Ministry of Higher Education and Scientific Research
AL-Mustaqbal University College of Science
Department of Biochemistry

Physical Chemistry

Lecture 6

Scholar year 2025-2026

First semester

Collision theory & Reaction Rates

By

Dr. Assel Amer Hadi

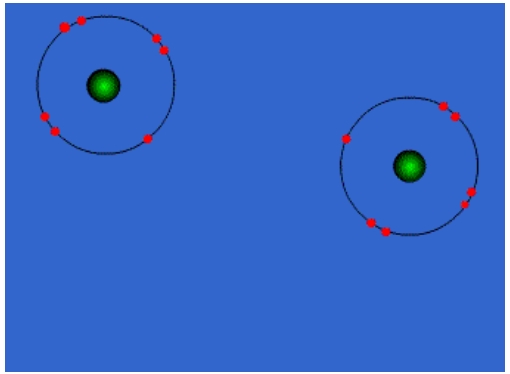
Collision Theory (Part-1)

Collision theory: is a chemistry model stating that for a chemical reaction to occur, reactant particles must collide with sufficient energy (at least the activation energy) and with the correct orientation .

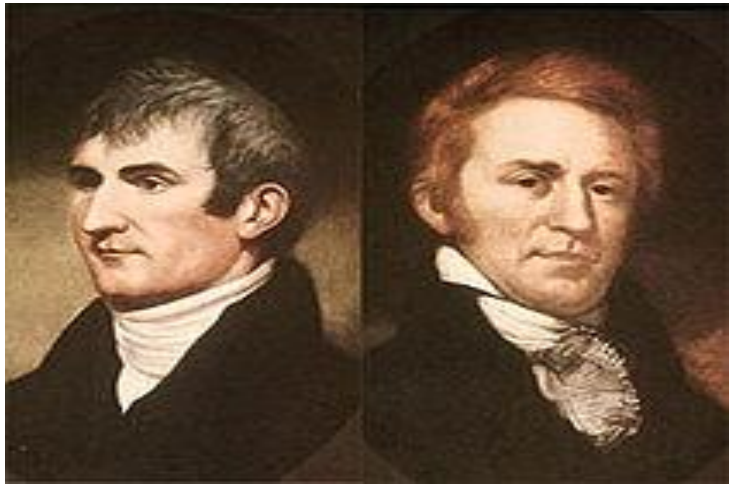
What are the requirements for a reaction ?

1) Molecule should collide

2) Collide with sufficient energy



Collision theory



Max Trautz &William Lewis

(1916-18)

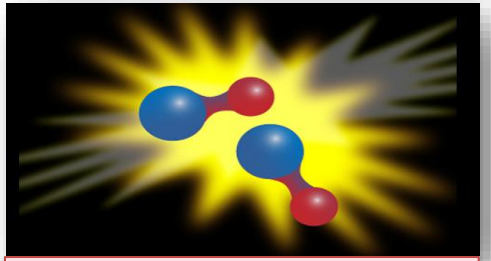
Collision theory was developed by Max Trautz and William Lewis.

Collision theory

It is Based on Kinetic Theory of Gases

Assumptions of Collision theory…

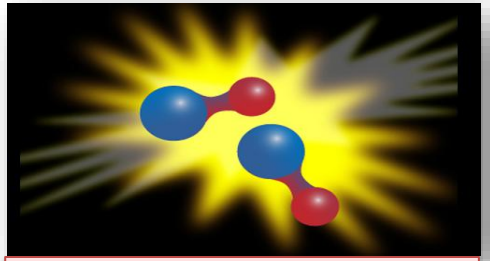
- Molecules are hard spheres
- Reaction occurs when molecules collide



Collision theory

Collision theory

Increase in temperature → Average K.E. of the Molecule increases



Collision theory

Increases no. of collisions per unit time

This increases the rate only by

Hence the increase in rate of a reaction is not simply due to the increase in collision frequency

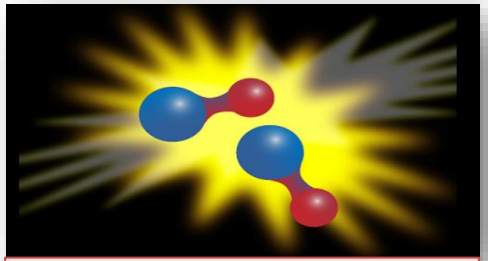
Collision Theory (Part-2)

Collision theory

Rate depends upon :

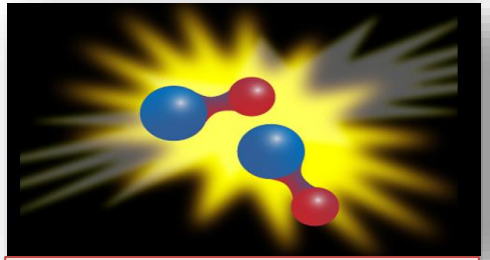
1. **Collision frequency**

2. **Effective collision**



Collision theory

1) Collision Frequency (Z)



Collision theory

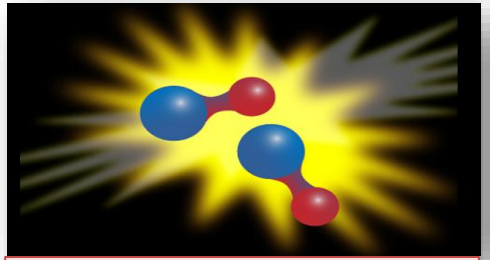
- The number of collisions that takes place per second per unit volume of the reaction mixture is known as collision frequency (Z).

In bimolecular gaseous reactions, Z is of the order of 10^{25} to 10^{28}

If all collisions are effective, the reactions must be very fast

All the collisions of the reacting species at a given temperature are not effective

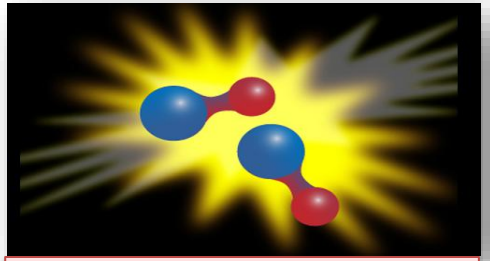
In actual practice, most chemical reactions take much longer



Collision theory

2. Effective collision

The basic requirement of collision theory is that the reacting species must collide.



Collision theory

Only a small fractions of collision is effective.

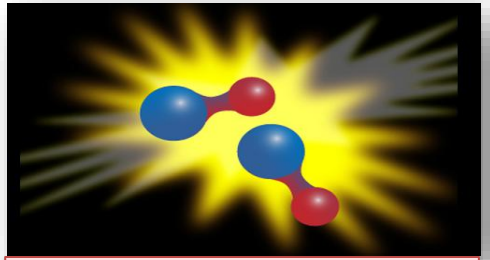
Effective collision ⇒ More or equal to threshold energy

Thus, the energy of collisions determines the possibility of a reaction

If the energy of the reacting molecules is less , collisions will be ineffective.

2. Effective collision

Threshold energy

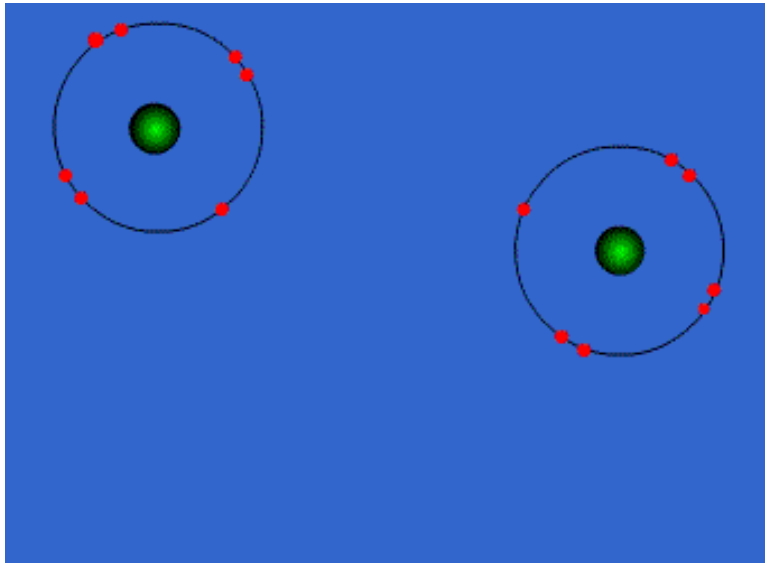


Collision theory

- The colliding molecules should posses a certain minimum amount of energy to give products. This minimum amount of energy is called Threshold energy.

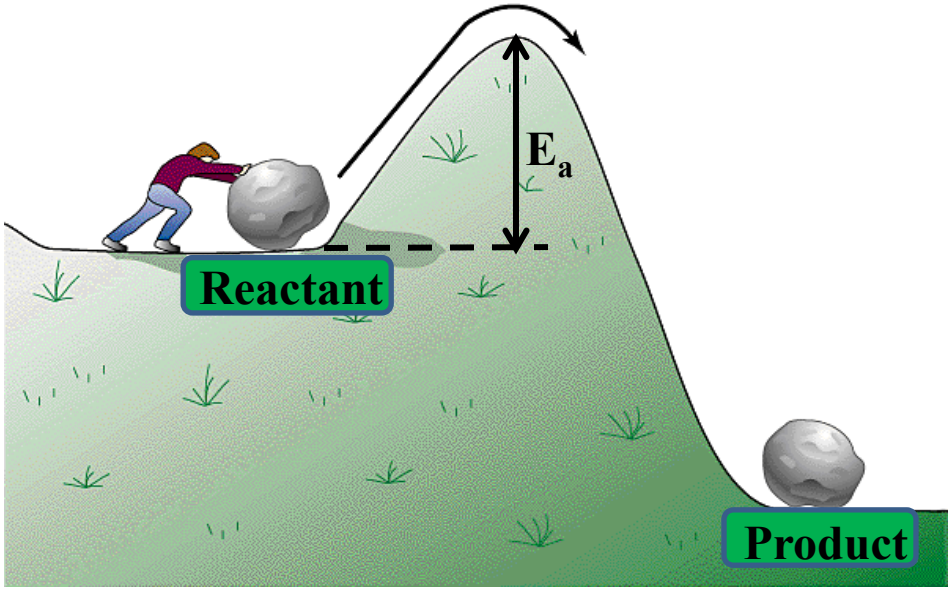
Requirements for a bimolecular reaction

1. Collision between reactant molecules



Requirements for a bimolecular reaction

2. Energy requirement (activation energy)

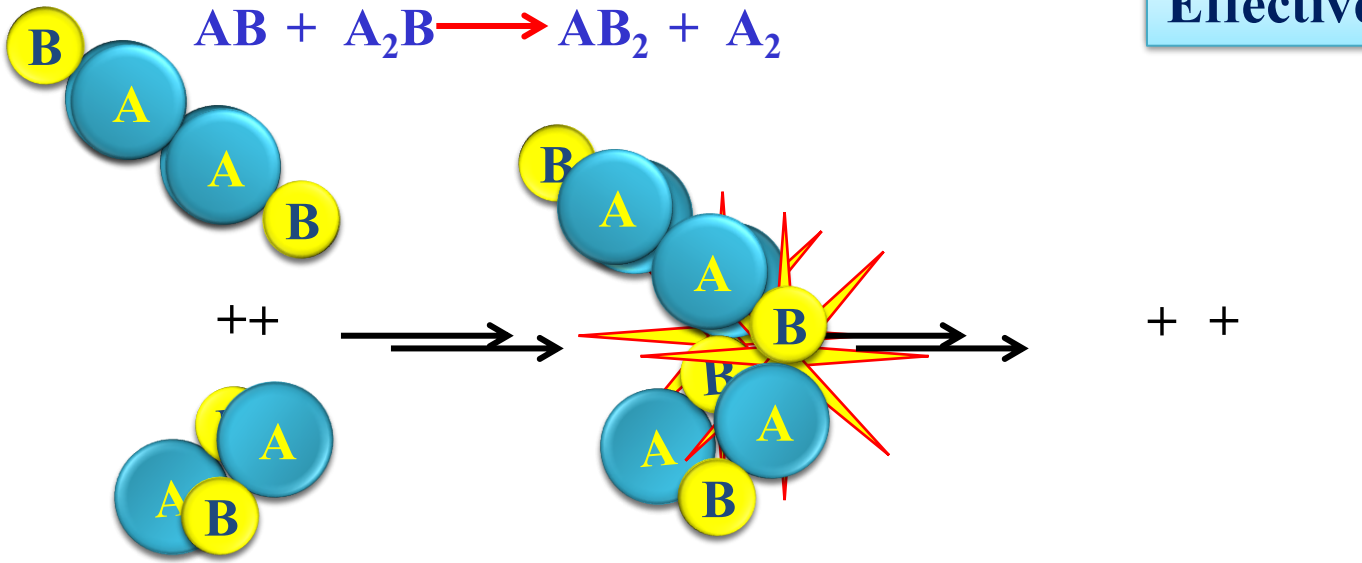


Requirements for a bimolecular reaction

3. Orientation of reactant molecules

$AB + A_2B \longrightarrow AB_2 + A_2$

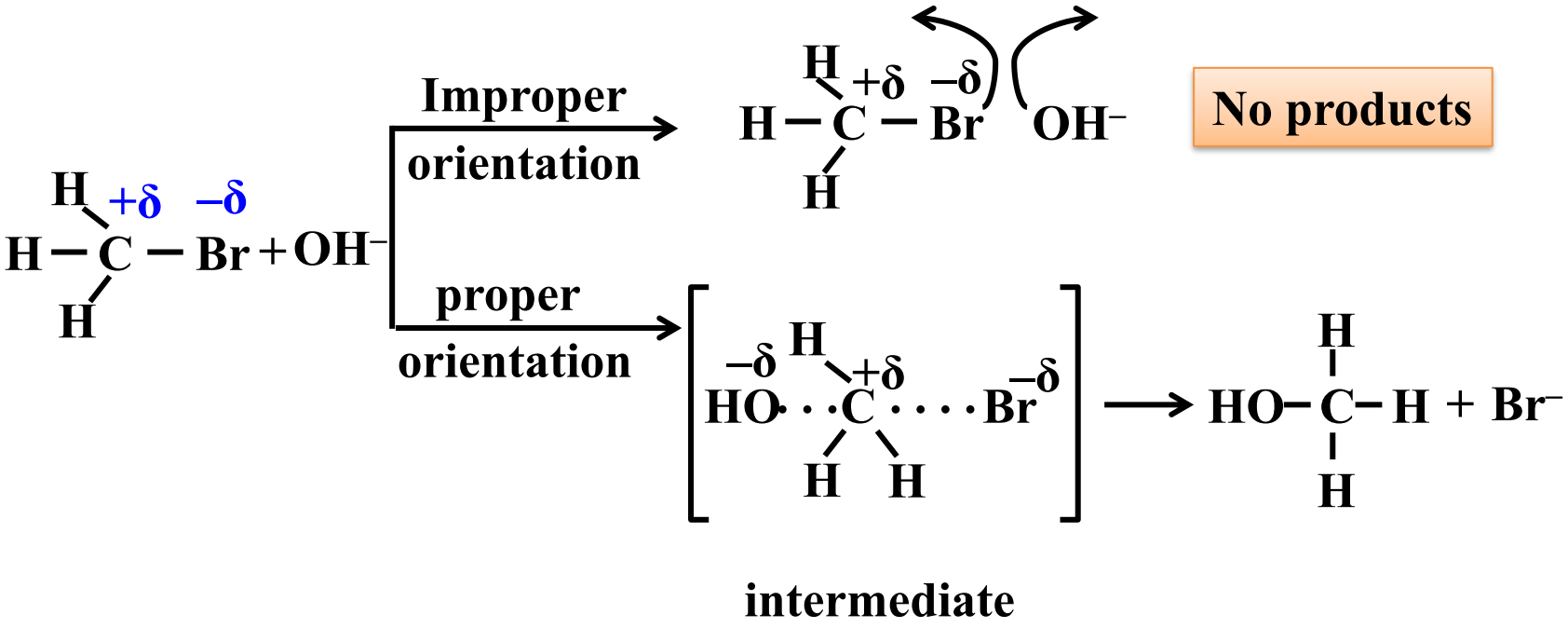
Effective collision



Reactants
collision
Products

Requirements for a bimolecular reaction

3. Orientation of reactant molecules



Potential energy barrier

Atoms require energy to overcome repulsion between B and AC

$$B + AC \longrightarrow B.....A.....C \longrightarrow BA + C$$

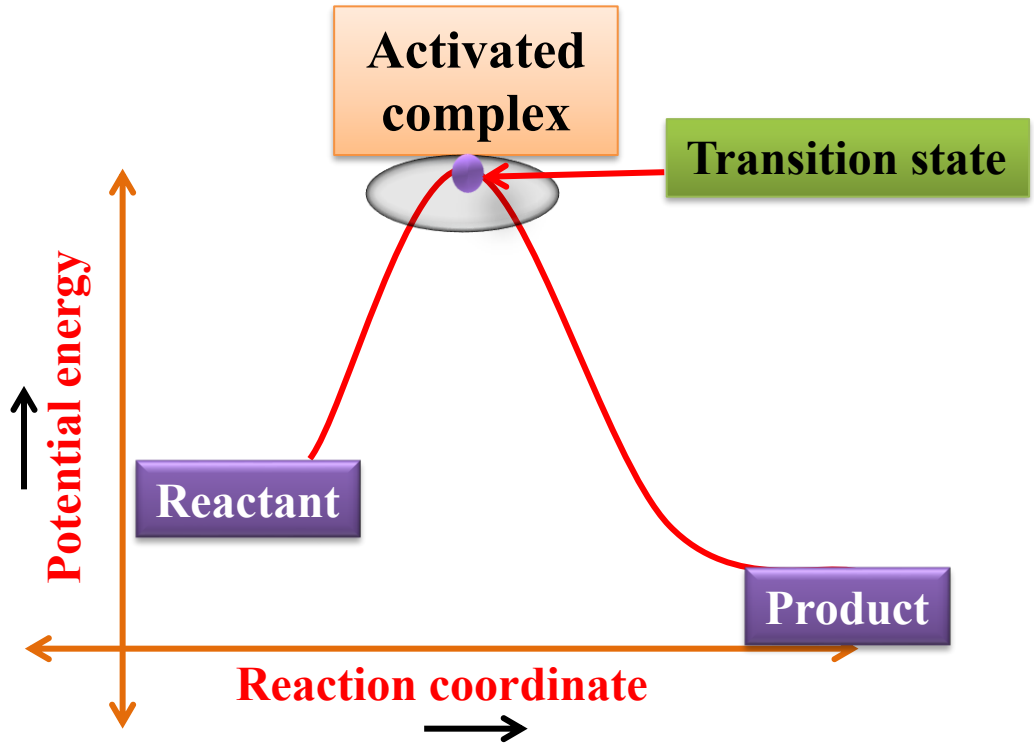
Reactants — Activated complex — Products

K.E. of colliding particles is converted into P.E. in an Activated complex
$\Rightarrow$ Transition state

Transition state $\Rightarrow$ Potential energy barrier

Energy comes from
K. E. of colliding particles

Potential energy barrier



Effective collision for bimolecular elementary reaction

- Collisions with sufficient kinetic energy
- Collision with proper orientation

$k = P Z e^{-Ea/RT}$

A = P.Z is called frequency or pre-exponential factor

P ⇒ Steric factor or probability factor

This equation is written in the form of Arrhenius equation

$k = A e^{-Ea/RT}$

MCQs

1. Which of the following affects the rate of reaction?

a) collision frequency

b) effective collision

c) both a & b

d) none of these

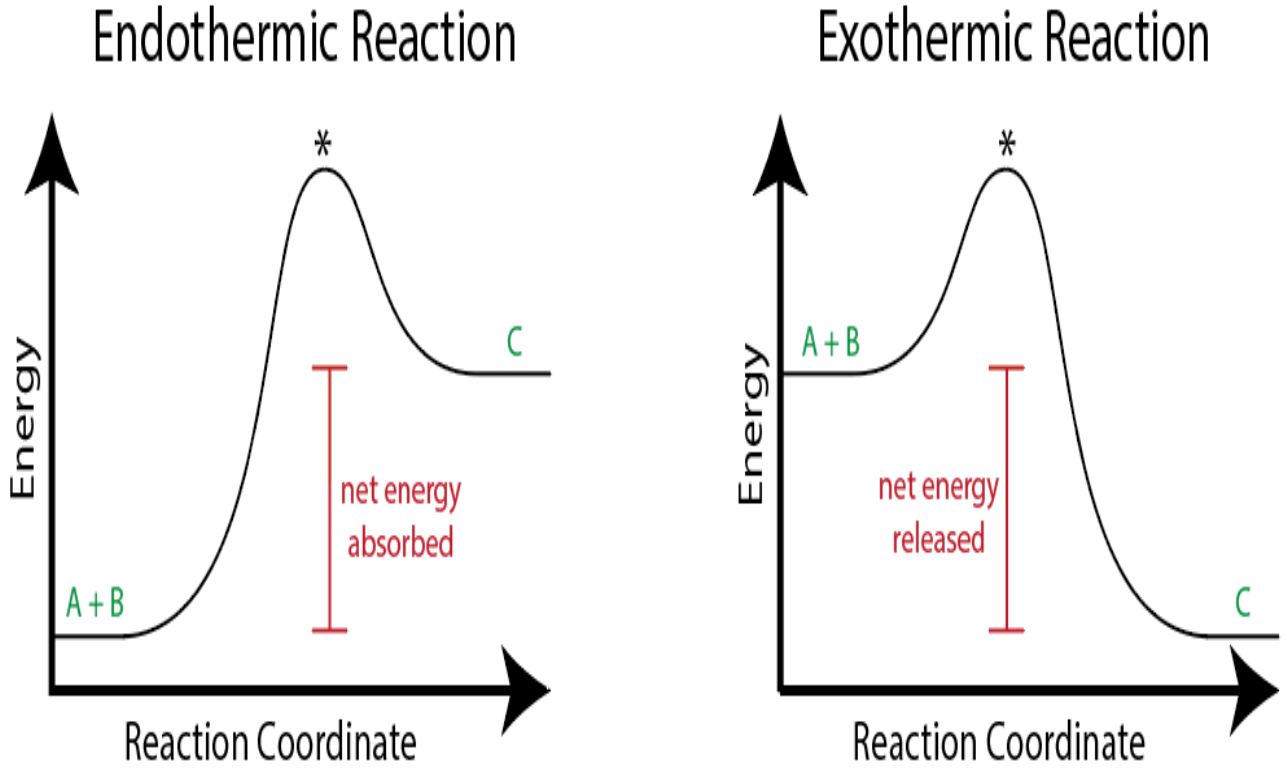
Comparison between **high activation energy** and **low activation energy**

Feature	High Activation Energy	Low Activation Energy
Definition	Requires a large amount of energy for reactants to transform into products.	Requires a small amount of energy for reactants to transform into products.
Reaction rate	The reaction occurs slowly, because few molecules have enough energy to reach the activation barrier.	The reaction occurs quickly, because many molecules have sufficient energy to react.
Temperature effect	Strongly affected by temperature — increasing temperature greatly speeds up the reaction.	Less affected by temperature — the reaction is already fast, so temperature has a smaller effect.
Energy barrier (Ea)	The potential energy barrier is high.	The potential energy barrier is low.
Examples	Rusting of iron, decomposition of water.	Combustion of hydrogen gas, neutralization reactions.

Comparison between **Endothermic** and **Exothermic** Reactions

Property	Endothermic Reaction	Exothermic Reaction
Definition	Absorbs heat from surroundings	Releases heat to surroundings
Heat Flow	Heat enters the system	Heat leaves the system
Temperature of Surroundings	Decreases	Increases
Energy of Products vs Reactants	Products have higher energy than reactants	Products have lower energy than reactants
Enthalpy Change (ΔH)	Positive (+ΔH)	Negative (−ΔH)
Effect of Increasing Temperature	Favored (reaction rate increases)	Opposed (reaction rate decreases)
Examples	Photosynthesis, melting of ice, decomposition of $CaCO_3$	Combustion of fuel, freezing of water, formation of H_2O
Energy Diagram	Reactants are lower; products are higher in energy	Reactants are higher; products are lower in energy

CHEMICAL KINETICS



Factors affecting reaction rate

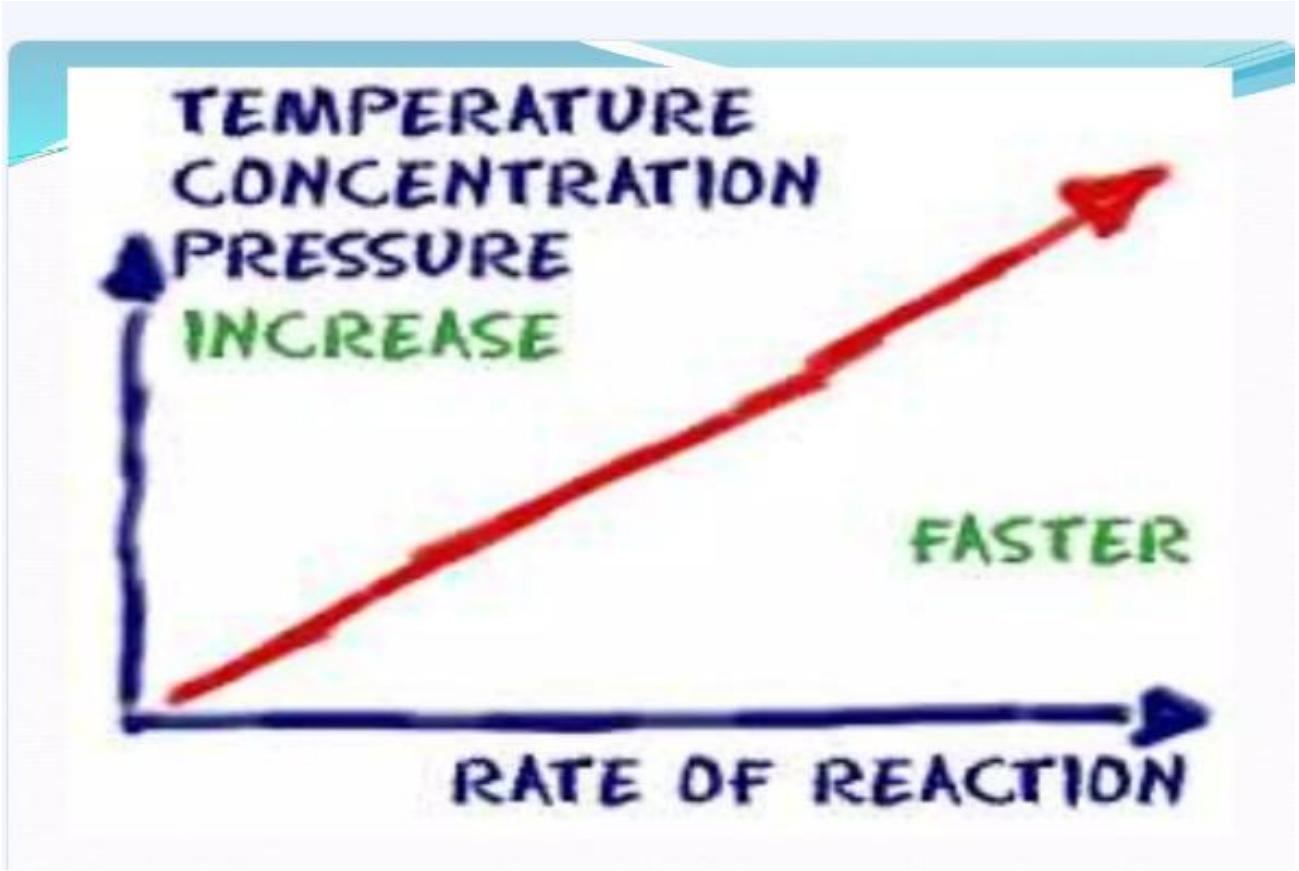
- Temperature
- Surface area
- Concentration of reactants
- Catalyst

Temperature

If the temperature is increased:

* the reactant particles move more quickly
* the reactant particles have more kinetic energy
* the reaction rate increases

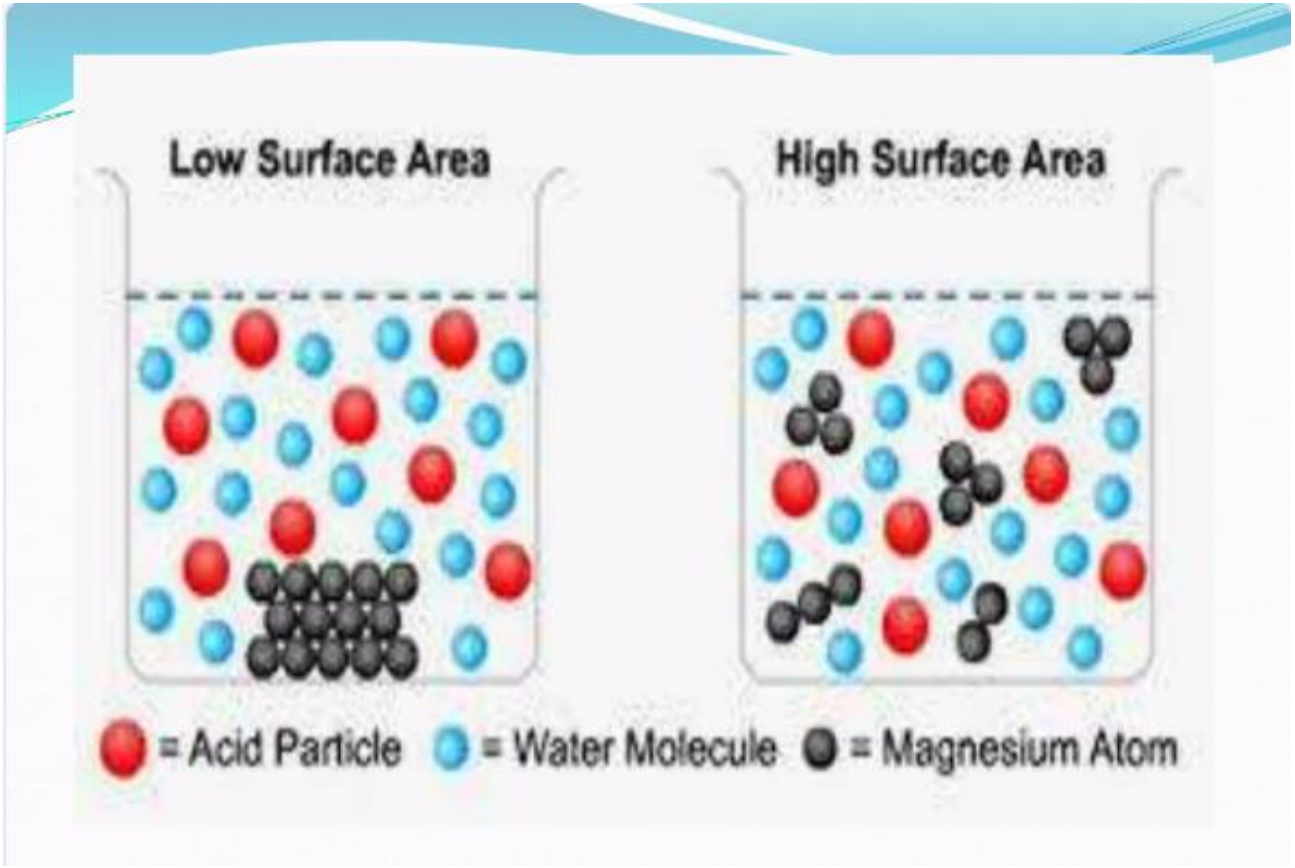
CHEMICAL KINETICS



Surface area

Larger surface area would have a larger space of collision between particles of a reaction.

CHEMICAL KINETICS

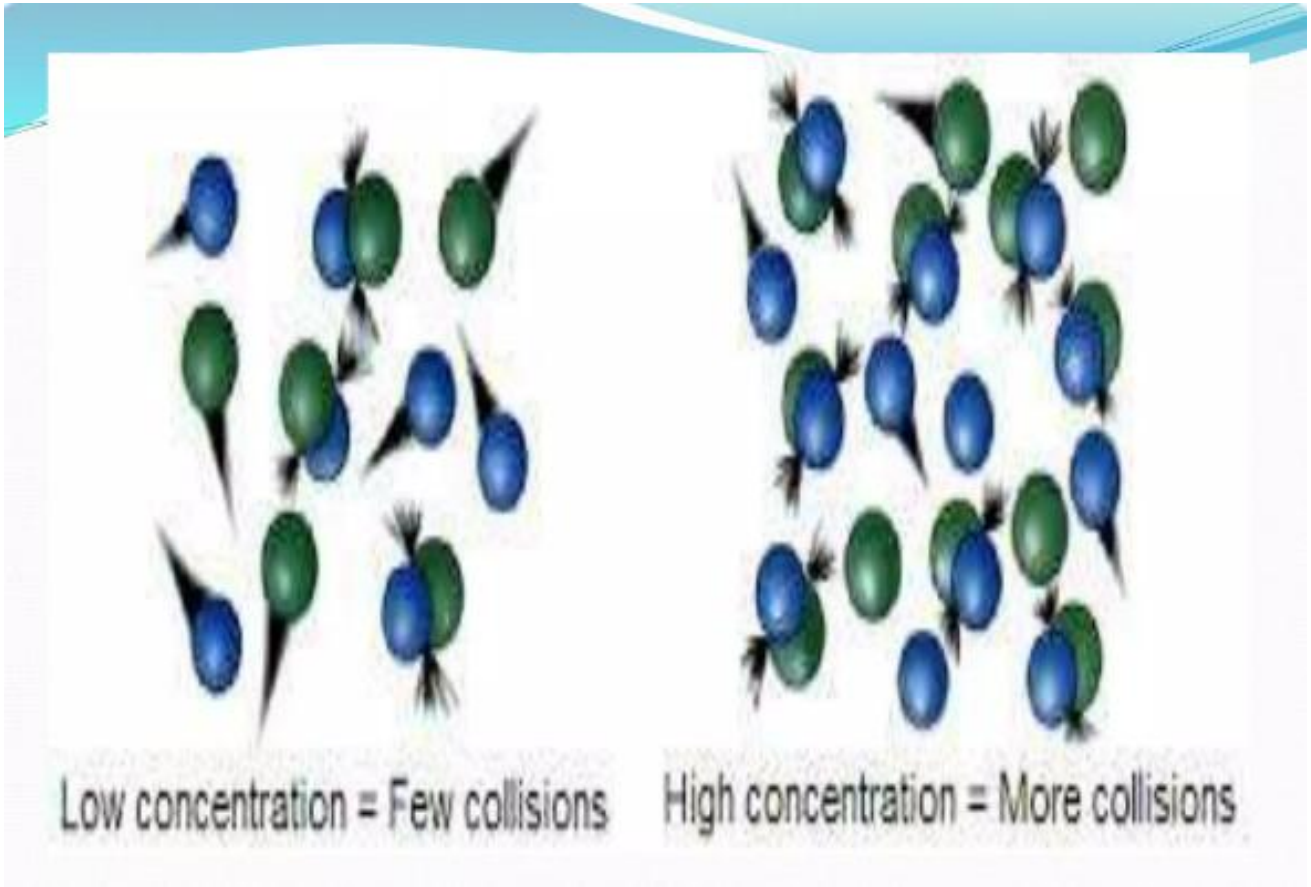


Concentration of reactants

If the concentration is increased:

* the reactant particles become more crowded
* there is a greater chance of the particles colliding;
* the rate of reaction increases

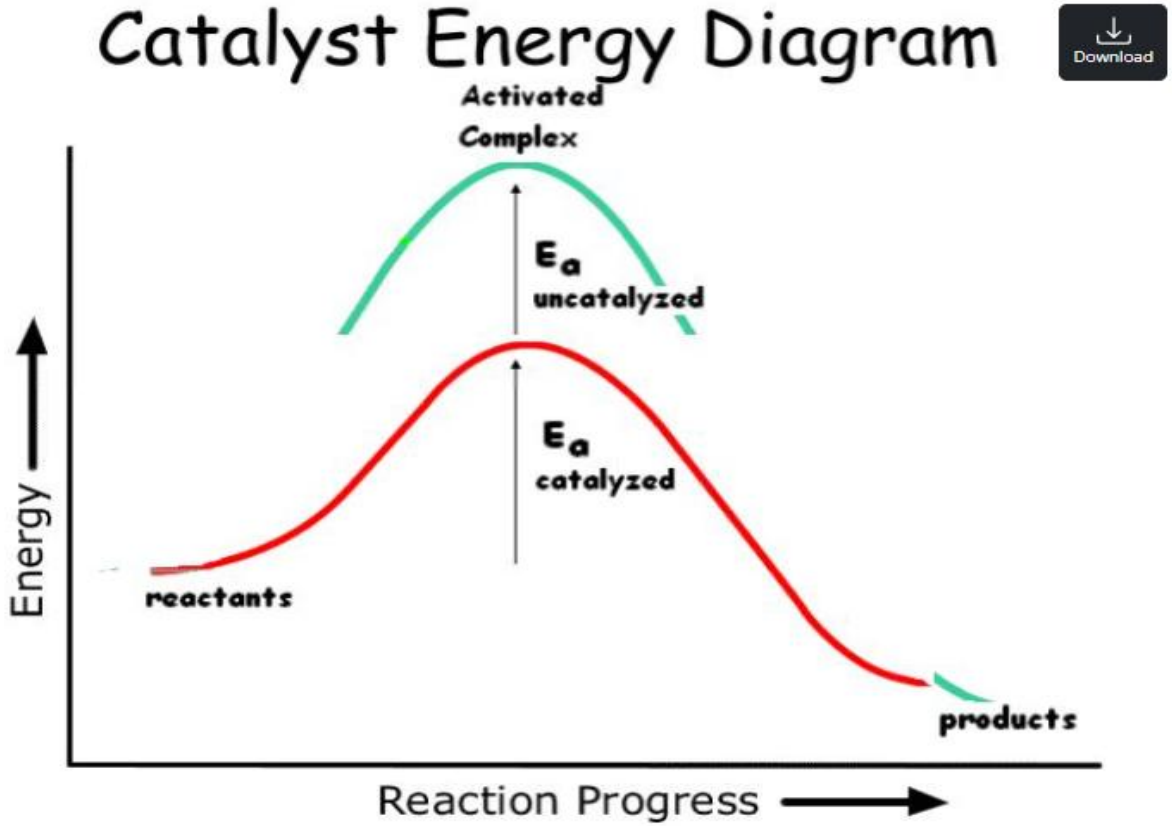
CHEMICAL KINETICS



Catalyst

Catalyst is a substance that makes a chemical reaction faster.

CHEMICAL KINETICS



Example

Download

Which would work faster: Aspirin in powder form or aspirin in tablet form? Explain why.

Answer: The aspirin would work faster if taken in powder form because the fact that it has been crushed increases surface area. This will make more frequent collisions and more frequent collisions with proper orientation – which will make the aspirin work faster.


Thank you…