Strong Acids and Bases

Acidic character of an acid is associated with the proton (H^+) in solution. Higher number of proton means stronger the acid. Similarly, the basic character is due to the presence of hydroxide ions (OH^-) in solution. Higher the number of hydroxide ions in solution means the stronger the base.

Strong acids and bases are strong electrolytes that are assumed to ionize completely in water. That means, when they are completely ionized, no non-ionized form is present is solution. The ionization of strong acids and bases are shown by using single arrows ($\rightarrow$) in chemical equations:

Strong acids

Hydrochloric acid:	$HCl(aq) + H_2O(l) \rightarrow H_3O^+(aq) + Cl^-(aq)$
Hydrobromic acid:	$HBr(aq) + H_2O(l) \rightarrow H_3O^+(aq) + Br^-$
Hydroiodic acid:	$HI(aq) + H_2O(l) \rightarrow H_3O^+(aq) + I^-$
Nitric acid:	$HNO_3(aq) + H_2O(l) \rightarrow H_3O^+(aq) + NO_3^-(aq)$
Perchloric acid:	$HClO_4(aq) + H_2O(l) \rightarrow H_3O^+(aq) + ClO_4^-(aq)$
Sulfuric acid:	$H_2SO_4(aq) + H_2O(l) \rightarrow H_3O^+(aq) + HSO_4^-$

Note that the sulfuric acid is the diprotic acid and ionizes in two stages. Here only the first stage of ionization is shown.

Strong Bases

Sodium hydroxide:	$NaOH(aq) \rightarrow Na^+(aq) + OH^-(aq)$
Potassium hydroxide:	$KOH(aq) \rightarrow K^+(aq) + OH^-(aq)$
Barium hydroxide:	$Ba(OH)_2(aq) \rightarrow Ba^{2+}(aq) + 2OH^-(aq)$

pH of Strong Acids and Bases

Calculating the pH of strong acids and bases is not very difficult if you remember that they completely ionize in solution. Let us illustrate this with the following example.

Example

Calculate the pH of (a) 2.5×10^{-4} M HCl solution and (b) 0.25M $Ba(OH)_2$ solution.

Answer

(a) HCl is strong acid and ionizes completely at equilibrium , which is given by

$$HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$$

According to this equation, one mole of HCl yields one mole of H^+ and one mole of Cl^- And also, when ionization is complete, no HCl is left in solution, only H^+ and Cl^- ions exist. Therefore,

$[H^+] = [Cl^-] = 2.5 \times 10^{-4}$ M

Then pH = - log (2.5×10^{-4}) = 3.6

(b) First of all, bases do not give the pH directly like acids because they do not produce H^+ ions. They rather give OH^- concentrations, which are converted to pH. $Ba(OH)_2$ is a strong base and ionizes according to the following equation.

$Ba(OH)_2(aq) \rightarrow Ba^{2+}(aq) + 2OH^-(aq)$

Each mole of $Ba(OH)_2$ produces one mole Ba^{2+} and two moles of OH^- ions, and no $Ba(OH)_2$ is left unionized in solution. Whatever the concentration of $Ba(OH)_2$ we started with, it is completely transformed into Ba^{2+} ion and OH^- ion. Then

$[OH^-] = 2 \times 0.25$ M = 0.50 M
pOH = -log(0.5) = 0.30
pH = 14.0 – pOH = 14.0 – 0.30 = 13.7

Ionization Constants of Strong Acids and Bases

Since strong acids and bases ionize completely, their ionization constants are very large and are not determinable by the experiments. Due to this, they are not available in the literature. Consider the following example to see how the ionization constants of strong acids are very large.

$HA(aq) \rightarrow H^+(aq) + A^-(aq)$

Here HA indicates the acid in a general form. At equilibrium, $[H^+] > 0$ and $[A^-] > 0$ and $[HA] = 0$. Thus the ionization constant becomes

$$K_a = \frac{[H^+][A^-]}{[HA]} = \frac{[H^+][A^-]}{0} = \infty$$

The mathematical interpretation of this equation is that anything upon zero is infinity, i.e., a very large number. Hence, ionization constants for acids are very large.

Same explanation can also be provided for ionization constants of strong bases.