Pakistan School
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المدرسة الباكستانية

Class: 10th

Subject: Chemistry

Topic

Equilibrium Constant and Law of Mass Action

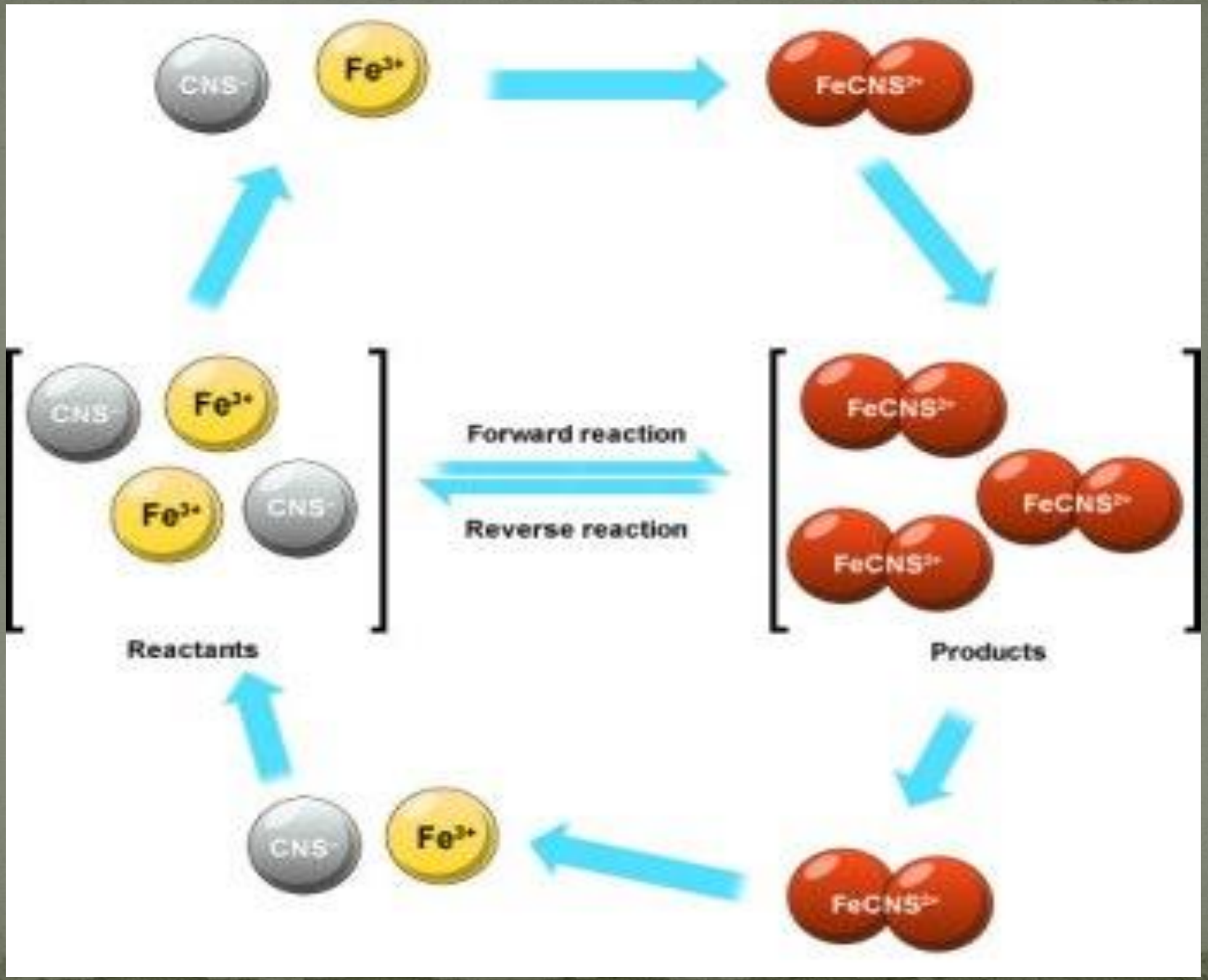
Objective

At the end of this lesson Students will be able to:

- Define Law of Mass Action
- Derive an Expression for the Equilibrium Constant.

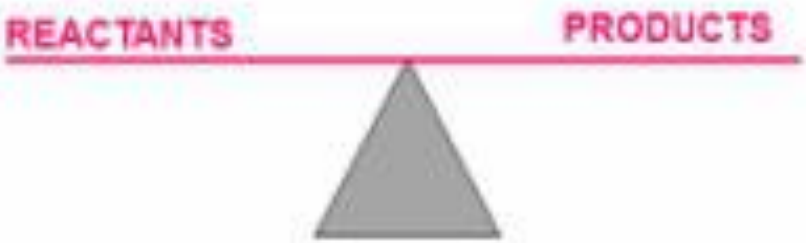
’Chemical Equilibrium??

- A state of a chemical reaction in which forward and reverse reactions take place at the same rate is called “Chemical Equilibrium”

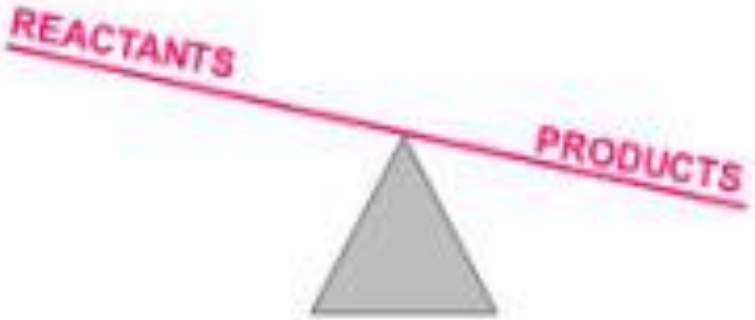

CNS⁻
Fe³⁺
FeCNS²⁺
Forward reaction
Reverse reaction
Reactants
Products

EFFECT OF CONCENTRATION ON EQUILIBRIUM

Dynamic Equilibrium
Rate forward reaction = rate reverse reaction



Increasing concentration of reactants increases
Rate forward reaction which produces more products

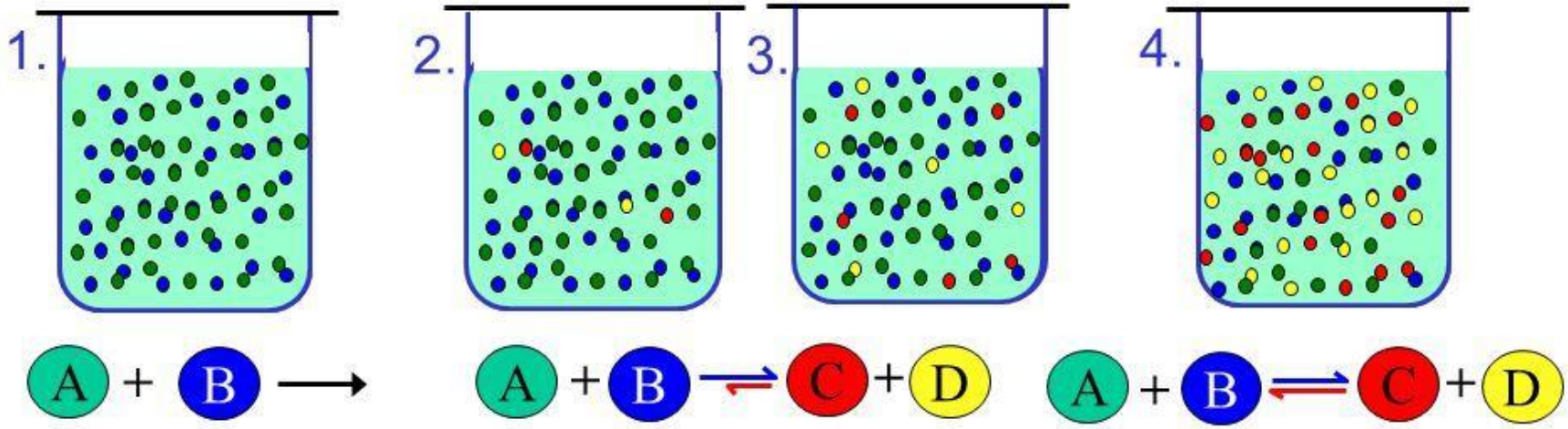


Equilibrium shifts to the right to restore balance
Rate forward reaction = rate reverse reaction

Dynamic Equilibrium:

Chemical equilibrium is a dynamic equilibrium. This is because reactions do not stop when they come to equilibrium state .The individual molecules keep on reacting continuously. But there is no change in the actual amounts of reactants and products. This means concentration of reactants and products become constant at equilibrium stage.

Chemical Equilibrium

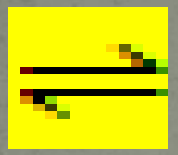


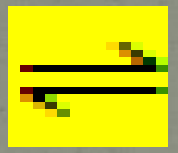
1. Reaction begins.
   - No products yet formed.
   - High rate of collisions between A & B.
   - Rate of forward reaction HIGH.

2 & 3 Products formed
   - Collisions between reactants decrease.
   - Rate of forward reaction DECREASES
   - Reverse reaction begins.

4. Rate of forward reaction EQUAL to rate of reverse reaction.
   - **Dynamic equilibrium** established.
   - Concentrations constant.

Write Forward and Reverse Reactions?

- $2NO_2$  N_2O_4

- $2SO_2 + O_2$  $2SO_3$

Law of Mass Action:

- **Introduction:**

  Two chemists C.M Gulberg and P. Waage in 1864 proposed the law of mass action to describe the equilibrium state.

- **"It states that the rate at which a substance reacts is directly proportional to its active mass and**

  the rate at which the reaction proceeds is directly proportional to the product of the active masses of the reactants."

Law of Mass Action:

It states that " the rate at which a substance react is proportional to its active mass and the rate of chemical reaction is proportional to the product of the active masses of the reacting substances."

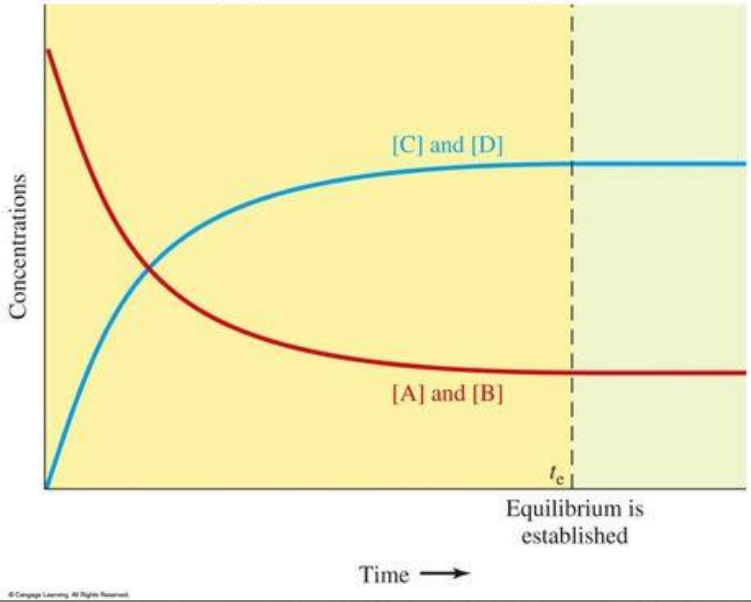
Active Mass:

The term "Active Mass " represents the concentration of reactants and products in moles.dm^{-3} for a dilute solution, and is expressed in terms of square brackets [ ].

Basic Concepts

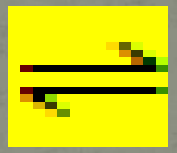
- Graphically, this is a representation of the rates for the forward and reverse reactions for this general reaction.

$$a\,A_{(g)} + b\,B_{(g)} \rightleftarrows c\,C_{(g)} + d\,D_{(g)}$$



Derivation of the Expression for the Equilibrioum Constant

Consider a hypothetical reaction in which 'a' moles of reactant A and 'b' moles of Reactant B react to give 'c' moles of product C and 'd' moles of product D at equilibrium.

- **aA + bB**  **cC + dD**

- According to the Law of mass action:
- Rate of forward reaction α $[A]^a [B]^b$
- Rate of forward reaction = K_f $[A]^a [B]^b$
- Rate of reverse reaction α $[C]^c [D]^d$
- Rate of reverse reaction = K_r $[C]^c [D]^d$
- Where K_f and K_r are the rate constants for forward

  and the reverse reactions respectively.

At Equilibrium Constant:

Rate of forward reaction = Rate of reverse reaction

Thus,

$$K_f [A]^a [B]^b = K_r [C]^c [D]^d$$

On rearranging

$$\frac{K_f}{K_r} = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

$$K_c = \frac{[C]^c [D]^d}{[A]^a [B]^b}$$

Equilibrium Constant:

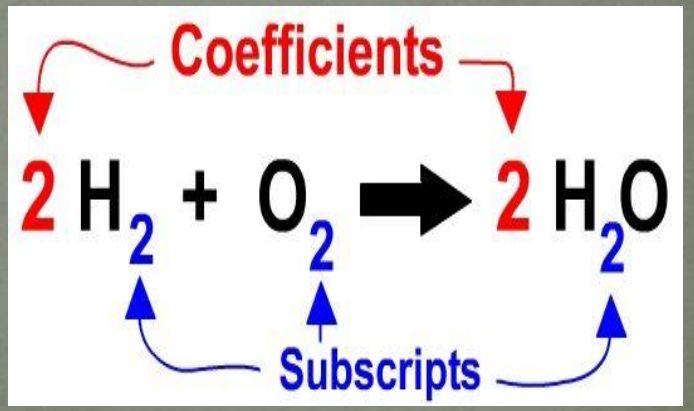
Where $K_c = \frac{Kf}{Kr}$ **and is known as equilibrium constant, and the above equation is known as equilibrium constant expression. The square brackets indicate the concentration of the chemical species at equilibrium in moles .dm^{-3}**

Equilibrium Constant (K_c) :

- **Equilibrium constant is defined as the ratio of the product of concentration of products to the product of concentration of reactants each raised to the power equal to the coefficient in the balanced chemical equation.**

$$aA + bB \rightleftharpoons cC + dD$$

$$K_c = \frac{[C]^c[D]^d}{[A]^a[B]^b}$$



Writing equilibrium constant expression:

$$2SO_2 + O_2 \rightleftharpoons 2SO_3$$

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

$$2N_2 + O_2 \rightleftharpoons 2NO_2$$

$$K_c = \frac{[SO3]2}{[SO2]2\,[O2]}$$

$$K_c = \frac{[NH3]2}{[N2]\,[H2]3}$$

$$K_c = \frac{[NO2]2}{[N2]2\,[O2]}$$

Plenary

- **Which scientist proposed the Law of Mass Action?**

  A) C.M Lewis B) C.M Wanderwa
  C) C.M Gulder D) C.M Guldberg

- **Define Mass Action?**
- **Rate of forward reaction α $[A]^a [B]^b$. (T/F)**
- Where _____ **and is known as equilibrium constant.**

Home wrok

- **Write equilibrium constant expression for the following reactions:**

$$CH_3COOH + C_2H_5OH \rightleftharpoons CH_3COOC_2H_5 + H_2O$$

$$2HF \rightleftharpoons H_2 + F_2$$

$$2H_2 + O_2 \rightleftharpoons 2H_2O$$

$$PCl_5 \rightleftharpoons PCl_3 + Cl_2$$


STAY
home
STAY
safe

ALLAH HAFIZZ