

# 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,  $\text{NH}_4\text{OH}$  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	$\text{NH}_4^+$	
Sodium ion	$\text{Na}^+$	
Potassium ion	$\text{K}^+$	
Calcium ion	$\text{Ca}^{2+}$	
Magnesium ion	$\text{Mg}^{2+}$	
Aluminium ion	$\text{Al}^{3+}$	
Lead ion	$\text{Pb}^{2+}$	
Zinc ion	$\text{Zn}^{2+}$	
Cupric ion	$\text{Cu}^{2+}$	Blue
Ferrous ion	$\text{Fe}^{2+}$	Light green
Ferric ion	$\text{Fe}^{3+}$	Yellow/brown
Nickel ion	$\text{Ni}^{2+}$	Green
Chromium ion	$\text{Cr}^{3+}$	Green
Manganese ion	$\text{Mn}^{2+}$	Pink

Colourless ions	Symbol	Coloured ions	Symbol	Colour
Chloride ion	$\text{Cl}^-$	Permanganate ion	$\text{MnO}_4^-$	Pink or Purple
Sulphate ion	$\text{SO}_4^{2-}$			
Carbonate ion	$\text{CO}_3^{2-}$	Dichromate ion	$\text{Cr}_2\text{O}_7^{2-}$	Orange
Nitrate ion	$\text{NO}_3^-$			
Hydride ion	$\text{H}^-$	Chromate ion	$\text{CrO}_4^{2-}$	Yellow
Bicarbonate ion	$\text{HCO}_3^-$			
Sulphide ion	$\text{S}^{2-}$			
Bromide ion	$\text{Br}^-$			
Acetate ion	$\text{CH}_3\text{COO}^-$			

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

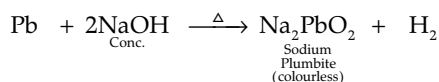
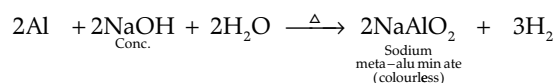
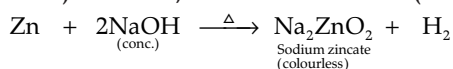
Ion	Salt (Colour)	Reaction	Precipitate formed	Colour of the precipitate	Solubility of the precipitate in an excess of $\text{NH}_4\text{OH}$
$\text{Mg}^{2+}$	$\text{MgSO}_4$ (Magnesium sulphate) (White)	$\text{MgSO}_4 + 2\text{NaOH} \rightarrow$ $\text{Mg}(\text{OH})_2\downarrow + \text{Na}_2\text{SO}_4$	$\text{Mg}(\text{OH})_2$ (Magnesium hydroxide)	White	Insoluble
$\text{Fe}^{2+}$	$\text{FeSO}_4$ (Ferrous sulphate) (Green)	$\text{FeSO}_4 + 2\text{NaOH} \rightarrow$ $\text{Fe}(\text{OH})_2\downarrow + \text{Na}_2\text{SO}_4$	$\text{Fe}(\text{OH})_2$ (Ferrous hydroxide or Iron (II) hydroxide)	Dirty green	Insoluble
$\text{Fe}^{3+}$	$\text{FeCl}_3$ (Ferric chloride) (Brown)	$\text{FeCl}_3 + 3\text{NaOH} \rightarrow$ $\text{Fe}(\text{OH})_3\downarrow + 3\text{NaCl}$	$\text{Fe}(\text{OH})_3$ (Ferric hydroxide or Iron (III) hydroxide)	Reddish brown	Insoluble
$\text{Cu}^{2+}$	$\text{CuSO}_4$ (Copper sulphate) (Blue)	$\text{CuSO}_4 + 2\text{NaOH} \rightarrow$ $\text{Cu}(\text{OH})_2\downarrow + \text{Na}_2\text{SO}_4$	$\text{Zn}(\text{OH})_2$ (Zinc hydroxide)	Pale blue	Soluble
$\text{Zn}^{2+}$	$\text{ZnSO}_4$ (Zinc sulphate) (Colourless)	$\text{ZnSO}_4 + 2\text{NaOH} \rightarrow$ $\text{Zn}(\text{OH})_2\downarrow + \text{Na}_2\text{SO}_4$ $\text{Zn}(\text{OH})_2 + 2\text{NaOH} \rightarrow$ (Excess) $\text{Na}_2\text{ZnO}_2 + 2\text{H}_2\text{O}$ Sodium zincate (Soluble)	$\text{Zn}(\text{OH})_2$ (Zinc hydroxide)	White gelatinous	Soluble
$\text{Pb}^{2+}$	$\text{Pb}(\text{NO}_3)_2$ (Lead nitrate) (Colourless)	$\text{Pb}(\text{NO}_3)_2 + 2\text{NaOH} \rightarrow$ $\text{Pb}(\text{OH})_2\downarrow + 2\text{NaNO}_3$ $\text{Pb}(\text{OH})_2 + 2\text{NaOH} \rightarrow$ (Excess) $\text{Na}_2\text{PbO}_2\downarrow + 2\text{H}_2\text{O}$ Sodium plumbite (Soluble)	$\text{Pb}(\text{OH})_2$ (Lead (II) hydroxide)	Chalky White	Soluble

Ca <sup>2+</sup>	Ca(NO <sub>3</sub> ) <sub>2</sub> (Calcium nitrate) (Colourless)	Ca(NO <sub>3</sub> ) <sub>2</sub> + 2NaOH → Ca(OH) <sub>2</sub> ↓ + 2NaNO <sub>3</sub>	Ca(OH) <sub>2</sub> (Calcium hydroxide)	White	Sparingly Soluble
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➤ **Action of Ammonium hydroxide (NH<sub>4</sub>OH) with solution of salts:**

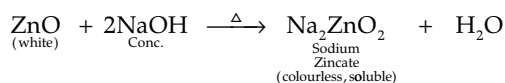
Ion	Salt (Colour)	Reaction	Precipitate formed	Colour of the precipitate	Solubility of the precipitate in an excess of NH <sub>4</sub> OH
Mg <sup>2+</sup>	MgCl <sub>2</sub> (Magnesium chloride) (White)	MgCl <sub>2</sub> + 2NH <sub>4</sub> OH → Mg(OH) <sub>2</sub> ↓ + 2NH <sub>4</sub> Cl	Mg(OH) <sub>2</sub> (Magnesium hydroxide)	White	Insoluble
Fe <sup>2+</sup>	FeSO <sub>4</sub> (Iron (II) sulphate) (Green)	FeSO <sub>4</sub> + 2NH <sub>4</sub> OH → Fe(OH) <sub>2</sub> ↓ + (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub>	Fe(OH) <sub>2</sub> (Iron (II) hydroxide)	Dirty green	Insoluble
Fe <sup>3+</sup>	FeCl <sub>3</sub> (Iron (III) chloride) (Brown)	FeCl <sub>3</sub> + 3NH <sub>4</sub> OH → Fe(OH) <sub>3</sub> ↓ + 3NH <sub>4</sub> Cl	Fe(OH) <sub>3</sub> Iron (III) hydroxide)	Reddish brown	Insoluble
Cu <sup>2+</sup>	CuSO <sub>4</sub> (Copper sulphate) (Blue)	CuSO <sub>4</sub> + 2NH <sub>4</sub> OH → Cu(OH) <sub>2</sub> ↓ + (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> Cu(OH) <sub>2</sub> + (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> + 2NH <sub>4</sub> OH → [Cu(NH <sub>3</sub> ) <sub>4</sub> ] SO <sub>4</sub> + 4H <sub>2</sub> O (Excess)	Cu(OH) <sub>2</sub> (Copper (II) hydroxide) Tetraammine copper (II) sulphate	Pale blue  Deep blue solution	Soluble
Zn <sup>2+</sup>	ZnSO <sub>4</sub> (Zinc sulphate) (Colourless)	ZnSO <sub>4</sub> + 2NH <sub>4</sub> OH → Zn(OH) <sub>2</sub> ↓ + (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> Zn(OH) <sub>2</sub> + (NH <sub>4</sub> ) <sub>2</sub> SO <sub>4</sub> + 2NH <sub>4</sub> OH → [Zn(NH <sub>3</sub> ) <sub>4</sub> ] SO <sub>4</sub> + 4H <sub>2</sub> O (Excess)	Zn(OH) <sub>2</sub> (Zinc(II) hydroxide)  Tetraammine zinc(II) sulphate	White gelatinous  colourless solution	Soluble  (Soluble)
Pb <sup>2+</sup>	Pb(NO <sub>3</sub> ) <sub>2</sub> (Lead (II) nitrate) (white)	Pb(NO <sub>3</sub> ) <sub>2</sub> + 2NH <sub>4</sub> OH → Pb(OH) <sub>2</sub> ↓ + 2NH <sub>4</sub> NO <sub>3</sub>	Pb(OH) <sub>2</sub> (Lead(II) hydroxide)	Chalky White	Soluble

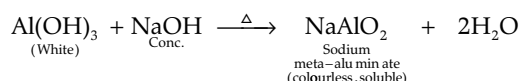
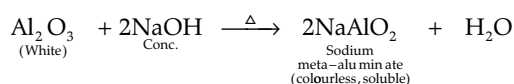
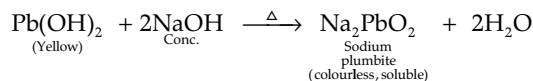
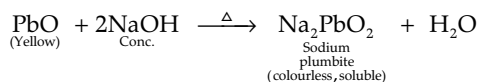
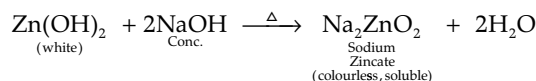
➤ **Action of Sodium hydroxide (NaOH) with zinc, aluminium and lead (action of alkalis on metals):**



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

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





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  $\text{NH}_4\text{OH}$  due to the formation of soluble amino compounds on further reaction with excess of  $\text{NH}_4\text{OH}$ .
- 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.

