Catalysis and Oscillatory Behaviour

Definition of Catalysis

- A **catalyst** is a substance that alters the rate of a chemical reaction without undergoing permanent chemical change. It provides an **alternative reaction pathway** with lower activation energy.

- Catalysis refers to the phenomenon in which the rate of a chemical reaction is altered by the presence of a substance called a catalyst, which itself remains chemically unchanged at the end of the reaction. A catalyst does not initiate a reaction but provides an alternative pathway that allows the reaction to occur more easily.
- In catalytic reactions, the catalyst forms temporary associations with reactant molecules, creating intermediate species. These intermediates decompose to give products and regenerate the catalyst. Because the catalyst lowers the energy barrier for the reaction, a larger fraction of reacting molecules can participate effectively, resulting in an increased reaction rate.

- The rate of a catalytic reaction generally depends on the concentration of both the reactant and the catalyst. However, once all catalyst sites are occupied, further increase in catalyst concentration may not increase the reaction rate.
- Catalytic reactions may be homogeneous (catalyst and reactants in the same phase) or heterogeneous (catalyst in a different phase from reactants).

General Characteristics of Catalytic Reactions

- Catalyst is not consumed.
- Small amount is sufficient.
- Catalyst changes **rate**, not equilibrium constant.
- Highly **specific** in nature.
- Catalyst may be **poisoned** or **promoted**.

Properties of Catalysts

1. **Catalyst Remains Chemically Unchanged:** A catalyst participates in the reaction but is regenerated at the end. Its mass and chemical composition remain the same after the reaction.

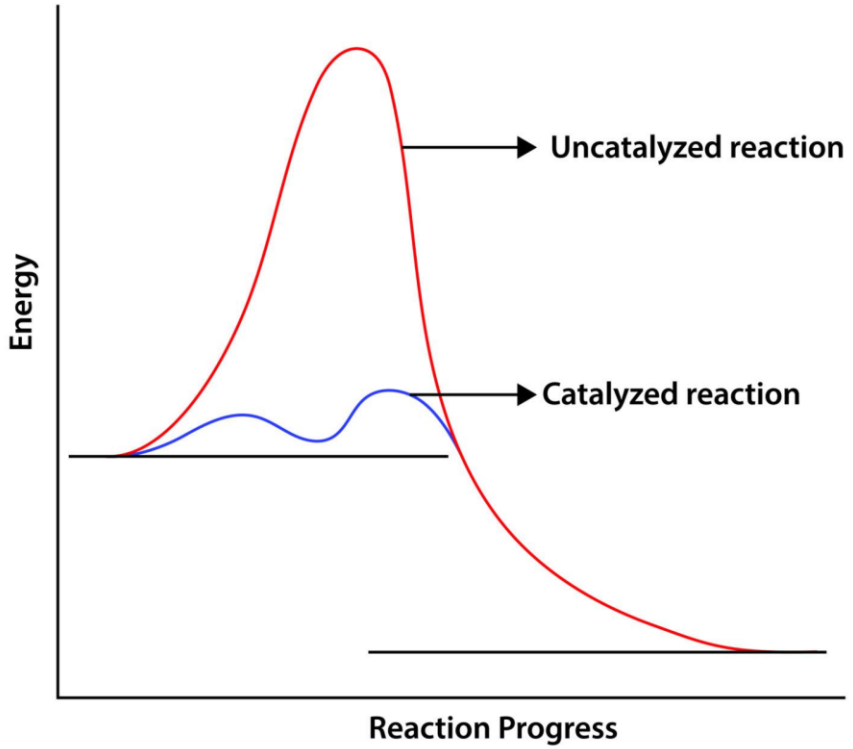
2. **Small Amount is Sufficient**: Only a small quantity of catalyst is required to bring about a large change in reaction rate. Even minute amounts can convert large quantities of reactants.

3. Catalyst Does Not Change the Equilibrium: A catalyst speeds up both the forward and reverse reactions equally. Therefore, it does not alter the position of equilibrium; it only helps the system reach equilibrium faster.

4. Highly Specific in Nature: A given catalyst generally catalyzes only a particular reaction or a specific type of reaction. This property is known as selectivity.

5. Catalyst Lowers Activation Energy: A catalyst provides an alternative reaction pathway with a lower energy barrier, making the reaction occur more easily.

Energy Profile of Catalyzed Reaction



A catalyst accelerates a reaction by lowering the activation energy through an alternative multi-step pathway without changing the overall thermodynamics of the reaction.

- Diagram represents variation of **potential energy** with **reaction coordinate** during a chemical reaction.
- Reactants start at the same energy level in both catalyzed and uncatalyzed reactions.
- Uncatalyzed reaction follows a pathway with a **high energy barrier**, represented by a tall peak.
- Catalyzed reaction follows an **alternative pathway** with a much **lower energy barrier**.
- Lower energy barrier allows a larger number of molecules to undergo successful collisions.
- Hence, the catalyzed reaction proceeds **faster** than the uncatalyzed reaction.
- Energy level of products remains **unchanged** in both cases.
- Overall energy change of reaction is **not affected** by the catalyst.
- Catalyst only changes the **pathway**, not the initial or final states.
- Therefore, a catalyst **increases reaction rate without being consumed**.