CHAPTER-4
ANALYTICAL CHEMISTRY

Revision Notes

- Qualitative analysis is carried out with the help of reagents. A reagent is a substance that reacts with another substance. Alkalis such as NaOH, KOH, NH_4OH are important laboratory reagents. These alkalis give characteristic tests with various metal ions from which these metal ions can be identified.

- **Colour of the Salts and Their Solutions:**

  The salts of normal elements, i.e., the elements of group 1, 2 and 13 to 17 are generally colourless. Salts of transition elements, i.e., the elements of group 3 to 12 are generally coloured.

Colourless Ions		
Cation	**Symbol**	**Colour**
Ammonium ion	NH_4^+	
Sodium ion	Na^+	
Potassium ion	K^+	
Calcium ion	Ca^{2+}	
Magnesium ion	Mg^{2+}	
Aluminium ion	Al^{3+}	
Lead ion	Pb^{2+}	
Zinc ion	Zn^{2+}	
Cupric ion	Cu^{2+}	Blue
Ferrous ion	Fe^{2+}	Light green
Ferric ion	Fe^{3+}	Yellow/brown
Nickel ion	Ni^{2+}	Green
Chromium ion	Cr^{3+}	Green
Manganese ion	Mn^{2+}	Pink

Colourless ions	Symbol	Coloured ions	Symbol	Colour
Chloride ion	Cl^-	Permanganate ion	MnO_4^-	Pink or Purple
Sulphate ion	SO_4^{2-}			
Carbonate ion	CO_3^{2-}	Dichromate ion	$Cr_2O_7^{2-}$	Orange
Nitrate ion	NO_3^-			
Hydride ion	H^-	Chromate ion	CrO_4^{2-}	Yellow
Bicarbonate ion	HCO_3^-			
Sulphide ion	S^{2-}			
Bromide ion	Br^-			
Acetate ion	CH_3COO^-			

➢ **Action of Sodium hydroxide (NaOH) with solution of salts of metals:**

Ion	Salt (Colour)	Reaction	Precipitate formed	Colour of the precipitate	Solubility of the precipitate in an excess of NH_4OH
Mg^{2+}	$MgSO_4$ (Magnesium sulphate) (White)	$MgSO_4 + 2NaOH \rightarrow Mg(OH)_2\downarrow + Na_2SO_4$	$Mg(OH)_2$ (Magnesium hydroxide)	White	Insoluble
Fe^{2+}	$FeSO_4$ (Ferrous sulphate) (Green)	$FeSO_4 + 2NaOH \rightarrow Fe(OH)_2\downarrow + Na_2SO_4$	$Fe(OH)_2$ (Ferrous hydroxide or Iron (II) hydroxide)	Dirty green	Insoluble
Fe^{3+}	$FeCl_3$ (Ferric chloride) (Brown)	$FeCl_3 + 3NaOH \rightarrow Fe(OH)_3\downarrow + 3NaCl$	$Fe(OH)_3$ (Ferric hydroxide or Iron (III) hydroxide)	Reddish brown	Insoluble
Cu^{2+}	$CuSO_4$ (Copper sulphate) (Blue)	$CuSO_4 + 2NaOH \rightarrow Cu(OH)_2\downarrow + Na_2SO_4$	$Zn(OH)_2$ (Zinc hydroxide)	Pale blue	Soluble
Zn^{2+}	$ZnSO_4$ (Zinc sulphate) (Colourless)	$ZnSO_4 + 2NaOH \rightarrow Zn(OH)_2\downarrow + Na_2SO_4$ $Zn(OH)_2 + 2NaOH \rightarrow$ (Excess) $Na_2ZnO_2 + 2H_2O$ Sodium zincate (Soluble)	$Zn(OH)_2$ (Zinc hydroxide)	White gelatinous	Soluble
Pb^{2+}	$Pb(NO_3)_2$ (Lead nitrate) (Colourless)	$Pb(NO_3)_2 + 2NaOH \rightarrow Pb(OH)_2\downarrow + 2NaNO_3$ $Pb(OH)_2 + 2NaOH \rightarrow$ (Excess) $Na_2PbO_2\downarrow + 2H_2O$ Sodium plumbite (Soluble)	$Pb(OH)_2$ (Lead (II) hydroxide)	Chalky White	Soluble

Ca^{2+}	$Ca(NO_3)_2$ (Calcium nitrate) (Colourless)	$Ca(NO_3)_2 + 2NaOH \rightarrow Ca(OH)_2\downarrow + 2NaNO_3$	$Ca(OH)_2$ (Calcium hydroxide)	White	Sparingly Soluble

➢ **Action of Ammonium hydroxide (NH_4OH) with solution of salts:**

Ion	Salt (Colour)	Reaction	Precipitate formed	Colour of the precipitate	Solubility of the precipitate in an excess of NH_4OH
Mg^{2+}	$MgCl_2$ (Magnesium chloride) (White)	$MgCl_2 + 2NH_4OH \rightarrow Mg(OH)_2\downarrow + 2NH_4Cl$	$Mg(OH)_2$ (Magnesium hydroxide)	White	Insoluble
Fe^{2+}	$FeSO_4$ (Iron (II) sulphate) (Green)	$FeSO_4 + 2NH_4OH \rightarrow Fe(OH)_2\downarrow + (NH_4)_2SO_4$	$Fe(OH)_2$ (Iron (II) hydroxide)	Dirty green	Insoluble
Fe^{3+}	$FeCl_3$ (Iron (III) chloride) (Brown)	$FeCl_3 + 3NH_4OH \rightarrow Fe(OH)_3\downarrow + 3NH_4Cl$	$Fe(OH)_3$ Iron (III) hydroxide)	Reddish brown	Insoluble
Cu^{2+}	$CuSO_4$ (Copper sulphate) (Blue)	$CuSO_4 + 2NH_4OH \rightarrow Cu(OH)_2\downarrow + (NH_4)_2SO_4$ $Cu(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \rightarrow [Cu(NH_3)_4]\,SO_4 + 4H_2O$ (Excess)	$Cu(OH)_2$ (Copper (II) hydroxide) Tetraammine copper (II) sulphate	Pale blue Deep blue solution	Soluble
Zn^{2+}	$ZnSO_4$ (Zinc sulphate) (Colourless)	$ZnSO_4 + 2NH_4OH \rightarrow Zn(OH)_2\downarrow + (NH_4)_2SO_4$ $Zn(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \rightarrow [Zn(NH_3)_4]\,SO_4 + 4H_2O$ (Excess)	$Zn(OH)_2$ (Zinc(II) hydroxide) Tetraammine zinc(II) sulphate	White gelatinous colourless solution	Soluble (Soluble)
Pb^{2+}	$Pb(NO_3)_2$ (Lead (II) nitrate) (white)	$Pb(NO_3)_2 + 2NH_4OH \rightarrow Pb(OH)_2\downarrow + 2NH_4NO_3$	$Pb(OH)_2$ (Lead(II) hydroxide)	Chalky White	Soluble

➢ **Action of Sodium hydroxide (NaOH) with zinc, aluminium and lead (action of alkalis on metals):**

$$Zn + \underset{(conc.)}{2NaOH} \xrightarrow{\Delta} \underset{\substack{\text{Sodium zincate}\\(\text{colourless})}}{Na_2ZnO_2} + H_2$$

$$2Al + \underset{Conc.}{2NaOH} + 2H_2O \xrightarrow{\Delta} \underset{\substack{\text{Sodium}\\\text{meta-alu min ate}\\(\text{colourless})}}{2NaAlO_2} + 3H_2$$

$$Pb + \underset{Conc.}{2NaOH} \xrightarrow{\Delta} \underset{\substack{\text{Sodium}\\\text{Plumbite}\\(\text{colourless})}}{Na_2PbO_2} + H_2$$

Similarly, we can write reactions with potassium hydroxide (KOH).

➢ **Action of alkalis on amphoteric metal oxides / metal hydroxides (Action with sodium hydroxide (NaOH):**

$$\underset{(white)}{ZnO} + \underset{Conc.}{2NaOH} \xrightarrow{\Delta} \underset{\substack{\text{Sodium}\\\text{Zincate}\\(\text{colourless, soluble})}}{Na_2ZnO_2} + H_2O$$

$$\underset{\text{(white)}}{Zn(OH)_2} + 2\underset{\text{Conc.}}{NaOH} \xrightarrow{\Delta} \underset{\substack{\text{Sodium Zincate}\\ \text{(colourless, soluble)}}}{Na_2ZnO_2} + 2H_2O$$

$$\underset{\text{(Yellow)}}{PbO} + 2\underset{\text{Conc.}}{NaOH} \xrightarrow{\Delta} \underset{\substack{\text{Sodium plumbite}\\ \text{(colourless, soluble)}}}{Na_2PbO_2} + H_2O$$

$$\underset{\text{(Yellow)}}{Pb(OH)_2} + 2\underset{\text{Conc.}}{NaOH} \xrightarrow{\Delta} \underset{\substack{\text{Sodium plumbite}\\ \text{(colourless, soluble)}}}{Na_2PbO_2} + 2H_2O$$

$$\underset{\text{(White)}}{Al_2O_3} + 2\underset{\text{Conc.}}{NaOH} \xrightarrow{\Delta} \underset{\substack{\text{Sodium meta-aluminate}\\ \text{(colourless, soluble)}}}{2NaAlO_2} + H_2O$$

$$\underset{\text{(White)}}{Al(OH)_3} + \underset{\text{Conc.}}{NaOH} \xrightarrow{\Delta} \underset{\substack{\text{Sodium meta-aluminate}\\ \text{(colourless, soluble)}}}{NaAlO_2} + 2H_2O$$

Similarly, we can write reactions with KOH.

Key Words

- **Analysis:** Involves the determination of chemical components present in a given sample in case of chemistry.
- **Analytical chemistry:** A branch of chemistry which deals with the experimental study of sample by qualitative as well as quantitative means.
- **Qualitative analysis:** Deals with the identification of unknown substances in a given sample by chemical tests.
- **Quantitative analysis:** Deals with the determination of composition of a mixture.
- **Precipitation:** It is the process of formation of an insoluble solid substance in water by mixing which is called precipitate.
- **Reagent:** It is a substance which reacts with another substance.

Key Terms

- When the sodium hydroxide solution is added drop by drop to the solution of metallic salts, the metal hydroxide formed gets precipitated.
- Colour of the precipitate identifies the specific metal ion.
- When ammonium hydroxide solution is added drop-wise to the solutions of metallic salts, precipitates of their hydroxides are formed, which are identified by their distinct colours.
- Some precipitated metallic hydroxides are soluble in excess of NH_4OH due to the formation of soluble amino compounds on further reaction with excess of NH_4OH.
- Certain metals like Zn, Al and Pb react with hot concentrated caustic alkalis (NaOH or KOH) to form the corresponding soluble salt and liberate hydrogen.
- Amphoteric oxides and hydroxides are those compounds which react with both acids and alkalis to form salt and water.

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