**Temperature Dependence of Rate Constant**

**Arrhenius Law**

\[ k = Ae^{-E_a/RT} \]

where

- \( E_a \) = Activation Energy
- \( A \) = Pre-Exponential Factor

Typically:

- \( E_a \sim 50\text{-}300 \text{ kJ/mole} \)
- \( A \text{ (unimolecular)} \sim 10^{12}\text{-}10^{15} \text{ sec}^{-1} \)
- \( A \text{ (bimolecular)} \sim 10^{11} \text{ liter/(mole sec)} \)
**Physical Interpretation of $E_a$**

Consider $A + B \rightarrow C$

\[ A \leftrightarrow B \Rightarrow (A \ldots B)^* \Rightarrow C \]

Reactants \hspace{1cm} Activated Complex \hspace{1cm} Product

\[ \text{Energy} \]

\[ \text{Reaction Coordinate} \]

Small $E_a$ \Rightarrow Weak T dependence \Rightarrow Fast reaction

Large $E_a$ \Rightarrow Strong T dependence \Rightarrow Slow reaction
Catalysis

A catalyst speeds up a reaction but is NOT destroyed or used up in the process.

Consider $A \overset{k_1}{\underset{k_{-1}}{\rightleftharpoons}} B$ (both slow)

Let $C$ be a catalyst

$A + C \overset{k_2}{\underset{k_{-2}}{\rightleftharpoons}} B + C$ (both fast)

$C$ acts to LOWER the $E_a$ for the reaction, often altering the mechanism.

Uncatalyzed

$A \Rightarrow A^* \Rightarrow B$

Catalyzed

$A + C \Rightarrow (A \overset{k_2}{\underset{k_{-2}}{\rightleftharpoons}} C)^* \Rightarrow B + C$
The Equilibrium \[ K_{eq} = \frac{[B]_{eq}}{[A]_{eq}} \] is unaltered.

Only the rate is changed through a lowering of \( E_a \).