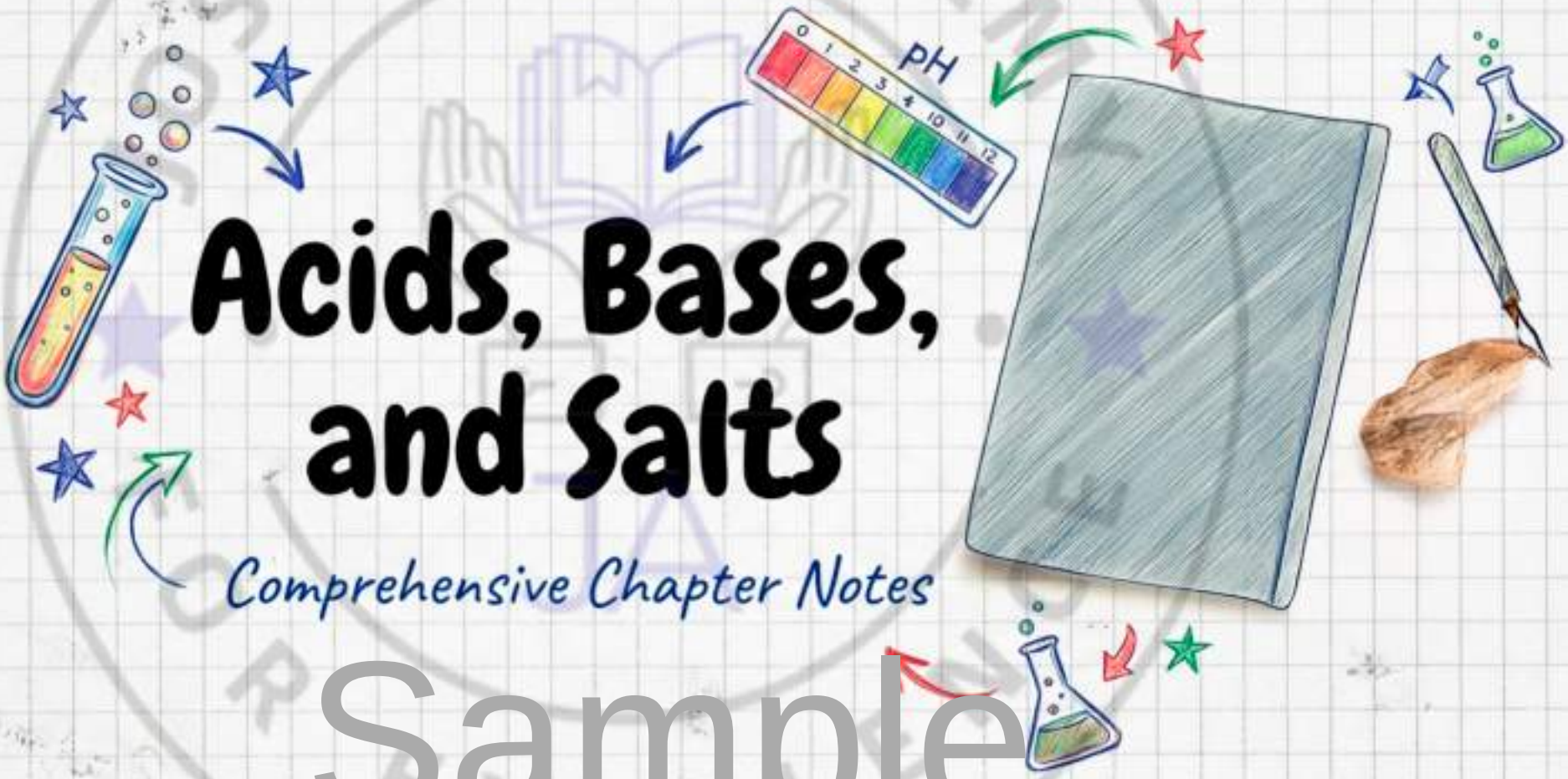
Class X CBSE
Science



Acids, Bases, and Salts

Comprehensive Chapter Notes

Joshi's Academy for Excellence

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Acids (Introduction)

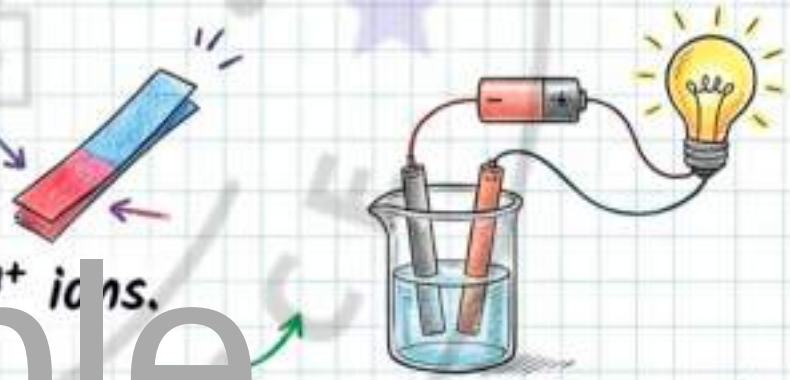
Derived from Latin word 'Acidus' = sour in taste.
Examples: Unripe mango, Lemon, Orange, Tomatoes, Vinegar, Curd.

Arrhenius Concept (1884): Acids are defined as compounds which contain one or more Hydrogen atoms. When they dissolve in water they produce H^+ ions or H_3O^+ ions.

$$HCl + H_2O \longrightarrow H_3O^+ + Cl^-$$

Physical Properties of Acids

1. Sour in taste.
2. Corrosive in nature (corrode metals).
3. Turn Blue Litmus → Red.
4. Electrolytes: Conduct electricity due to H^+ ions.
5. Soluble in water.



Common Acids

HCl (Hydrochloric), H_2SO_4 (Sulphuric), HNO_3 (Nitric), CH_3COOH (Acetic), H_2CO_3 (Carbonic), H_3PO_4 (Phosphoric), HNO_2 (Nitrous), H_2SO_3 (Sulphurous).

Daily Life Examples & The H^+ Ion

Acids in Daily Life	
Curd	→ Lactic acid
Lemon / Orange	→ Citric acid
Stomach	→ dil HCl
Spinach, Tomato	→ Oxalic acid
Baking powder	→ Tartaric acid
Grapes, Tamarind	→ Tartaric acid
Vinegar	→ Acetic acid
Cold drinks	→ Carbonic acid
Apple	→ Malic acid
Red Ant	→ Formic acid

All Acids Contain H^+ Ion

Hydrogen ions do not exist as H^+ alone; they are unstable. They combine with polar water molecules to form Hydronium ion $[H_3O]^+$.

$$HCl + H_2O \longrightarrow H^+ + Cl^-$$

$$H^+ + H_2O \longrightarrow [H_3O]^+$$

So the acidic property is due to the presence of $[H_3O]^+$ ions.

Classification of Acids (Source & Strength)

1. Basis of Source / Origin

Organic Acids

Naturally occurring (plants/animals).
Weak acids. Not harmful to eat.
Exampe: Vinegar, Citric acid, Milk, Curd.

Mineral (Inorganic) Acids

Obtained from minerals on earth crust.
Corrosive, harmful, dangerous.
Example: HCl, H_2SO_4, HNO_3, H_3PO_4.

Note: Exception – H_2CO_3 (Carbonic acid) is mineral but weak.

2. Basis of Strength (Ionization)

Strong Acids

Complete ionization in aqueous solution.
Strength ∝ concentration of H^+ ions.
Example: All mineral acids.

$$H_2SO_4 + H_2O \longrightarrow 2H^+ + SO_4^{2-}$$

Weak Acids

Partial / Incomplete ionization.
Example: Organic acids.

$$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$$

Classification (Concentration & Basicity)

3. Basis of Concentration

Dilute Acid: Acid quantity is less, water is more
(e.g., 90% water / 10% HCl)

Concentrated Acid: Acid quantity is high, water is low
(e.g., 90% HCl / 10% H_2O)

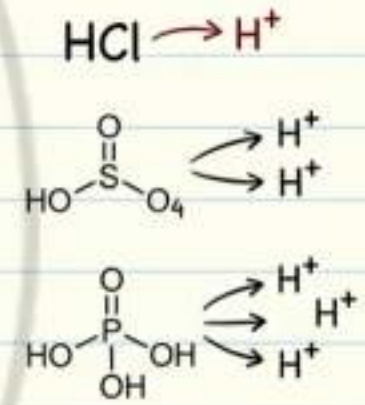
4. Basis of Basicity

(Definition: Number of H^+ ions produced per molecule)

Monobasic: Produces 1 H^+
(HCL, CH_3COOH, HBr, HI)

Dibasic: Produces 2 H^+
(H_2SO_4, H_2CO_3)

Tribasic: Produces 3 H^+
(H_3PO_4)



CRITICAL WARNING: Dilution of an Acid

Rule: Acid to Water (Gradually with stirring). **NOT** Water to Acid.

Reason: Highly Exothermic reaction. Adding water to acid causes explosion/splashing due to heat generated.

Acidic Behavior & Water

Common Feature: Acids produce H^+/H_3O^+ when dissolved in water.

Not All Hydrogen Compounds are Acids

HCl, HNO_3 → Acidic (produce H^+).

Glucose ($C_6H_{12}O_6$), Alcohol (C_2H_5OH) → Neutral. They contain H but do not ionize/produce H^+.

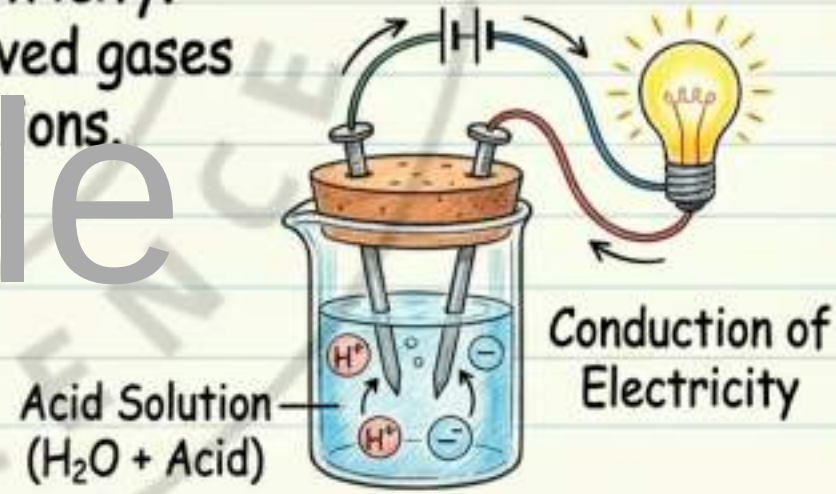
Distilled vs. Rain Water

Distilled: Neutral. No ions. Does not conduct electricity.

Rain Water: Conducts electricity. Contains dissolved gases (CO_2 , SO_2) which form acids (H_2CO_3, H_2SO_3) and ions.

Absence of Water

Acids only breakdown in water. In solid/gaseous state (dry), they do not show acidic behavior.



Chemical Properties of Acids

1. **Corrosive Nature:** Mineral acids cause burns. "Eat up" wood, cloth, stone, metals. **Storage:** Glass jars (never metal).

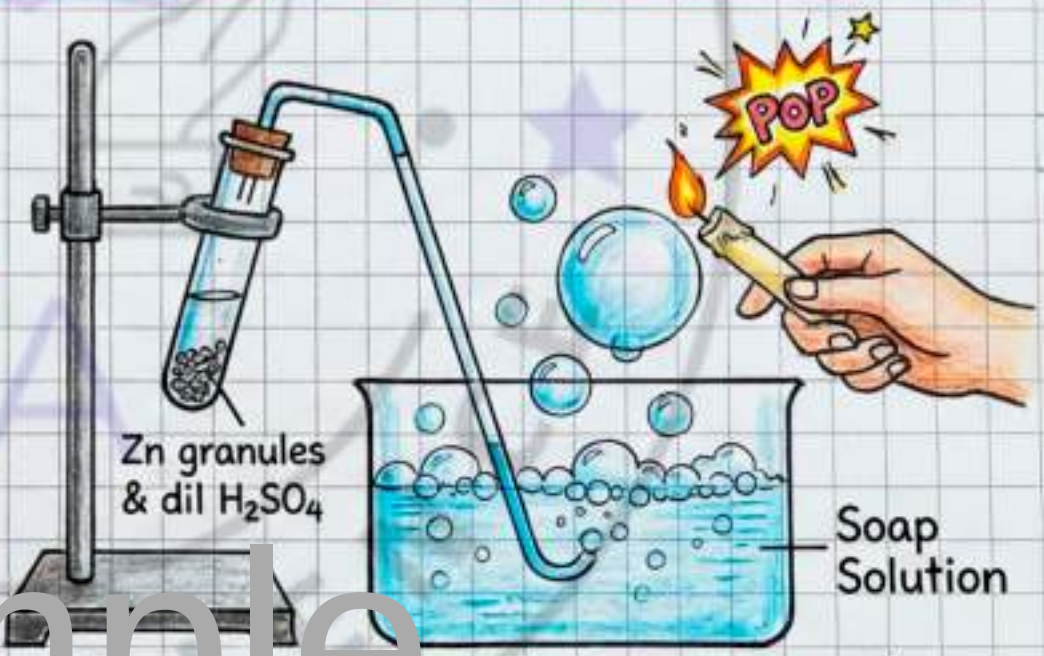
Warning: Do not keep curd/sour substances in Brass/Copper vessels (forms poisonous salts).

2. **Reaction with Metals:**

$$\text{Metal} + \text{Acid} \longrightarrow \text{Salt} + H_2\uparrow$$

$$Zn + \text{dil } H_2SO_4 \longrightarrow ZnSO_{4(aq)} + H_2\uparrow$$

Note: Displacement reaction (Zn > H).



Testing H_2 gas with burning candle

Chemical Properties of Acids

3. Reaction with Metal Oxides (Neutralization):

Metal Oxide + Acid → Salt + Water

$CuO + 2HCl \rightarrow CuCl_2$ (Blue-Green) $+ H_2O$

$MgO + H_2SO_4 \rightarrow MgSO_4 + H_2O$

4. Reaction with Metal Hydroxides:

Metal Hydroxide + Acid → Salt + Water

$Mg(OH)_2 + 2HCl \rightarrow MgCl_2 + 2H_2O$ (Milk of Magnesia antacid)

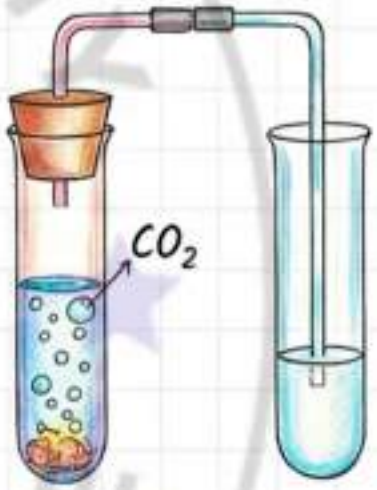
5. Reaction with Carbonates/Bicarbonates:

Carbonate/Bicarbonate + Acid → Salt + CO_2 + H_2O

$Na_2CO_3 + HCl \rightarrow NaCl + CO_2\uparrow + H_2O$

Uses: H_2SO_4 (Fertilizers), HCl (Textile), HNO_3 (Explosives).

Lime Water Test



$Ca(OH)_2 + CO_2 \rightarrow CaCO_3\downarrow + H_2O$

(Milky White)

Excess gas:

$CaCO_3 + H_2O + CO_2 \rightarrow Ca(HCO_3)_2$

(Soluble/Clear).

Bases

Arrhenius Concept – 1884

Bases are those chemical substances, when they dissolve in water, produce **Hydroxide ions OH^-**. They can neutralize an acid.

Physical Properties

- ✓ Bases are bitter in taste.
- ✓ They turn red litmus to blue.
- ✓ They give OH^- ions when they dissolve in water or aqueous solution.
- ✓ They also act as an electrolyte and conduct electricity due to presence of OH^- ions.

$$NaOH + H_2O \longrightarrow Na^+(aq) + OH^-$$

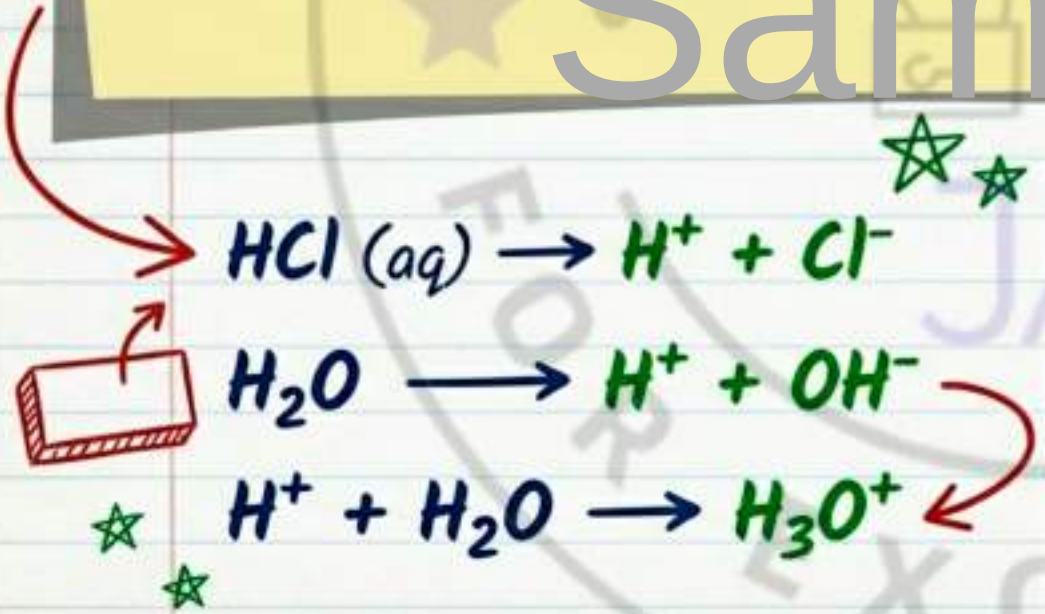
Examples: NH_4OH, $Ca(OH)_2$

Q. How is the concentration of hydroxyl ions affected when the solution of base is diluted?

Ans: When the solution of base is diluted by mixing more water then the concentration of OH^- ions per unit volume decreases.

Q: How is concentration affected when acid is diluted?

Ans: When the concentrated solution of an acid is diluted by mixing water then the concentration of H^+ ions per unit volume decreases.



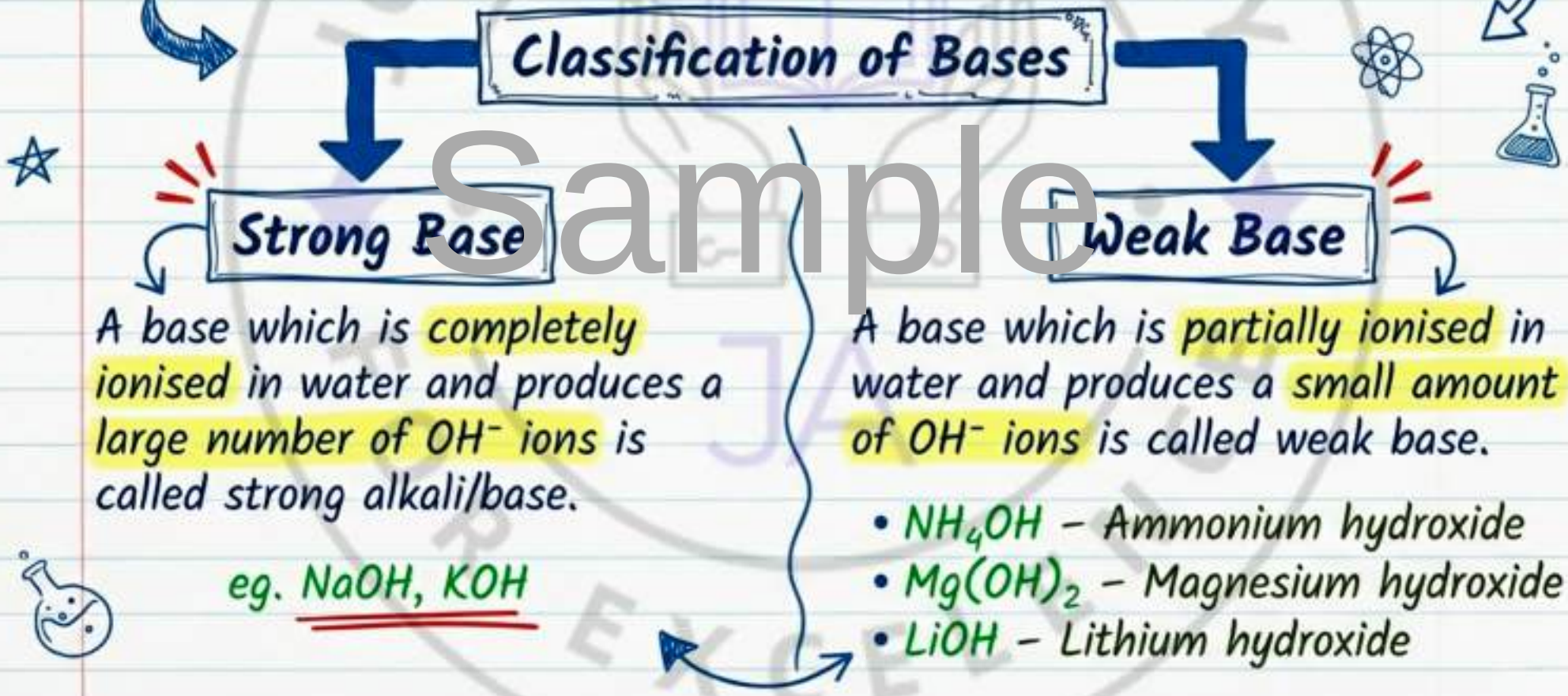
$$HCl\ (aq) \rightarrow H^+ + Cl^-$$

$$H_2O \longrightarrow H^+ + OH^-$$

$$H^+ + H_2O \rightarrow H_3O^+$$

Classification of Bases

On the basis of their **Strength** (Ionisation power)



A base which is completely ionised in water and produces a large number of OH^- ions is called strong alkali/base.

eg. NaOH, KOH

A base which is partially ionised in water and produces a small amount of OH^- ions is called weak base.

- NH_4OH – Ammonium hydroxide
- $Mg(OH)_2$ – Magnesium hydroxide
- $LiOH$ – Lithium hydroxide

Classification: On the basis of their Acidity

We call it acidity because it replaces H^+ ions and takes its position.

Monoacidic bases

The base/alkali on complete ionisation produces one OH^- ion in aqueous solution.

eg. NaOH, KOH, LiOH

Diacidic bases

The base on complete ionisation produces two OH^- ions in aqueous solution.

eg. $Ca(OH)_2$, $Mg(OH)_2$, $Be(OH)_2$

Triacidic bases

The base on complete ionisation produces three hydroxyl ions in aqueous solution.

eg. $Al(OH)_3$

Classification: On the basis of Concentration

It means the **amount of water** present in them.

Concentrated Base

Amount of water is less and amount of base is more.

eg. conc. NaOH

Dilute Base

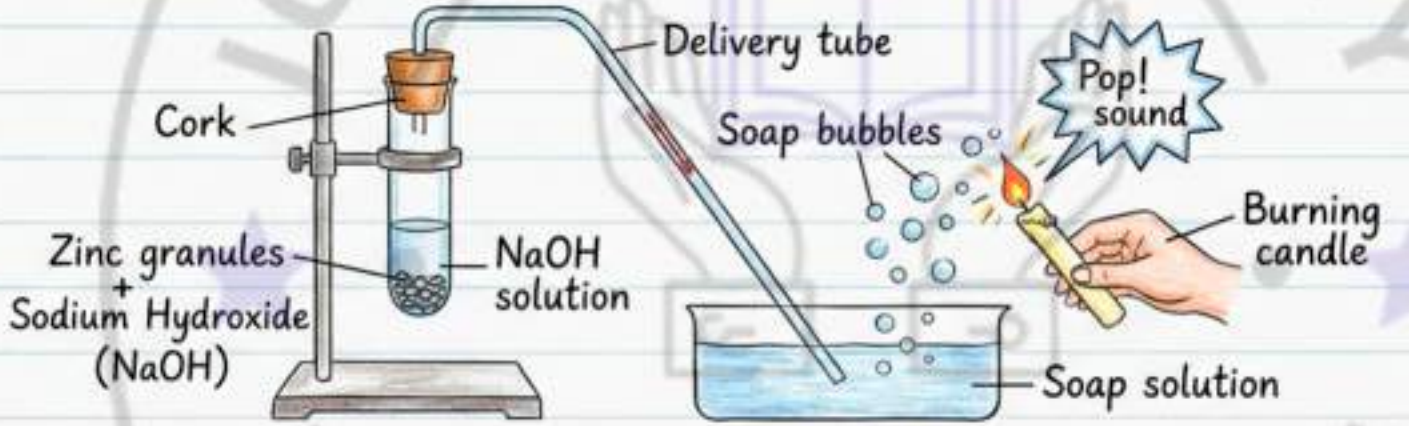
Amount of water is more and amount of base is less.

eg. dil. NaOH

Chemical Properties of Bases

I. Reaction with metals

All metals don't react with base. Only few metals (Al, Zn, Pb) which are **Amphoteric** in nature react with base and form **complex salts.**



$$NaOH + Zn(s) \longrightarrow Na_2ZnO_2\ (aq) + H_2\uparrow$$

(Sodium Zincate)

($Na_2ZnO_2 \rightarrow 2Na^+ + ZnO_2^{2-}$ where ZnO_2^{2-} is Zincate ion)

$$NaOH + Al(s) \longrightarrow NaAlO_2 + H_2\uparrow$$

(Sodium aluminate)

H_2 gas is evolved, which is collected by downward displacement of water.

Chemical Properties

2. Reaction with non-metal oxide

→ Non-metal oxide + base ⟶ Salt + water

Non-metallic oxides are acidic in nature so they react with base to form salt and water (Neutralisation reaction).

$$Ca(OH)_2 + CO_2 \longrightarrow CaCO_3 + H_2O$$

(Base) (Acidic Oxide) (Salt)

Metal oxides are basic in nature, so they don't react with base. (Exception: Amphoteric metals like Al, Zn react with both).

3. Neutralisation reaction

When acid and base reacts with each other, they form salt and water.

$$NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O$$

Uses of Bases

1. Sodium Hydroxide – NaOH

- Used in manufacture of soap, paper, rayon etc.
- It is starting material for many compounds.
- Largely used in Lab and Industries.

2. Calcium Hydroxide

- Used in making whitewash, bleaching powder.

3. Magnesium Hydroxide

- Used as an antacid to reduce acidity in stomach.

4. Sodium Carbonate

- Used in softening hard water, used in washing soda.

5. Sodium Bicarbonate

- Used in fire extinguisher.

Salts

- Salt is a general name, it doesn't refer only to common salt – NaCl.
  Salt family is a huge family.

Formation

- Salts are formed when acid and base react with each other (Neutralisation).

  Equation: Acid + Base ⟶ Salt + Water

  eg. $HCl + NaOH \longrightarrow NaCl + H_2O$

- Also formed when metal oxide reacts with acid $CaO + HCl \longrightarrow CaCl_2 + H_2O$

Structure

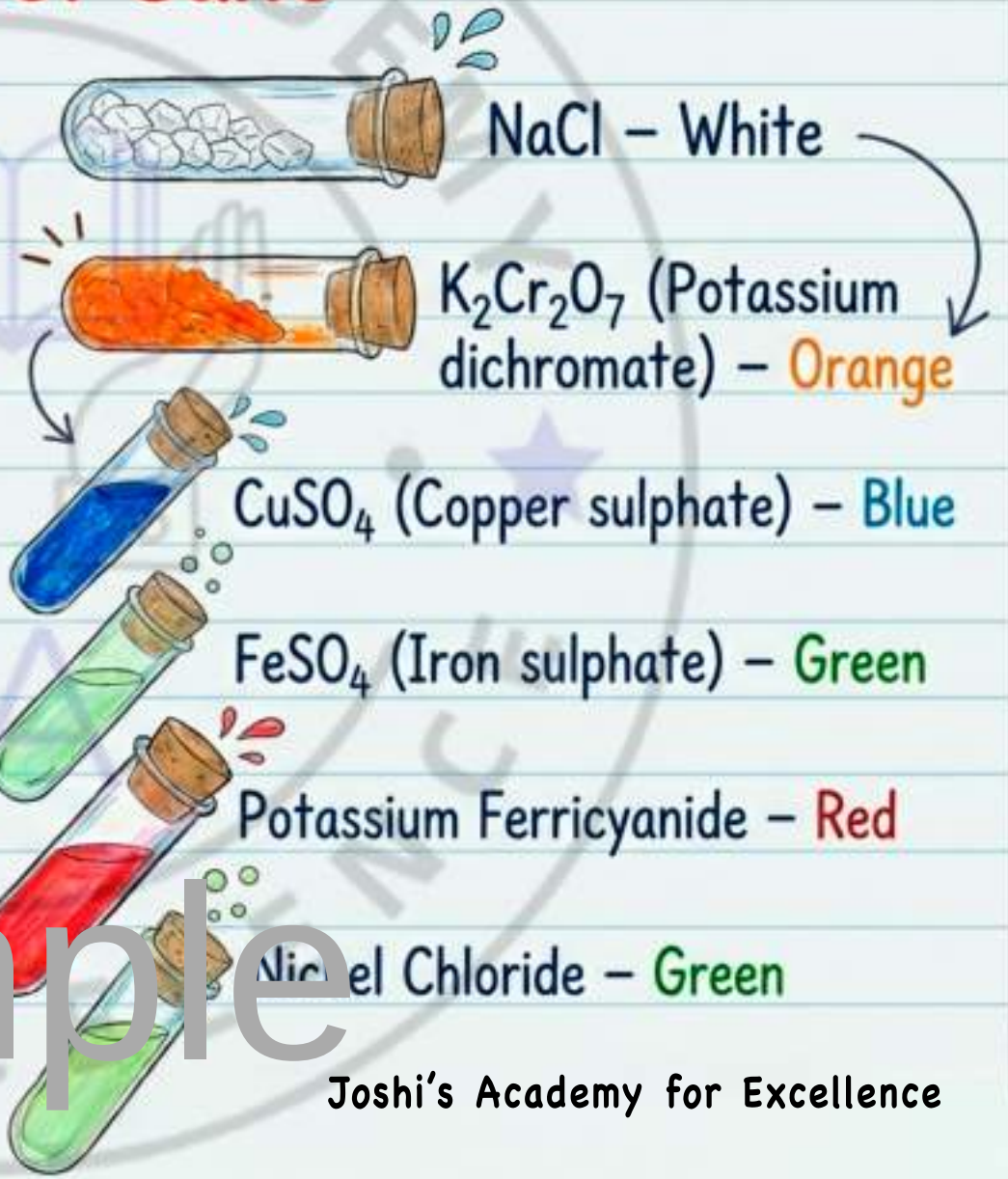
- A salt is an ionic compound. When dissolved, gives Cation (+ ion) and Anion (- ion).

  eg. $NaCl \longrightarrow Na^+ + Cl^-$

  eg. $NaHSO_4$ (Sodium Hydrogen Sulphate) $\longrightarrow Na^+, H^+, SO_4^{2-}$

Properties of Salts

- Solids
- High Melting and Boiling point
- Soluble in water
- Ionic compounds
- Conduct electricity
- They are neutral compounds



Types of Salts

1. Normal Salt

It doesn't contain any H^+ or OH^- ion. Formed by complete replacement of H^+ ions. Eq: $NaOH + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O$ (excess)

2. Acid Salt

Caveat

Partial replacement of H^+ ions. Shows some acidic behaviour.

Eq: $KOH + \text{dil. } H_2SO_4 \longrightarrow KHSO_4 + H_2O$ (less amount) ✓

Examples: $NaHSO_4$, NaH_2PO_4

Note: HCl & HNO_3 cannot make acid salt (only 1 H^+). Only dibasic/tribasic acids can.

3. Basic Salt

Partial replacement of OH^- ions from the base. Contains OH^-.

Eq: $Pb(OH)_2 + HCl \longrightarrow Pb(OH)Cl + H_2O$ (Basic Lead Chloride)

Eq: $Cu(OH)_2 + HCl \longrightarrow Cu(OH)Cl + H_2O$ (Basic Copper Chloride)

Types of Salts

4. Double Salt: At least two salts joined by a dot. Crystalline. Formed by mixing saturated solution of two simple salts.

- Alum (Phitkari): $K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$
- Mohr's salt: $(NH_4)_2SO_4 \cdot FeSO_4 \cdot 6H_2O$

5. Mixed Salts: Fixed proportion of two salts sharing either a common cation or anion. No H^+/OH^-.

- $NaKSO_4$ (Na^+, K^+ – 2 cations; SO_4^{2-} – 1 anion)
- $NaKCO_3$ (Sodium Potassium Carbonate)
- Bleaching Powder ($CaOCl_2$): Ca^{2+} (1 cation); OCl^-, Cl^- (2 anions)

6. Complex Salt: Coordinate compounds. Simple ion + Complex ion.

- $[Zn(NH_4)_4]SO_4$ (Tetra amine zinc sulphate) — Complex ion; Simple ion
- $Na[Ag(CN)_2]$ (Sodium Silver Cyanide) — Simple ion; Complex ion

Acid – Base Indicators

A chemical substance used to identify whether a given substance is an **acid** or **base** by a change in its colour.

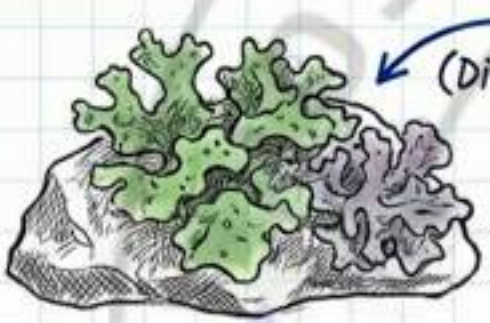
Why use indicators?
We cannot taste or touch chemicals! They are poisonous, have burning properties, and are corrosive in nature.

Types of Indicators

- Natural Indicators – Obtained directly from nature (e.g., Turmeric)
- Synthetic Indicators – Artificially made by humans (e.g., Methyl orange)
- Olfactory Indicators – Related to smell (e.g., Vanilla essence)
- Universal Indicators – Mixture of chemical dyes; provides information about the strength of acids/bases.

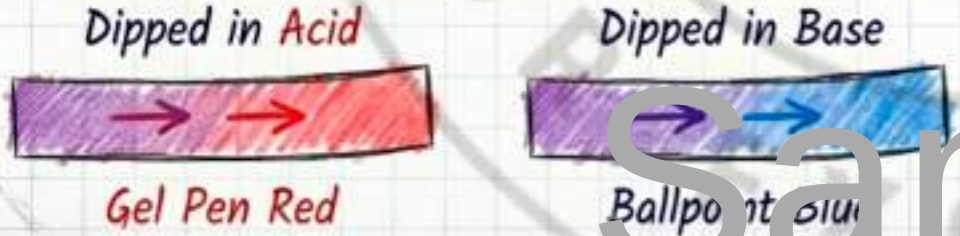
Natural Indicators (Obtained from Nature)

1. Litmus

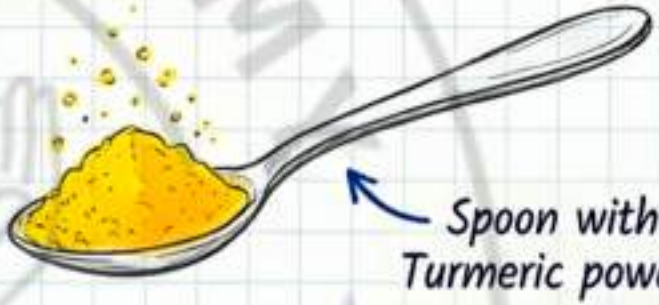


Origin: Purple dye extracted from Lichen plant.
Neutral State: In water, solution is neutral (Purple).

Litmus Paper:
Paper dipped in this solution and dried.



2. Turmeric



Properties: Yellow coloured natural dye.
Neutral State: Dissolves in water to give neutral solution.

- Basic water solution → Reddish pink colour
- Acidic solution → No change (remains Yellow)

Other Natural Indicators

Indicator	Neutral (in water)	Acid	Base
 Rose	Purple	Dark pink	Green
 Red Cabbage	Red	Red (no change)	Green
 Hydrangea (flower)	Blue	Blue (no change)	Pink

Synthetic Indicators

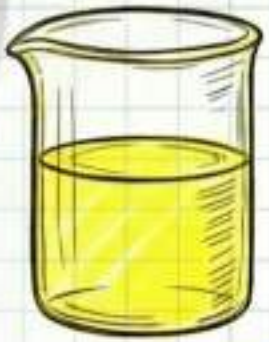
(Artificial/Man-made chemical dyes)

★ Useful in acid base titration.

Phenolphthalein Indicator

Neutral	Acid	Base
		
Colourless	Colourless	Pink colour

Methyl Orange

Neutral	Acid	Base
		
Orange colour	Red colour	Yellow colour

Olfactory Indicators

Related to the sense of smell. Substances whose odour changes in acidic or basic medium.

1. Onion

Has a characteristic smell.
Acidic medium: Smell remains same (not vanished).
Basic medium: Smell is completely vanished
(Example: cotton strip soaked in onion juice overnight).

2. Vanilla essence

Has a characteristic smell.
Acidic medium: Smell remains same.
Basic medium: Smell disappears.

3. Clove oil

Has a peculiar smell.
Result: It has a different smell in acid and basic medium.

Summary: Indicators in Different Media

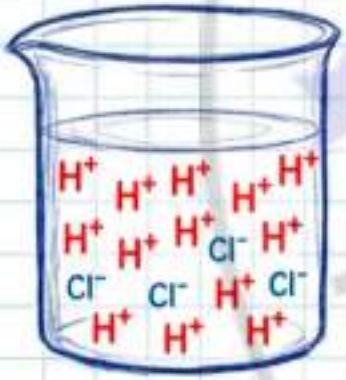
Indicator	Neutral Medium	Acidic Medium	Basic Medium
Litmus	Purple	Red	Blue
Turmeric	Yellow	No change	Red brown
Rose Petals	Purple	Dark pink	Green
Red Cabbage	Red	No change	Green
Hydrangea Flower	Blue	No change	Pink
Onion Extract	Characteristic smell	Same smell	Smell vanished
Vanilla Essence	Characteristic smell	Same smell	Smell disappears
Phenolphthalein	Colourless	Colourless	Pink colour
Methyl Orange	Orange colour	Red colour	Yellow colour

Strength of Acid and Base & Universal Indicators

Common indicators only tell us if a substance is acid or base. They cannot indicate relative strength (strong vs weak).

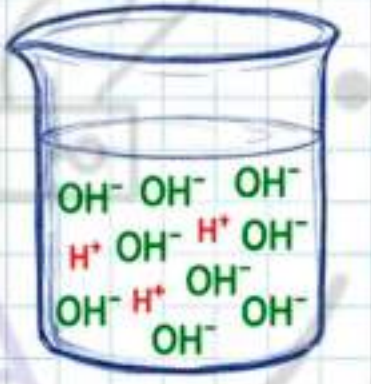
How strong are acid or base? Strength depends on H^+ ion concentration.

$HCl + H_2O \rightarrow H^+ + Cl^- + H^+ + OH^-$



H^+ ion concentration is more

$NaOH + H_2O \rightarrow Na^+ + OH^- + H^+ + OH^-$



H^+ ion concentration is less

OH^- is more

Universal Indicator: A mixture of many types of dyes which give different colours. With the help of colours, we can find out the strength of acid or base using the pH scale.

The pH Scale

History:

Discovered in 1990 by Peter Sorenson.

$$pH = -\log_{10}[H^+]$$

(Negative logarithm of base 10 of H^+ ion concentration).

Important Relationship:

$$pH \propto \frac{1}{[H^+ \text{ ion concentration}]}$$

Etymology:

German 'Potenz' = Power.

Means 'Power of Hydrogen'.

Concept:

Scale measures concentration of H^+ ions. No unit, only numbers.

High pH value
Low H^+ concentration

Low pH value
High H^+ concentration

pH Scale Categories

Acidic Solution (pH < 7)

Contains high H^+.

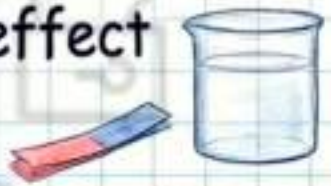
Examples:

- Sulphuric Acid (H_2SO_4): pH 0 (Dark red, strong strong acid)
- Citric Acid (Lemon juice): pH 2.5 (Orange, weak acid)

Neutral Solution (pH = 7)

Examples: Pure water, Sugar solution, Sodium chloride solution.

Result: No effect on litmus.



Summary:

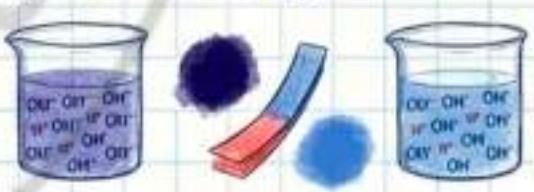
pH = 7 → Neutral
pH < 7 → Acidic
pH > 7 → Basic

Basic Solution (pH > 7)

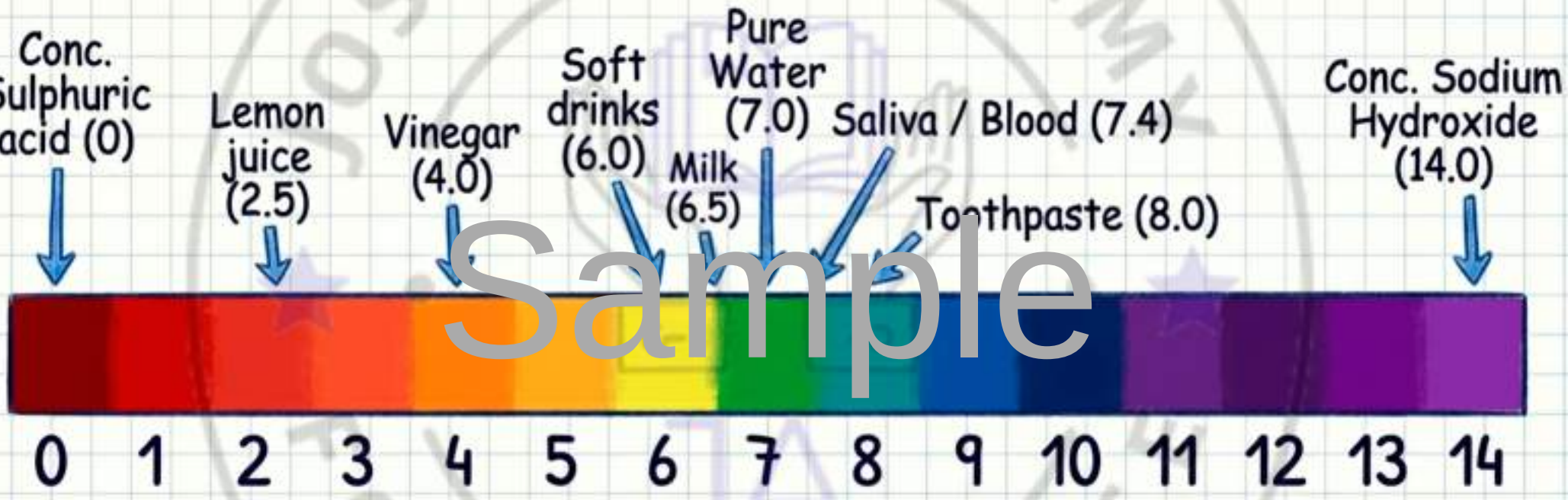
Contains less H^+ and more OH^-.

Examples:

- Sodium Hydroxide: pH 14 (Strong base)
- Blood: pH 7.4 (Weak base)



pH Values & Colour Chart



0: Dark red, 1-2: Red, 3: Orange-red, 4: Orange, 5: Orange-yellow,
6: Yellow, 7: Green, 8: Greenish blue, 9: Blue, 10: Navy blue,
11: Purple, 12: Dark purple, 13-14: Violet.

pH of Salts

Salts are neutral compounds. Though aqueous solutions of many salts are neutral (pH=7), some show slight acidic or basic behaviour due to hydrolysis.

Salt	pH	Nature
NaCl	7	Neutral salt
NH_4Cl	6	Acidic salt
Na_2CO_3	9	Basic salt

Neutral Salts

Formed by: Strong Acid + Strong Base.

pH: 7.

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

(Strong acid + Strong base) (Neutral salt)

Types of Salts (Acidic & Basic)

Acidic Salts

Formed by: Strong Acid + Weak Base.
pH: Less than 7.
Equation 1: HCl (Strong) + NH_4OH (Weak) → NH_4Cl (Ammonium Chloride)
Equation 2: $H_2SO_4 + NH_4OH \rightarrow (NH_4)_2SO_4$
Note: In aqueous solution, nature is acidic.

Basic Salts

Formed by: Weak Acid + Strong Base.
pH: More than 7.
Equation: CH_3COOH (Weak) + NaOH (Strong) → CH_3COONa (Sodium Acetate) + H_2O
Note: CH_3COONa is a basic salt.

Role of pH in Daily Life (Part 1)

1. Tooth Decay

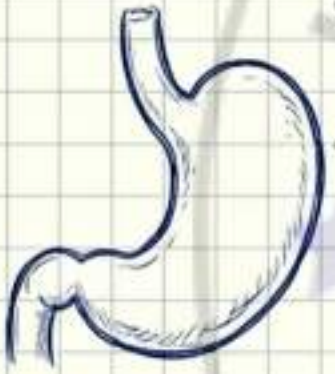
- pH of mouth is 5.5.
- Process: Sugar + Bacteria → Acid.
- Effect: Acid lowers pH below 5.5. Bacteria become active and tooth decay starts. Acid corrodes teeth.
- Prevention: Clean mouth after eating. Use toothpaste (basic) to neutralize acid.

2. Soil pH & Plant Growth

- Optimum range: 6.7 to 7.5
- Problem (Acidic pH < 6):
  - Treated with Quicklime (CaO), Slaked lime ($Ca(OH)_2$), or Chalk ($CaCO_3$). These are basic and neutralize acidity.
- Problem (Basic pH > 7.5): Alkalinity reduced by adding decaying organic matter (manure/compost). Naturally acidic, neutralizes the soil.

Role of pH in Daily Life (Part 2)

1. Digestive System



- Stomach pH: 1.4 (produces dil HCl for digestion).
- Issue: Indigestion/ Overeating → Excess acid → Pain & irritation (acidity).
- Remedy: Antacids (mild base) like $Mg(OH)_2$ (Milk of magnesia) or baking soda. Neutralizes acid.

2. Sensitivity to pH Change

- Survival: Living organisms survive in narrow pH range.
- Human Body: Range 7.0 to 7.8. Outside this, systems are disturbed.
- Aquatic Animals: Acid rain (pH < 5.6) due to SO_2, CO_2, NO_2 in atmosphere.
- Effect: Lowers river pH, killing aquatic life.
- Prevention: Add $CaCO_3$ to water bodies to neutralize.

Self Defence by Animals & Plants (Chemical Warfare)

Injecting painful and irritating acids & bases.

- Honey Bee: Sting injects Formic Acid (HCOOH). Causes pain/irritation.
- Prevention: Rub mild base (soda) or metal coil.

- Wasp: Sting injects Alkaline liquid.
- Prevention: Rub mild acid (vinegar).

- Red Ant: Injects Methanoic Acid (HCOOH).

- Nettle Plant: Stinging hair leaves inject Methanoic Acid. Causes burning pain.