Analytical Chemistry - Uses of Ammonium Hydroxide & Sodium Hydroxide

Analytical Chemistry

In the qualitative analysis of compounds, their colour helps in their identification. The table given below shows some examples of colourless and coloured ions.

Colourless		Coloured		
Cation	**Symbol**	**Cation**	**Symbol**	**Colour**
Ammonium	NH_4^+	Cupric	Cu^{2+}	Blue
Sodium	Na^+	Ferrous	Fe^{2+}	Light green
Potassium	K^+	Ferric	Fe^{3+}	Yellowish-brown
Calcium	Ca^+	Nickel	Ni^{2+}	Green
Magnesium	Mg^{2+}	Chromium	Cr^{3+}	Green
Aluminium	Al^{3+}	Manganese	Mn^{2+}	Pink
Lead	Pb^{2+}			
Zinc	Zn^{2+}			
Anion	**Symbol**	**Anion**	**Symbol**	**Colour**
Chloride	Cl^-	Permanganate	MnO_4^-	Pink or Violet
Sulphate	SO_4^{2-}	Dichromate	$Cr_2\,O_7^{2-}$	Orange
Carbonate	CO_3^{2-}	Chromate	CrO_4^-	Yellow
Nitrate	NO_3^-			
Bicarbonate	HCO_3^-			
Sulphide	S^{2-}			

Bromide	Br^-			
Acetate	CH_3COO^-			

Chemical reactions of the soluble salt solutions with NaOH and NH_4OH

Some soluble salts (except sodium and potassium) react with sodium hydroxide and ammonium hydroxide to form insoluble precipitates.

Reactions with sodium hydroxide solution

Aqueous ferrous sulphate (green in colour) reacts with NaOH to form iron (II) hydroxide, which is insoluble in alkali.

$FeSO_4 + 2NaOH \rightarrow Na_2SO_4 + Fe(OH)_2$

Other such reactions are shown below:

$$Ca(NO_3)_2 + 2\ NaOH \longrightarrow \underset{\text{White precipitate}}{Ca(OH)_2(\downarrow)} + 2\ NaNO_3$$

$$\underset{\text{Yellow}}{FeCl_3} + 3\ NaOH \longrightarrow 3\ NaCl + \underset{\text{Reddish-brown precipitate}}{Fe(OH)_3(\downarrow)}$$

$$ZnSO_4 + 2\ NaOH \longrightarrow Na_2SO_4 + \underset{\text{Gelatinous white precipitate}}{Zn(OH)_2(\downarrow)}$$

$$Zn(OH)_2 + 2\ NaOH \longrightarrow \underset{\text{Colourless}}{Na_2ZnO_2} + 2\ H_2O$$

$$\underset{\text{Blue}}{CuSO_4} + 2\ NaOH \longrightarrow \underset{\text{Pale blue precipitate}}{Cu(OH)_2(\downarrow)} + Na_2SO_4$$

$$Pb(NO_3)_2 + 2\ NaOH \longrightarrow \underset{\text{White precipitate}}{Pb(OH)_2(\downarrow)} + 2\ NaNO_3$$

$$Pb(OH)_2 + 2\ NaOH \longrightarrow \underset{\text{Colourless}}{Na_2PbO_2} + 2\ H_2O$$

$$NH_4Cl + 2\ NaOH \xrightarrow{\Delta} NaCl + H_2O + NH_3(\uparrow)$$

Reactions with ammonium hydroxide:

Aqueous ferrous sulphate (green in colour) reacts with NH_4OH to form iron (II) hydroxide, which is insoluble in excess of ammonium hydroxide.

$$FeSO_4 + 2NH_4OH \longrightarrow (NH_4)_2SO_4 + Fe(OH)_2$$

Other such reactions are shown below:

$$\underset{\text{Yellow}}{FeCl_3} + 3\ NH_4OH \longrightarrow \underset{\text{Reddish-brown precipitate}}{Fe(OH)_3(\downarrow)} + 3\ NH_4Cl$$

$$\underset{\text{Blue}}{CuSO_4} + 2\ NH_4OH \longrightarrow \underset{\text{Pale blue precipitate}}{Cu(OH)_2(\downarrow)} + (NH_4)_2SO_4$$

$$Cu(OH)_2 + 4\ NH_4OH \longrightarrow \underset{\text{Deep blue solution}}{[Cu(NH_3)_4](OH)_2} + 4\,H_2O$$

$$\underset{\text{Colourless}}{ZnSO_4} + 2\ NH_4OH \longrightarrow \underset{\text{Gelatinous white precipitate}}{Zn(OH)_2(\downarrow)} + (NH_4)_2SO_4$$

$$Zn(OH)_2 + 4\ NH_4OH \longrightarrow \underset{\text{Colourless solution}}{[Zn(NH_3)_4](OH)_2} + 4\,H_2O$$

$$\underset{\text{Colourless}}{Pb(NO_3)_2} + 2\ NH_4OH \longrightarrow \underset{\text{White precipitate}}{Pb(OH)_2(\downarrow)} + 2\ NH_4NO_3$$

Amphoteric nature of zinc and aluminium metals, their oxides and hydroxides

- **Amphoteric nature of zinc and aluminium metals:** As zinc and aluminium metals displace hydrogen from the acids as well as alkali, therefore, they are amphoteric in nature.

$$Zn + H_2SO_4(\text{dil.}) \longrightarrow ZnSO_4 + H_2(g)$$

$$2Al + 3H_2SO_4(\text{dil.}) \longrightarrow Al_2(SO_4)_3 + 3H_2(g)$$

$$Zn + 2\,NaOH\,(\text{dil}) \xrightarrow{\Delta} Na_2\,ZnO_2 + H_2\ (g)$$

$$2Al + 2NaOH + 2H_2O \xrightarrow{\Delta} 2\,NaAlO_2 + 3H_2\ (g)$$

- **Amphoteric nature of zinc and aluminium oxides:** As the oxides of zinc and aluminium react with acids as well as alkalies to form salt and water, they are amphoteric in nature.

$$ZnO + H_2SO_4(\text{dil.}) \longrightarrow ZnSO_4 + H_2O$$

$$Al_2O_3 + 3H_2SO_4(\text{dil.}) \longrightarrow Al_2(SO_4)_3 + 3H_2O$$

$$ZnO + 2NaOH \xrightarrow{\Delta} Na_2ZnO_2 + H_2O$$

$$Al_2O_3 + 2NaOH \xrightarrow{\Delta} Na_2AlO_2 + H_2O$$

- **Amphoteric nature of hydroxides of zinc and aluminium metals:** As the hydroxides of zinc and aluminium react with acids as well as alkalies to form salt and water as the only products, therefore, they are amphoteric in nature.

$$Zn(OH)_2 + H_2SO_4(dil.) \longrightarrow ZnSO_4 + 2H_2O$$

$$2Al(OH)_3 + 3H_2SO_4(dil.) \longrightarrow Al_2(SO_4)_3 + 6H_2O$$

$$Zn(OH)_2 + 2NaOH \xrightarrow{\Delta} Na_2ZnO_2 + 2H_2O$$

$$Al(OH)_3 + NaOH \xrightarrow{\Delta} NaAlO_2 + 2H_2O$$

- **Amphoteric nature of lead oxide:** As the oxide of lead react both with hydrochloric acid and sodium hydroxide, it is amphoteric in nature.

$$PbO + 2HCl \rightarrow PbCl_2 + H_2O$$

$$PbO + 2NaOH + H_2O \rightarrow Na_2[Pb(OH)_4]$$

- **Amphoteric nature of lead hydroxide:** As the hydroxide of lead react both with hydrochloric acid and sodium hydroxide, it is amphoteric in nature.

$$Pb(OH)_2 + 2HCl \rightarrow PbCl_2 + 2H_2O$$

$$Pb(OH)_2 + 2NaOH \rightarrow Na_2[Pb(OH)_4$$