B.Sc. (Honours) Part-I

Paper-IA

Topic: Bronsted-Lowry Concept

UG

Subject-Chemistry

Dr. Laxman Singh

Asst. Professor

Department of Chemistry

R.R.S. College (PPU)

(Mokama, Patna)

Acid & Base

Acids and bases can be classified on the basis of their properties.

Acids:

(i) They are sour in taste.

(ii) They react with some metals and produce hydrogen

(iii) They react with carbonate (Na_2CO_3) and bicarbonate ($NaHCO_3$) and produce CO_2:

(iv) Solution of acids in water conducts electricity.

(v) They change the colour of litmus from blue to red.

Base:

(i) They have bitter taste.

(ii) They change colour of litmus from red to blue.

(iii) They are slippery in nature.

(iv) Aqueous base solution conducts electricity.

Bronsted–Lowry acids and bases Concept: Bronsted in 1923 proposed that a substance capable of donating a proton to any substance is acid and a base can be defined as a species capable of accepting proton from any other substance.

$HCl_{(aq)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$

Bronsted acid

$NH_3 + H^+ \rightarrow NH_4^+$

Bronsted base

There are three types of acids and bases according to Bronsted-Lowry listed in table 1.

Table 1 Bronsted–Lowry acids and bases

Type	Acid	Base
Molecular	HCl, HBr, $HClO_4$, H_2SO_4, H_3PO_4, H_2O	NH_3, N_2H_4, amines, H_2O
Cationic	NH_4^+, $[Fe(H_2O)_6]^{3+}$, $[Al(H_2O)_6]^{3+}$	$[Fe(H_2O)_5(OH)]^{2+}$ $[Al(H_2O)_5(OH)]^{2+}$
Anionic	HS^-, HCO_3^-, HSO_4^-, $H_2PO_4^-$	Cl^-, Br^-, OH^-, HSO_4^-, CO_3^{2-}, SO_4^{2-}

Acids:

(i) Molecular acids

HCl, H_2SO_4, CH_3COOH

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

$H_2SO_4 \rightleftharpoons HSO^- + H^+$

$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$

(ii) Anion acids

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

(Bisulphate)

(iii) Cation acids

$H_3O^+ \rightleftharpoons H_2O + H^+$

Hydroxonium

Bases:

(i) Molecular bases

$CH_3NH_2 + H^+ \rightleftharpoons CH_3NH_3^+$ (Cations)

(ii) Anion bases (OH^-, S^{2-}, CO_3^{2-}, Cl^-, Br^-, NO_3^-)

$OH^- + H^+ \rightleftharpoons H_2O$ (Neutral molecule)

(iii) Cationic bases

$[Fe(H_2O)_5OH]^{2+} \overset{2^+H^+}{\rightleftharpoons} (Fe(H_2O)_6)^{3+}$

Conjugate acids and bases:

Bronsted-Lowry also gave the concept of conjugate acid base pair. Conjugate base is a species that remains when one proton has been removed from the acid.

$Acid_1 \rightleftharpoons H^+ + base$
Conjugate base

Conjugate acid results from the addition of proton to a base

$Base_2 \rightleftharpoons H^+ \rightleftharpoons acid_2$
Conjugate acid

An acid base pair which is different by a proton is called conjugate acid base pair.

$$\text{Conjugate acid} \rightleftharpoons \text{Conjugate base} + H^+$$

Conjugate pair

$$\underset{Acid_1}{CH_3Coo_4} + \underset{Base_2}{H_2O} \rightleftharpoons \underset{Acid_2}{H_3O^+} + \underset{Base_1}{CH_3Coo^-}$$

Conjugate pair

The sum of these two reactions is

$Acid_1 + base_2 \rightleftharpoons Acid_2 + base_1$

Therefore, any acid-base reaction involves two acids and two bases.
These acids and bases are called conjugate pairs.

$$\underset{Acid_1}{HCl} + \underset{Base_2}{H_2O} \rightleftharpoons \underset{Acid_2}{H_3O} + \underset{Base_1}{Cl^-}$$

Relative strength of conjugate acid – base pairs

	Acid	Conjugate base	
	$HClO_4$	ClO_4^-	
	HI	I^-	
Strong acids	HBr	Br^-	Increasing
	HCl	Cl^-	base
	H_2SO_4	HSO_4^-	Strength
	HNO_3	NO_3^-	

	H_3O^+	H_2O	
	HSO_4^-	SO_4^{2-}	
Weak acids	HF	F^-	
	HNO_2	NO_2^-	
	HCOOH	$HCOO^-$	
	CH_3COOH	HCOO	
	NH_4^+	NH_3	
	HCN	CN^-	

H_2O	OH^-
NH_3	NH_2^-

- Acids stronger than H_3O^+, react with water to produce H_3O^+ and their conjugate bases.

$$HCl + H_2O \rightleftharpoons H_3O^+ + Cl^-_{(aq)}$$

- Acids weaker than H_3O^+, react with water to a much smaller extent. Bases like O^{2-} (oxide) stronger than OH^-, react with water to produce OH^-.

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

Therefore, oxide ion does not exist in solution.

$$NH_2^- + H_2O \longrightarrow NH_3 + OH^-$$

Merits of Bronsted–Lowry Concept:

1. This concept can explain the acidic/basic nature of a substance in aqueous (H_2O) as well as in other protonic solvents like liq. NH_3, liq. HF.
2. This concept also explains acid base reaction taking place in gaseous phase.

$$\underset{\text{Acid}}{HCl\ (g)} + \underset{\text{Base}}{NH_3\ (g)} \rightleftharpoons \underset{\text{Acid}}{NH_4^+} + \underset{\text{Base}}{Cl^-} \quad \text{or } NH_4^+\ Cl^-$$

Limitations of Bronsted–Lowry concept:

This concept cannot explain the acid-base reactions taking place in non-protonic solvents, like liq. SO_2, liq. BF_3, BrF_3, $AlCl_3$, $POCl_3$ etc. in which no proton transfer takes place.

$$\underset{\text{Acid}}{SO_2} + \underset{\text{Base}}{SO_2} \rightleftharpoons \underset{\text{Acid}}{SO^{2+}} + \underset{\text{Base}}{SO_4^{2-}}$$

$$\underset{\text{Acid}}{BrF_3} + \underset{\text{Base}}{BrF_3} \rightleftharpoons \underset{\text{Acid}}{BrF_4^+} + \underset{\text{Base}}{BrF_2^-}$$