Quadrant II – Transcript and Related Materials

Programme: Bachelor of Science

Subject: Chemistry

Paper Code: CHC 109

Paper Title: Inorganic Chemistry

Unit: Acids, Bases and Non-aqueous Solvents

Module Name: Bronsted theory

Module No: 15

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Notes ------------------

<u>Bronsted Concept (Protonic Concept)</u>

Bronsted and Lowry in 1923 proposed a concept for acid and bases which does not involve solvent participation. According to the concept an acid is a proton donor and a base is a proton acceptor.

For example

$$HCl \rightarrow H^+ + Cl^-$$

HCl loses one proton to give Cl^- ion, hence it is an acid. Similarly, Cl^- accepts the proton and hence is a base

$$Cl^- + H^+ \rightarrow HCl$$

During an acid –base reaction when an acid loses a proton its residual part has a tendency to regain the proton. Hence it acts as a base.

Therefore, a general equation can be given as

$$\text{Acid} \rightleftarrows H^+ + \text{Base}$$

For example

$$HCl \rightarrow H^+ + Cl^-$$

HCl loses one proton to give Cl^- ion, and Cl^- accepts the proton

$$Cl^- + H^+ \rightarrow HCl$$

<u>Conjugate acid-base pairs</u>

The ionization of acetic acid in water may be represented as

$$\underset{\text{acid}}{CH_3COOH} + \underset{\text{base}}{H_2O} \rightleftarrows \underset{\text{acid}}{H_3O^+} + \underset{\text{base}}{CH_3COO^-}$$

**In the above reaction, acetic acid donates a proton to water and thus acts as an acid.
Water accepts a proton and therefore acts as a base.
In the reverse reaction hydronium ion donates a proton to the acetate ion, and therefore acts as an acid.
The acetate ion accepts a proton and therefore behaves as a base.
Such pairs of substances which can be formed from one another by the gain or loss of a proton are known as conjugate acid-base pairs.
The two acids or bases can be distinguished by referring those on the right side of the equation as conjugate acid and conjugate base**

$$\underset{\text{acid}}{HCl} + \underset{\text{Base}}{NH_3} \rightleftarrows \underset{\text{Conjugate acid}}{NH_4^+} + \underset{\text{Conjugate base}}{Cl^-}$$

In the above equation NH_4^+ is conjugate acid of base NH_3 and Cl^- is conjugate base of acid HCl.

Similarly in the equation

$$\underset{\text{acid}}{HCl} + \underset{\text{Base}}{CH_3COOH} \rightleftarrows \underset{\text{Conjugate acid}}{CH_3COOH_2^+} + \underset{\text{Conjugate base}}{Cl^-}$$

<u>Relative Strengths of Acid-Base Pairs</u>

The strength of an acid depends upon its tendency to lose protons and the strength of a base depends upon its tendency to donate protons.

Consider the following reaction:

$$HCl + H_2O \rightleftarrows H_3O^+ + Cl^-$$

If an acid such as hydrochloric acid, is a strong acid, it will have a strong tendency to donate protons.

Thus, the equilibrium lies very much to the right and the reverse reaction representing the gain of protons by the chloride ions to form HCl, takes place to a very small extent.

Accordingly, Cl^- ion is a weaker base than H_2O since the latter has a greater tendency to take up a proton.

In the reaction, $CH_3COOH + H_2O \rightleftarrows H_3O^+ + CH_3COO^-$

Acetic acid has considerably less tendency to donate protons and is therefore a much weaker acid.

It ionizes to a small extent, i.e., the equilibrium lies mostly towards the left

It follows therefore, that CH_3COO^- ion has a much greater tendency to take up protons and hence is a stronger base than H_2O

In the above reaction, acetic acid and hydronium ion may be regarded as two acids competing with each other to donate protons. Since the equilibrium lies towards the left hydronium ion is a stronger acid, than acetic acid.

In short, while acetate ion is a stronger base than water, its conjugate acid, acetic acid is a weaker acid than hydronium ion.

As a general rule, the stronger an acid, the weaker must be its conjugate base and vice versa.

If HCl is strong, its conjugate base Cl- is weak.

If a base CH_3COO^- is strong, its conjugate acid CH_3COOH is weak

Water is a weak base because its conjugate acid, hydronium ion (H_3O^+) is a strong acid.

At the same time, water is a very weak acid because its conjugate base, hydroxide ion OH- is a very strong base