# Reaction Rates and Equilibrium

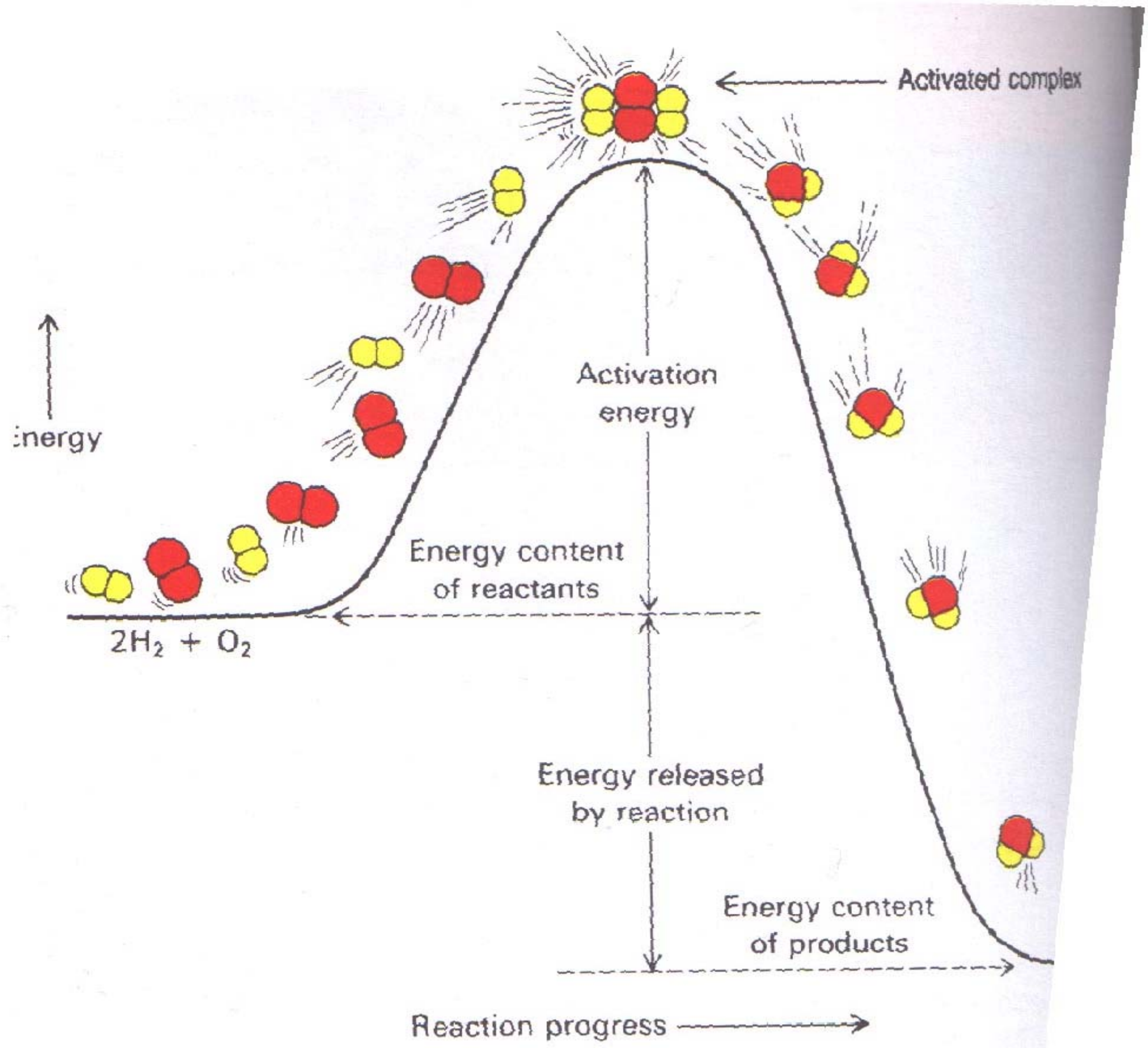
## Collision Theory

When one substance is mixed with another, the two substances do not react on a macroscopic basis, but react as their individual particles (atoms, molecules, or ions) come together. The factors that affect how these particles come together are the factors that influence the rate of a reaction.

In order for the reaction to occur, the particles involved must collide with each other, the more often the particles collide, the faster the reaction occurs. Not every collision results in a reaction. The colliding molecules must have enough energy to react and form an activated complex. This minimum amount of energy is called the activation energy.

The activated complex is the temporary arrangement of atoms as they change from reactants into products.

# Exothermic Reaction



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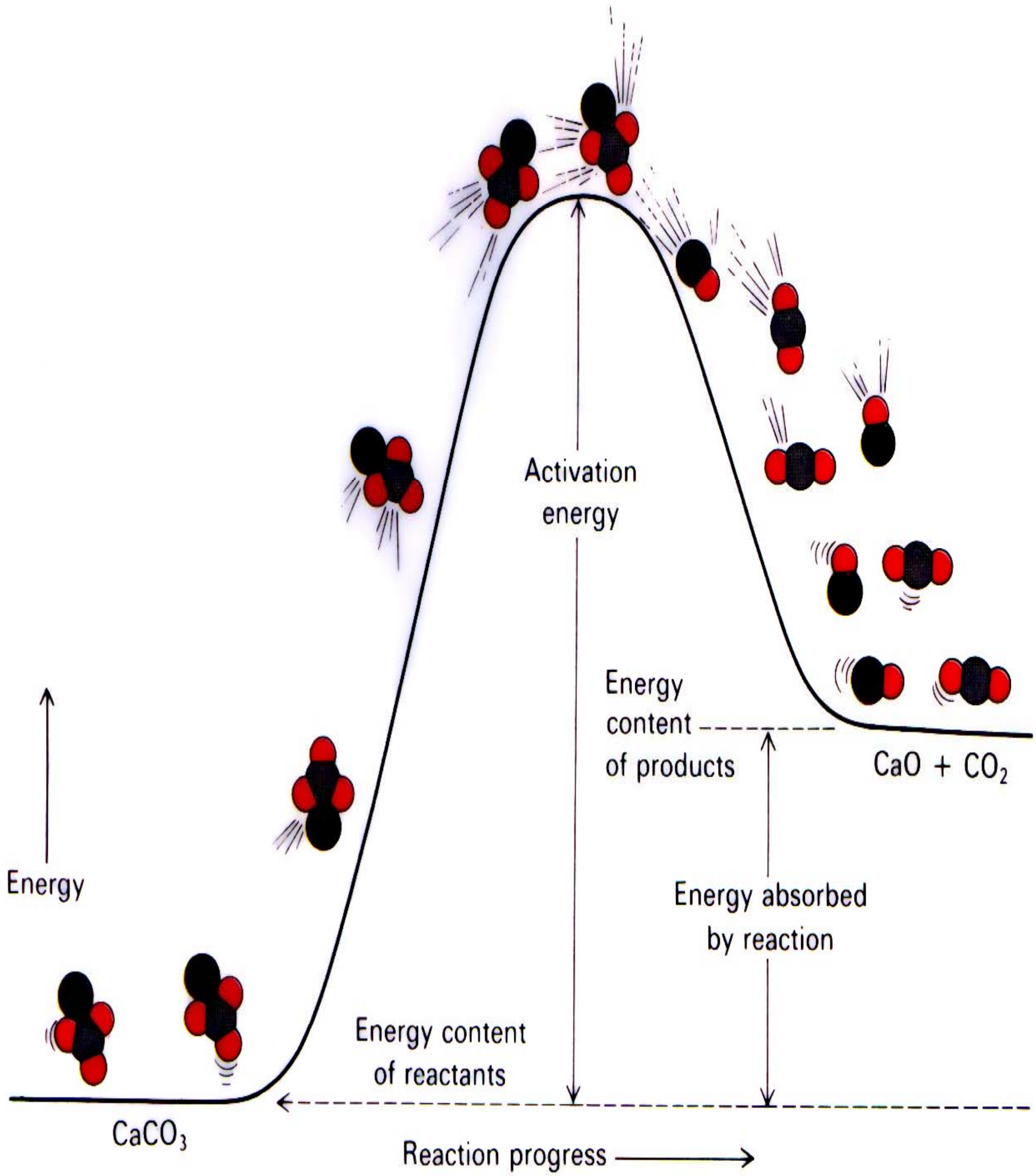


# Reaction Rate

## Effect of Temperature on Reaction Rate

Increasing the temperature increases the rate of a reaction. At higher temperatures, the particles have more energy, move faster and collide more frequently. More importantly, the higher energy of the particles means that more of the particles have sufficient energy (activation energy) to have a successful collision (form an activated complex).

In an exothermic reaction, the addition of a small amount of heat can often have a dramatic effect on the rate of reaction. This small addition of energy gives a few particles the activation energy, they react and release more energy, which is absorbed by more particles, which react and release more energy, …

## Effect of Concentration on Reaction Rate

Increasing the concentration of the reactants increases the rate of a reaction. When there are more particles per unit volume, they will collide more frequently, causing the rate to increase.

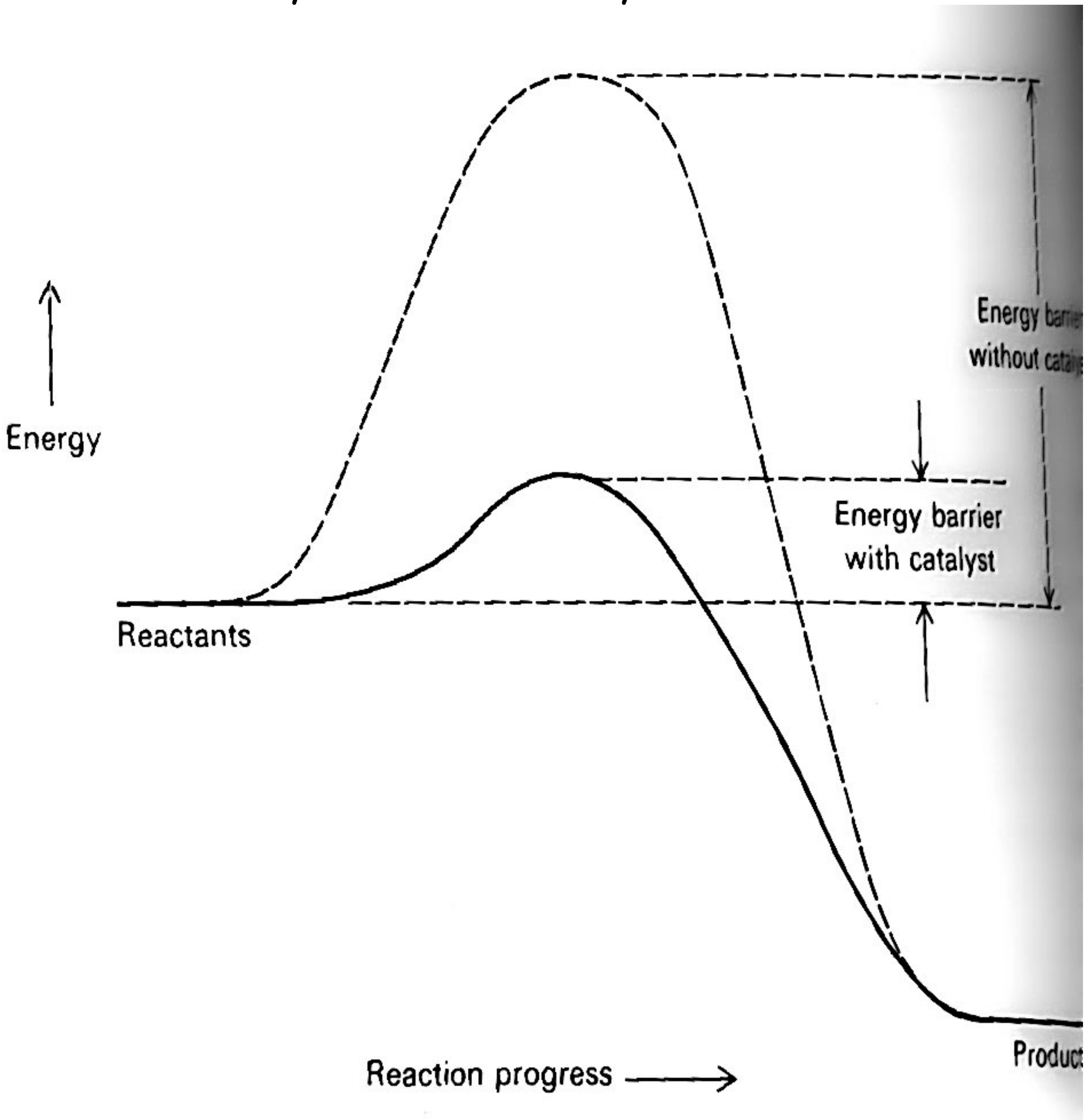
## Effect of Particle Size/Surface Area

Decreasing particle size/increasing surface area increases the rate of a reaction. When the surface area is increases, there is more contact between the reactants, the number of collisions increase, and therefore the rate of reaction also increases.

## Effect of Catalysts

A catalyst is a substance that increases the rate of a chemical reaction without being permanently consumed by the reaction. A catalyst provides a different pathway or mechanism for the reaction that has a lower activation energy. When the activation energy is lower, more of the particles will have sufficient energy to react, more of the collisions are successful therefore the reaction rate increases.

# Catalyzed vs. Un-catalyzed Reaction




A catalyst increases the rate of a reaction by lowering the activation energy.

## Effect of the Nature of the Reactant

The nature of the reactants involved will determine the kind of reaction that occurs. Reactions with bond rearrangements or electron transfer take longer than reactions without these changes. Ionic reactions (such as double displacement or neutralization) occur almost instantly.

In reactions with acids, stronger acids ($H_2SO_4$, $HNO_3$, $HClO_4$, HCl, HF, and HI) will occur faster than reactions with weak acids (all other acids).

In reactions with metals, more active metals (see activity series) will react faster than less active metals.

## Reaction Mechanism

Most reactions occur in a series of steps. Each step normally involves the collision of only two particles. There is little chance of three or more particles colliding with the proper position and sufficient energy to cause a reaction.

If a reaction consists of several steps such as the following:

A ö B

B ö C

C ö final product

One of the steps will be slower than all the others. This step is called the rate determining step. The other faster steps will not affect the rate of the reaction.

The series of steps that must occur for a reaction to go to completion is called the reaction mechanism.

# Le Châtelier's Principle

If a stress is applied to a system at equilibrium, the equilibrium will shift to relieve the stress.

Equilibrium = A state in which no net change takes place in a system

Dynamic Equilibrium = An equilibrium in which tow or more changes are taking place simultaneously, but at the same rate.

In reaction equilibrium, both the forward and reverse reactions are taking place simultaneously, at the same rate, so that no net change occurs.

Concentration

- Increase [reactant] = shifts to use up the added reactants and produce more products
  - Shifts right
- Increase [product] = shifts to use up added product and product more reactants
  - Shifts left
- Decrease [reactant] = shifts to produce more reactants
  - Shifts left
- Decrease [product] = shifts to produce more products
  - Shifts right

Temperature

- Increase = favours the endothermic direction.
  - The reaction shifts in the direction that uses up the added energy.
- Decreasing = favours the exothermic direction.
  - The reaction shifts in the direction that produces energy.

Pressure/Volume

- Increasing pressure/Decreasing volume favours fewer gas molecules.
  - The reaction shifts to relieve the pressure.
- Decreasing pressure/Increasing volume favours more gas molecules.
  - The reaction shifts to restore the pressure.