# Acids and Bases

There are several concepts to explain the acids and Bases. Some of them are discussed below.

## Arhenius Concept :

(Acid:) An acid is a substance which dissociates to give hydrogen ions when dissolved in water.

Thus HCl gas is an acid because when dissolved in water it gives Hydrogen ion.

$$HCl_{(g)} + Water \rightleftharpoons H^+_{(aq)} + Cl^-_{(aq)}$$

(aq) indicates that ions are hydrated. it means associated with one or more molecules of water.

Base: Base is a substance which dissociates in to hydroxyl ions when dissolved in water

Thus NaOH is a base because it furnishes hydroxyl ion in aqueous solution.

$$NaOH + Water \rightleftharpoons Na^+_{(aq)} + OH^-_{(aq)}$$

* High dielectric constant of water lower the force of attraction between oppositively charged ions and thus cause the dissociation of electrolyte.

Hydronium ion: Hydrogen ion is merely a proton. Smallest ion known, no any electron so it has strong tendency to get hydrated or exists largely as attached to a molecul of water forming $H_3O^+$ ion. (Hydronium ion)

Due to simplicity, Arhenius concept was widely accepted and used.
It fails to account for the behaviour of acids and bases in solvents other than water. ie in non-aqueous solvents.

## Proton Transfer Theory: Lowry and Bronsted Concept:

* More Genral Definition
* Applicable to aquous as well as non-aquous solu$^{n}$s

**Acid:** Acid is a substance which has a tendency to donate a proton to any other substance.
* Acid is a proton donor.

**Base:** Base is a substance which has a tendency to accept a proton from any other substance.
* Base is a proton acceptor.

* When acid looses a proton then its remaining part has a tendency to gain the proton. therefore it behaves as base.

An acid and Base therefore may be defined by a general equation

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

* Ionisation of acetic acid.

$$CH_3COOH + H_2O \rightleftharpoons H_3O^+ + CH_3COO^-$$

Acid Base Acid Base.

* ~~Acid~~ Acid donates proton to water and thus act as an acid.
* Water accepts a proton and therefore act as base.

* In the reverse action $H_3O^+$ donates a proton to acetate ion and act as acid
* Acetate ion accepts the proton from $H_3O^+$ hence act as base.
** Such pairs of substances which can formed from one another by the gain or loss of proton are known as <u>Conjugate Acid-Base pairs</u>.
* Acetic Acid is conjugate acid of Acetate ion
* Water is conjugate base of Hydronium ion.

<u>Conclusion from Above Discussion</u>:

* A substance is able to show its acetic character only if another substance capable of accepting a proton is present.
* Hydrogen ion in aquous solution does not exist as $H^+$ but as hydrated ion $H_3O^+$.
* Not only molecules but even ions may act as acids or bases. like in above ions and the given one.

$$\underset{\text{Acid}}{HCl} + \underset{\text{Base}}{H_2O} \rightleftharpoons \underset{\text{Acid}}{H_3O^+} + \underset{\text{Base}}{Cl^-}$$

$$\text{Acid}_1 + \text{Base}_2 \rightleftharpoons \text{Acid}_2 + \text{Base}_1.$$

* $\text{Acid}_1$ and $\text{Base}_1$ are conjugate acid-base pairs of each other
* $\text{Acid}_2$ & $\text{Base}_2$ are conjugate acid-base pairs of each other.

* An acid requires a solvent that can take up a proton. for its ionization.

Likewise

* A Base requires a solvent that can give up a proton. for its ionization.
* Water ($H_2O$) Possess both Basic and acidic properties. So acid as well as base can ionise in water.
* Such substances which act as acid as well as Base are known as ~~Amphoteric~~ Amphiprotic.

$$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$$

Base$_1$ Acid$_2$ Acid$_1$ Base$_2$.

* Ammonium ion is conjugate acid for Ammonia (Base).
* $OH^{\ominus}$ is conjugate bas of $H_2O$ (

## Relative Strength of Acid and Base:

According to this concept (Lowry & Bronsted) strength of an acid. depends upon tendency to loose the proton.

Strength of a base depends upon tendency to gain the protons.

eg. Hydrochloric acid is a strong acid. It has a strong tendency to donate protons.

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

the revers of this reaction is representing the gain of protons by $Cl^-$ ion. leading to formation of HCl but upto a very small extent.

* So $Cl^-$ is weaker base than $H_2O$.

$$CH_3COOH + H_2O \rightleftharpoons H_3O^+ + CH_3COO^-$$

* Acetic acid has considerably less tendency to donate proton so weak acid. Than that of $H_3O^{\oplus}$.
* $CH_3COO^{\ominus}$ has much greater tendency to gain the protons so strong Base. than that of $H_2O$

# * Stronger the acid weaker will be its conjugate Base.
and.
Stronger the Base weaker will be its conjugate acid.

* It may be pointed out strong acids like HCl, $HNO_3$, $H_2SO_4$ being covalent compounds. get ionise only in solvent like water which can take up protons.
* Strong Bases such as NaOH, KOH & $Ba(OH)_2$ being electrovalent compounds, exist as ions even in solid state.

The basic charecter of these cpds is excutively due to presence of hydroxyl ion. which is always therefore no interaction with a solvent like water is necessasory in such cases.

Lux-Flood Concept : Proposed by Lux and Extended by Flood.

* It consider acid-base reactions in terms of specific ~~relation~~ reaction of oxide ions and it is mainly used for molten oxides at high temprature.

Acid : Acid is a substance which accepts oxide ion.

* So Also known as oxide ion accepter.

**Base:** Base is a substance which donates oxide ion.

* Base is an oxide-donar.

$$\underset{\text{Base}}{CaO} + \underset{\text{Acid.}}{SiO_2} \longrightarrow CaSiO_3.$$

$$\underset{\text{Base}}{PbO} + \underset{\text{Acid.}}{SO_3} \longrightarrow PbSO_3.$$

* This concept has very limited scope.

## The Solvent-System (or Autoionisation) Concept

* Put Forward by Fanklin

**Acid:** An acid is a substance which, in a solvent, increases the concentration of a cation characterstic of the solvent

**Base:** A base is a substance which, in a solvent, increases the concentration of an anion characterstic of the solvent.

* The characterstic cations and anions of the solvent are the ions produced during its autoionization.

**Autoionization of water:**

$$2H_2O \rightleftharpoons \underset{\text{Solvent cation}}{H_3O^+} + \underset{\text{Solvent anion.}}{OH^-}$$

* Thus in water substance giving $H_3O^+$ ions are acid.
* Those which give $OH^-$ ions are Base.

## Liquid Ammonia Undergoes Autoionization

$$2NH_3 \rightleftharpoons \underset{\text{Solvent cation}}{NH_4^+} + \underset{\text{Solvent anion}}{NH_2^-}$$

* According to solvent-system concept in liq. $NH_3$. substances which give $NH_4^+$ ions act as acid.
* Substances giving $NH_2^{\ominus}$ act as base.

For eg.:

$$NH_4Cl \xrightleftharpoons{Liq.NH_3} NH_4^{\oplus} + Cl^{\ominus}$$

* $NH_4Cl$ act as acid.

$$KNH_2 \xrightleftharpoons{Liq.NH_3} K^+ + NH_2^{\ominus}$$

* $KNH_2$ act as Base.

## Autoionization of Liquid Nitrogen tetraoxide

$$N_2O_4 \rightleftharpoons \underset{\text{Solvent cation}}{NO^+} + \underset{\text{Solvent anion.}}{NO_3^-}$$

* Substances which furnish $NO^{\oplus}$ are known as acids
* Substances which furnishes $NO_3^{\ominus}$ are known as Bases. in this solvent

$$NOCl \xrightleftharpoons{Liq.N_2O_4} NO^+ + Cl^{\ominus}$$

* NOCl act as acid.

$$NaNO_3 \underset{Liq.N_2O_4}{\rightleftharpoons} Na^+ + NO_3^{\ominus}$$

* $NaNO_3$ act as Base.