

Unit 1 Chemical Substances: Nature & Behaviour

Chapter 2:

Acids, Bases & Salts

→ Introduction to Acids, Bases and Salts classification of matter

On the basis of

- Composition** - elements, compounds and mixtures
- State** - solids, liquids and gases.
- solubility** - suspensions, colloids and solutions.

Types of mixtures - homogeneous and heterogeneous
Types of compounds - covalent and ionic

→ what is an Acid and a Base?

📌 Ionisable and non-Ionisable compounds

An Ionisable compound when dissolved in water or in its molten state, dissociates into ions almost entirely.
Ex - NaCl, HCl, KOH etc.

A non-ionisable compound does not dissociate into ions when dissolved in water or in its molten state.
Ex - glucose, acetone etc.

📌 Arrhenius theory of acids and bases.

Arrhenius acid - when dissolved in water, dissociates to give $H^+(aq)$ or H_3O^+ ion.

Arrhenius base - when dissolved in water, dissociates to give OH^- ion.

Examples

Acids

- Hydrochloric Acid (HCl)
- Sulphuric acid (H_2SO_4)
- Nitric acid (HNO_3)

Bases

- Sodium hydroxide (NaOH)
- Potassium hydroxide (KOH)
- Calcium hydroxide

→ Bronsted Lowry theory

A Bronsted acid is a $H^+(aq)$ ion donor.

A Bronsted base is a $H^+(aq)$ ion acceptor.



HCl - Bronsted acid Cl^- - conjugate acid

NH_3 - Bronsted base NH_4^+ - conjugate acid

Physical test to Identify an acid or base.

1. Taste - An acid tastes sour whereas a base tastes bitter. The method of taste is not advised as an acid or a base could be contaminated or corrosive.

2. Effect on Indicators by acids and bases

- An Indicator is a chemical substance which shows a change in its physical properties, mainly colour or odour when brought in contact with acid or a base.
- Below mentioned are commonly used indicators and the different colours they exhibit.

a) Litmus

In neutral solution - Purple

In acidic solution - red

In basic solution - blue

- Litmus is also available as strips of paper in two variants - red litmus and blue litmus.
- An acid turns a moist blue litmus paper to red.
- An base turns a moist red litmus paper to blue.

b) Methyl orange

In neutral solution - Orange

In acidic solution - red

In basic solution - yellow

c) Phenolphthalein

In neutral solution - colourless

In acidic solution - remains colourless

In basic solution - pink

→ Acid - Acids are those substance which dissociates (or ionise) on dissolving in water to produce hydrogen ions $[H^+(aq)_{cons}]$.

★ Physical Properties

- Acidic substances exhibit characteristics of acidity or dryness.
- Strong acids behave as strong electrolytes in solution, meaning they dissociate completely into ions, facilitating the conduction of electricity.

- weak acids, in contrast, act as weak electrolytes, partially dissociating into ions and thus exhibiting less conductivity compared to strong acids.

★ Chemical Properties

1) When acids react with metals, hydrogen gas is evolved.

• General Equation: $\text{Acid} + \text{Metal} \rightarrow \text{Metallic salt} + \text{Hydrogen gas}$

• Examples of such reactions include:

- Hydrochloric acid (HCl) reacting with zinc (Zn) forms zinc chloride (ZnCl_2) and hydrogen gas (H_2).

- Acetic acid (CH_3COOH) reacting with zinc (Zn) produces zinc acetate ($\text{CH}_3\text{COO}_2\text{Zn}$) and hydrogen gas (H_2).

- Nitric acid (HNO_3) reacting with zinc (Zn) results in the formation of zinc nitrate ($\text{Zn}(\text{NO}_3)_2$) and hydrogen gas (H_2).

2) When acids react with metal carbonates (and metal hydrogen carbonates), carbon dioxide gas is produced along with the formation of salts and water.

• General Equation

$\text{Metal carbonate} + \text{Acid} \rightarrow \text{Salt} + \text{Carbon dioxide} + \text{Water}$

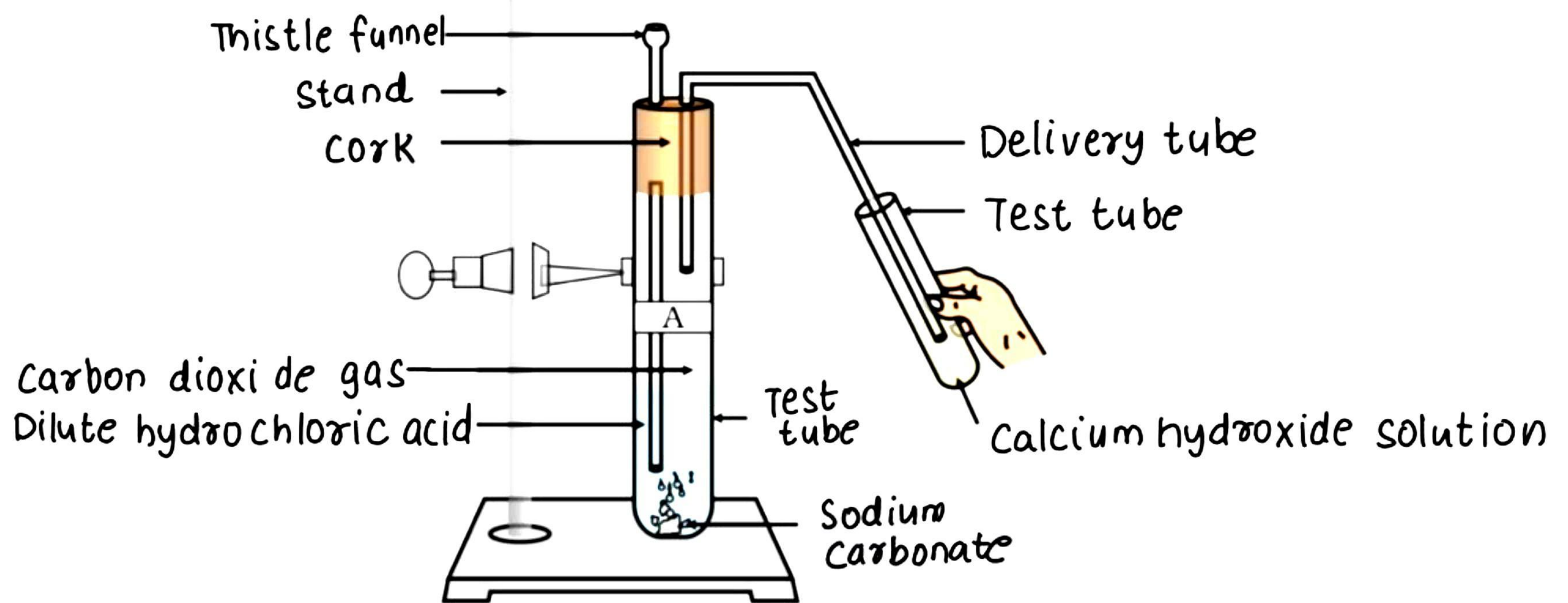
$\text{Metal hydrogen carbonate} + \text{Acid} \rightarrow \text{Salt} + \text{Carbon dioxide} + \text{Water}$

• Examples of such reactions include:

- Sodium carbonate (Na_2CO_3) reacting with hydrochloric acid (HCl) yields sodium chloride (NaCl), water (H_2O) and carbon dioxide gas (CO_2).

- Sodium hydrogen carbonate (NaHCO_3) reacting with hydrochloric acid (HCl) produces sodium chloride (NaCl), water (H_2O) and carbon dioxide gas (CO_2).

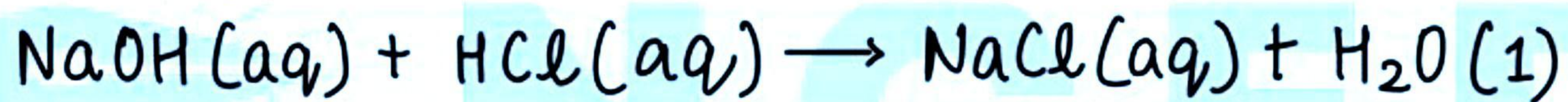




Passing Carbon-dioxide gas through Calcium hydroxide Solution

3) Acid react with Base form salt and water

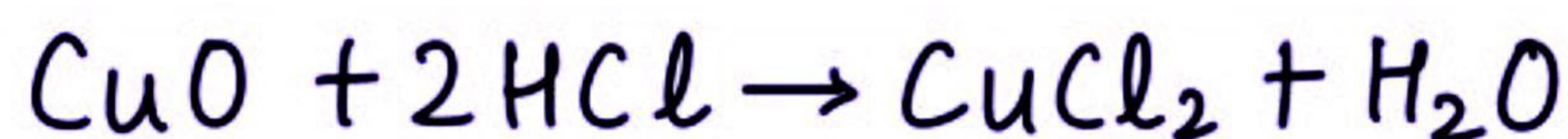
Acid Base salt water



4) When Metal oxide react with acids

They form salts and water. Metal oxides are commonly referred to as basic oxides because they tend to produce basic solutions when dissolved in water.

Metal oxide + Acid \rightarrow Salt and water



The solution turns blue-green.

➔ **Base** - Bases are substances that, when dissolved in water, ionize to yield hydroxide ions ($\text{OH}^{\ominus}(\text{aq})$). They dissociate to release OH^{\ominus} ions in aqueous solutions, making defines bases, distinguishing them from acids and other substances in solution.

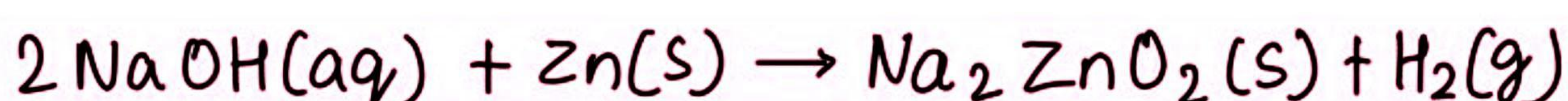
★ Physical Properties

- Bases are Bitter in taste.
- It turn red litmus paper into blue
- They are good conductor of electricity.

★ Chemical properties

1) Base react with some metal to form hydrogen gas

Base metal salt + $\text{H}_2(\text{g})$



2) Non-metallic oxide react with base, form salt and water.
 Non-metallic oxide + Base salt water



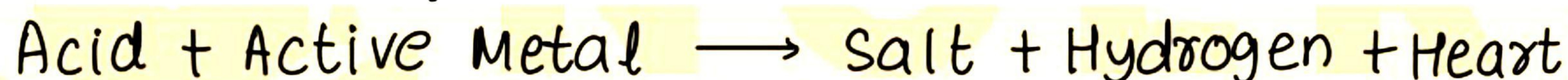
[Non-metallic oxide are acidic in nature]

3) Saponification - Bases react with fats or oils to produce soap and glycerol. This process is known as saponification.

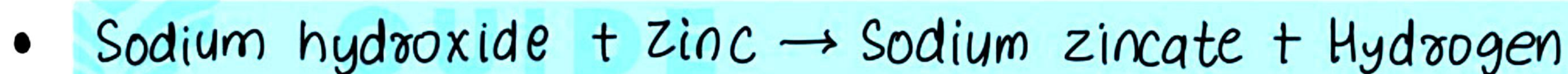
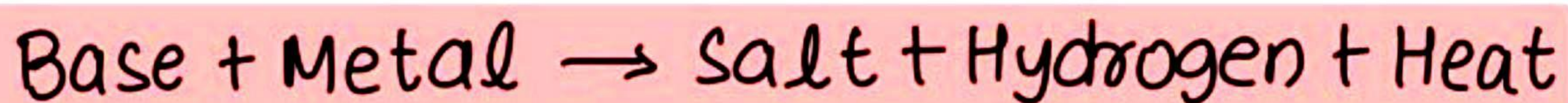
4) Precipitation - Bases can form insoluble hydroxides with some metal ions, resulting in precipitation reactions.

➔ Acid-Base Reactions - when an acid reacts with a base, a neutralization reaction occurs, leading to the production of salt and water as the end products. This traditional method represents an acid-base neutralization reaction as a reaction as a double-replacement reaction

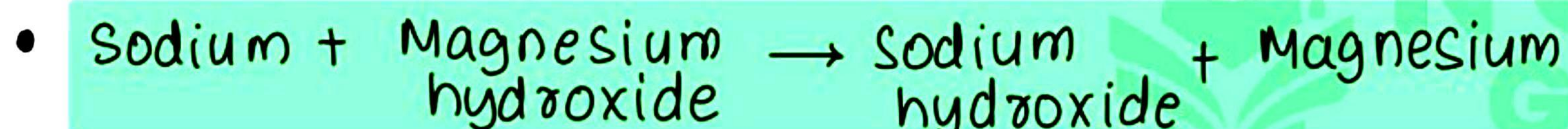
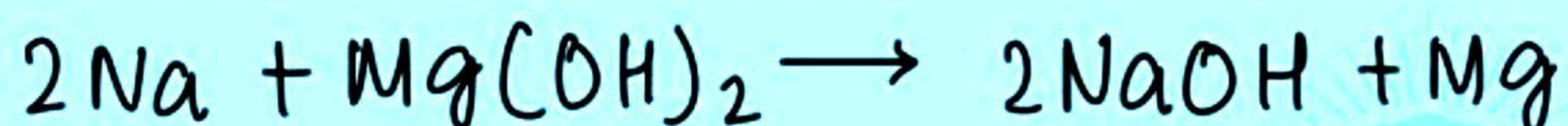
📌 Reactions of Acids and Bases with Metals
 when reacting with metals, acids typically produce salt and hydrogen gas, while bases generally do not react with metals and thus do not produce hydrogen gas



Example:

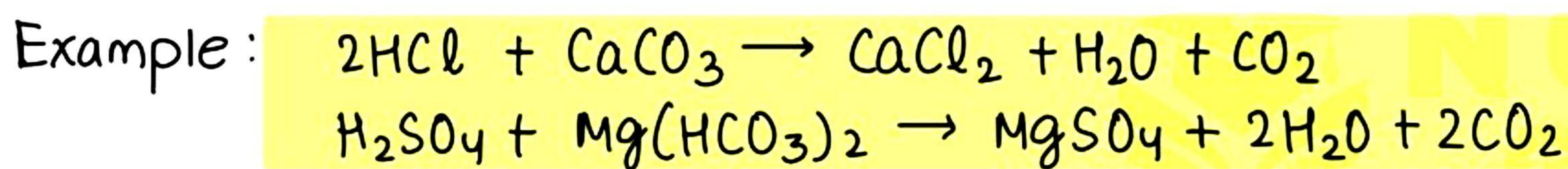
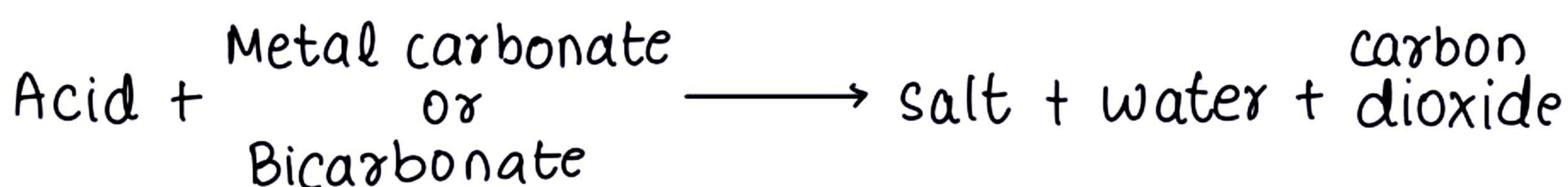


Moreover, a more reactive metal displaces a less reactive metal from its base



📌 Interaction of Acids with Metal Carbonates and Bicarbonates:
 when acids react with metal carbonates or bicarbonates, the resultant reaction produces carbon dioxide, metal salts and

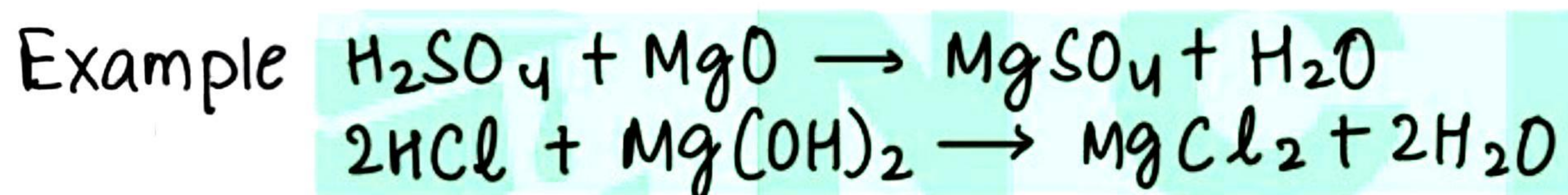
water. For instance, the reaction between hydrochloric acid and sodium carbonate yields sodium chloride, carbon dioxide and water. It's noteworthy that if the released carbon dioxide is passed through lime water, it causes the lime water to turn milky.



Effervescence indicates the release of CO_2 gas.

Acid-Base Reactions

- Reaction of Metal Oxides and Hydroxides with Acids: Metal oxides or hydroxides exhibit basic properties. $\text{Acid} + \text{Base} \rightarrow \text{salt} + \text{water} + \text{Heat}$



- Reaction of Non-metal oxides with bases: Non-metal oxides are acidic. $\text{Base} + \text{Nonmetal Oxides} \rightarrow \text{Salt} + \text{water} + \text{Heat}$



- Reaction of Acids and Bases: A common example involves hydrochloric acid and sodium hydroxide, both strong substances, yielding salt and water.



➔ **Water** - Acids and Bases in Aqueous solutions upon addition to water, acids and bases ionize into their constituent ions facilitating the conduction of electricity.

Difference Between a Base and an Alkali:

• Base

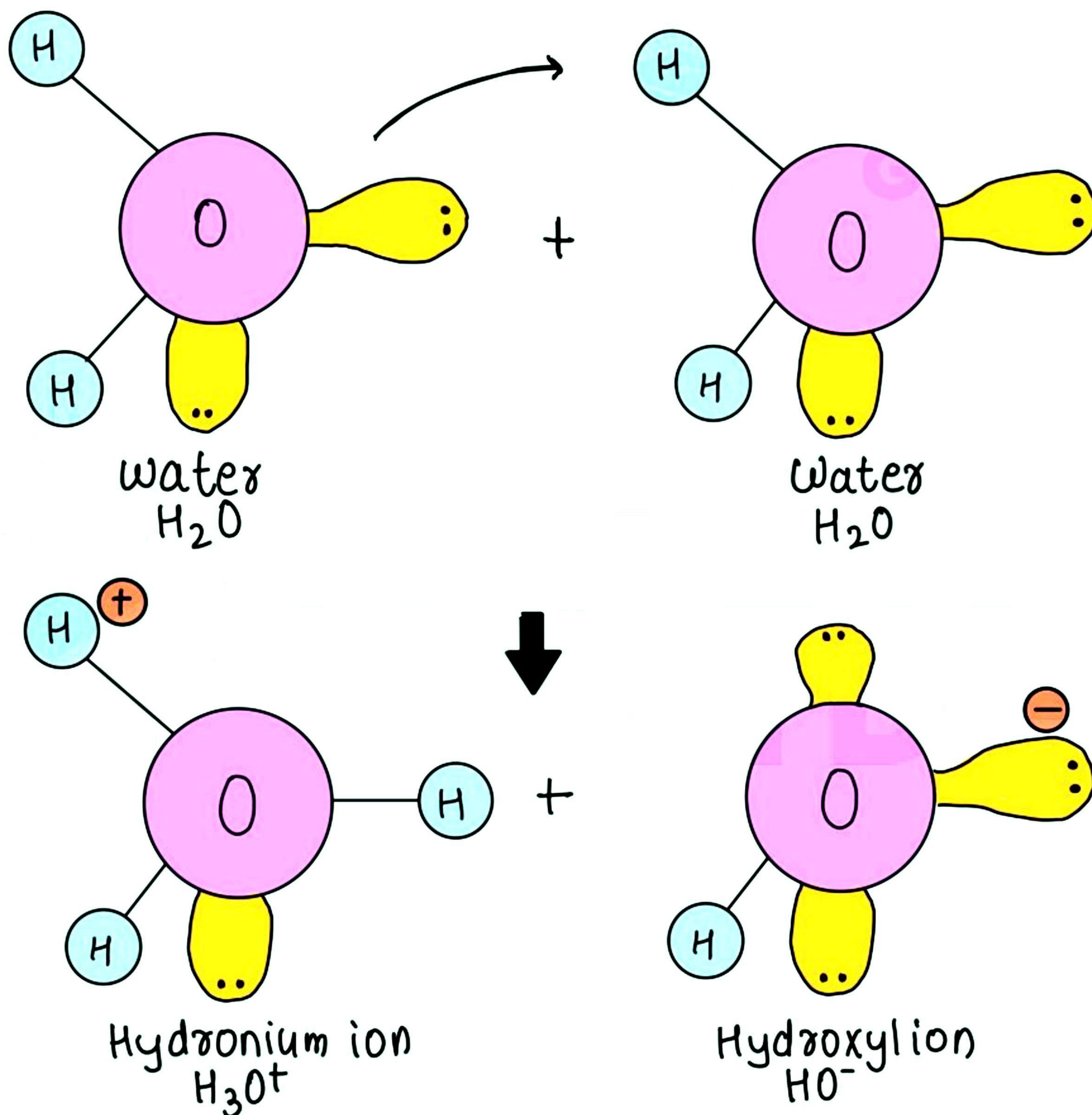
- Base engage in neutralization reactions with acids.
- They consist of metal oxides, metal hydroxides, metal carbonates and metal bicarbonates.
- The majority of bases are insoluble in water.

• Alkali

- Alkali refers to an aqueous solution of a base, primarily metallic hydroxides.

-It dissolves in water and dissociates to produce OH^- ions. While all alkalis are bases, are alkalis.

→ **Hydronium Ion** - The formation of hydronium ion occurs when a hydrogen ion accepts a lone pair of electrons from the oxygen atom of water molecule, resulting in the establishment of a coordinate covalent bond.



→ **Dilution** - Dilution involves decreasing the concentration of a solution by incorporating additional solvent, typically water. This process is notably exothermic. When diluting acid, it's imperative to add the acid to water and not vice versa.

→ **Strong Acid or Base**

Strong Acid or Base in the case of a strong acid or base, every molecule from a given quantity dissociates entirely in water to yield their respective ions, $\text{H}^+(\text{aq})$ for acids and $\text{OH}^-(\text{aq})$ for bases.

Weak Acid or Base: Conversely, a weak acid or base indicates that only a small fraction of the molecules from a specific amt dissociate in water to generate their respective ions, $H^+(aq)$ for acids and $OH^-(aq)$ for bases.

Dilute acid: Contains less number of $H^+(aq)$ ions per unit volume.

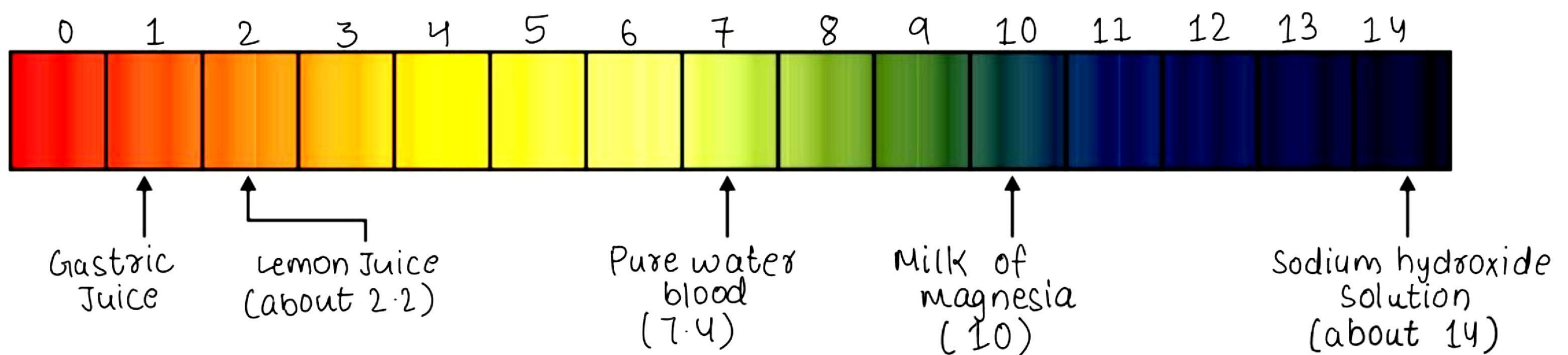
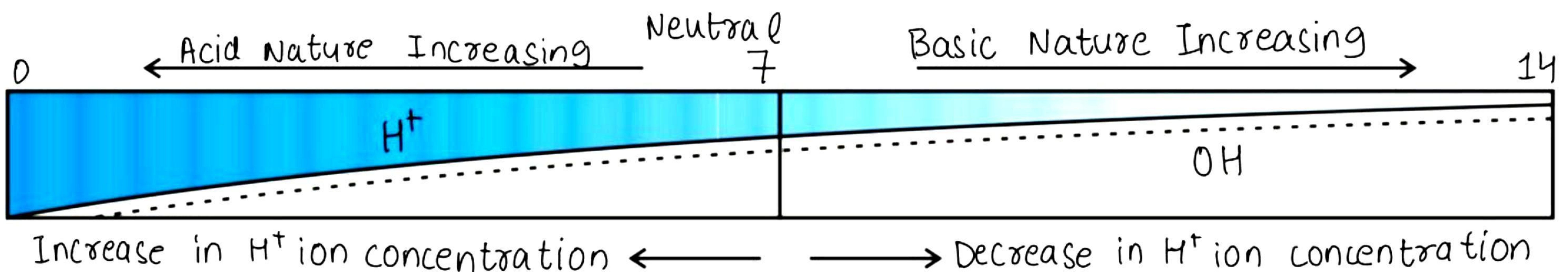
Concentrated acid: Contains more number of $H^+(aq)$ ions per unit volume.

A universal indicator: Covers the pH spectrum from 0 to 14, indicating the acidity or alkalinity level of a solution. A solution achieves neutrality at a pH of 7.

➔ **pH** - pH is calculated using the formula $pH = -\log_{10} [H^+]$. In pure water, where $[H^+]$ equals $[OH^-]$, both concentrations are 10^{-7} mol/L. Therefore, the pH of pure water is 7. The pH scale extends from 0 to 14. Solutions with a pH less than 7 are acidic, while those with a pH greater than 7 are basic.

📌 Importance of pH in Everyday Life

Are plants and animals pH sensitive? Our body works within the pH range of 7.0 to 7.8 when pH of rainwater is less than 5.6, it is called **Acid rain**. When acid rain flows into the rivers, it lowers the pH of the river water. The survival of aquatic life in such rivers becomes difficult.



📌 What is the pH of the soil in your backyard?

Plants require a specific pH range for their healthy growth. To find out the pH required for the healthy growth of a plant, you can collect the soil from various places and check the pH in the manner described below in 2.12. Also, you can note

down which plants are growing in the region from which you have collected the soil.

📌 PH in our digestive System

It's fascinating how our stomach naturally generates hydrochloric acid, aiding in the digestion process without damaging its lining. However, during episodes of indigestion, excessive acid production can lead to discomfort and irritation. To alleviate this discomfort individuals often turn to antacids, which are bases capable of neutralizing the surplus acid. One such remedy, likely mentioned earlier in this chapter, is Magnesium hydroxide, commonly known as Milk of Magnesia, which serves as a gentle base frequently utilized for this purpose.

📌 PH change as the cause of tooth decay

Tooth decay initiates when the mouth's pH drops below 5.5. Tooth enamel, composed mainly of calcium hydroxyapatite, is exceptionally resilient but corrodes at pH levels under 5.5. Mouth bacteria generate acids by breaking down sugars and leftover food particles, contributing to decay. Regular mouth cleaning after meals, ideally with basic toothpaste, can neutralize excess acids, thus thwarting tooth decay.

➔ Self defence by animals and plants through chemical warfare

Animals and plants employ chemical warfare for self-defense. When stung by a bee, the acid left behind induces pain and irritation. Applying a mild base such as baking soda to the affected area provides relief. Similarly, the stinging hairs of nettle leaves release methanoic acid, resulting in a burning sensation.

⚠ NOTE

Natural Source	Acid	Natural Source	Acid
Vinegar	Acetic acid	Sour milk (curd)	Lactic Acid
Orange	Citric acid	Lemon	Citric Acid
Tamarind	Tartaric acid	Ant Sting	Methanoic Acid
Tomato	Oxalic acid	Nettle sting	Methanoic Acid

➔ Salts

📌 Salts :- A salt is a combination of an anion of an acid and a cation of a base.

Examples :- KCl , $NaNO_3$, $CaSO_4$ etc.

Salts are usually prepared by neutralization reaction of an acid and a base.

📌 **Common Salt** - Sodium chloride (NaCl) is referred to as common salt because it's used all over the world for cooking.

📌 **Family of Salts** - Salts having the same cation or anion belong to the same family.
Examples :- NaCl, KCl, LiCl.

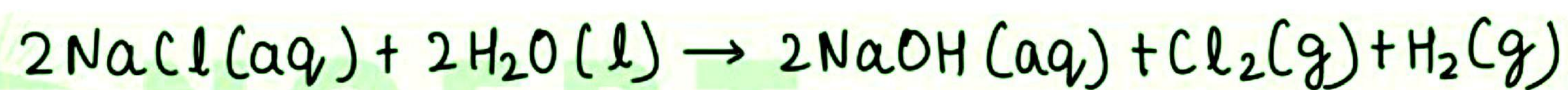
📌 **pH of salts**

- A salt of a strong acid and a strong base will be neutral in nature. $\text{pH} = 7$ (approx).
- A salt of a weak acid and a strong base will be basic in nature $\text{pH} > 7$.
- A salt of a strong acid and a weak base will be acidic in nature $\text{pH} < 7$.

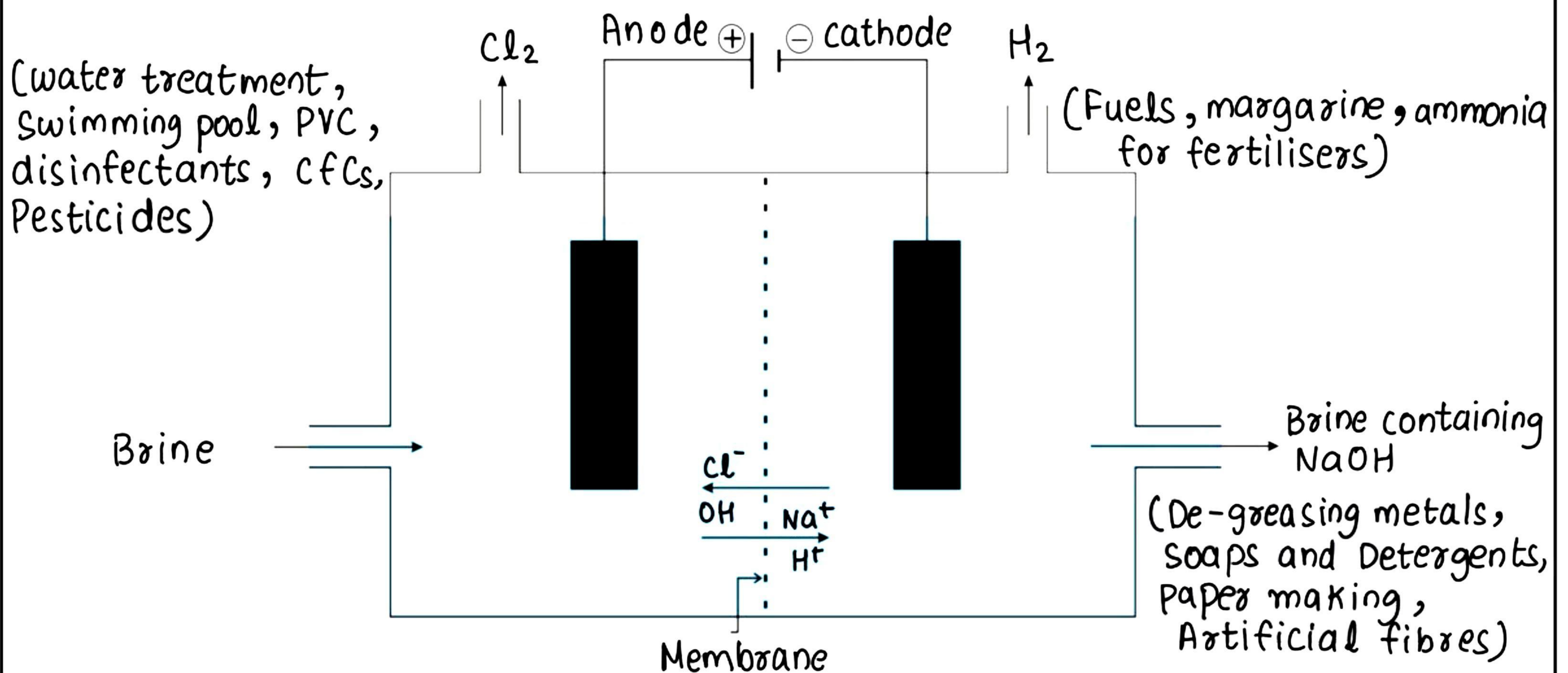
The pH of a salt of a weak acid and a weak base is determined by conducting pH test.

➔ **Sodium Hydroxide** - When an electric current is passed through saline water known as brine, it undergoes a process wherein sodium hydroxide is formed. This process is referred to as the chlor-alkali process because it yields both chlorine and alkali, specifically sodium hydroxide.

The chemical Equation representing this process is



At one electrode, known as **anode**, chlorine gas is released, while at the other electrode, the cathode, hydrogen gas is produced. In proximity to the cathode, a solution of sodium hydroxide is obtained.



Chlor - Alkali process

→ Bleaching Powder

Chemical Formula - $\text{Ca}(\text{OCl})\text{Cl}$ or CaOCl_2

Preparation - $\text{Ca}(\text{OH})_2(\text{aq}) + \text{Cl}_2(\text{g}) \rightarrow \text{CaOCl}_2(\text{aq}) + \text{H}_2\text{O}(\text{l})$

On Interaction with water - Bleaching powder release chlorine which is responsible for bleaching action

→ Baking Soda

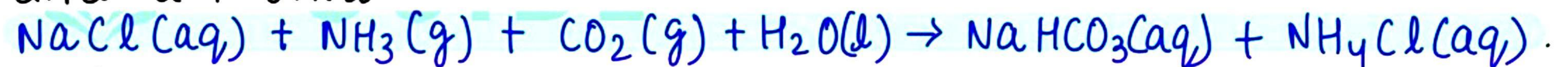
Chemical name - Sodium hydrogen carbonate

Chemical formula - NaHCO_3

Preparation (Solvay process) -

a) limestone is heated : $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$

b) CO_2 is passed through a concentrated solution of sodium chloride and ammonia:



USES:

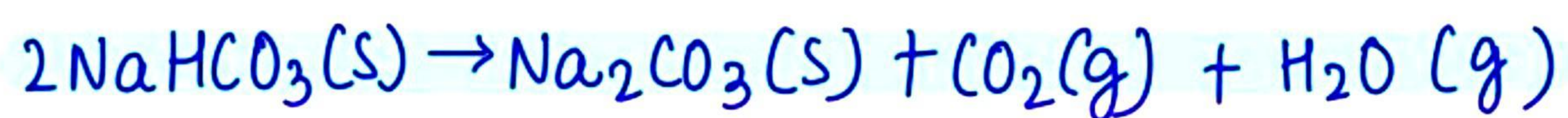
- Textile Industry
- Paper Industry
- Disinfectant

→ Washing Soda

Chemical name - Sodium carbonate decahydrate.

Chemical formula - Na_2CO_3

Preparation : By heating NaHCO_3

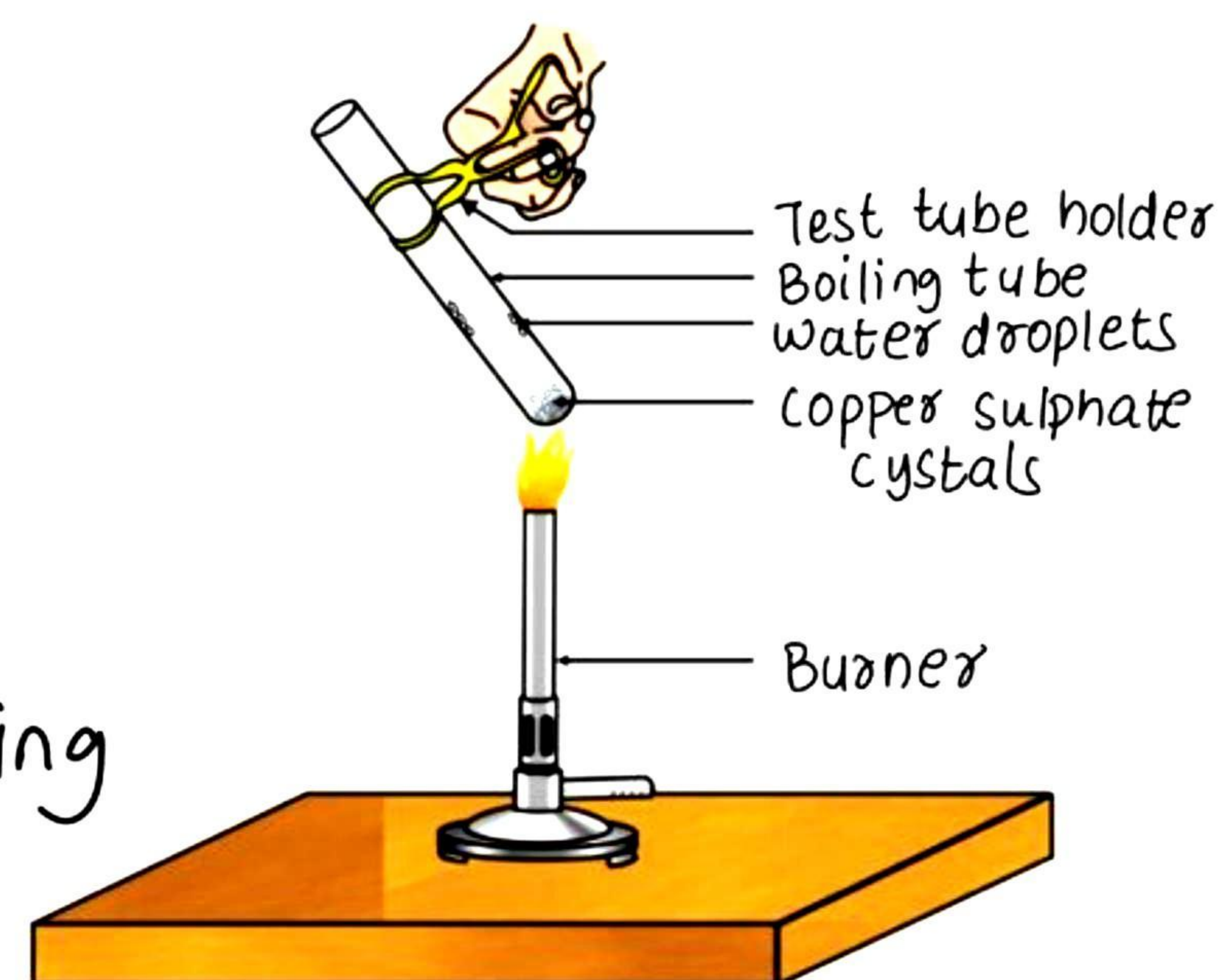


USES:

- In glass, soap and paper industries
- Domestic cleaner.
- Softening of water

→ Crystals of salts

Certain salts form crystals by combining with a definite proportion of water. The water that combines with the salt is called **water of crystallisation**.



→ Plaster of paris

Removing water of crystallisation

Gypsum, $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}(\text{s})$ on heating at 100°C (373K) gives $\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ and $\frac{3}{2}\text{H}_2\text{O}$

$\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ is plaster of paris

$\text{CaSO}_4 \cdot \frac{1}{2}\text{H}_2\text{O}$ means two formula units of CaSO_4 share one molecule of water.

USES: Cast for healing fractures.