addition of $\text{MnO}_2$ and condense as black.<br>Light brown vapours with pungent smell and intensify on addition of Cu turnings.<br>Colourless, odourless gas burns with blue flame at the mouth of test tube and turns lime water milky. |
| 3.    | $\text{BaCl}_2$<br>$\text{C}_2\text{H}_5\text{OH}$ and conc. $\text{H}_2\text{SO}_4$<br>Conc. $\text{HNO}_3$ and $(\text{NH}_4)_2\text{MoO}_4$<br>Sand and conc. $\text{H}_2\text{SO}_4$ | $\text{SO}_4^{2-}$<br>$\text{BO}_3^{3-}$<br>$\text{PO}_4^{3-}$<br>$\text{F}^-$                                                      | White precipitate of $\text{BaSO}_4$ , insoluble in conc. $\text{HNO}_3$ .<br>Green edged blue flame of $(\text{C}_2\text{H}_5)_3\text{BO}_3$ .<br>A canary yellow precipitate of $(\text{NH}_4)_3\text{PO}_4 \cdot 12\text{MoO}_3$ .<br>Waxy white deposit of silicic acid i.e. $\text{H}_4\text{SiO}_4$ or $\text{Si}(\text{OH})_4$ .                                                                                        |

**Identification of Acid Radicals**

Group : I  
 Group acidic radicals :  $\text{CO}_3^{2-}$ ,  $\text{SO}_3^{2-}$ ,  $\text{S}^{2-}$ ,  $\text{NO}_2^-$   
 Group reagent : dil. HCl or dil.  $\text{H}_2\text{SO}_4$

**ANALYSIS OF BASIC RADICALS****Group - II :**

Group - II is categorised as group-IIA and Group-IIB. The ions of this group do not react with HCl but precipitate with  $\text{H}_2\text{S}$  in dilute mineral acidic medium.

The Group-IIA sulphides of these cations are insoluble in ammonium polysulphide. The Group-IIB sulphides of these cations are soluble in ammonium polysulphide.

**Group-IIA**

- (i) Mercury (II) ion
- (ii) Bismuth (III) ion
- (iii) Copper (II) ion
- (iv) Cadmium (II) ion

**Group-IIB**

- (i) Arsenic (III) ion
- (ii) Antimony (III) ion
- (iii) Tin (II) ion
- (iv) Tin (IV) ion

**Group-III :**

Group-III cations do not react with dil. HCl or with  $\text{H}_2\text{S}$  in dilute acidic medium.

Group-III cations precipitate with ammonium hydroxide

- (i) Iron (III) ion
- (ii) Aluminium (III) ion
- (iii) Chromium (III) ion

**Group-IV :**

Group-IV cations form sulphides with  $\text{H}_2\text{S}$  in presence of  $\text{NH}_4\text{OH}$ , these sulphides are insoluble in  $\text{NH}_4\text{OH}$ .

- (i) Zinc (II) ion
- (ii) Manganese (II) ion
- (iii) Cobalt (II) ion
- (iv) Nickel (II) ion

**Group-V :**

Group-V cations give precipitate with ammonium carbonate in presence of  $\text{NH}_4\text{Cl}$  in neutral or slightly alkaline medium.

- (i) Barium (II) ion
- (ii) Strontium (II) ion
- (iii) Calcium (II) ion

**Group-VI :**

Group-VI cation reacts with  $\text{Na}_2\text{HPO}_4$  to form precipitate

- (i) Magnesium (II) ion
- (ii) Sodium (I) ion
- (iii) Potassium (I) ion
- (iv) Lithium (I) ion

**Group Zero :**

Group zero cation *i.e.*  $\text{NH}_4^+$  reacts with NaOH to give  $\text{NH}_3$  gas

| Group | Group Reagent                                                                     | Basic Radicals                                                                                                                                                                   | Colour and Composition of Precipitate                                                                                                                                                                                                 |
|-------|-----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.    | Dil. HCl                                                                          | Ag <sup>+</sup><br>Pb <sup>+2</sup><br>Hg <sub>2</sub> <sup>+2</sup>                                                                                                             | AgCl — White<br>PbCl <sub>2</sub> — White<br>Hg <sub>2</sub> Cl <sub>2</sub> — White                                                                                                                                                  |
| 2.    | H <sub>2</sub> S in presence of dil. HCl                                          | Hg <sup>+2</sup><br>Pb <sup>+2</sup><br>Bi <sup>+3</sup><br>Cu <sup>+2</sup><br>Cd <sup>+2</sup><br>As <sup>+3</sup><br>Sb <sup>+3</sup><br>Sn <sup>+2</sup><br>Sn <sup>+4</sup> | HgS — Black<br>PbS — Black<br>Bi <sub>2</sub> S <sub>3</sub> — Black<br>CuS — Black<br>CdS — Yellow<br>As <sub>2</sub> S <sub>3</sub> — Yellow<br>Sb <sub>2</sub> S <sub>3</sub> — Orange<br>SnS — Brown<br>SnS <sub>2</sub> — Yellow |
| 3.    | NH <sub>4</sub> OH in presence of NH <sub>4</sub> Cl                              | Fe <sup>+3</sup><br>Cr <sup>+3</sup><br>Al <sup>+3</sup>                                                                                                                         | Fe(OH) <sub>3</sub> — Reddish Brown<br>Cr(OH) <sub>3</sub> — Green<br>Al(OH) <sub>3</sub> — White                                                                                                                                     |
| 4.    | H <sub>2</sub> S in presence of NH <sub>4</sub> OH                                | Mn <sup>+2</sup><br>Co <sup>+2</sup><br>Ni <sup>+2</sup>                                                                                                                         | MnS — Buff<br>CoS — Black<br>NiS — Black                                                                                                                                                                                              |
| 5.    | (NH <sub>4</sub> ) <sub>2</sub> CO <sub>3</sub> in presence of NH <sub>4</sub> OH | Ba <sup>+2</sup><br>Sr <sup>+2</sup><br>Ca <sup>+2</sup>                                                                                                                         | BaCO <sub>3</sub> — White<br>SrCO <sub>3</sub> — White<br>CaCO <sub>3</sub> — White                                                                                                                                                   |
| 6.    | Na <sub>2</sub> HPO <sub>4</sub>                                                  | Mg <sup>+2</sup>                                                                                                                                                                 | Mg(NH <sub>4</sub> )PO <sub>4</sub> — White                                                                                                                                                                                           |
| Zero  | NaOH                                                                              | NH <sub>4</sub> <sup>+</sup>                                                                                                                                                     | NH <sub>3</sub> gas                                                                                                                                                                                                                   |

