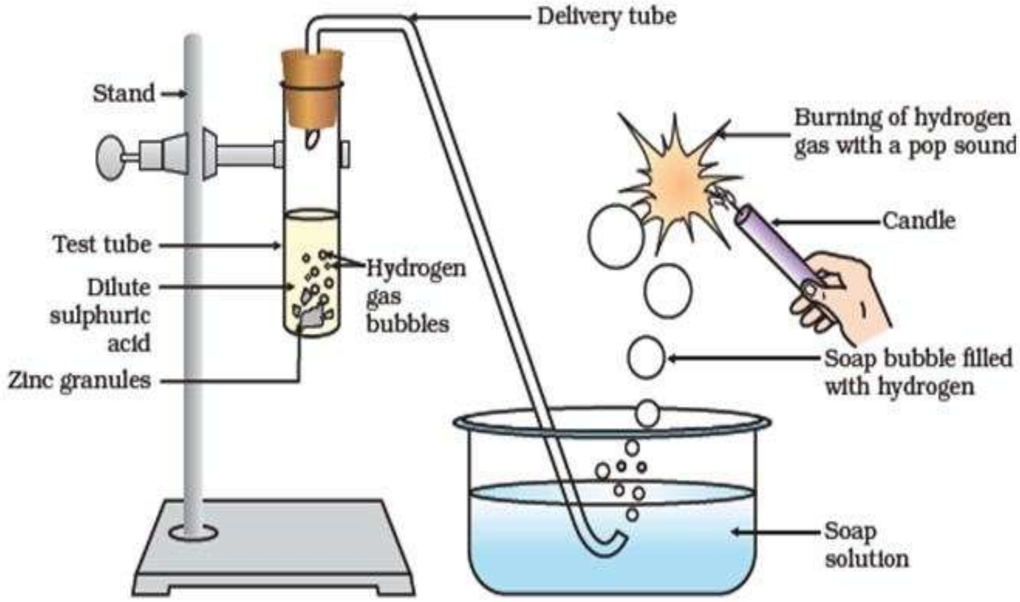
Acids, Bases and Salts

Reaction of Acids & Bases with metals



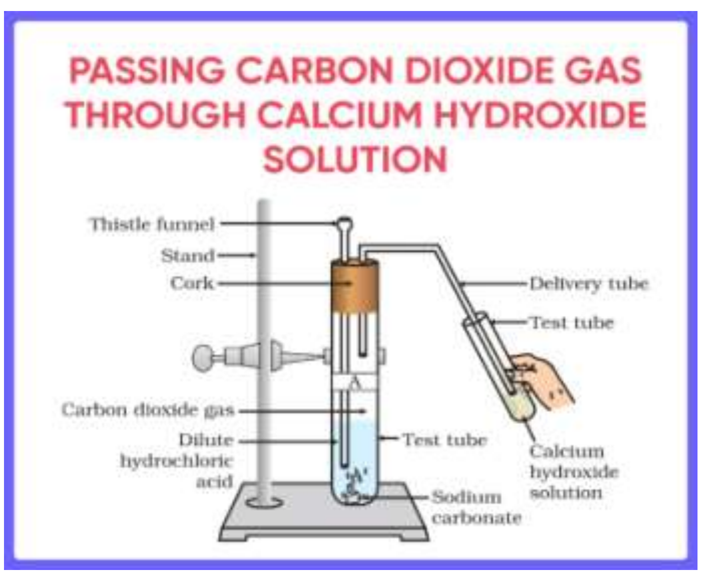
Reaction of zinc granules with dilute sulphuric acid and testing hydrogen gas by burning

Acid + Metal → Salt + Hydrogen gas

Eg:- 2NaOH(aq) + Zn(s) → Na_2ZnO_2 (s) + H_2 (g) (Sodium zincate)

Hydrogen is formed in the reaction. However, such reactions are not possible with all metals.

Reaction of Metal Carbonates and Metal Hydrogen carbonates React with Acids



$Na_2CO_3(S) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$

$NaHCO_3(S) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l) + CO_2(g)$

On passing the carbon dioxide gas evolved through lime water,

$Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(S) + H_2O(l)$
(Lime water) (White precipitate)

On passing excess carbon dioxide the following reaction takes place:

$CaCO_3(s) + H_2O(I) + CO_2(g) \rightarrow Ca(HCO_3)_2(aq)$
(Soluble in water)

Limestone, chalk and marble are different forms of calcium carbonate. All metal carbonates and hydrogen carbonates react with acids to give a corresponding salt, carbon dioxide and water.

Metal carbonate/Metal hydrogen carbonate + Acid → Salt + Carbon dioxide + Water

Reaction of Acids with Bases

The effect of a base is nullified by an acid and vice-versa. The reaction taking place is written as –

$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

The reaction between an acid and a base to give a salt and water is known as a neutralization reaction. In general, a neutralization reaction can be written as –

Base + Acid → Salt + Water

Reaction of Metallic Oxides with Acids

The general reaction between a metal oxide and an acid can be written as –

Metal oxide + Acid → Salt + Water

Eg:- $CuO + 2HCl \rightarrow Cucl_2 + H_2O$

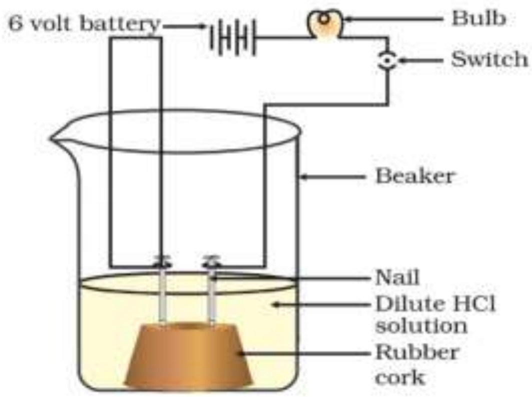
Since metallic oxides react with acids to give salts and water, similar to the reaction of a base with an acid, metallic oxides are said to be basic oxides.

Reaction of a Non-metallic Oxide with Base

The reaction between carbon dioxide and calcium hydroxide. Calcium hydroxide, which is a base, reacts with carbon dioxide to produce a salt and water. Since this is similar to the reaction between a base and an acid, we can conclude that nonmetallic oxides are acidic in nature.

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

Reaction of Acid & Bases with water



Acid solution in water conducts electricity

The bulb will start glowing in the case of acids. But you will observe that glucose and alcohol solutions do not conduct electricity. Glowing of the bulb indicates that there is a flow of electric current through the solution. The electric current is carried through the acidic solution by ions.

Acids contain H+ ion as cation and anion such as Cl^- in HCl, NO_3^- in HNO_3, $SO^{2-}{}_4$ in H_2SO_4, CH_3COO^- in CH_3COOH. Since the cation present in acids is H^+, this suggests that acids produce hydrogen ions, H^+ (aq), in solution, which is responsible for their acidic properties

Hydrogen ions cannot exist alone, but they exist after combining with water molecules. Thus hydrogen ions must always be shown as H+ (aq) or hydronium ion (H_3O^+).

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

What happens when a base is dissolved in water.

$NaOH(s) \xrightarrow{H_2O} Na^+(aq) + OH^-(aq)$

$KOH(s) \xrightarrow{H_2O} K^+(aq) + OH^-(aq)$

$Mg(OH)_2\,(s) \xrightarrow{H_2O} Mg^{2+}(aq) + 2OH^-(aq)$

Bases generate hydroxide (OH^-) ions in water. Bases which are soluble in water are called alkalis.

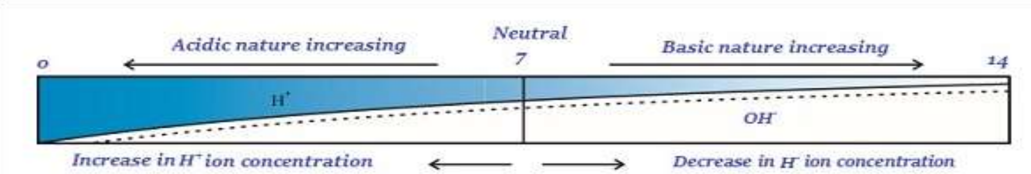
- All bases do not dissolve in water. An alkali is a base that dissolves in water. They are soapy to touch, bitter and corrosive.

Mixing an acid or base with water results in decrease in the concentration of ions (H_3O^+/OH^-) per unit volume. Such a process is called dilution and the acid or the base is said to be diluted.

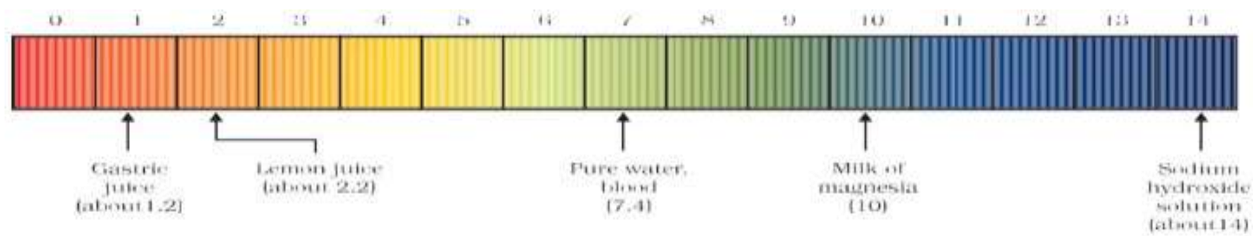
HOW STRONG ARE ACID OR BASE SOLUTIONS?

A scale for measuring hydrogen ion concentration in a solution, called pH scale has been developed. The p in pH stands for 'potenz' in German, meaning power. On the pH scale we can measure pH generally from 0 (very acidic) to 14 (very alkaline). pH should be thought of simply as a number which indicates the acidic or basic nature of a solution. Higher the hydronium ion concentration, lower is the pH value.

The pH of a neutral solution is 7. Values less than 7 on the pH scale represent an acidic solution. As the



Variation of pH with the change in concentration of $H^+(aq)$ and $OH^-(aq)$ ions pH value increases from 7 to 14, it represents an increase in OH^- ion concentration in the solution, that is, increase in the strength of alkali.



pH of some common substances shown on a ph paper (colours are only a rough guide)

The strength of acids and bases depends on the number of H^+ ions and OH^- ions produced, respectively. If we take hydrochloric acid and acetic acid of the same concentration, say one molar, and then these produce different amounts of hydrogen ions. Acids that give rise to more H+ ions are said to be strong acids, and acids that give less H^+ ions are said to be weak acids.

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. Living organisms can survive only in a narrow range of pH change. When pH of rain water 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.

pH in our digestive system

It is very interesting to note that our stomach produces hydrochloric acid. It helps in the digestion of food without harming the stomach. During indigestion the stomach produces too much acid and this causes pain and irritation. To get rid of this pain, people use bases called antacids. These antacids neutralize the excess acid. Magnesium hydroxide (Milk of magnesia), a mild base, is often used for this purpose.

pH change as the cause of tooth decay

Tooth decay starts when the pH of the mouth is lower than 5.5. Tooth enamel, made up of calcium hydroxyapatite (a crystalline form of calcium phosphate) is the hardest substance in the body. It does not dissolve in water, but is corroded when the pH in the mouth is below 5.5. Bacteria present in the mouth produce acids by degradation of sugar and food particles remaining in the mouth after eating. The best way to prevent this is to clean the mouth after eating food. Using toothpastes, which are generally basic, for cleaning the teeth can neutralize the excess acid and prevent tooth decay.

Self defence by animals and plants through chemical warfare

Bee-sting leaves an acid which causes pain and irritation. Use of a mild base like baking soda on the stung area gives relief. Stinging hair of nettle leaves inject methanoic acid causing burning pain.

Some naturally occurring acids

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

pH of Salts (Buffer Solution)

Salts of a strong acid and a strong base are neutral with pH value of 7. On the other hand, salts of a strong acid and weak base are acidic with pH value less than 7 and those of a strong base and weak acid are basic in nature, with pH value more than 7.

Common salt — A raw material for chemicals

The common salt thus obtained is an important raw material for various materials of daily use, such as sodium hydroxide, baking soda, washing soda, bleaching powder and many more.

Eg:- (1) NaCl (Sodium Chloride)

(2) Bleaching powder ($CaOCl_2$)

Bleaching powder is used –

(i) for bleaching cotton and linen in the textile industry, for bleaching wood pulp in paper factories and for bleaching washed clothes in laundry;
(ii) as an oxidizing agent in many chemical industries; and
(iii) to make drinking water free from germs.

(3) Baking soda ($NaHCO_3$)

Uses of Baking soda –

(i) For making baking powder, this is a mixture of baking soda (sodium hydrogen carbonate) and a mild edible acid such as tartaric acid. When baking powder is heated or mixed in water, the following reaction takes place –

$NaHCO_3 + H^+ \rightarrow CO_2 + H_2O$ + Sodium salt of acid
(From any acid)

Carbon dioxide produced during the reaction can cause bread or cake to rise making them soft and spongy.

(ii) Sodium hydrogen carbonate is also an ingredient in antacids. Being alkaline, it neutralizes excess acid in the stomach and provides relief.

(iii) It is also used in soda-acid fire extinguishers.

(4) Washing soda ($Na_2CO_3.10H_2O$)

Uses of washing soda –

(i) Sodium carbonate (washing soda) is used in glass, soap and paper industries.
(ii) It is used in the manufacture of sodium compounds such as borax.
(iii) Sodium carbonate can be used as a cleaning agent for domestic purposes.
(iv) It is used for removing permanent hardness of water.

(5) Plaster of Paris ($CaSO_4.1/2H_2O$)

$CaSO_4.1/2H_2O + 1\frac{1}{2}H_2O \rightarrow CaSO_4.2H_2O$
(Plaster of Paris) Gypsum)

Plaster of Paris is used for making toys, materials for decoration and for making surfaces smooth.

(6) Copper Sulphate ($CuSO_4.5H_2O$)