Chem12 Acids-20

Brönsted - Lowry Theory

The **Arrhenius** definitions of acids and bases given earlier were found to be inadequate as they failed to explain several things, such as :

- NH_3 acts like a base when dissolved in water.
- H^+ ions are not found in an aqueous acidic solution.
- The nature of the solvent (usually water) is very important in determining the behavior of an acid.
- When a salt is added to water, the solution may be acidic, basic, or neutral.
- Some species are **amphiprotic**. These are substances that can act as a base or an acid. (e.g. water)

Brönsted and Lowry proposed a new definition of acids and bases that explained these discrepancies.

An **acid** is a proton (H^+) donor. A **base** is any species which is a proton acceptor.

Example : When HCl acid is added to water, it **was** believed that it produced H^+ ions. But it was later found that the HCl donated a proton to a water molecule forming a **hydronium** ion (H_3O^+) and a Cl^- ion. The equation is given below.

$$HCl(aq) + H_2O(l) \rightarrow H_3O^+(aq) + Cl^-(aq)$$

In the above example, according to Brönsted-Lowry theory, HCl is the acid and H_2O is the base. In this case, we don't have an equilibrium reaction. HCl is a very strong acid, so all of the HCl dissociates.

Example : $HCN(aq) + H_2O(l) \leftrightarrow H_3O^+(aq) + CN^-(aq)$

HCN is a weak acid. In this case, we have an equilibrium reaction. All of the HCN does not dissociate.

Example : $KNH_2(s) \rightarrow K^+(aq) + NH_2^-(aq)$, K^+ is a spectator ion. That is, it does not contribute to the reaction.

$$NH_2^-(aq) + H_2O(l) \rightarrow NH_3(aq) + OH^-(aq)$$

Example : $Li_2O(s) \rightarrow 2Li^+(aq) + O^{2-}(aq)$, Li^+ is a spectator ion. So, we have :

$$O^{2-}(aq) + H_2O(l) \rightarrow 2OH^-(aq)$$

In the above two examples, KNH_2, and Li_2O are strong bases.

Example : When a base such as NH_3 (ammonia) is added to water we have the reaction :

$NH_3(aq)$	+	$H_2O(l)$	<->	$NH_4^+(aq)$	+	$OH^-(aq)$
base		acid		acid		base

In this example NH_3 and NH_4^+ are called **conjugate acid-base pairs**.

Also, there is an equilibrium because ammonia is a weak base.

Exercise 1) Give the Brönsted-Lowry definition of an acid and a base.

Exercise 2) Are the following strong or weak acids? Give the ionization equation. (See the acid strength table)

a) H_2SO_4 b) HNO_2 c) H_3PO_4

Exercise 3) Identify each of the following as a strong or weak base. (See previous notes on strong bases)

a) RbOH b) $Sr(NH_2)_2$ c) $Cu(OH)_2$

Exercise 4) Write the complete dissociation equation for the salt Potassium Carbonate. Show that it is a base. (Hint : K^+ is a spectator ion.)

Exercise 5) Give the conjugate acid for each of the following :

a) H_2O b) HCO_3^- c) HPO_4^{2-}

d) OH^- e) SO_4^{2-} f) CH_3OH

Exercise 6) Give the conjugate base for each of the following :

a) HF b) H_3O^+ c) NH_3

d) NH_4^+ e) HPO_4^{2-} f) HSO_3^-

Answers : 1) Acid - Proton donor, Base - Proton acceptor, 2)a) strong; H_2SO_4 -> $H^+ + HSO_4^-$, b) weak; HNO_2 <-> $H^+ + NO_2^-$, c) weak; H_3PO_4 <-> $H^+ + H_2PO_4^-$, 3)a) strong, b) strong, c) weak, 4) K_2CO_3 <-> $2K^+ + CO_3^{2-}$; $CO_3^{2-} + H_2O$ <-> $HCO_3^- + OH^-$, 5)a) H_3O^+,b) H_2CO_3, c) $H_2PO_4^-$, d) H_2O, e) HSO_4^-,f) $CH_3OH_2^+$, 6) a) F^-, b) H_2O, c) NH_2^-, d) NH_3, e) PO_4^{3-}, f) SO_3^{2-}.