Chapter- 4

Chemical Reactions

A chemical reaction involves a change from reactant substance to product substances and the product substances will have physical and chemical properties different from those of the reactants.

Types of Chemical Reactions:

1) Precipitation Reaction:

In these reaction, mixing solution of two ionic substances and a solid ionic substance is formed (precipitate).

It occurs in aqueous solution because one product ~~was~~ is insoluble.

A per precipitate is an insoluble solid compound formed during a chemical reaction is solution.

When we write a precipitation reaction as molecular equation, the reaction has the form of an exchange reaction.

In precipitation reaction, the anions exchange between two cations (one vice versa)

For example,

$$MgCl_2 + 2AgNO_3 \rightarrow 2AgCl + Mg(NO_3)_2$$

Solubility rules for Ionic Compounds

Rule - 1

Elements: Li^+, Na^+, K^+, NH_4^+

Statement: Group 1/IA compounds and ammonium compounds are soluable.

Exceptions: No exceptions.

Rule - 2

Elements: $C_2H_3O_2^-$, NO_3^-

Statement: Acetates and Nitrates are soluble

Exception: no exceptions.

Rules - 3

Elements: Cl^-, Br^-, I^-

Statement: Most chlorides, Bromides and Iodides are soluble

Exceptions: $AgCl$, Hg_2Cl_2, $PbCl_2$, $AgBr$, $HgBr_2$, $PbBr_2$, AgI, HgI_2, Hg_2I_2, PbI_2

Rule-4

Elements : SO_4^{2-}

Statements: Most sulphates are soluble.

Exceptions : $CaSO_4$, $SrSO_4$, $BaSO_4$, Ag_2SO_4, Hg_2SO_4, $PbSO_4$

Rule-5

Elements: CO_3^{2-}

Statements: Most carbonates are insoluble

Exception: Group IA carbonates, $(NH_4)_2CO_3$

Rule-6

Elements: PO_4^{3-}

statement: Most phosphates are insoluble.

Exceptions : Group IA phosphates, $(NH_4)_3PO_4$

Rule-7

Elements: S^{2-}

Statements: Most sulphide are insoluble.

Exceptions: Group IA sulphides, $(NH_4)_2S$

Rule-8

Elements: OH^-

Statements: ~~Group IA hydroxides, $Ca(OH)_2$~~

Exceptions: Group IA

Rule - 8

Elements: OH^-

Statements: Most hydroxides are insoluble

Exceptions: Group IA hydroxides, $Ca(OH)_2$, $Sr(OH)_2$, $Ba(OH)_2$.

Example of Precipitation reactions:

$$MgCl_2 + 2AgNO_3 \rightarrow 2AgCl + Mg(NO_3)_2$$

According to the rule 3, Magnisium chloride is soluble and according to rule 2 silver Nitrate is also soluble. The products are Silver chloride and magnisium nitrate. According to rule 3 silver chloride is insoluble, whereas $Mg(NO_3)_2$ is soluble according to rule-2. So, here Silver chloride is a precipitate here.

2) Acid-base Reactions:

Acid reacts with bases to form salt and water.

Acid and base definations:

Arrhenius concept (1884): An **acid** is a compound that releases H^+ ion in H_2O. For example,

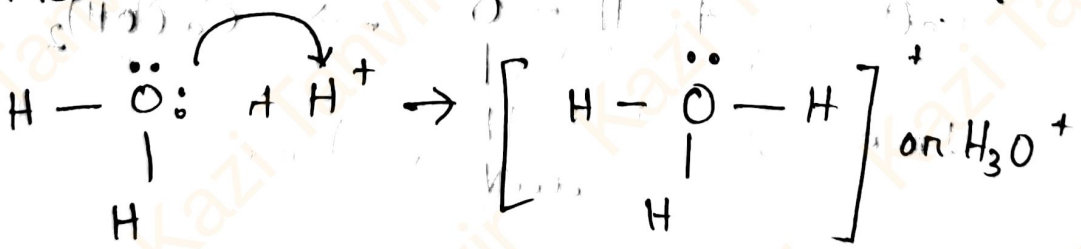
$$HCl + H_2O \Longrightarrow H_3O^+ + Cl^-$$

A **base** is a compound that releases OH^- ion in H_2O. For example,

$$NaOH + H_2O \rightarrow Na^+ + OH^-$$

Limitations:

1) Free H^+ ions do not exist in water



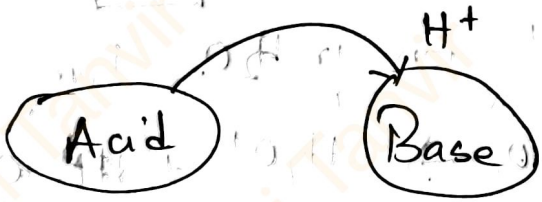
2) Limited to water only

3) Some bases do not contain OH^-. Example:

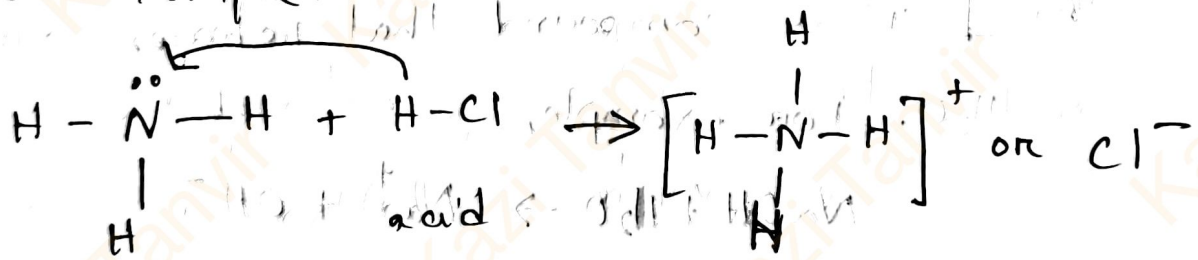
NH_3, CaO

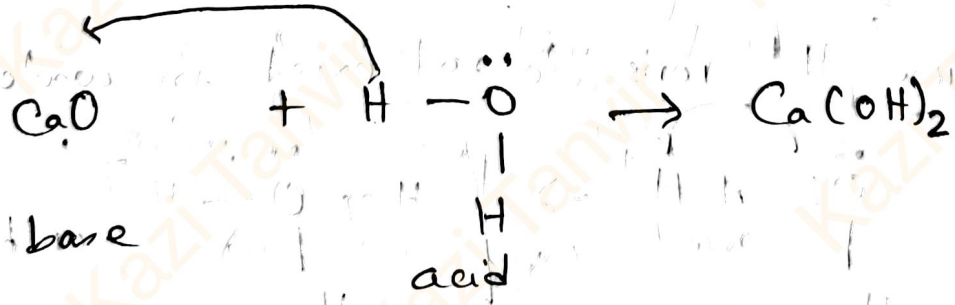
Bronsted - Lowry concept (1923):

* An Acid is any molecule or ion that can donate a proton (H^+).
* A base is any molecule or ion that can accept a proton (H^+)



For example:





Bronsted-Lowry is better than Arrhenius concept:

a) Not limited to aqueous solution.

$$NH_3 + HCl \rightleftharpoons NH_4^+ + Cl^-$$

b) Release of OH^- is not necessary to be base.

$$NH_3 + H^+ \rightleftharpoons NH_4^+$$

base acid

"An acid is proton donor, while a base is a proton accepton."

Amphiprotic Substances: Molecules or ions have a nature of both Bronsted acid and Bronsted base are known as amphiprotic. For example, H_2O.

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

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

Other examples: HS^-, $Al(H_2O)$ etc.

Lewis Concept: (1930)

Acid is a substance that can accept a pair of electron.

Base is a substance that can donate a pair of electron

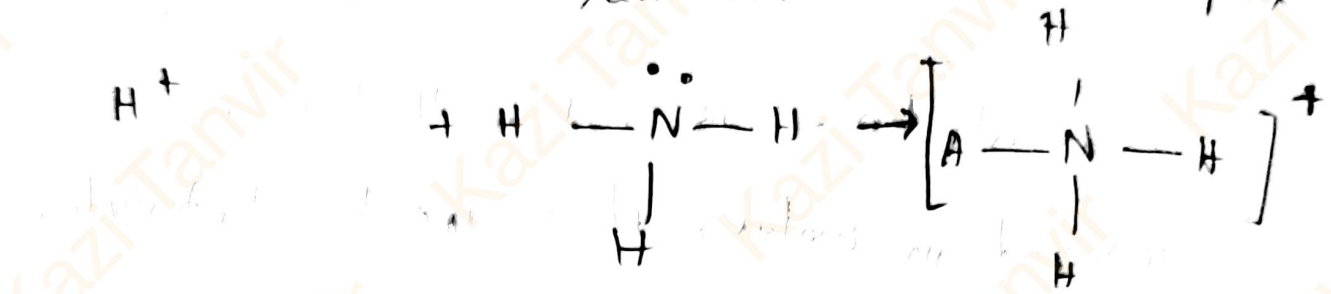
$$A + :B \rightarrow A - B$$

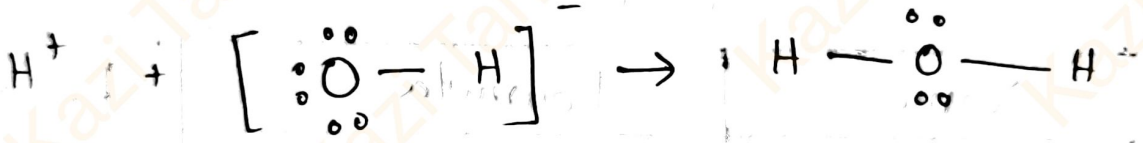
acid — Lewis

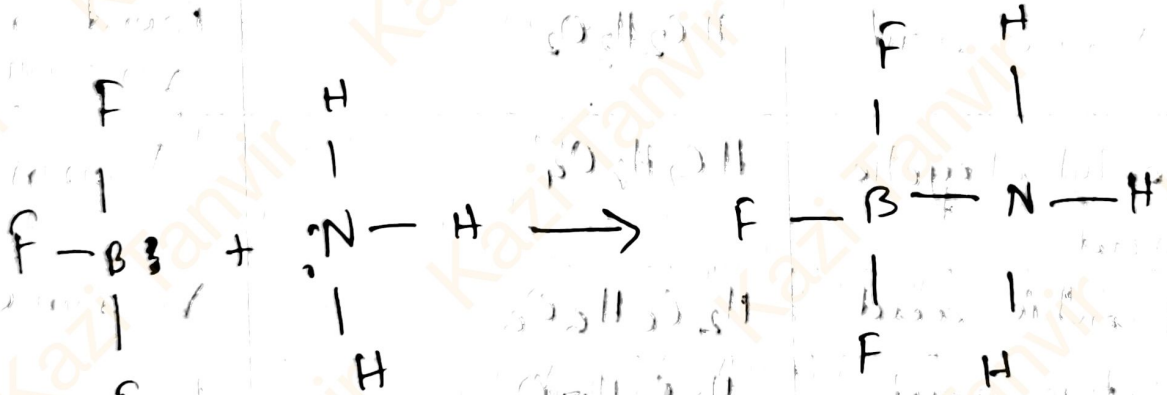
base — Lewis

The combination of a lewis acid and lewis base is called a complex. All cations or molecules ~~short~~ lacking a pair of electron are known as Lewis Acid. All anions or molecules having a lone pair of electrons are known as Lewis base

Examples:







A **strong acid** is an acid that ionizes completely in water; it is a strong electrolyte.

A **weak acid** is an acid that ionizes partially in water, it is a weak electrolyte.

A **strong base** is a that is present in aqueous solution entirely as ions, it is a strong electrolyte.

A weak base is a base that is ~~are~~ partially ionized in water, it is weak electrolyte.

common acids and bases:

Name	Formula	Remarks
Acetic acids	$HC_2H_3O_2$	Found in vinegar
Acetylsalicyclic acid	$HC_9H_7O_4$	Aspirin
Ascorbic acid	$H_2C_6H_6O_6$	Vitamin C
Citric acid	$H_3C_6H_5O_7$	Lime juice
Hydrochloric acid	HCl	gastic juice
Sulphuric acid	H_2SO_4	Battery acid
Base		
Ammonia	NH_3	household cleaner
Calcium hydroxide	$Ca(OH)_2$	slake lime
Magnisewm hydroxide	$Mg(OH)_2$	ataeid, laxative

Strong and weak acid / base:

Strong acids:

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

Strong Bases:

$LiOH$, $NaOH$, KOH, $Ca(OH_2)$, $Sr(OH)_2$, $Ba(OH)_2$

Weak acid:

HCN, HF, CH_3COOH, H_2CO_3, H_3PO_4, $HCOOH$, HNO_2

Weak base:

NH_3, $Mg(OH)_2$, $Al(OH)_3$, Na_2CO_3, $NaHCO_3$, CH_2NH_2, C_5H_5N

Non metal oxides are acidic. Ex: $SO_2 + H_2O = H_2SO_4$

Metal oxides are basic. Ex: $CaO + H_2O = Ca(OH)_2$

Neutralization Reactions:

A neutrilization Reaction is a reaction of an acid and a base that results in an ionic compound and possibly water.

The ionic compound that is the product of a neutrilization reaction is called salt. The salt formed in a neutrilization reaction consists of cations obtained from the base and anions obtained from the acid. For example,

$$2\,HCl + Ca(OH)_2 \rightarrow CaCl_2 + H_2O$$

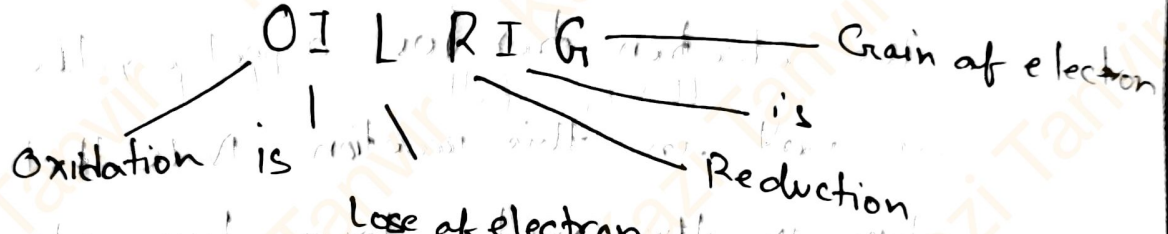
$$HCN + KOH \rightarrow KCN + H_2O$$

Oxidation - Reduction reactions:

Redox reactions includes all chemical reactions in which atoms have their oxidation state changed; in general, redox reaction involves the transfer of electrons between species.

Oxidation state of an atom in a substance, in the actual charge of an atom if it exsists as a monatomic ion, or a hypothetical charge assigned to the atom in the substance by simple rules

An oxidation reduction reaction is one in which one or more atom changes the oxidation number, implying that there has been a transfer of electrons



Formerly, the term ~~oxidant~~ oxidation meant "reaction with oxygen".

for example,

$$Ca_{(s)} + Cl_{2(g)} \rightarrow CaCl_{2(s)}$$

In this reaction, calcium atom is oxidized, because it increases in oxidation number (from 0 to +2)

$$Fe + CuSO_4 \longrightarrow FeSO_4 + Cu$$

The net ionic eqn

$$Fe + Cu^{2+} \longrightarrow Fe^{2+} + Cu$$

The electron transfer aspect of the reaction is apparent in this reaction. Note that each iron atom in the metal loses two electrons to form an iron (II) ion and each copper (II) ion gains two electron to form a copper atom in the metal. The net affect is that two electrons are transfered from each iron atom in metal to each copper (II) ion.

Oxidation is a half-reaction in which there is a loss of electron (increase in oxidation number)
Reduction is a half reaction in which there is a gain of electrons (decrease in oxidation number)

Thus, the eqn $Fe \rightleftharpoons Fe^{2+} + 2e^-$ represents the oxidation half-reaction and the eqn $Cu^{2+} + 2e^- \rightarrow Cu$ represents the reduction half reaction.

An Oxidizing Agent is a species that gain electrons and oxidizes another species, it is itself reduced.

a reducing agent is a species that loss electrons and reduces another speies, it is itself oxidized.

$$Fe_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Fe^{2+} + Cu$$

Reducing agent — oxidizing agent

Importance of Redox:

1) Photosynthesis
2) Respiration
3) combustion engine
4) to produce metals from ores.