Introduction

Based on apparent properties, Robert Boyle classified the substance into acids and bases.

Acids	Bases
1. Sour to taste	Bitter to taste
2. Turn blue litmus to red	Turn red litmus to blue
3. Neutralize bases	Neutralize acids
4. Liberate H_2 gas on reaction with metals	They are soapy to touch
5. Aqueous solutions are good conductors	Aqueous solutions are good conductors
6. They decompose metal carbonates and bicarbo-nates to liberate CO_2	

- According to Lavoiser all acids must contain oxygen. But dray proved that all acids must contain Hydrogen but not oxygen.
  Eg: HCl, HBr, HI, HF etc,.
- The chemical behaviour of acids and bases is explained by following three theories.
  1) Arrhenius theory
  2) Bransted - lowery theory
  3) Hewis theory

Arrhenius theory of acids – bases :
The basis for this theory is the Arrhenius theory of electrolytic dissociation.

- **Acids :** Which gives $H^{\oplus}$ ions in aqueous solution.
  Eg: HCl , H_2SO_4, HNO_3
- **Bases :** Which give $OH^{\ominus}$ ions in aqueous solutions Eg : NaOH , KOH, etc,.
- **Salt :** Which neither gives $H^{\oplus}$ nor $OH^{\ominus}$ ions when ionised in water.
- **Neutralisation :** It is the reaction of acid and base to form salt and water.
  It is the reaction of $H^{\oplus}$ ions with $OH^{\ominus}$ ions to form H_2O.

$$HCl + NaOH \rightarrow NaCl + H_2O$$

(or)

$$H^{\oplus} + OH^{\ominus} \rightarrow H_2O$$

Ionization of Arrhenius acids (HX) :

$$HX \rightleftharpoons H^{\oplus} + X^{\ominus}$$

$$K_a = \frac{[H^{\oplus}][X^-]}{[HX]}$$

- **Ionization of Arrhenius base (MOH) :**

$$MOH \rightleftharpoons M^{\oplus} + OH^{\ominus}$$

$$K_b = \frac{[M^{\oplus}][OH^-]}{[MOH]}$$

- Degree of ionisation (α) = $\frac{no.of molecules ionised}{total no.of molecules dissolved}$

$K_a \rightarrow$ acid ionisation constant (or) acid dissociation constant

$K_b \rightarrow$ base ionisation constant (or)

base dissociation constant

⍰ $\rightarrow$ It is the fraction of the substance which is ionised.

Strength of acids and bases :

The strength of acid or base will depend on the extent of ionisation.

- **Strong acids :** Which ionise completely even at moderate concentrations.

  Strong acids have

  1. higher K_a value
  2. lower P^{Ka} value
  3. percentage of ionisation is all most 100%
  4. Degree of ionisation all most equal to 1

     Eg: $HClO_4$, HI, HBr, H_2SO_4, HCl, HNO_3

Weak acids : Which ionise partially even at moderate concentrations, weak acids have,

1. lower K_a value
2. higherp^{K_b}value
3. percentage of ionisation much less than 100%
4. Degree of ionisation less than 1

   Eg: All organic acids,H_2CO_3, HCN, H_3PO_4 etc.

Strong bases: Which ionise completely even at moderate concentration.

Strong base have .

1. higher K_b value
2. lower P^{Kb} value
3. percentage of ionisation is all most 100% is
4. Degree of ionisations all most equal to 1

   Eg: Hydroxides of IA and II A except Mg, Be

Weak bases : Which ionise partially even at moderate concentrations weak bases have,

1. lower K_b value
2. higher P^{Kb} value
3. percentage of ionisation is much less than 100%
4. Degree of ionisation is much less than 1

   Eg: $Al(OH)_3$, NH_4OH, $Fe(OH)_3$ etc.

Comparison of strength of acids and bases :

If two acids are at same concentrations

$$\frac{strength of acid_1}{strength of acid_2} = \frac{\alpha_1}{\alpha_2} = \sqrt{\frac{K_{a_1}}{K_{a_2}}}$$

If two bases are at same concentrations

$$\frac{strength of base_1}{strength of base_2} = \frac{\alpha_1}{\alpha_2} = \sqrt{\frac{K_{b_1}}{K_{b_2}}}$$

Ostwald's law of dilution :

The degree of ionisation of a substance (weak electrolyte) is inversely proportional to square root of its molar concentration (or) directly proportional to square root of its dilution.

$\alpha \propto \frac{1}{\sqrt{C}}$; $\alpha = \sqrt{\frac{K}{C}}$

- **Basicity or protocity :** Number of $H^{\oplus}$ ions given by one molecule of acid.

  Eg :

Eg	Base
HCl	1
H_2SO_4	2
H_3PO_4	3

- Ionisation of polyprotic acid :

  Polyprotic acid will ioinise in step wise. The first step ionisation occurs to large extent than the later step ionisations.

  $H_2SO_4 \rightleftharpoons HSO_4^- + H^{\oplus}$ K_1

  $HSO_4^- \rightleftharpoons H^{\oplus} + SO_4^{2-}$ K_2

  over all $K_a = K_1 \times K_2$

  $K_1 > K_2$

- Acidity (or) Hydroxicity of base: It is the number of OH^- ions given by one molecule of base

  $NaOH \rightarrow 1$

  $Ca(OH)_2 \rightarrow 2$

  $Al(OH)_3 \rightarrow 3$

- These polyhydroxy bases also ionizes step wise as those of acids.

Draw backs of Arrhenius theory :

1) It is limited to aqueous medium.
   Eg: aq. HCl is acid but HCl gas is not acid
2) It fails to explain acidic nature of non metallic oxides.
   Eg : CO_2, SO_2, SO_3 etc.
3) It fails to explain basic nature of substances like NH_3, PH_3, $NH_2 - NH_2$.
4) It fails to explain acidic nature of non protonic acids like BF_3, $AlCl_3$ etc.,
5) It fails to explain the nature of salts like $CuSO_4$ aq. $Al_2(SO_4)_3$ aq. On the litmus paper (blue $\rightarrow$ red)
6) It fails to explain the stability of $H^{\oplus}$ which is a mere proton [$H^{\oplus}$ ion actually exits as $H_3O^{\oplus}$ or $H_9O_4^+$]

- **Modified Arrhenius theory :**
  This modified theory will explain the nature of some more acids and bases.
- **Acid :** Which increase the concentration of $H_3O^{\oplus}$ by interacting with solvent.
  Eg: CO_2 , SO_2
  $CO_2 + 2H_2O \rightleftharpoons HCO_3^- + H_3O^{\oplus}$
- **Base :** Which increases the concentration of OH^{-} ions by interacting with solvent.
  Eg: $NH_3 + H_2O \rightleftharpoons NH_4^{\oplus} + OH^-$