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CATALYSIS

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The word 'catalysis' was first used by Berzelius in 1836

Doberciner in 1825 observed that the Manganese dioxide affected the rate of decomposition of Potassium Chlorate.

Berzelius defined the catalysis as

"It is the Phenomenon in which the presence of a foreign substance could accelerate its rate without being used up in that reaction".

He called the foreign substance as Catalysis,

Later on, it was reported that Catalysist could also retard the rate of reaction...

Thus this definition of Berzelius was generalised and a new definition was setup for it.

" Catalyst is any substance which can change the speed of the reaction without being used up in that reaction and the Phenomenon is known as Catalysis.

Some Examples of Catalysis are given below.

(i) $KClO_3 + [MnO_2] \xrightarrow{400^\circ C} 2KCl + 3O_2 + [MnO_2]$

$[MnO_2]$ increases the rate of decomposition of $KClO_3$.

(ii) $C_2H_4 + H_2 \xrightarrow[\Delta]{Ni} C_2H_6$

Ni [finely divided] is Catalysist.

(iii) $SO_2 + \frac{1}{2}O_2 \xrightarrow[\text{or } NO]{Pt} SO_3$

Pt or NO is Catalysit.

(iv) $N_2 + 3H_2 \rightleftharpoons 2NH_3$. [Fe is Catalyst]

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Types of Catalysis :- There are two types of Catalysis

(A) Homogeneous Catalysis (B) Heterogeneous Catalysis.

(A) **Homogeneous Catalysis** :—

In homogeneous Catalysis, the Catalyst and reactants are in the same Phase. Some examples of gaseous and liquid Phase are given below

(i) Example from gaseous phase :—

In the lead chamber process for the manufacture of Sulphuric acid, Nitric Oxide (NO) gas Catalyses the reaction between SO_2 and O_2.

$$2\,SO_2 + O_2 \xrightarrow{NO} SO_3$$

In this example, the reactants (SO_3 and O_2) and the Catalyst (NO) are in the gaseous Phase.

(ii) Example from Liquid Phase :—

The inversion of Cane Sugar is Catalysed by a mineral acid (i.e HCl, H_2SO_4 and HNO_3 ... etc)

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow{H^+} C_6H_{12}O_6 + C_6H_{12}O_6$$

Cane Sugar — Glucose — Fructose

Here the Catalyst and reactants are in the liquid Phase.

(B) Heterogeneous Catalysis: —

In heterogeneous Catalysis, the Catalyst is present in a different Phase than that of reactants; Examples are

(i) Heterogeneous Catalyst involving Solid Reactants

The example for this type is the decomposition of Potassium-Chlorate in the presence of Solid MnO_2, which acts as a Catalyst.

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

The both reactant and Catalysts are Solid but different Solids Constitute different Phases and so the reactant and Catalyst are in different Phase i.e. (MnO_2) Catalyst are in separate phase from the Solid reactant $KClO_3$.

(ii) Heterogeneous Catalysis involving Liquid Reactants: —

The decomposition of Hydrogen Peroxide is Catalysed by Colloidal solution of gold and Platinum.

$$H_2O_2(l) \xrightarrow{Pt \text{ or } Au} 2H_2O + O_2$$

Here, H_2O_2 is a liquid reactant.

(iii) Heterogeneous Catalysis involving Gaseous Reactant: —

Combination of SO_2 and O_2 in the presence of finely divided Platinum is an example of this type: -

$$SO_2(g) + O_2(g) \xrightarrow{Pt(s)} 2SO_3$$

Characteristics of Catalysis.

1. A Catalyst does not change its mass and chemical Composition at the end of the reaction. But Physical change in Catalyst may occur like change in Size of Particle, Change in Colour etc.

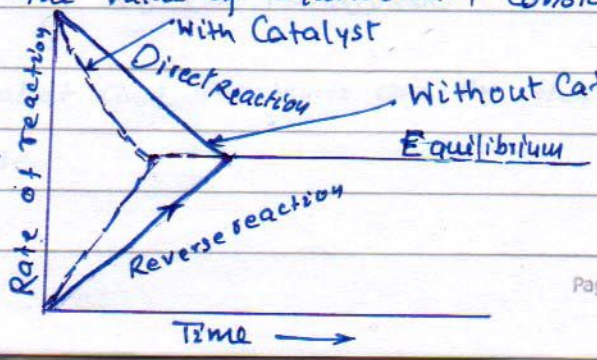
2. A Small amount of Catalyst is generally needed for Carrying out reaction.

In Case of heterogeneous Catalysis a Catalyst is not Consumed during the reaction and it is regenerated at the end of the reaction

But in heterogeneous Catalysis the rate of reaction varies with the Concentration of Catalyst For example the rate of Conversion or inversion of Cane Sugar is proportional to the molar Concentration of Catalyst H^+ ion (i.e dil acid).

3. A Catalyst accelerates the direct and reverse reaction equally.

Therefore it only changes the time needed to attainment of equilibrium. The position of equilibrium and the value of equilibrium Constant remain the Same.



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4. A catalyst can not generally start a reaction.
e.g. Dry H_2 and O_2 do not react even if they are left in contact for years but in presence of a little water catalyst, the reaction proceeds.

5. There is a specific catalyst for a particular reaction analogous to a specific key of a standard lock.
e.g. α-glucoside is hydrolysed by the enzyme maltose catalyst and not by emulsion catalyst which can hydrolyse β-glucoside.

6. Even then same reactants give different products in presence of different catalysts
e.g. (a) $CO + H_2 \xrightarrow{Cu} HCHO$ (Formaldehyde)
(b) $CO + 2H_2 \xrightarrow[250^\circ C]{ZnO + Cr_2O_3} CH_3OH$ (Methyl alcohol)
(c) $CO + 3H_2 \xrightarrow{Ni} CH_4 + H_2O$

7. The presence of a small amount of foreign substances activated or deactivated the catalyst.
e.g. Mo promotes the activity of Fe catalyst in the manufacture of NH_3 by Haber process whereas As_2O_3 destroys the efficiency of spongy Pt catalyst in the manufacture of H_2SO_4 by Contact Process.

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8. The Catalyst acts more efficiently at a particular temperature called the Optimum temperature.
e.g. the activity of enzymes is maximum at 25-40°c
At low temp (0°c) or high (75°c) temperature, the enzymes are almost inactive.

9. In heterogeneous Catalysis, the solid Catalyst is more effective in finely divided state than in bulk
e.g. finely divided nickel has better Catalytic activity than lumps of solid nickel.

10. A Catalyst generally cannot change the nature of products of the reaction e.g. On decomposition, $KClO_3$ gives KCl and O_2 whether MnO_2 Catalyst is added or not.

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