

Principles of Chemical Engineering

Reaction Engineering

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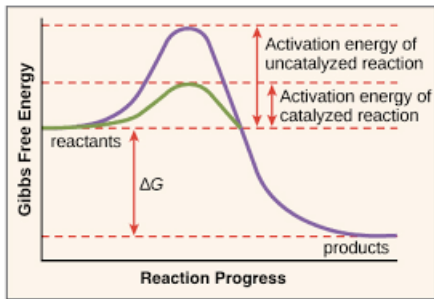
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Catalysis

- Catalysis is the process of modifying a chemical reaction with the use of a substance known as a catalyst. This process only works with chemicals that have an existing reaction, and it is used to accelerate the reaction for commercial purposes.
- Catalyst reduce the activation energy required for a reaction. Catalysis does not affect the equilibrium composition in case of a reversible reaction.

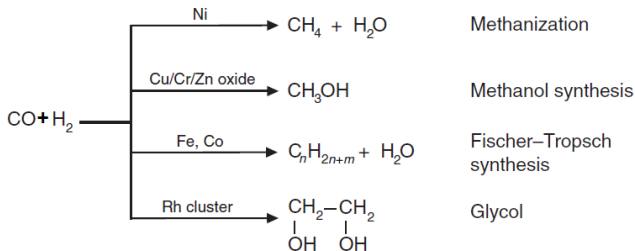
Effect of Catalyst on Activation Energy



- An uncatalyzed reaction requires a higher activation energy than does a catalyzed reaction.
- There is no difference in free energy between catalyzed and uncatalyzed reactions. Hence, equilibrium composition for a reversible reaction, is not affected by catalyst usage.

Role of Catalyst in Reactions

- A catalyst accelerates a chemical reaction without affecting the position of the equilibrium.
- Apart from accelerating reactions, catalysts have another important property: they can influence the selectivity of chemical reactions. This means that completely different products can be obtained from a given starting material by using different catalyst systems.



Reactions of synthesis gas (CO+H₂)



Role of Catalyst in Reactions (contd..)

- Catalysts can be gases, liquids, or solids. Most industrial catalysts are liquids or solids, whereby the latter react only via their surface.
- The importance of catalysis in the chemical industry is shown by the fact that 75% of all chemicals are produced with the aid of catalysts.
- Approximately 80% of all catalytic processes require heterogeneous catalysts, 15% homogeneous catalysts and 5% biocatalysts.
- Numerous organic intermediate products, required for the production of plastics, synthetic fibers, pharmaceuticals, dyes, crop-protection agents, resins, and pigments, can only be produced by catalytic processes.



Role of Catalyst in Reactions (contd..)

- Catalysts have been successfully used in the chemical industry for more than 100 years, examples being the synthesis of sulfuric acid, the conversion of ammonia to nitric acid, and catalytic hydrogenation. Later developments include new highly selective multicomponent oxide and metallic catalysts, zeolites, and the introduction of homogeneous transition metal complexes in the chemical industry.
- Typical examples:
 - Sulfuric acid (contact process) — V_2O_5
 - Nitric acid by NH_3 oxidation — Pt/Rh
 - Methanol synthesis from CO/H_2 — ZnO/Cr_2O_3
 - Cracking of hydrocarbons — Al_2O_3/SiO_2
 - Hydrogenation of vegetable oils — Ni