THE pH SCALE

When any compound gets dissolved in water, it dissociates and releases or accepts H+ ions. We can guess the nature of that compound by comparing the concentration of H_3O^+ and OH^-. If it has

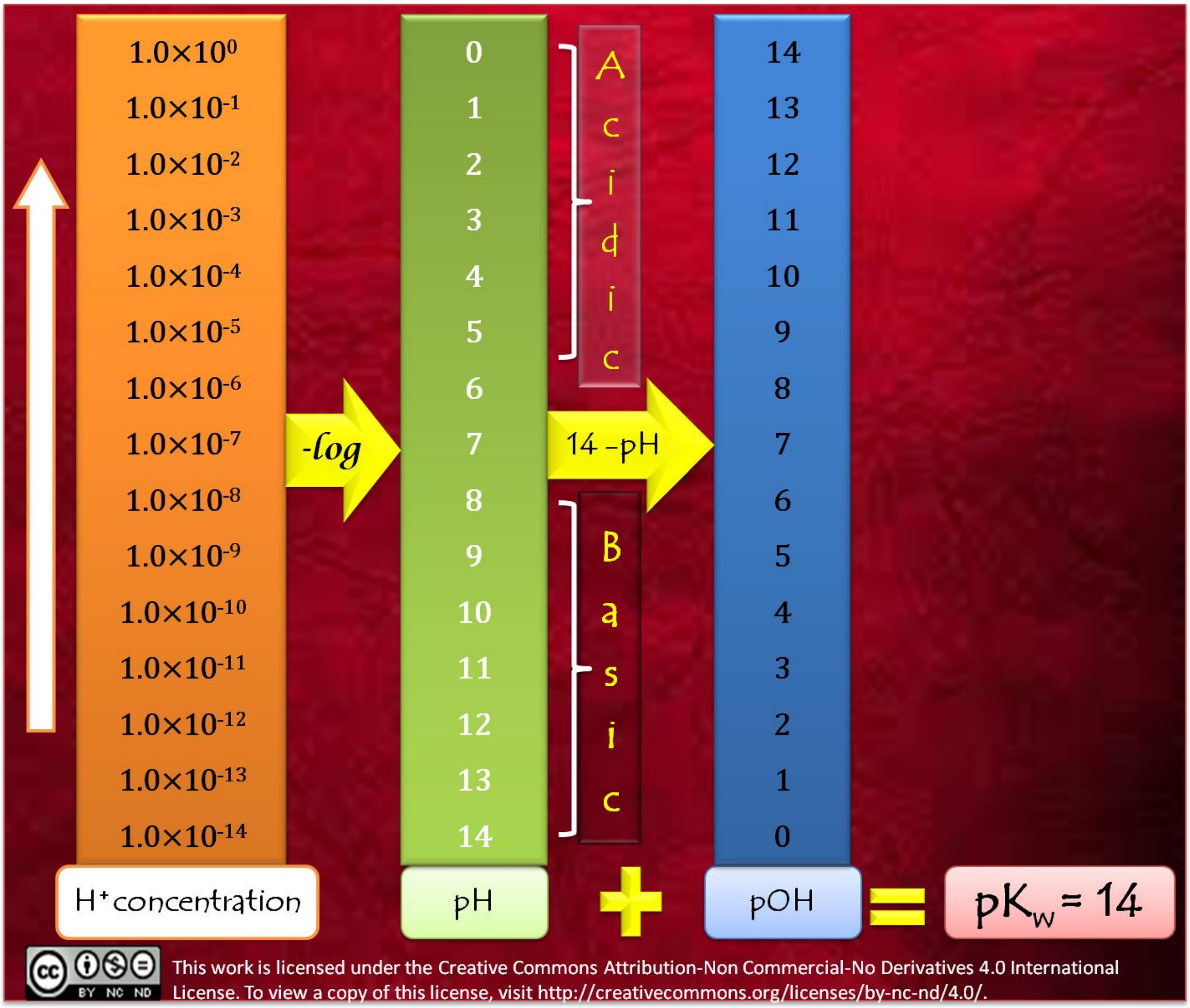
$[H_3O^+] > [OH^-]$ it will be acidic

$[H_3O^+] = [OH^-]$ it will be neutral

$[H_3O^+] < [OH^-]$ it will be basic

But how can we find out the strength of any acid or base? There is a scale to measure this strength, which is known as pHscale. To develop a scale it is wiser to choose one parameter, that's why scientists have chosen the Hydrogen ion concentration.

The concentration of H^+ and OH^- found experimentally in water is 1.0×10^{-7} M. Other compounds also have H^+ concentration in the same range. It will be quite difficult to memories and write such a large number for various compounds, so scientists have developed an easier way. They defined the H^+ concentration in terms of log, so that they can cut these digits short to a single number.



If you take log of 1.0×10^{-7} it will be -7. Again there is a problem, it is a negative value. To solve this problem, they have taken the negative log so that they can have positive values for scale. Let's see how we calculate pH:

pH is negative log to the base 10 of concentration of hydrogen ion.

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

Thus the pH of water will be:

$= -\log [1.0\times10^{-7}] = 7$

How can we measure the strength of a particular compound in pH scale? What is its lower or upper limit? The pH scale ranges from 0 to 14. Let's see why it is up to 14 only and not more than 14. When acidic H_3O^+ and basic OH^- combine, they form water. If we study the dissociation of water we can solve the mystery of 14.

$2H_2O \rightleftharpoons H_3O^+ + OH^-$

Or

$H_2O + H_2O \rightleftharpoons H_3O^+ + OH^-$

One molecule of water acts as acid and gives off proton (H^+) and other molecule acts as base and accepts that proton. Thus they establish equilibrium. Let's calculate Equilibrium constant for above reaction:

$K = [H_3O^+][OH^-] / [H_2O]$

Water is present here as a medium itself and its concentration is constant, so we can include it with K. Now K will become $K_w$which is called as ionic product of water.

$K_w = [H_3O^+]\ [OH^-]$

The concentration of H_3O^+ and OH^- found experimentally is 1.0×10^{-7} M. Dissociation of H_2O produces same amount of H_3O^+ and OH^-, that's why we get equal concentration of H_3O^+ and OH^-. Acidic and basic factors are equal in case of water, that's why it is neutral in nature.

If we take negative log on both sides of the equation, we get:

$-\log K_w = -\log \{[H^+][OH^-]\}$

$-\log K_w = -\log [H^+] + (-\log [OH^-])$

$= -\log [1.0\times10^{-7}] + (-\log [1.0\times10^{-7}])$

$= 7+7 = 14$

$pK_w = pH + pOH = 14$

It means that in every solution the product of H^+ and OH^- ion concentration remains constant. And that's why pH scale's limits are from 0 to 14.

In case of water there is equal concentration of H^+ and OH^- ions, so it is neutral. Its pH is 7 which mean 7 is the midpoint in pH scale. If the solution of any compound has H+ concentration more than that of water's H^+ concentration [1.0×10^{-7}], then it will be acidic and will have pH less than 7, similarly if a solution has less H^+ concentration than that of water then it will be basic and will have pH more than 7.

Strong acids and bases, when dissolved in water, quickly release H^+ or OH^- ions, so we can get the exact concentration of these ions and we are able to calculate their pH easily. But how will you calculate the pH of weak acids or bases which don't release all their H^+ or OH^- ions. How can we get to know their H^+ concentration and how can we calculate their pH? In the next post we will try to calculate the pH of such weak acids and base.

Source : http://chemistrynotmystery.blogspot.in/2015/01/the-ph-scale.html