The pH Scale:

A litmus solution or litmus paper can be used to determine whether a given solution is acidic or basic. But suppose you have two acidic solutions containing different amounts of acids in them. How can you say which solution is more acidic? Similar is the case with the basic solutions. This problem is solved by using a scale known as the pH scale introduced by S P Sorensen in 1909. pH of a solution indicates which solution is more acidic or more basic than the other.

The acidity or basicity (alkalinity) of a solution is usually expressed in terms of a function of the H^+ ion concentration. This function is called the pH of a solution.

The pH of an aqueous solution is the negative logarithm of its H+ ion concentration. That is,

$$pH = -\log [H^+].$$

$$pOH = -\log [OH^-].$$

Note: $[H^+]$ and $[OH^-]$ denote the concentrations of H^+ and OH^- ions respectively.

The concentrations of H^+ and OH^- ions in aqueous solutions are usually very small numbers and therefore difficult to work with. Since pH is the negative logarithm of $[H^+]$, we get positive' numbers and the inconvenience of dealing with small numbers is eliminated.

It should be noted here that pH is only a number, because we can take the logarithm of a number and not of a unit. Therefore, pH of a solution is a dimensionless quantity.

In a neutral solution, $[H^+] = 1.0 \times 10^{-7}$ M.

$\therefore$ $pH = -\log (1.0 \times 10^{-7}) = 7.$

We can say that the pH of a neutral solution is 7. In an acidic solution, $[H^+] > 1.0 \times 10^{-7}$ M.

Let us assume, $[H^+] = 1.0 \times 10^{-5}$ M.

- $pH = -\log (1.0 \times 10^{-5}) = 5.$

Here, we find that the pH of an acidic solution is less than 7.

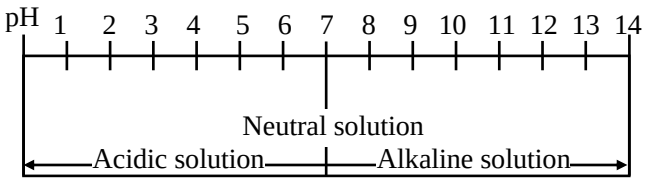
In an alkaline solution, $[H^+] < 1.0 \times 10^{-7}$ M. Let

as assume, $[H^+] = 1.0 \times 10^{-9}$ M.

- $pH = -\log (1.0 \times 10^{-9}) = 9.$

In other words, the pH of an alkaline solution is more than 7.

The pH of different solutions at 298 K can now be expressed on the pH scale as shown below.



Rules for pH scale (at 298 K)

1. Acidic solutions have pH less than 7.
2. The lower the pH, the more acidic is the solution.
3. Neutral solutions or pure water has pH equal to 7.
4. Basic solutions have pH greater than 7.
5. The higher the pH, the more basic is the solution.

The pH values of some common solutions

Substance	pH
Gastric juice	1.0
Lemon juice	2.5
Vinegar	3.0
Wine	3.5
Tomato juice	4.1
Acid rain	5.6
Urine	6.0
Milk	6.5
Pure water	7
Blood	7.4
Lime water	11.0

Role of pH in everyday life:

pH plays a very important role in our everyday life.

1. **In our digestive system :** Hydrochloric acid produced in our stomach helps the digestion of food without causing any harm to the stomach. But when the amount of the acid goes beyond a certain limit due to indigestion, pain and irritation are created in the stomach. So, in order to neutralize the effect of excess acid, a mild base called antacid is usually taken. Magnesium hydroxide (milk of magnesia) is a mild base which is usually used as an antacid.
2. **Acids cause tooth decay :** When we eat sugary food, it gets degraded by bacteria present in the mouth and an acid is formed. When the pH becomes lower than 5.5, tooth enamel gets corroded. Saliva, which is slightly alkaline, produced in the mouth neutralizes some acid, but excess acid remains unaffected. The excess acid can be removed only by the use of toothpaste which is alkaline. Neem stick contains alkaline juice. So, the cleaning of tooth by Neem stick also helps to reduce tooth decay.
3. **Acid is produced in fatigued muscle :** As a result of physical exercise, stiffness and pain in the muscle starts due to the formation of lactic acid. The supply of oxygen in the muscle is reduced. This causes difficulty in the release of energy leading to increase in the rate of anaerobic metabolism. As a result, lactic acid gets accumulated in the muscles.
4. **Some animals and plants contain acids :** Honey-bee injects an acid through its stings which causes pain and irritation. Hence, a mild base like baking soda is applied to treat the wound. Similarly, nettle leaves, which have stinging hairs, when touched inject formic acid in our body. This causes a burning pain.

   Note : Nettle is a stinging plant. When one accidentally touches its hairs, a painful effect is produced. As a remedy, the affected area is rubbed with the dock plant. The dock plant is alkaline which neutralizes the effect of the acid.
5. **The brilliance of a tarnished copper vessel can be restored by using acid :** You know, lemon juice contains an acid. In order to clean a copper vessel, we rub it with the piece of a lemon. The tarnish on the vessel is caused by the formation of a layer of basic copper oxide. Since lemon juice contains citric acid, it reacts with the copper oxide to form copper citrate and is washed away. The vessel then regains its shining appearance.
6. **pH of soil :** Soils are generally acidic. Plants require definite pH range for their proper growth. They do not grow in alkaline soil. Many plants do not grow properly in highly

acidic or highly alkaline soil. So, highly acidic soil is treated by spreading quicklime, slaked lime or calcium carbonate to lower its acidity.

pH of Salts:

The aqueous solutions of all kinds of salts do not have the same pH value.

(i) Salts of strong acids and strong bases : Sodium chloride (NaCl), potassium nitrate (KNO_3), sodium sulphate (Na_2SO_4), etc., are salts of this category. The aqueous solutions of these salts are neutral with pH value of 7.

(ii) Salts of strong acids and weak bases : Aluminium chloride ($AlCl_3$), copper sulphate ($CuSO_4$), zinc sulphate ($ZnSO_4$), etc., are salts of this category. The aqueous solutions of these salts are acidic with pH value less than 7.

(iii) Salts of weak acids and strong bases : Sodium acetate (CH_3COONa), sodium carbonate (Na_2CO_3) and sodium hydrogencarbonate ($NaHCO_3$) are examples of this category of salts. The aqueous solutions of these salts are basic in nature with pH value more than 7