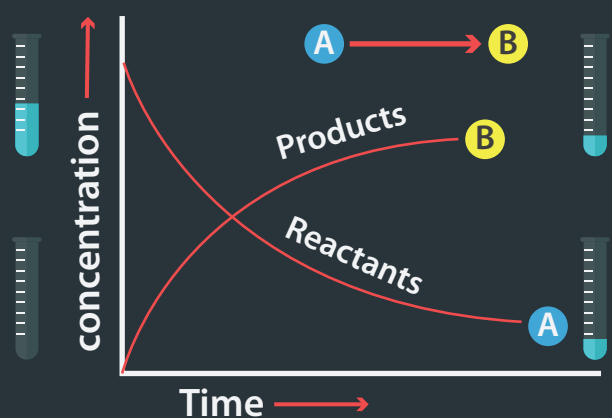


Rate of Reaction



Appearance of Products $\Delta[P] = [P_2] - [P_1]$

Disappearance of Reactants $\Delta[R] = [R_2] - [R_1]$

$$\Delta t = t_2 - t_1$$

$$+\Delta[P]/\Delta t$$

Equal

$$-\Delta[R]/\Delta t$$

Rate of Reaction Units: $\text{mol L}^{-1} \text{s}^{-1}$

Rate Law

(Always determined experimentally)

For a given reaction
 $aA + bB + cC + dD$

Rate law is given by

$$d[R]/dt = k [A]^x [B]^y$$

Order of reaction
with respect to A

Order of reaction
with respect to B

Rate of Reaction in $\text{mol L}^{-1} \text{s}^{-1}$

Rate constant

Concentration of
Reactants in mol L^{-1}

x and y may or may not be equal to the stoichiometric coefficients of the reactants.

Overall order of Reaction $\rightarrow x+y$

Integrated Rate equations

Zeroth order

First order

Second order

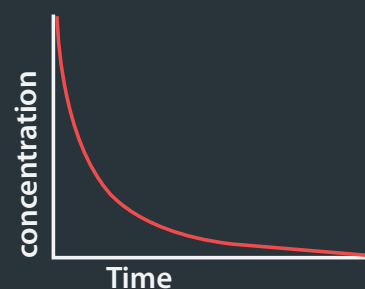
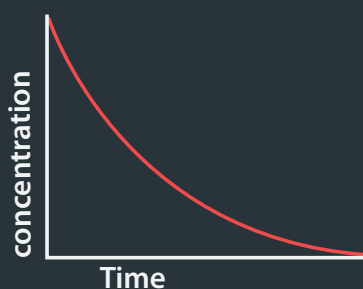
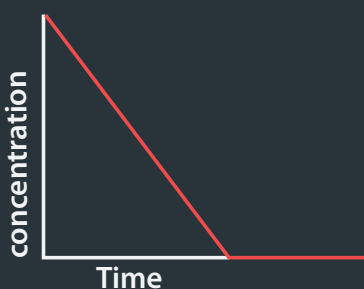
Differential rate law

$$\text{Rate} = -\frac{\Delta[A]}{\Delta t} = k$$

$$\text{Rate} = -\frac{\Delta[A]}{\Delta t} = k[A]$$

$$\text{Rate} = -\frac{\Delta[A]}{\Delta t} = k[A]^2$$

Concentration vs. time



Integrated rate law

$$[A] = [A]_0 - kt$$

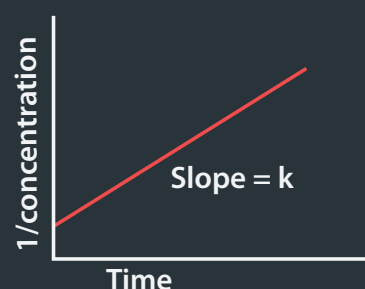
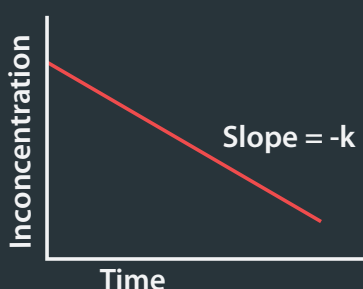
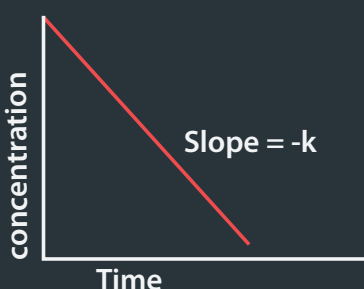
$$[A] = [A]_0 e^{-kt}$$

or

$$\ln[A] = \ln[A]_0 - kt$$

$$\frac{1}{[A]} = \frac{1}{[A]_0} + kt$$

Straight-line plot to determine rate constant



Relative rate vs. concentration

[A], M Rate, M/s

1	1
2	1
3	1

[A], M Rate, M/s

1	1
2	2
3	3

[A], M Rate, M/s

1	1
2	4
3	9

Half-life

$$t_{1/2} = \frac{[A]_0}{2k} + kt$$

$$t_{1/2} = \frac{0.693}{k}$$

$$t_{1/2} = \frac{1}{k[A]_0}$$

Units of k, rate constant

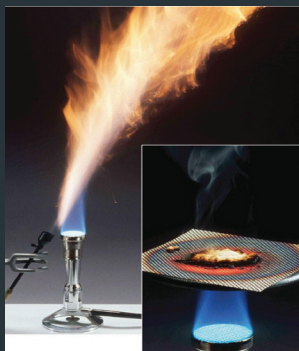
M/s

1/s

$\text{M}^{-1} \text{s}^{-1}$

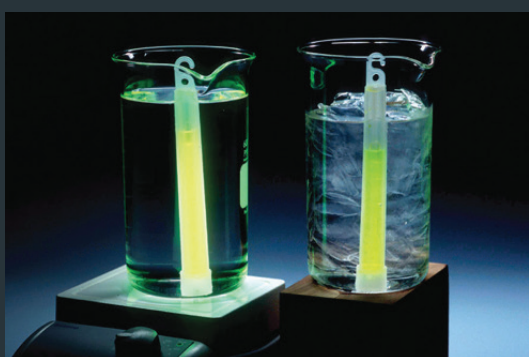
Factors Influencing Rate of a Reaction

Nature of Reactants



- Faster rate when both the reactants are in liquid phase.
- Collision frequency is more in liquid phase
- The reaction rate of a heterogeneous reaction depends on the surface area of the more condensed phase.

Temperature



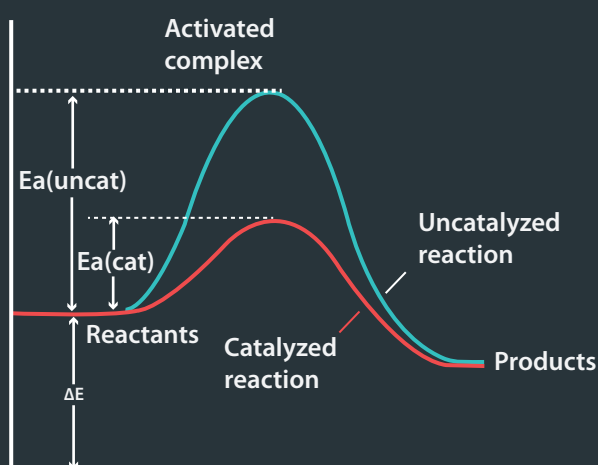
- The reaction rate of virtually all reactions increases with increase in temperature
- Temperature increases Average kinetic energy of the particle increasing the collision frequency of the constituent particles.

Concentration of the Reactants



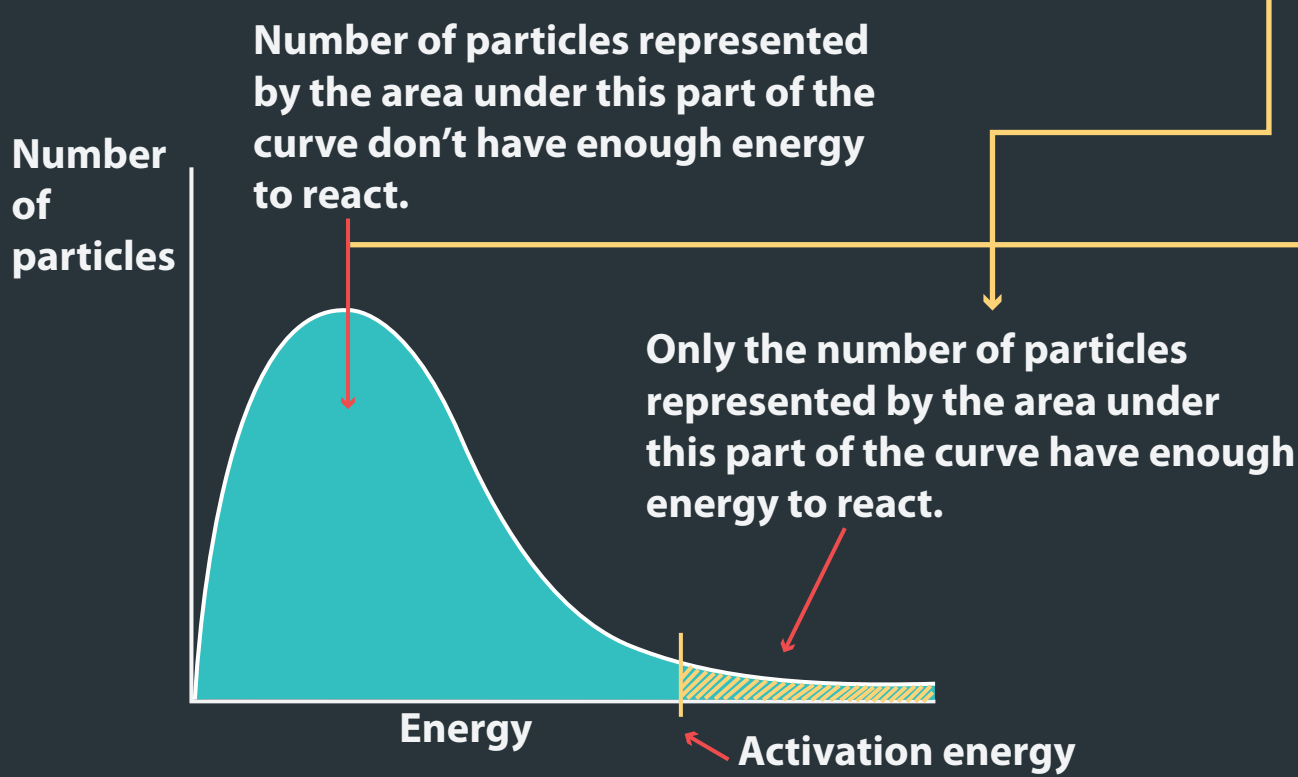
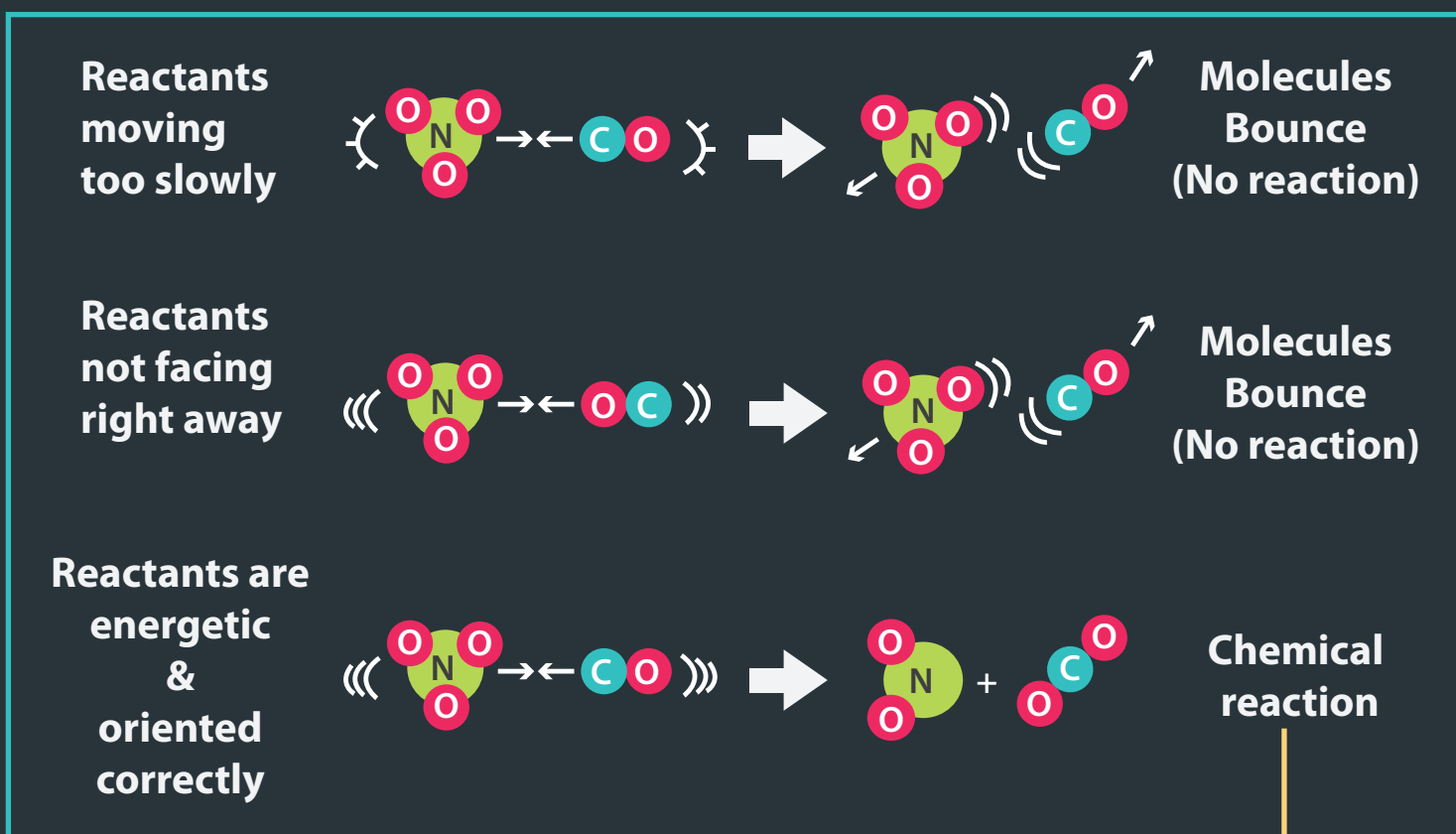
- The reaction rate usually increases as the concentration of the reactants increases.
- The more reactant particles that collide per unit time, the more often a reaction between them can occur.

Presence of a Catalyst



- The catalyst provide an alternate pathway to the reaction to proceed.
- The catalysed pathway has a lower Activation Energy.
- Because of its lower Activation Energy, the reaction rate of a catalysed reaction is faster than the reaction rate of the uncatalyzed reaction at the same temperature

Collision Theory

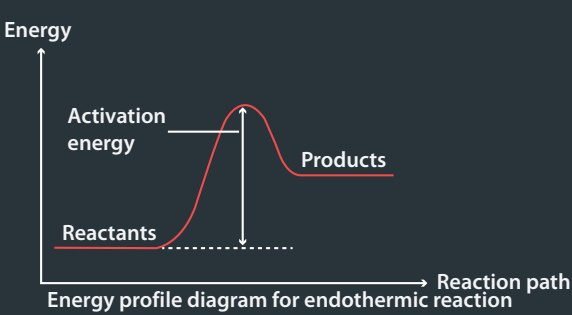
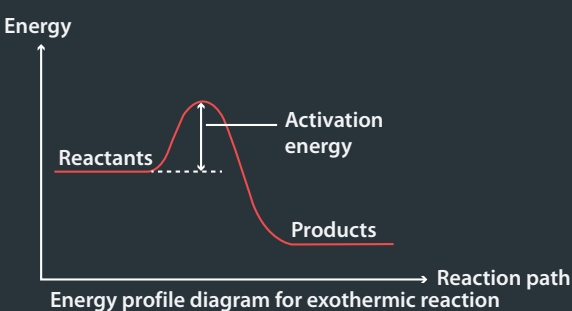


Rate of reaction = $Z_{AB} e^{-E_a/RT}$

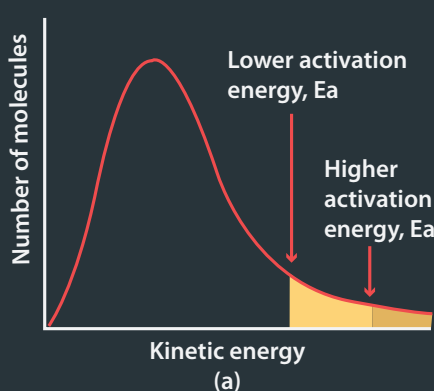
Collision Frequency → Z_{AB}

Fraction of molecules having energy more than the activation energy (E_a). → $e^{-E_a/RT}$

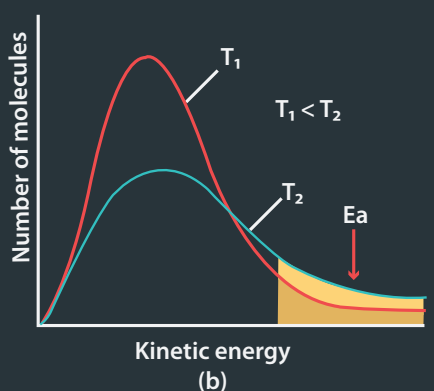
Temperature and Rate relationship



- The reaction coordinate represents the profile of energy change when reactants change into products.
- Some of the energy releases when the complex decomposes to form products.
- Therefore, the final enthalpy of the reactions depends only on the nature of the reactants and products.



- The peak of the curve in the graph corresponds to the most probable kinetic energy.
- When the temperature increases, the maxima of the curve moves to the higher energy value. Therefore, the curve broadens.



Arrhenius Equation

$$k = A e^{-\frac{E_a}{RT}}$$

k = Rate constant

A = Pre-exponential factor

R = Universal gas constant

T = Absolute temperature (in Kelvin)

E_a = Activation energy (in the same units as $R \cdot T$)