

# Analytical Chemistry – Uses of Ammonium Hydroxide and Sodium Hydroxide

## Introduction

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The determination of the chemical components in a given sample is called analysis.

### Types of Analysis

- **Qualitative Analysis:** It involves the identification of unknown substances.
- **Quantitative Analysis:** It involves the identification of the composition of a mixture.

### Reagents

- Reagent: It is a substance which reacts with another substance.
- Alkalis are important laboratory reagents.
- Sodium hydroxide and ammonium hydroxide are the most commonly used alkalis, which give characteristic tests with various metal cations, and thus, a cation can be identified.

## Colours of Salts and their Solutions

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Salts of representative elements (normal elements), i.e. the elements of Group IA to Group VII A are generally **colourless**.

Salts of transition elements, i.e. salts of elements of Group IB to VIIB and Group VIII are generally **coloured**.

Colourless ions		Coloured ions		
<i>Cation</i>	<i>Symbol</i>	<i>Cation</i>	<i>Symbol</i>	<i>Colour</i>
Ammonium ion	$\text{NH}_4^+$	Cupric ion	$\text{Cu}^{2+}$	Blue
Sodium ion	$\text{Na}^+$	Ferrous ion	$\text{Fe}^{2+}$	Light green
Potassium ion	$\text{K}^+$	Ferric ion	$\text{Fe}^{3+}$	Yellowish brown
Calcium ion	$\text{Ca}^{2+}$	Nickel ion	$\text{Ni}^{2+}$	Green
Magnesium ion	$\text{Mg}^{2+}$	Chromium ion	$\text{Cr}^{3+}$	Green
Aluminium ion	$\text{Al}^{3+}$	Manganese ion	$\text{Mn}^{2+}$	Pink
Lead ion	$\text{Pb}^{2+}$			
Zinc ion	$\text{Zn}^{2+}$			
<i>Anion</i>	<i>Symbol</i>	<i>Anion</i>	<i>Symbol</i>	<i>Colour</i>
Chloride ion	$\text{Cl}^-$	Permanganate ion	$\text{MnO}_4^-$	Pink or purple
Sulphate ion	$\text{SO}_4^{2-}$	Dichromate ion	$\text{Cr}_2\text{O}_7^{2-}$	Orange
Carbonate ion	$\text{CO}_3^{2-}$	Chromate ion	$\text{CrO}_4^{2-}$	Yellow
Hydrogen carbonate ion	$\text{HCO}_3^-$			
Sulphide ion	$\text{S}^{2-}$			
Bromide ion	$\text{Br}^-$			
Acetate ion	$\text{CH}_3\text{COO}^-$			

## Precipitation

It is the process of formation of an insoluble solid when solutions are mixed. The solid thus formed is known as a precipitate.

## Action of Sodium Hydroxide Solution on Metallic Salt Solutions

Salt formed solution	+ Alkali	→	Metallic hydroxide (ppt.)	+	Salt in solution	Solubility of the ppt. in excess of alkali
<b>1. Calcium salt [Ca<sup>2+</sup> ion]</b>	Ca(NO <sub>3</sub> ) <sub>2</sub> + 2NaOH	→	Ca(OH) <sub>2</sub> (White ppt.)	+	2NaNO <sub>3</sub> (colourless)	Sparingly soluble
<b>2. Iron</b>						Insoluble
<b>(A) Ferrous salt [Fe<sup>2+</sup> ion]</b>	FeSO <sub>4</sub> + 2NaOH	→	Fe(OH) <sub>2</sub> (dirty green, gelatinous ppt.)	+	Na <sub>2</sub> SO <sub>4</sub> (colourless)	
<b>(B) Ferric salt [Fe<sup>3+</sup> ion]</b>	FeCl <sub>3</sub> + 3NaOH	→	Fe(OH) <sub>3</sub> (Reddish brown ppt.)	+	3NaCl (colourless)	
<b>3. Copper salt [Cu<sup>2+</sup>]</b>	CuSO <sub>4</sub> + 2NaOH	→	Cu(OH) <sub>2</sub> (Pale blue ppt.)	+	Na <sub>2</sub> SO <sub>4</sub> (colourless)	Insoluble
<b>4. Zinc salt [Zn<sup>2+</sup> ion]</b>	ZnSO <sub>4</sub> + 2NaOH	→	Zn(OH) <sub>2</sub> (white, gelatinous ppt.)	+	Na <sub>2</sub> SO <sub>4</sub> (colourless)	Soluble Zn(OH) <sub>2</sub> + 2NaOH (excess) → Na <sub>2</sub> ZnO <sub>2</sub> + 2H <sub>2</sub> O (colourless)
<b>5. Lead salt [Pb<sup>2+</sup> ion]</b>	Pb(NO <sub>3</sub> ) <sub>3</sub> + 2NaOH	→	Pb(OH) <sub>2</sub> (White ppt.)	+	2NaNO <sub>3</sub> (colourless)	Soluble Pb(OH) <sub>2</sub> + 2NaOH (excess) → Na <sub>2</sub> PbO <sub>2</sub> + 2H <sub>2</sub> O (colourless)
<b>6. Ammonium salt [NH<sub>4</sub><sup>+</sup>]</b>	NH <sub>4</sub> Cl + NaOH	→	NaCl	+	H <sub>2</sub> O + NH <sub>3</sub>	

## Action of Ammonium Hydroxide on certain Salt Solutions

Salt Solution	+ Ammonium hydroxide	→ Metal hydroxide	+ Salt formed in solution	Solubility of the ppt. in excess of ammonium hydroxide
<b>1. Calcium salt</b> Ca(OH) <sub>2</sub> does not precipitate even with the addition of excess of NH <sub>4</sub> OH.				
<b>2. Iron</b> <b>(A) Iron (II) salt [Fe<sup>2+</sup> ion]</b> 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> (dirty green ppt.) (colourless) <b>(B) Iron (III) salt [Fe<sup>3+</sup> ion]</b> FeCl <sub>3</sub> + 3NH <sub>4</sub> OH → Fe(OH) <sub>3</sub> + 3NH <sub>4</sub> Cl (reddish brown ppt.) (colourless)				Insoluble
<b>3. Copper (II) salt [Cu<sup>2+</sup> ion]</b> 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> (pale blue ppt.) (colourless in solution) With excess of NH <sub>4</sub> OH, the ppt. dissolves 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 Tetrammine Copper (II) sulphate (deep blue solution)				Soluble
<b>4. Zinc salt [Zn<sup>2+</sup> ion]</b> 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> (white, gelatinous ppt.) (colourless)				Soluble

## Action of Alkalis on certain Metals

Metal	+ Alkali	→	Salt	+	Hydrogen
1. Zinc Zn	+ 2NaOH	→	Na <sub>2</sub> ZnO <sub>2</sub> Sodium zincate (colourless)	+	H <sub>2</sub>
2. Aluminium 2Al	+ 2NaOH + 2H <sub>2</sub> O	→	2NaAlO <sub>2</sub> Sodium meta aluminate (colourless)	+	H <sub>2</sub>
3. Lead Pb	+ 2NaOH	→	Na <sub>2</sub> PbO <sub>2</sub> Sodium plumbate (colourless)	+	H <sub>2</sub>

## Action of Alkalis on Metal Oxides

**Amphoteric oxides and hydroxides:** Compounds which react with both acids and alkalis to form salt and water are called amphoteric oxides and hydroxides.

Amphoteric oxide/hydroxide	Oxide/hydroxide	+ Alkali	→	Salt	+ Water
1. Zinc oxide/Zinc hydroxide	i. ZnO	+ 2NaOH	→	Na <sub>2</sub> ZnO <sub>2</sub>	+ H <sub>2</sub> O
	ii. Zn(OH) <sub>2</sub>	+ 2NaOH	→	Na <sub>2</sub> ZnO <sub>2</sub>	+ 2H <sub>2</sub> O
2. Aluminium oxide/Aluminium hydroxide	i. Al <sub>2</sub> O <sub>3</sub>	+ 2NaOH	→	2Na AlO <sub>2</sub>	+ H <sub>2</sub> O
	ii. Al(OH) <sub>3</sub>	+ NaOH	→	Na AlO <sub>2</sub>	+ 2H <sub>2</sub> O
3. Lead oxide/Lead hydroxide	i. PbO	+ 2NaOH	→	Na <sub>2</sub> PbO <sub>2</sub>	+ H <sub>2</sub> O
	ii. Pb(OH) <sub>2</sub>	+ 2NaOH	→	Na <sub>2</sub> PbO <sub>2</sub>	+ 2H <sub>2</sub> O