# 7.CHEMICAL EQUILIBRIUM & ACIDS-BASES

## STUDY NOTES

[1VSAQ & 1SAQ]

## I) CHEMICAL EQUILIBRIUM

### TYPES OF CHEMICAL REACTIONS

**1) Forward reaction:** It's the reaction in which the 'reactants are converted into products'.

**2) Backward reaction:** It's the reverse reaction in which 'products react back to give the reactants'.

**3) Reversible reactions:** These are reactions which can take place in both the forward and the backward directions. **Ex:** Redox reactions

### Equilibrium state - Types

It is the state at which the rate of the forward reaction is equal to the rate of the backward reaction in a reversible reaction. Chemical equilibrium is dynamic. It shifts either forward or backward

**1) Homogeneous equilibrium** [ $H_{2(g)} + I_{2(g)} \rightleftharpoons 2HI_{(g)}$ ]

It is the equilibrium state in which both the reactants and products are in the same physical state.

**2) Heterogeneous equilibrium** [ $CaCO_{3(s)} \rightleftharpoons CaO_{(s)} + CO_{2(g)}$ ]

It is the equilibrium state in which both the reactants and products are in different physical states.

### Equilibrium constants ( $K_c$, $K_P$)

For a general reaction, $aA + bB \rightleftharpoons cC + dD$

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}; \qquad K_p = \frac{P_C^c P_D^d}{P_A^a P_B^b}; \quad K_p = K_c(RT)^{\Delta n}; \quad \Delta n = (c+d)-(a+b)$$

### Le-Chatelier's principle

If a system at equilibrium is disturbed then the system tends to shift its equilibrium position in the direction which counters the disturbance.

### Factors that effect the equilibrium position

1) Concentration 2) Pressure 3) Temperature of reactants, products

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**HUMAN LIFE is all about BALANCE!**

**'Equilibrium'** in Economics occurs when 'Demand and Supply become Equal'.
While walking, riding a cycle / bike we balance our frame of Centre of Mass.
Such balancing position occurs even in reversible Chemical Reactions also.
"ఇక ఈ రోజు నుండి Perfect Plan ప్రకారం చదవడం మొదలెట్టాలి" అని మీరెన్నోసార్లు అనుకున్నారు కదా!
ఒక మంచి ముహూర్తంలో పక్కా Equilibrium state of mind తో చదవడానికి కూర్చుంటారు.
అంతే సరిగ్గా అప్పుడే మన చదువును distrub చేసేలా అనుకోని సంఘటనలు అకస్మాత్తుగా జరుగుతాయి.
సరిగ్గా ఇలానే కొన్ని Chemical reactions కూడా చక్కగా సాగిపోతుంటే అనుకోని అవాంతరాలు Pressure, Temperature, Concentration అనే శత్రు రూపాల్లో వచ్చి దాడి చేసి వాటి Equilibrium State ను disturb చేస్తుంటాయి. దాంతో ఆ Dynamic Equilibrium Position కొంచెం ముందుకో వెనక్కో Shift అవుతుంది.
అటువంటి విపత్కర పరిస్థితులను ఎలా Handle చేయాలో Mr. Le-Chatelier చెప్పారు.

## II) ACIDS & BASES

### Classification of Solutions on the basis of concentration

1) Acids 2) Bases 3) Salts

### I) BRONSTED ACID - BASE THEORY [PROTON Theory]

**1) Acid:** "Bronsted acid is a proton donor"

**Ex:** $HCl$, $H_2SO_4$, $CH_3COOH$

**2) Base:** "Bronsted base is a proton acceptor"

**Ex:** $NH_3$, $H_2O$, $OH^-$

**3) Amphoteric substance**

A substance which can act as both proton donor and acceptor. **Ex:** Water

**4) Conjugate acid and base pair**

It is a pair of 'acid and base' differing by 'one proton'.

**Ex:** $\underset{\text{Acid}_1}{HCl} + \underset{\text{Base}_2}{H_2O} \rightleftharpoons \underset{\text{Acid}_2}{H_3O^+} + \underset{\text{Base}_1}{Cl^-}$

$HCl$ & $Cl^-$ is a conjugate acid-base pair; $H_3O^+$ & $H_2O$ is another conjugate acid-base pair.

### II) LEWIS THEORY OF ACIDS AND BASES [ELECTRON PAIR Theory]

Electron pair acceptor is an acid; and electron pair donor is a base.

**Types of Lewis acids**

1) All cations are Lewis acids. **Ex:** $Ag^+$,$Co^{+3}$, $Cu^{+2}$, $Fe^{+3}$ [d-block elements]

2) Molecules in which the central atom has incomplete octet and possessing vacant orbital.
**Ex:** $BF_3$, $BCl_3$, $AlCl_3$, $FeCl_3$ [Group-13 elements]

3) Compounds in which the central atom has available d-orbitals and may expands its octet.
**Ex:** $SiF_4$, $SnCl_4$, $SF_4$, $TeF_4$ [G 14, G 16 elements]

4) Molecules having multiple bonds between atoms of dissimilar electro negativities
**Ex:** $CO_2$,$SO_2$,$SO_3$,$NO_2$

5) Elements with an electron sextet. **Ex:** S, O.

**Types of Lewis bases**

1) All anions are Lewis bases. **Ex:** $Cl^-$, $OH^-$, $CN^-$, $NH_2^-$, $F^-$, $SCN^-$ (thio cyanate ion)

2) Molecules with one or two lone pairs of electrons on the central atom.
**Ex:** $H_2\ddot{O}$, $N\ddot{H}_3$, $C_5H_5N$ (pyridine)

3)Molecules with multiple bonds
**Ex:** CO, NO, HC ≡ CH, $H_2C = CH_2$.

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### సీతారాముల CONJUGATE ACID -BASE PAIR

$\underset{\text{Acid}_1}{\text{సీత}} + \underset{\text{Base}_1}{\text{రాముడు}} \rightleftharpoons \underset{\text{Acid}_2}{\text{రమ}} + \underset{\text{Base}_2}{\text{సీతయ్య}}$

(సీత+సీతయ్య) ఒక conjugate acid-base pair అయితే (రాముడు+రమ) మరో conjugate acid-base pair

### Math Conjugates

**(Comes in Second Inter Complex Numbers)**

Complex conjugate of **a+ib** is **a–ib :** $(a+ib)(a-ib) = a^2+b^2$ [ Real number]

## Ionic product of water ($K_w$)

It is the product of the concentrations of $H^+$ and $OH^-$ ions, in water, at a given temperature.

Thus $K_w = [H^+][OH^-]$

## Ionic equilibrium

It is the equilibrium which is established between 'un-ionised molecules and ions' in the solutions of **weak electrolytes.**

## Classification of aqueous solutions in terms of pH value

Neutral solution: $[H^+] = 1.0\times10^{-7}$ M. $\therefore$ pH = 7

Acidic solution: $[H^+] > 1.0\times10^{-7}$ M $\therefore$ pH < 7

Basic solution: $[H^+] < 1.0\times10^{-7}$ M $\therefore$ pH > 7

## Buffer solutions

These are the solutions which maintain constant pH.

These solutions resist any change in its pH value on dilution or on addition of a small amount of strong acid or a strong alkali.

## Types of buffer solutions

### 1) Acid buffer solution

It is a mixture of a 'weak acid and its salt with a strong base'.

### 2) Base buffer solution

It is a mixture of 'weak base and its salt with a strong acid'.

## Salt Hydrolysis

It is the reaction of a salt with water to form an acid and a base.

Hydrolysis of salts is the 'reverse process of neutralisation'.

$$\text{Salt} + \text{Water} \rightleftharpoons \text{Acid} + \text{Base}$$

## Solubility product

It is the product of the concentrations of the cation and the anion in a saturated solution of a salt.

Thus, $K_{sp} = [Mn+][An-]$

## Common ion effect

The solubility of an electrolyte (salt, acid, base) in water decreases on addition of an electrolyte (acid, base or salt) which has one ion (cation or anion) common with the electrolyte.

## IMPORTANT IPE FORMULAE

1. pH + pOH = 14
2. $pH = -\log_{10}[H^+]$ = –ve logarithm of $[H^+]$
3. $pOH = -\log_{10}[OH^-]$ = –ve logarithm of $[OH^-]$
4. $\log_{10} 2 = 0.3010$
5. $\log ab = \log a + \log b$
6. $\log a^n = n\log a$
7. Basicity of $HCl$, $HNO_3$ = 1
8. Basicity of $H_2SO_4$ = 2

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### TYPES OF REACTIONS

In a **Synthetic Reaction** two or more reactants combine to form a single product.

In a **Decomposition Reaction** one reactant breaks down into two or more products.

**Synthesis:** Production of a Chemical compound by reactions from simpler compounds

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Actually **Contact Process** is applied for the production of **Sulphuric Acid.**

But in the Contact Process, $SO_3$ and Oleum are also obtained.

Burning of 'Sulphur ore' produces 'hot $SO_2$ gases'.

They come in **contact** with Catalyst Bed.

Hence the name contact is given to the process.