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Class ⇒ B.Sc.(Hons.) Part II
Subject ⇒ Chemistry
Paper ⇒ IIIA Physical Chemistry
Chapter ⇒ Catalysis
Topic ⇒ Acid-Base catalysis, Enzyme Catalysis

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Acid - Base Catalysis

A number of homogeneous catalytic reactions are known which are catalysed by ~~ab~~ acids or base or both acids and bases are called Acid- Base Catalysis.

Arrhenius pointed out that acid catalysis brought about by H^+ ions supplied by strong Acids, while base catalysis was caused by OH^- ions supplied by strong bases.

Examples of Acid - Base Catalysis

(1) Inversion of Cane sugar

$$\underset{\text{Cane sugar}}{C_{12}H_{22}O_{11}} + H_2 \xrightarrow{H^+} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

(2) Keto - enol tautomerism of Acetone.

$$\underset{\text{Keto form}}{CH_3-\overset{O}{\overset{\|}{C}}-CH_3} \xrightarrow{H^+} \underset{\text{Enol form}}{CH_3-\overset{OH}{\overset{|}{C}}=CH_2}$$

(3) Decomposition of Nitramide.

$$NH_2NO_2 \xrightarrow{H^+} N_2O + H_2O$$

Date:

(4) Hydrolysis of an Ester

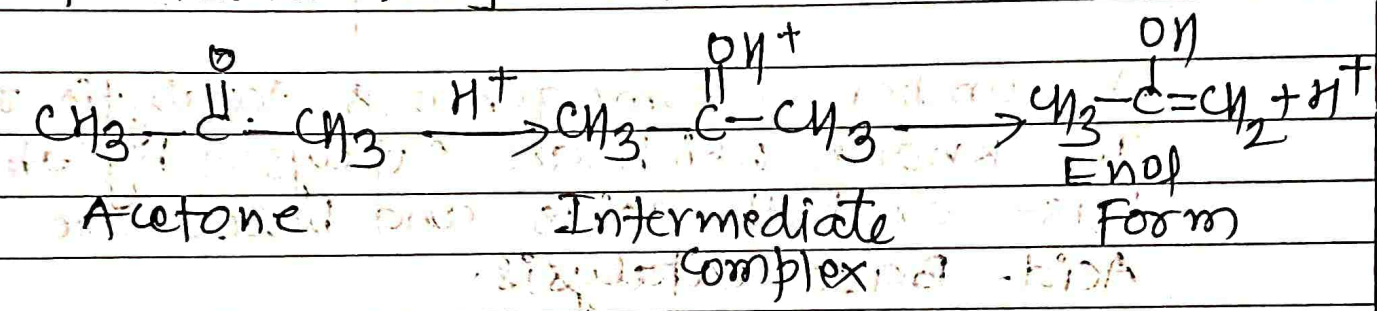
$$CH_3COOC_2H_5 \xrightarrow[\text{or } OH^-]{H^+} CH_3COOH + C_2H_5OH$$

Ethyl acetate — Acetic acid — Ethanol

Mechanism of Acid-Base Catalysis

(i) In acid catalysis, the H^+ (or a proton donated by Bronsted acid) forms an intermediate complex with the reactant, which then reacts to give back the proton.

e.g. The mechanism of keto-enol tautomerism of Acetone is



(ii) In Base catalysis, the OH^- ion (or any Bronsted base) accepts a proton from the reactant to form an intermediate complex which then reacts or decomposed to regenerate the OH^- (or Bronsted base).

e.g. The decomposition of Nitramide by OH^- ions and CH_3COO^- ions.

ⓐ By OH^- ions

$$NH_2NO_2 + OH^- \longrightarrow H_2O + NHNO_2^-$$

Intermediate Complex

$$NHNO_2^- \longrightarrow N_2O + OH^-$$

ⓑ By CH_3COO^- ions

$$NH_2NO_2 + CH_3COO^- \longrightarrow CH_3COOH + NHNO_2^-$$

$$NHNO_2^- \longrightarrow N_2O + OH^-$$

$$OH^- + CH_3COOH \longrightarrow H_2O + CH_3COO^-$$

Enzyme Catalysis

Enzymes are protein molecules present in the living organism.

All enzymes have been found to be complex protein molecules.

Enzymes are protein molecules which act as catalyst to speed up organic reactions in living cells. The catalysis brought about by enzyme is called Enzyme catalysis.

The reaction in Enzyme catalysis occurs at a specific site on the protein molecule. This is called active site. The reactants in an enzyme reaction are called substrates.

Examples of Enzyme Catalysis

Biochemical reactions catalysed by enzymes are

(1) Inversion of cane sugar ($C_{12}H_{22}O_{11}$) by Invertase present in yeast.

$$\underset{\text{Cane sugar}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{\text{Invertase}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

(2) Conversion of glucose into ethanol by zymase present in yeast.

$$\underset{\text{Glucose}}{C_6H_{12}O_6} \xrightarrow{\text{zymase}} \underset{\text{Ethanol}}{2C_2H_5OH} + 2CO_2$$

(3) Hydrolysis of urea by urease present in soya bean

$$\underset{\text{urea}}{NH_2-\overset{O}{\overset{\|}{C}}-NH_2} + H^+ \xrightarrow{\text{urease}} 2NH_3 + CO_2$$

* The name of enzymes are written on the arrow.

Mechanism of Enzyme Catalysis

The mechanism of enzyme catalysis is proposed by Michaelis and Menten.

$$E + S \rightleftharpoons \underset{\text{complex}}{ES} \longrightarrow P + E$$

Where E = enzyme, S = substrate (reactant)
ES = activated complex, P = Products.

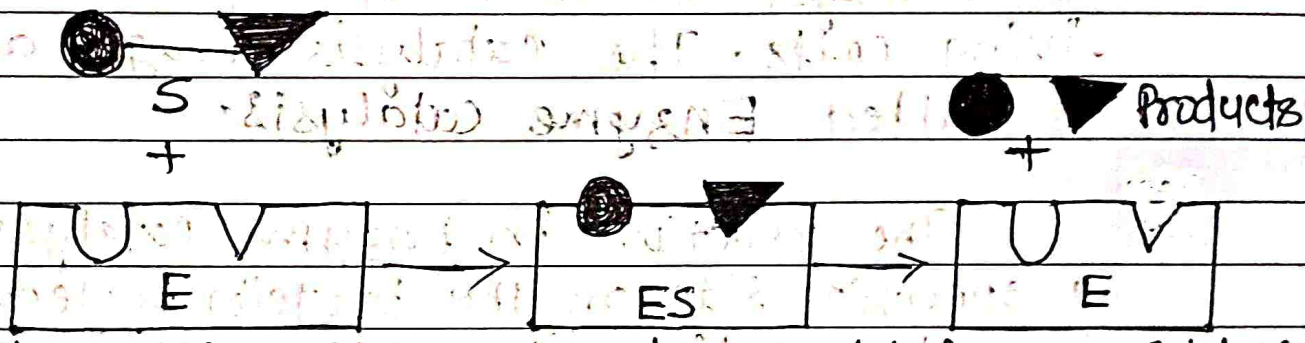


Fig:- Illustration of the lock-and-key model of enzyme catalysis

Characteristics of Enzyme catalysis

(1) Enzymes are the most efficient catalysts known.
(2) Enzyme catalysis is marked by absolute specificity.
(3) The rate of enzyme catalysed reactions is maximum at the optimum temperature.
e.g. The optimum temp., of enzyme reactions occurring in human body is 37°C (98.6°F)
(4) The rate of enzyme catalysed reaction is maximum at the optimum pH.
(5) Enzymes are markedly inhibited or poisoned.
(6) catalytic activity of enzymes is greatly enhanced by the presence of Activators or coenzymes.

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