4/6/21

Class ⇒ B.Sc.(Hons.) Part II
Subject ⇒ Chemistry
Paper ⇒ III A (Physical Chemistry)
Chapter ⇒ Catalysis
Topic ⇒ Definition And Classification

Name ⇒ Dr. Amarendra Kumar
Deptt. of Chemistry
Jain College, Ara.

Catalysis

Greek word,
Kata = Wholly
lein = to loosen

A substance which alters the rate of a chemical reaction, itself remaining chemically unchanged at the end of the reaction is called **catalyst** and the process is called **catalysis**.

A catalyst may increase or decrease the rate of a reaction.

Positive Catalyst

A catalyst which enhances the rate of a reaction is called a positive catalyst and the process is called Positive catalysis.

e.g. (1) Decomposition of Potassium chlorate in presence of MnO_2 as catalyst.

$$2KClO_3 \xrightarrow{MnO_2} 2KCl + 3O_2$$

(2) Manufacture of Ammonia by Haber's process using finely divided iron as catalyst.

$$N_2 + 3H_2 \xrightarrow{Fe} 2NH_3$$

(3) Oxidation of SO_2 to SO_3 using NO as Catalyst.

$$SO_2 + \frac{1}{2}O_2 \xrightarrow{NO} SO_3$$

Negative catalyst

A catalyst which retards the rate of a reaction is called a Negative catalyst and the process is called Negative catalysis.

e.g. (1) Oxidation of chloroform is retarded in the presence of a small quantity of ethyl alcohol.

$$\underset{\text{Chloroform}}{2CHCl_3} + O_2 \xrightarrow{C_2H_5OH} \underset{\text{Phosgene}}{2COCl_2} + 2HCl$$

(2) Decomposition of Hydrogenperoxide is retarded in the presence of traces of Acetanilide.

$$2H_2O_2 \xrightarrow{\text{Acetanilide}} 2H_2O + O_2$$

Types of catalysis

There are two main types of catalysis
(1) Homogeneous Catalysis
(2) Heterogeneous Catalysis

(1) Homogeneous Catalysis

The catalysis in which the catalyst is in the same phase as the reactants and is evenly distributed throughout is called Homogeneous catalysis.

Homogeneous catalysis occurs in gas phase or the liquid (Solution) phase.

In gas phase ⇒ e.g. (1) oxidation of SO_2 to SO_3 with nitric oxide (NO) as catalyst.

$$\underset{(gas)}{2SO_2} + \underset{(gas)}{O_2} \xrightarrow{\underset{(gas)}{NO}} \underset{(gas)}{2SO_3}$$

(2) Decomposition of CH_3CHO with Iodine (I_2) as catalyst.

$$\underset{\text{vapour}}{CH_3CHO} \xrightarrow[\text{vapour}]{I_2} \underset{\text{gas}}{CH_4} + \underset{\text{gas}}{CO}$$

(3) Decomposition of O_3 in presence of NO or N_2O_5.

$$\underset{\text{gas}}{2O_3} \xrightarrow[\text{gas}]{NO} \underset{\text{gas}}{3O_2}$$

In solution phase (Many reactn. in soln. are catalysed by acid (H^+) and base (OH^-))

e.g. (1) Hydrolysis of canesugar (sucrose) in aqueous soln. in the presence of mineral acid as catalyst (Inversion of cane sugar)

$$\underset{\text{(aqueous)}}{C_{12}H_{22}O_{11}} + \underset{\text{(liquid)}}{H_2O} \xrightarrow{H_2SO_4/H^+(aq)} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose (aqueous)}}{C_6H_{12}O_6}$$

Cane sugar

(2) Hydrolysis of an ester in the presence of Acid or Alkali.

$$\underset{\text{Ethyl acetate}}{CH_3COOC_2H_5} + H_2O \longrightarrow \underset{\text{Acetic acid}}{CH_3COOH} + \underset{\text{Ethanol}}{C_2H_5OH}$$

(3) Decomposition of H_2O_2 in the presence of I^- (Iodide ion) as catalyst.

$$2H_2O_2 \xrightarrow{I^-} 2H_2O + O_2$$

(2) Heterogeneous Catalysis

The catalysis in which the catalyst is in a different physical phase from the reactants is called **Heterogeneous catalysis.**

e.g. Heterogeneous catalysis occurs in the gas, liquid or the solid phase.

Heterogeneous catalysis with gaseous reactants (Contact or Surface catalysis)

(1) Combination of SO_2 and oxygen in the presence of finely divided Pt or V_2O_5 as catalyst for manufacture of H_2SO_4

$$\underset{gas}{2SO_2} + \underset{gas}{O_2} \xrightarrow[Solid]{Pt/V_2O_5} \underset{gas}{2SO_3}$$

(2) Combination of Nitrogen and Hydrogen to form Ammonia in the presence of finely divided iron. (Haber process for Ammonia)

$$\underset{(gas)}{N_2} + \underset{(gas)}{3H_2} \xrightarrow[Solid]{Fe} \underset{(gas)}{2NH_3}$$

(3) Hydrogenation reactions of unsaturated organic compounds are catalysed by finely divided Ni.

$$\underset{\substack{Ethene \\ (gas)}}{H_2C=CH_2} + H_2 \xrightarrow[Solid]{Ni} \underset{\substack{Ethane \\ (gas)}}{H_3C-CH_3}$$

Heterogeneous catalysis with liquid reactants

(1) Decomposition of aqueous H_2O_2 is catalysed by MnO_2 or Pt in colloidal form,

$$\underset{Liquid}{2H_2O_2} \xrightarrow[Solid]{Pt} 2H_2O + O_2$$

(2) $$\underset{(liquid)}{C_6H_6} + \underset{(liquid)}{CH_3COCl} \xrightarrow[(Solid)]{AlCl_3} C_6H_5COCH_3 + HCl$$

Heterogeneous catalysis with solid reactants

The decomposition of Potassium chlorate is catalysed by MnO_2

$$\underset{Solid}{2KClO_3} \xrightarrow[(Solid)]{MnO_2} 2KCl + 3O_2$$

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