Acids, Bases& Salts
pH Scale

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pH scale was introduced by S P Sorensen in 1909. 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,

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

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

Similarly,

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 numbers, 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.

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

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.

$$pH = -\log(1.0 \times 10^{-9}) = 5.$$

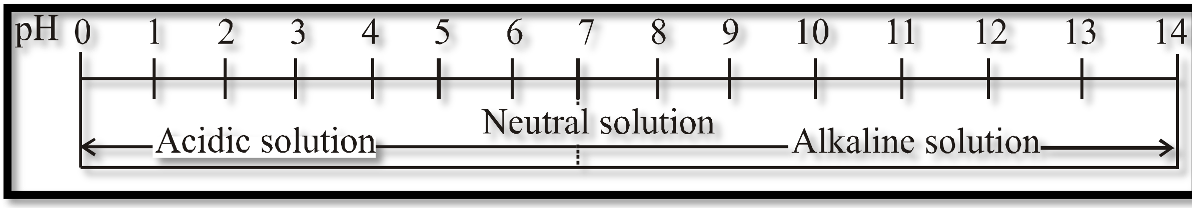
Here, we find that the pH of an acidic solution is less than 7.

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.



¬ **Rule 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 for some common solutions:**

Substance	pH	Substance	pH
Gastric juice	1.0	Tomato juice	4.1
Lemon juice	2.5	Acid rain	5.6
Vinegar	3.0	Urine	6.0
Pure water	7.0	Blood	7.4
Lime water	11.0	Milk	6.5
Wine	3.5		

Illustration :

What is the sum of pH & pOH for a solution?

Solution :

$pH + pOH = 14$

Illustration :

10^{-2} M HCl is diluted 100 times. Its pH is.

Solution :

$$[H^+] = \frac{10^{-2}}{10^{2}} = 10^{-4}$$

pH of 10^{-4} M HCl is 4

Now it will be clear that

- the pH of a neutral solution is 7.
- the pH of an solution is less than 7 and the pH decreases as the acidic character increases and
- the pH of a basic solution is more than 7 and the pH increases as the basic character increases.

Note that the pH scale is logarithmic and if te pH values of two solutions differ by 1, the solution of lower pH has 10 times as many hydrogen ions per unit volume as the one of higher pH. A solution of pH = 1 is, therefore, 10 times more acidic than one pH = 2 and one of pH = 10 is ten times more basic than one pH = 9.

Illustration :

What will Hydrogen ion concentration of 0.001 N NaOH solution?

Solution :

$[H^+]\ [OH^-] = 10^{-14}$

$[H^+]\ [10^{-3}] = 10^{-14}$

$$[H^+] = \frac{10^{-14}}{10^{-3}} = 10^{-11}$$

Illustration :

What is the pH values of 0.1 M and 0.01 M HCl solutions?

Solution :

HCl is a strong acid and so it will dissociate in an aqueous solution practically completely into H^+ ions.

0.1 M HCl

$[H^+] = 0.1 = 10^{-1}$

So,

$$\mathrm{pH} = \frac{1}{[\mathrm{H}^+]} = \log_{10} \frac{1}{10^{-1}} = \log_{10} 10^1 = 1$$

0.0.1 M HCl

$[\mathrm{H}^{+|}] = 0.1 = 10^{-2}$

So,

$$\mathrm{pH} = \log_{10} \frac{1}{10^{-2}} = \log_{10} 10^2 = 2$$