ACIDS AND BASES

- Some substances like fruits, tamarind, graphs, curd and lemon are sour.
- They are said to be acidic.
- Some substances like sodium bicarbonate and green tea are bitter in taste.
- They are said to be basic.
- Acids and bases react with each other and also with water.
- As a result they are important biologically, industrially and environmentally.
- Among the medicines we use, aspirin is acidic and antacids are basic.
- Dietary fats are acids and the chemical compounds in DNA are bases.

Acids

- The term acid is derived from the Latin word 'acidus' which means sour.
- Chemical compounds which have sour taste are called acids generally.
- All acids contain one or more replaceable hydrogen atoms in their molecules and when dissolved in water they release H^+ ions.
- Hydrochloric acid (HCl), Sulphuric acid ($H2SO_4$) and Nitric acid (HNO_3) release hydrogen ions (H^+) when dissolved in water.

Hydrochloric + Water →Hydrogen + Chloride

acid ion ion

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

Sulphuric acid + Water →Hydrogen + Sulphate

ion ion

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

- Swedish chemist Svante Arrhenius proposed a theory on acids.
- According to him, an acid is a substance which furnishes H^+ ions or H_3O^+ ions in aqueous solution.
- Acids can be classified into organic acids and inorganic acids depending on the sources.
- These are called organic acids. Examples: Citric acid, tartaric acid etc.

Organic acids and their sources

Name of the Acid	Source
Citric acid	Oranges, Lemon
Lactic acid	Sour milk
Oxalic acid	Tomatoes
Acetic acid	Vinegar
Malic acid	Apple
Tartaric acid	Tamarind

- Man produces acids artificially in industries.
- These acids are called mineral acids or inorganic acids.
- Examples: Hydrochloric acid (HCl), Sulphuric acid (H_2SO_4), Nitric acid (HNO_3) etc.,

Properties of Acids

Physical properties

- Acids are sour in taste.
- They are corrosive in nature.
- Strong acids can spoil substances like human skin, clothes and paper.
- Generally acids exist in liquid state but few acids exist in solid state too. E.g. Benzoic acid
- Acids are colourless.
- Acids change the colour of the indicators.
- Blue litmus paper turns red and methyl orange turns pink when treated with acids.

- They are soluble in water.
- Solutions of acids conduct electricity.

Chemical properties

Reaction with metals

- Metals like zinc, magnesium, aluminum, iron etc., react with acids like hydrochloric acid, sulphuric acid to form metal salts and release hydrogen gas.

Metal + Dilute acids →Metal salt + Hydrogen

Example:

Zinc + Hydrochloric →Zinc chloride + Hydrogen

Acid

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2 \uparrow$$

Iron + Sulphuric acid →Ferrous + Hydrogen

Sulphate

$$Fe + H_2SO_4 \rightarrow FeSO_4 + H_2 \uparrow$$

- Take a clean test tube with holder and pour some dilute hydrochloric acid.
- Add few pieces of magnesium ribbon slowly.
- Now show a burning match stick near the mouth of the test tube.
- The gas burns with a pop sound.
- From this it is observed that hydrogen gas is formed due to the reaction between acid and metal.
- Copper or brass cooking vessels are coated with tin metal (eyam).
- If it is not coated the organic acids present in the food materials will react with copper and make the food poisonous.
- The tin isolates the vessel from the action of acids and prevents food poisoning.

Reaction with metal carbonates and bicarbonates

- When carbonates and bicarbonates come into contact with dilute acids carbon dioxide is given out along with water.
- For example, limestone (calcium carbonate) reacts with dilute sulphuric acid to form calcium sulphate, carbon dioxide and water.

Calcium carbonate + dil Sulphuric acid → Calcium sulphate + Carbon dioxide + Water

$$CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + CO_2 + H_2O$$

Reaction with metal oxide

- Oxides of various metals react with dilute acids to form their metallic salts and water.

Metal oxides + dilute Acid → Metal salts + Water

Example:

Calcium oxide + Hydrochloric acid → Calcium chloride + Water

$$CaO + 2HCl \rightarrow CaCl_2 + H_2O$$

Uses of Acids

- Hydrochloric acid present in our stomach helps in the digestion of foodstuff.
- Vinegar (acetic acid) is used to preserve food materials.
- Benzoic acid is also used to preserve food materials like pickles.
- Sodium or potassium salts of higher fatty acids are used to make washing and bathing soaps.
- Sulphuric acid is called the king of chemicals.
- It is an effective dehydrating agent.
- It is used in various industries to make detergents, paints, fertilizers and many more chemicals.
- Hydrochloric acid, Nitric acid and Sulphuric acid are important laboratory reagents.
- Cells of all living organisms contain the fundamental nuclear material called nucleic acids.
- Animals have deoxy ribo nucleic acid (DNA) whereas plants contain ribo nucleic acid (RNA).

- Pickles remain in good condition for long time because they contain vinegar (acetic acid) or benzoic acid.

Bases

- Soaps are slippery in nature.
- Soaps are slippery due to the presence of 'base'.
- Bases are chemical substances that are corrosive and bitter in taste.
- A lot of bleaches, soaps, detergents, kinds of toothpaste, etc., are bases.
- Bases release hydroxide ions in water.
- The chemical substances that release hydroxide ions when dissolved in water are called as bases. Examples: Sodium hydroxide (NaOH) and Potassium hydroxide (KOH).

  Sodium hydroxide →Sodium ion + Hydroxide ion

  $NaOH \rightarrow Na^{+} + OH^{-}$

  Potassium hydroxide →Potassium ion + Hydroxide ion

  $KOH \rightarrow K^{+} + OH^{-}$
- Water soluble bases are called Alkalis.
- Bases like sodium hydroxide, potassium hydroxide, calcium hydroxide and ammonium hydroxide are highly soluble in water and hence they are called alkalis.
- Certain chemical substances which do not release hydroxide ions when dissolved in water also behave as bases.
- Examples: Sodium carbonate, Sodium bicarbonate, Calcium carbonate etc.

Common bases in some products

Base	Formula	Products
Magnesium hydroxide	$Mg(OH)_2$	Milk of magnesia
Sodium hydroxide	NaOH	Detergent
Ammonium hydroxide	NH_4OH	Solution for cleaning windows
Calcium hydroxide	$Ca(OH)_2$	Lime water

Potassium hydroxide	KOH	Soap

- Sodium carbonate (Na_2CO_3) is commercially called washing soda.
- Similarly sodium bicarbonate ($NaHCO_3$) is commercially called baking soda.
- Caustic soda is sodium hydroxide (NaOH) and caustic potash is potassium hydroxide (KOH).

Properties of Bases

Physical properties

- Bases generally exist in solid state but some bases exist in liquid state also.
- E.g. Ammonium hydroxide, calcium hydroxideBases give soapy touch only in aqueous media not in dry nature.
- Bases are bitter in taste.
- Bases are corrosive in nature.
- When come in contact with the skin frequently they form painful blisters.
- Bases are generally colourless.
- Bases also change the colour of the indicators.
- Red litmus paper turns blue when treated with bases.
- Similarly, they turn methyl orange yellow and phenolphthalein pink.
- Bases also conduct electricity in aqueous solution.

Chemical properties of bases

Reaction with metals

- Generally metals do not react with bases.
- Metals like Aluminium and Zinc react with bases like sodium hydroxide forming aluminates and release hydrogen.

Aluminum + Sodium hydroxide + Water →

Sodium aluminate + Hydrogen

$2Al + 2NaOH + 2H_2O \rightarrow 2NaAlO_2 + 3H_2$

Reaction with metal oxides

- All bases react with non metallic oxides to form salt and water.

- For example sodium hydroxide reacts with carbon dioxide to form sodium carbonate.

Sodium hydroxide + Carbon dioxide →

Sodium carbonate + Water

$2NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$

Reaction with ammonium salts

- Bases react with ammonium salts to form metal salts, ammonia gas and water.

Sodium hydroxide + Ammonium chloride →

Sodium chloride + Ammonia + Water

$NH_4Cl + NaOH \rightarrow NaCl + NH_3 + H_2O$

- Though acids and bases have some unique properties there are certain similarities between them.
- They are corrosive in nature.
- They undergo ionization in aqueous solution.
- They conduct electricity in aqueous solution.
- They undergo neutralization reaction.

Difference between acids and bases

Acids	Bases
They produce H^+ ions in water.	They produce OH^- ions in water.
They are sour in taste.	They are bitter in taste.
Few acids are in solid state.	Most of the bases are in solid state.
Acids turn blue litmus paper red.	Bases turn red litmus paper blue.

Uses of Bases

- i) Potassium hydroxide is used to make bathing soaps.
- ii) Sodium hydroxide is used to make washing soaps.
- iii) Sodium hydroxide is also used in paper industries, textile industries and in the preparation of medicines.
- iv) Calcium hydroxide is used for white washing.

- v) Aluminum hydroxide and magnesium hydroxides are used in antacids to cure acidity problems.
- vi) Ammonium hydroxide is used to manufacture fertilizers, nylon, plastics and rubber.

Neutralisation Reaction

- When neutrality is achieved between two different chemical substances with different chemical properties through a reaction then it is called neutralization in chemistry.
- Thus neutralization is a chemical reaction in which an acid and a base react with each other to form salt and water.
- Neutralization reaction between an acid and a base can be written as:

  Acid + Base → Salt + Water
- In this reaction, H^+ and Cl^- ions are produced by the hydrochloric acid and Na^+ and OH^- ions are produced by the base sodium hydroxide.
- When these ions combine together sodium chloride (NaCl) salt and water are produced.

Salts produced by neutralization

Acid	Base	Salt
Hydrochloric acid HCl	Sodium hydroxide NaOH	Sodium chloride NaCl
Sulphuric acid H_2SO_4	Sodium hydroxide NaOH	Sodium sulphate Na_2SO_4
Nitric acid HNO_3	Sodium hydroxide NaOH	Sodium nitrate $NaNO_3$
Acetic acid CH_3COOH	Sodium hydroxide NaOH	Sodium acetate CH_3COONa

Neutralisation reactions in our daily life

Ant bite

- Whenever bees or red ants bite they inject an acid called formic acid.
- These acids cause burning sensation and pain.
- To suppress the pain a suitable base in the form of calcium hydroxide (readily available at home) is applied so as to neutralise the formic acid.

Wasp bite

- When we are bitten by wasp, we feel the burning sensation and pain.
- It is due to an alkaline substance injected by the insect.
- To neutralise the alkalinity we use vinegar which is an acid.

Tooth decay

- Generally it is advised by the doctors that we should brush our teeth twice a day.
- This is because the bacteria present in our mouth decompose the food particles stuck in the gaps between our teeth thereby causing acid formation which leads to tooth decay.
- To prevent this we have to neutralize the acid.
- When we brush with tooth powder or tooth paste containing weak bases, the acid gets neutralized.
- So our teeth will be strong and healthy.

Acidity

- As we know, hydrochloric acid present in our stomach helps the digestion of food material along with the enzymes secreted by liver, gallbladder and pancreases.
- Sometimes due to excessive production of hydrochloric acid in our stomach we feel burning sensation in food pipe and in chest area.
- If this happens again and again ulcer will be formed in stomach and food pipe, which further aggravates the conditions.
- In order to neutralize, antacids which are nothing but weak bases like aluminum and magnesium hydroxides are used.
- As a result the acidity is removed.

Agriculture

- Acidic soil is not suitable for plant growth.

- So farmers add lime fertilisers such as powdered lime (CaO), limestone ($CaCO_3$) or ashes of burnt wood to the soil to neutralise the acidity.

Industries

- Effluents from the industries contain acids such as sulphuric acid.
- It is treated by adding lime to neutralise it before it is discharged into rivers and streams.
- Similarly, in power stations fossil fuels such as coal are burnt to produce electricity.
- Burning fossil feuls will liberate sulphur dioxide gas as an acidic pollutant in the air.
- Hence, power stations treat this acidic gas using powdered lime (CaO) or limestone ($CaCO_3$) to neutralise it so that air pollutant can be prevented.

Indicators

- An indicator or acid–base indicator is a chemical substance which indicates the acidic or basic nature of a solution by suitable colour change.
- These may be natural or synthetic.

Natural indicators

- Natural indicators are chemical substances which are obtained from the natural resources.
- Litmus, turmeric juice, China rose petals, red cabbage, grape juice and beetroot juice are the indicators obtained from natural resources.

Turmeric indicator

- In acidic solution turmeric indicator paper has no change in colour.
- That means it remains yellow.
- In basic solution the colour changes from yellow to red.

Hibiscus flower indicator

- Some hibiscus flowers soaked in warm water for about 5 to 10 minutes forms a solution.
- This solution can be used as indicator.
- In acidic solution, the colour will be changed to deep pink or deep red.
- In basic solution, the colour will be changed into a green.

Beet root juice indicator

- Extracts of beet root are also used as an indicator for identifying the acidic or basic nature of a solution.

Litmus

- Litmus is the most common indicatorz used in the laboratories.
- Litmus is a natural indicator which is extracted from lichens.
- It is available in the form of solution or in the form of strips prepared by absorbing litmus solution on filter paper.
- It is either red or blue in colour. Blue litmus paper turns red in acidic solution and red litmus paper turns blue in the basic solution.

Synthetic indicators

- An indicator prepared from artificial substances is known as synthetic indicators.
- Phenolphthalein and methyl orange are the examples for synthetic indicators.

Phenolphthalein

- Phenolphthalein is a colourless compound.
- Its alcoholic solution is used as an indicator.
- It is colourless in acidic solution but turns pink in basic solution.

Methyl orange

- Solid methyl orange is dissolved in hot water and its filtrate is used as an indicator.
- It turns red in acidic solution and yellow in basic solution.

Colour Changing Indicators

Indicator	Acidic solution	Basic solution
Blue litmus	Red	No change in colour
Red litmus	No change in colour	Blue
Phenolphthalein	Colourless	Pink
Methyl orange	Red	Yellow