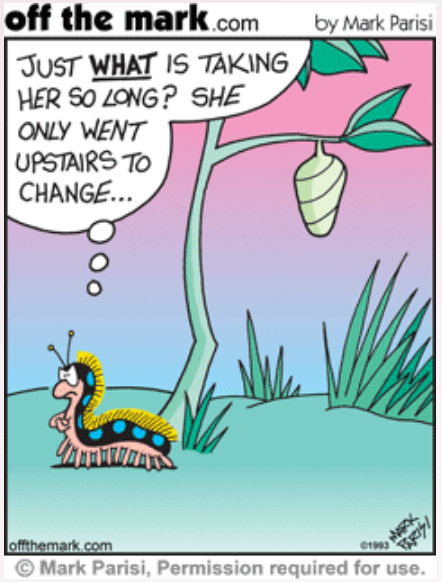
RATE THEORIES

RATE THEORIES

1. Collision Theory

2. Transition State Theory



3. Catalysts

RATE THEORIES

COLLISION THEORY:

The rate of rxn is proportional to the number of effective/successful collisions per second between reactant molecules.

What factors determine whether reactants could form a molecule?

(e.g. is bumping into each other enough?)

RATE THEORIES

COLLISION THEORY:

Not all collisions are effective.

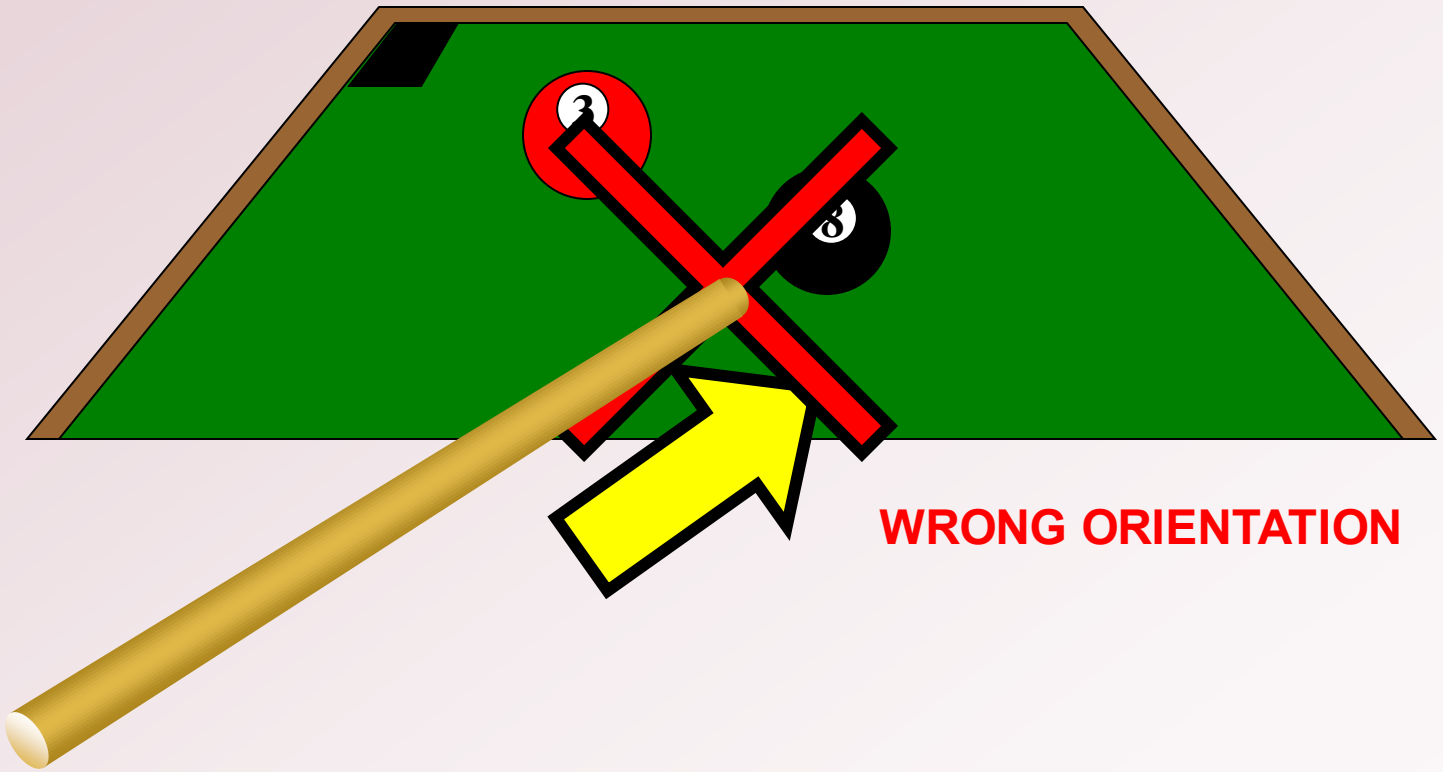
Effective collision: A collision that actually results in the production of product molecules

In a game of pool, what are the two conditions that are required for an effective collision?

RATE THEORIES

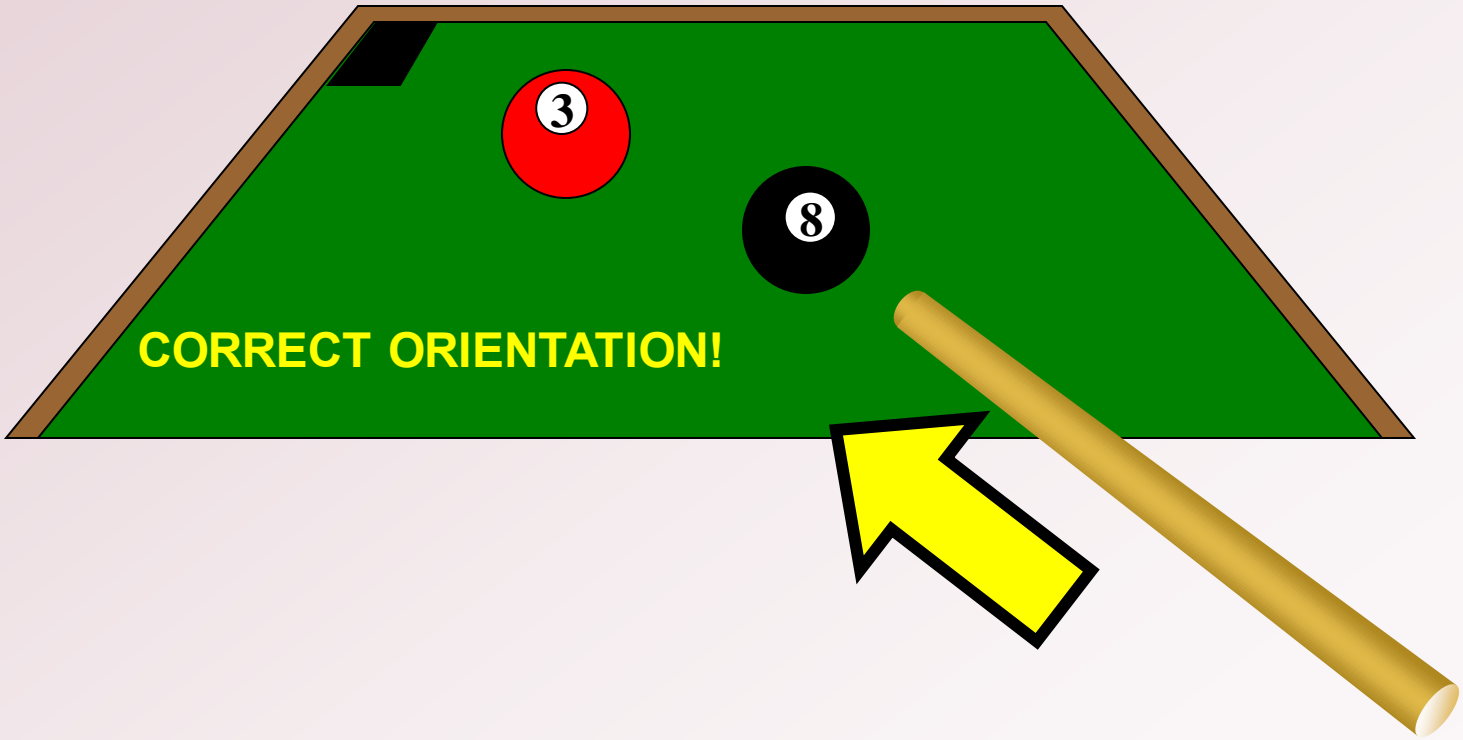
COLLISION THEORY:

Not all collisions are effective



RATE THEORIES

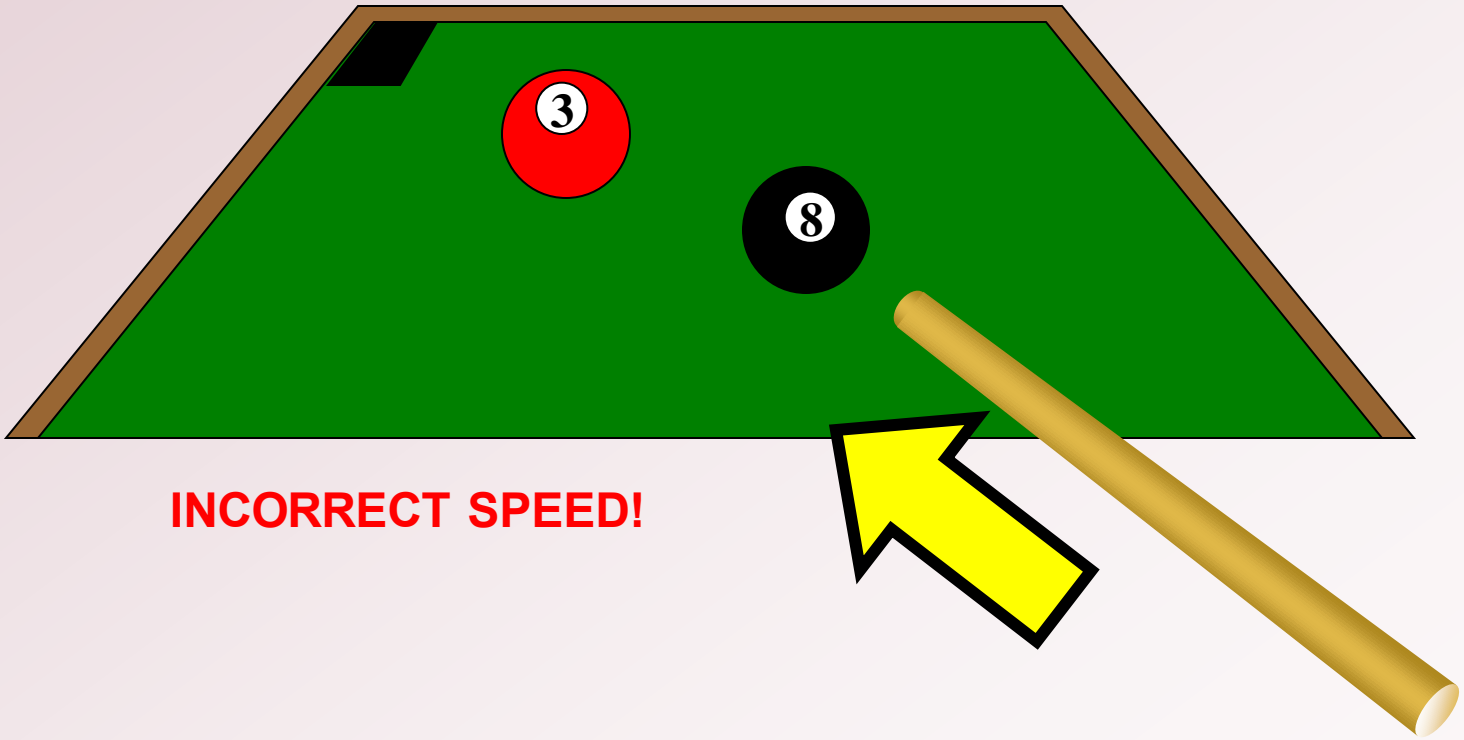
COLLISION THEORY:



RATE THEORIES

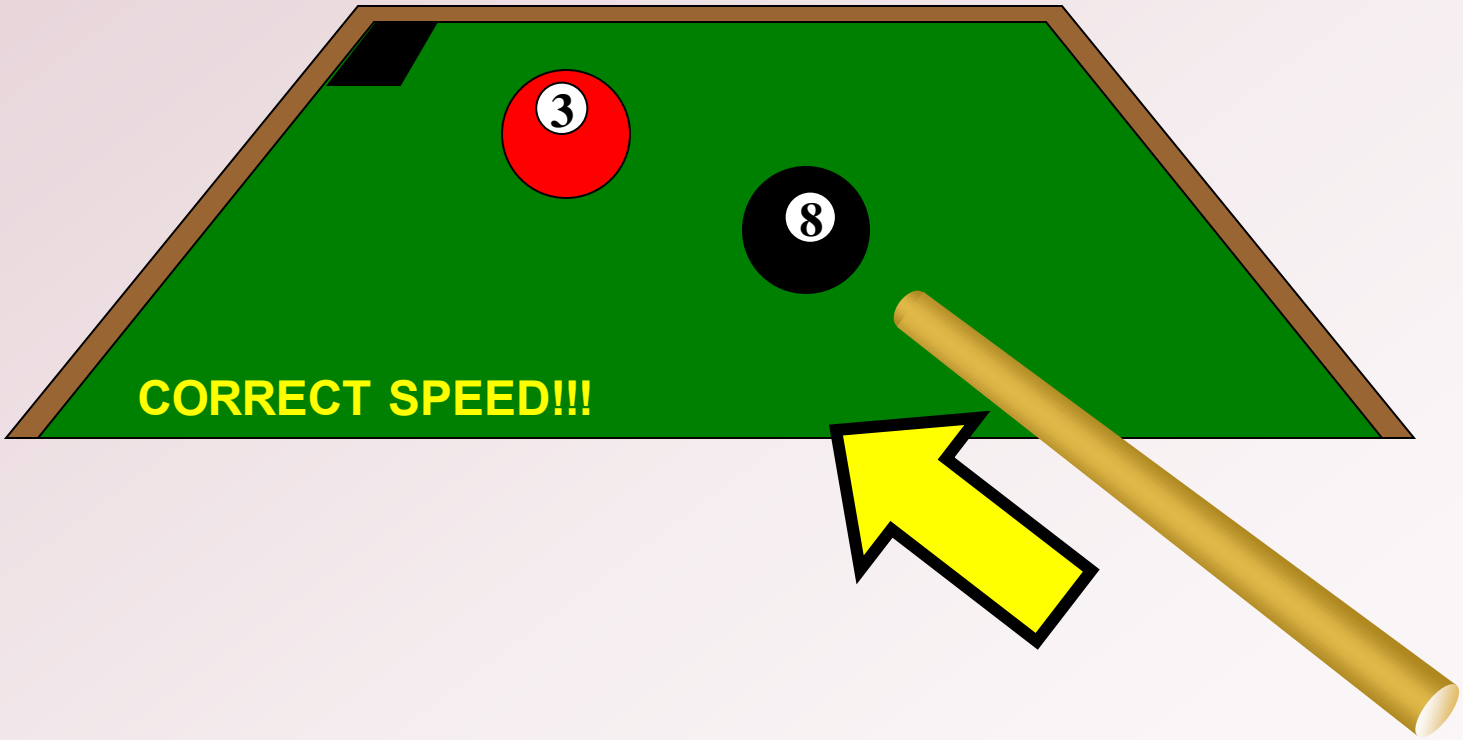
COLLISION THEORY:

Not all collisions are effective



RATE THEORIES

COLLISION THEORY:



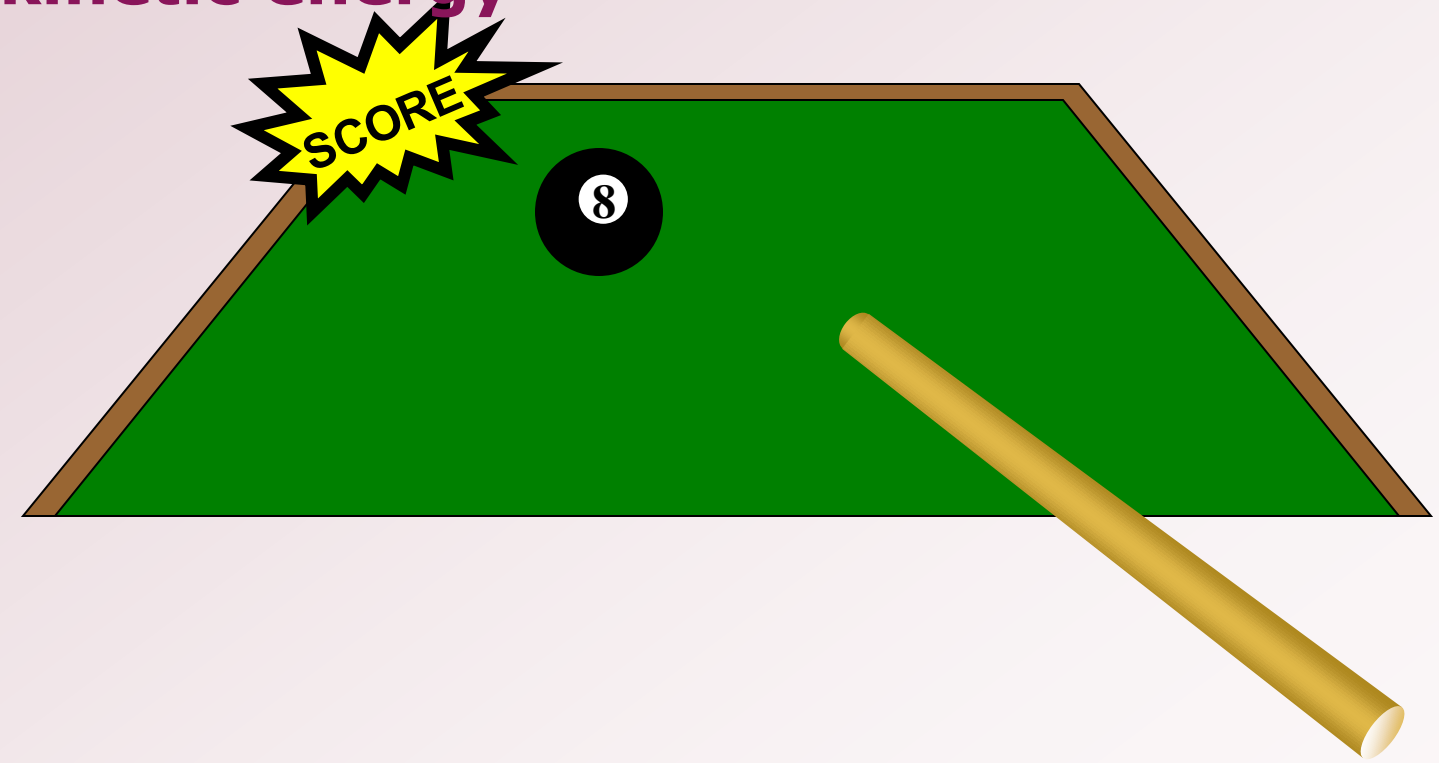
RATE THEORIES

COLLISION THEORY:

For a collision to be effective, the molecules must collide with the proper:

1)orientation

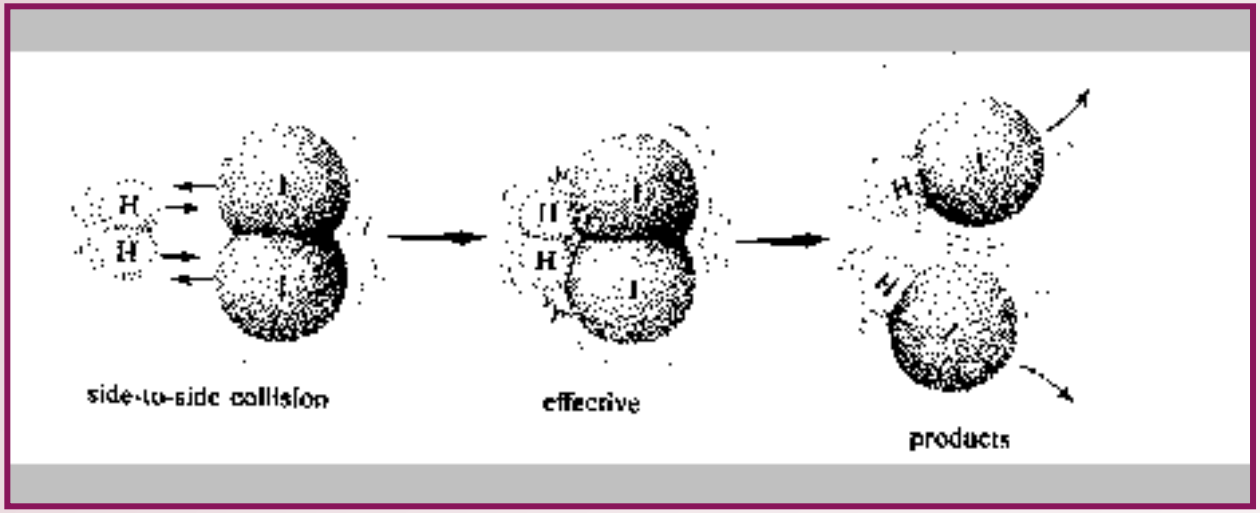
2)kinetic energy

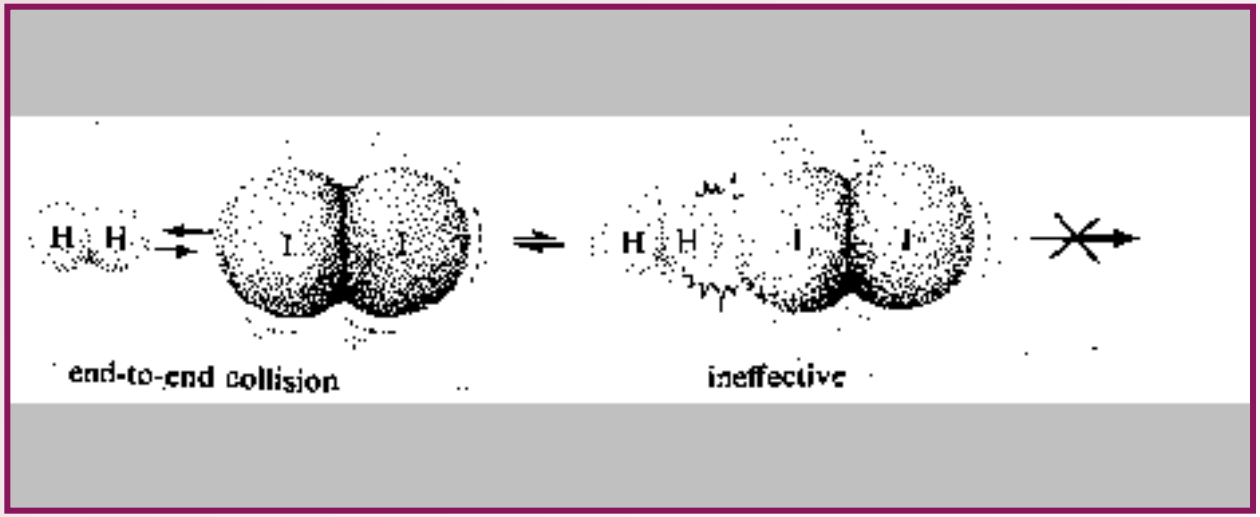


RATE THEORIES

COLLISION THEORY:

- **Orientation**: $H_2 + I_2 \rightarrow 2\ HI$

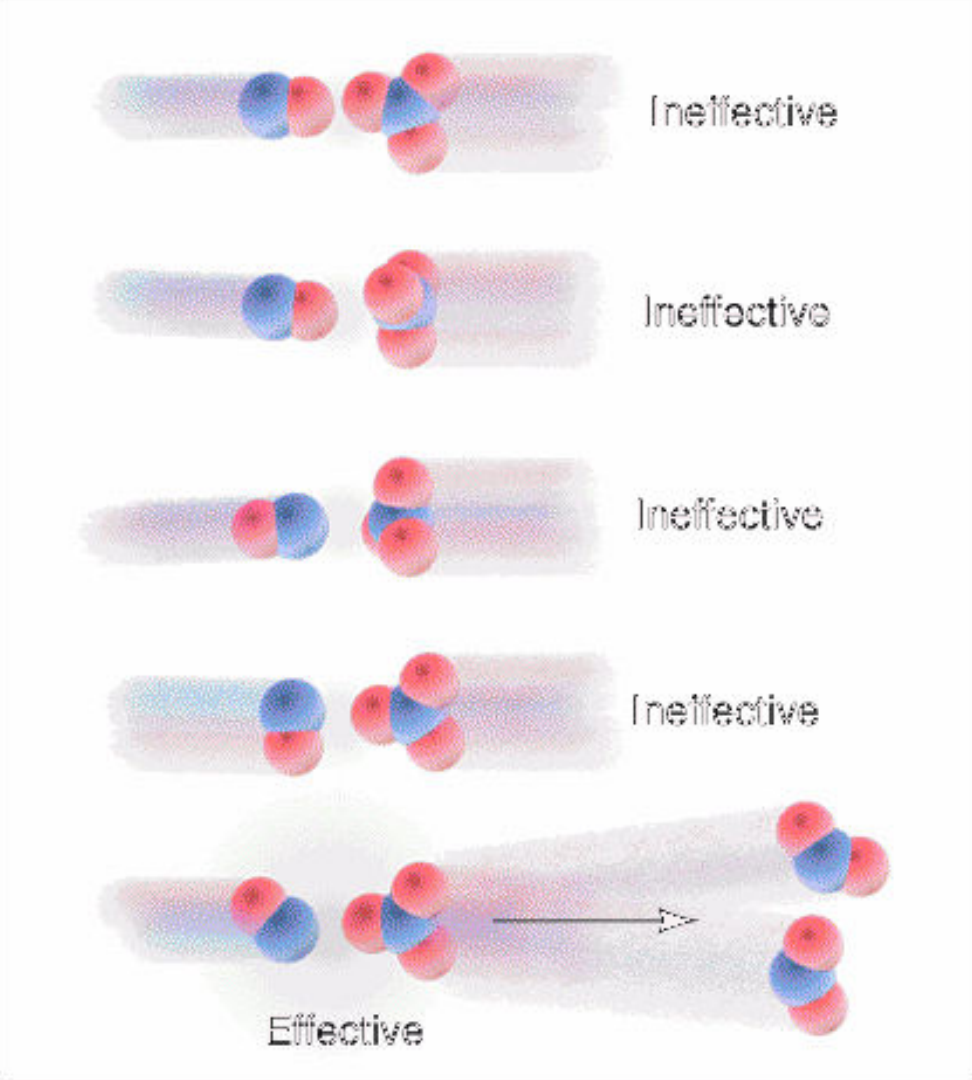




RATE THEORIES

COLLISION THEORY:

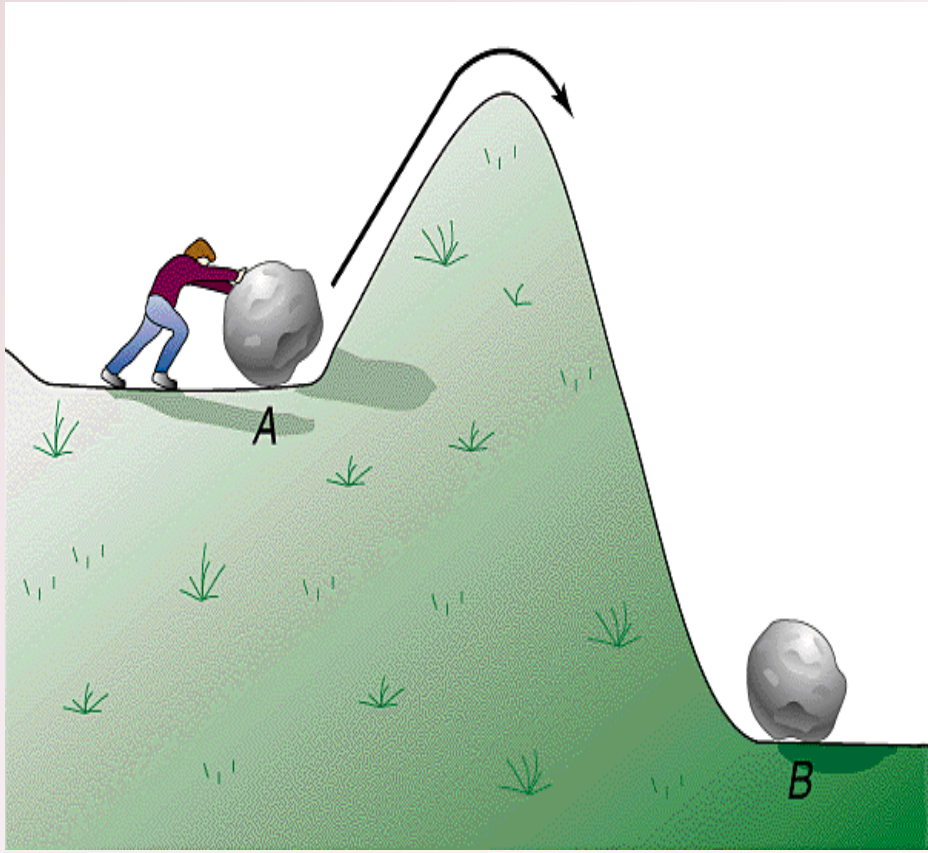
- **Orientation**: $NO + NO_3 \rightarrow 2\ NO_2$



RATE THEORIES

COLLISION THEORY:

- **Kinetic energy**: A minimum kinetic energy, called activation energy (E_a), is required between reactants for a reaction to proceed.
  - E_a is unique to each reaction

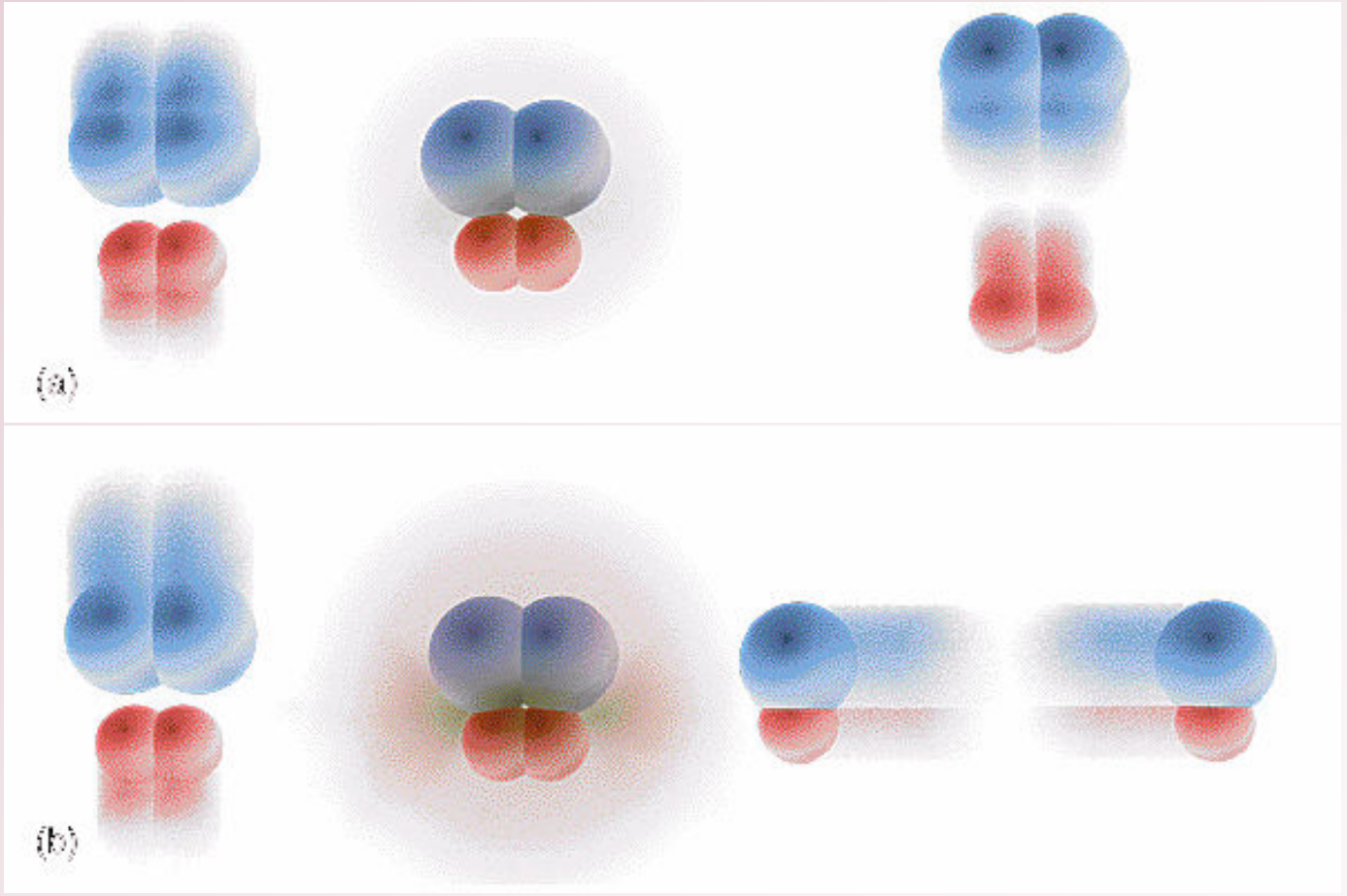


Higher temperatures result in a higher percentage of reactants with enough energy to react.

RATE THEORIES

COLLISION THEORY:

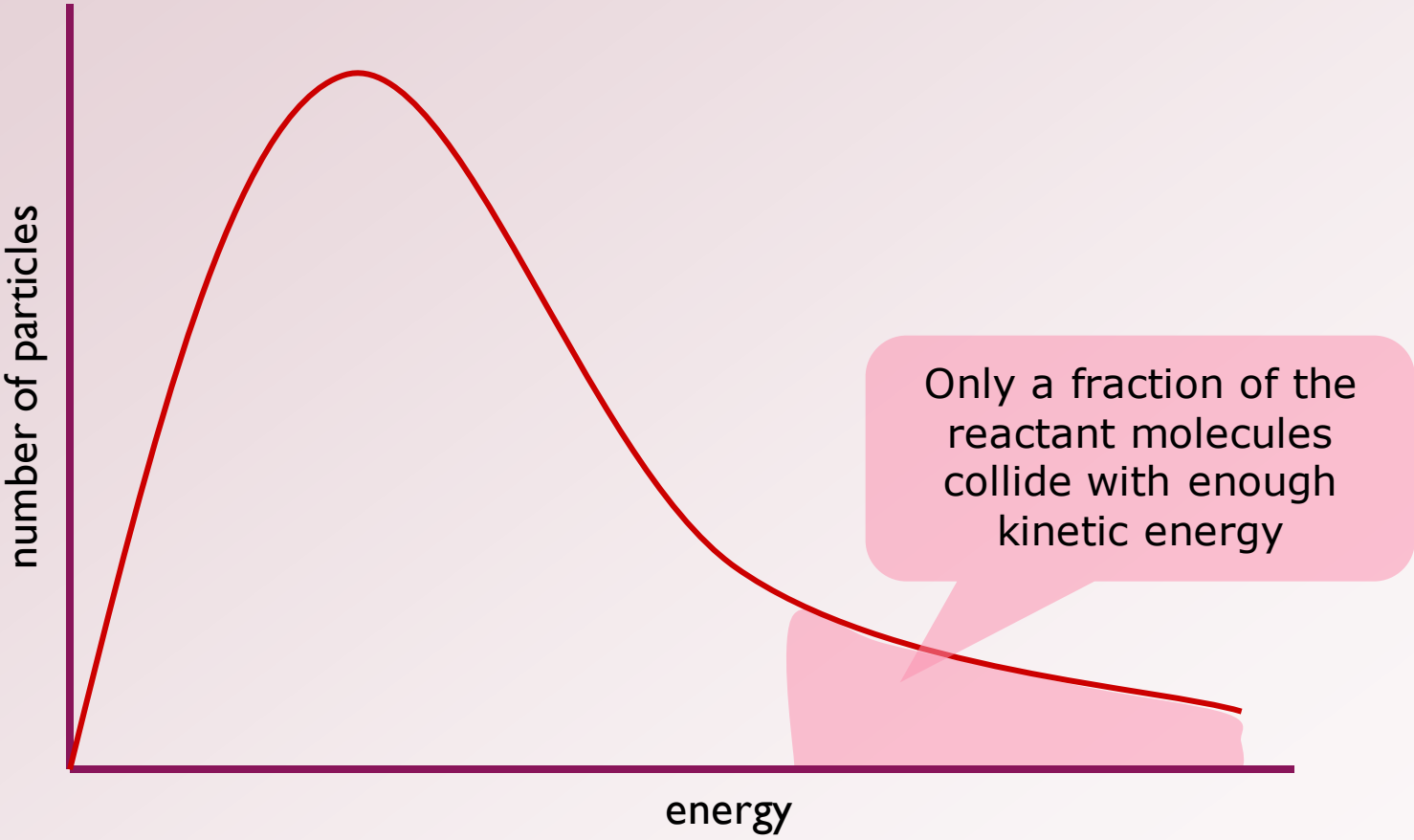
- **Kinetic energy**:



RATE THEORIES

COLLISION THEORY:

- **Kinetic energy**:



RATE THEORIES

COLLISION THEORY:

Factors affecting effective collisions:

1. molecule orientation
2. molecule energy

Collision Theory Animation

Collision Theory Applet

RATE THEORIES

COLLISION THEORY:

To ↑ rate of reaction, the frequency of collisions or the fraction of effective collisions must be increased

Factors that Increase Frequency of Collisions:

-Concentration

-Surface Area

-Temperature

We have discussed these factors before

Factors Increase Fraction of Effective Collisions:

-Nature of Reactant

-Catalyst

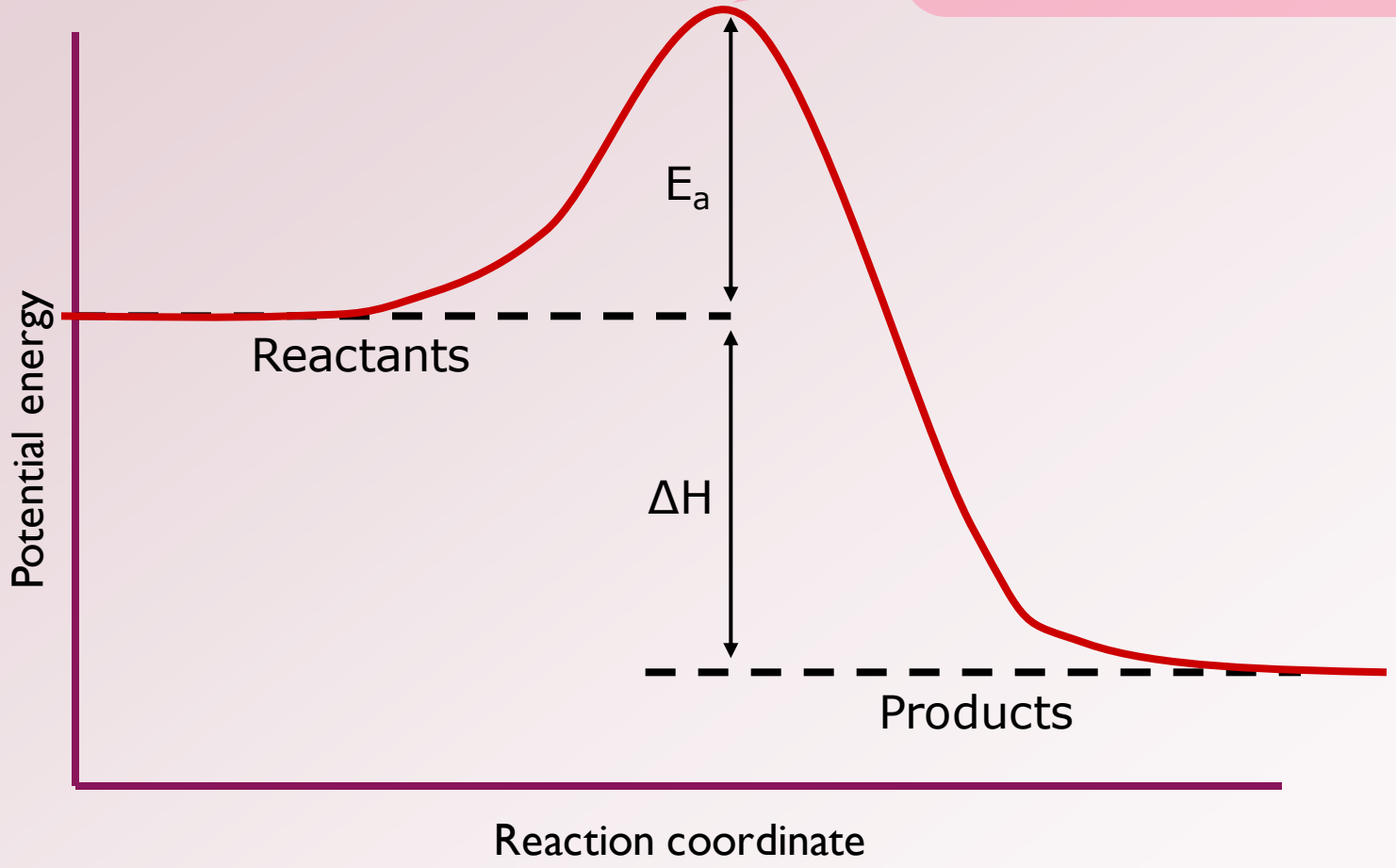
-Temperature

RATE THEORIES

TRANSITION STATE THEORY:

Potential energy diagrams

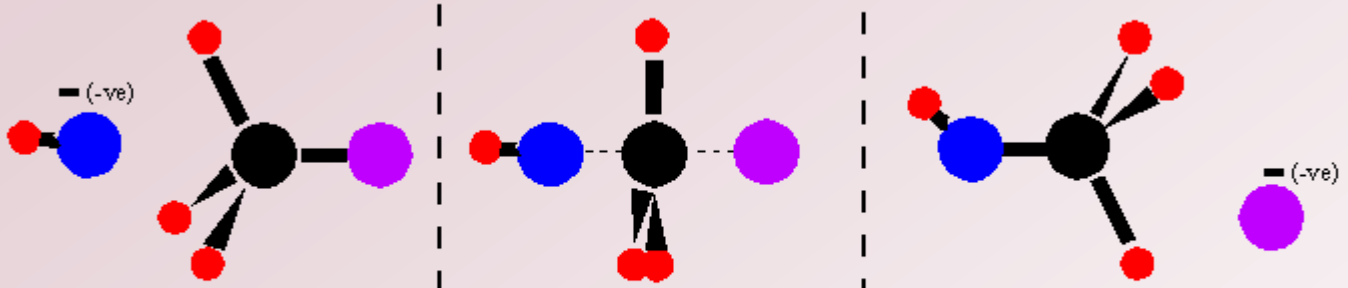
The transition state complex (or activated complex) is formed at this peak

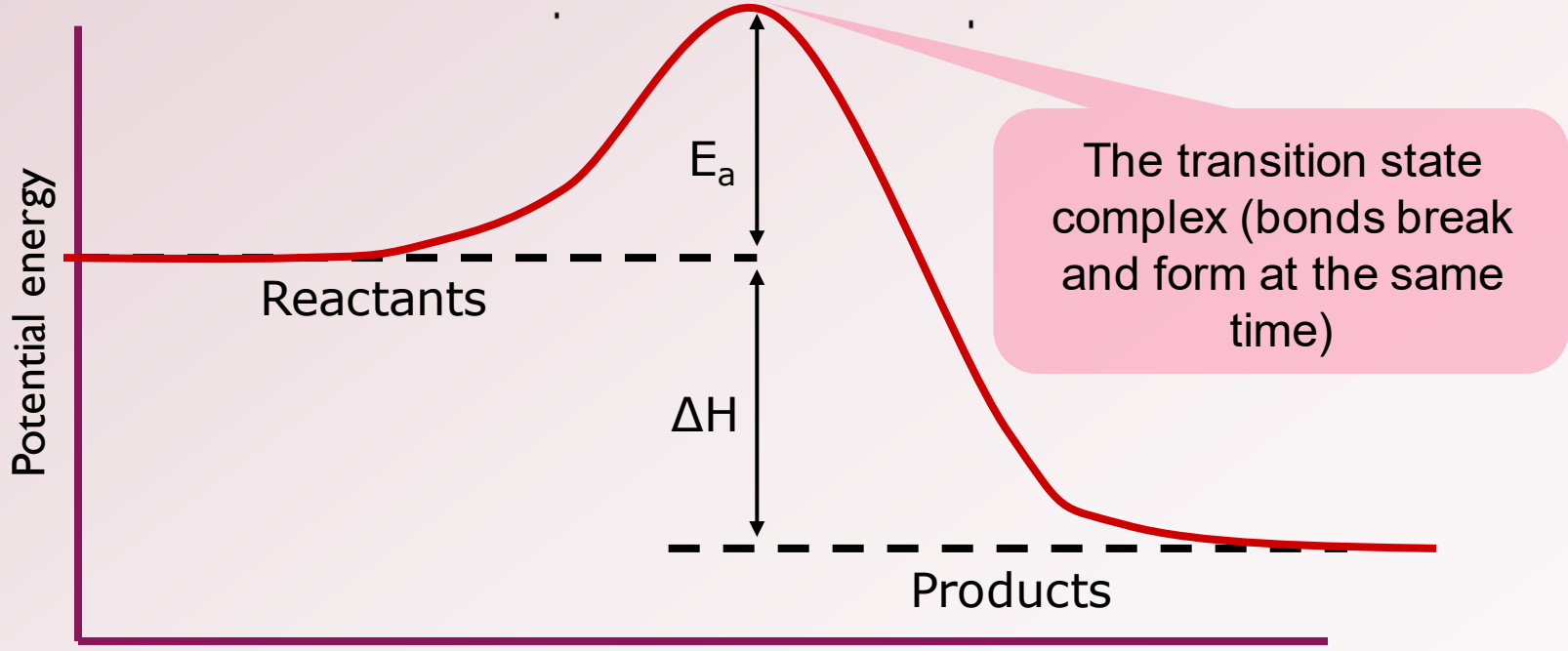


RATE THEORIES

TRANSITION STATE THEORY:

Potential energy diagrams



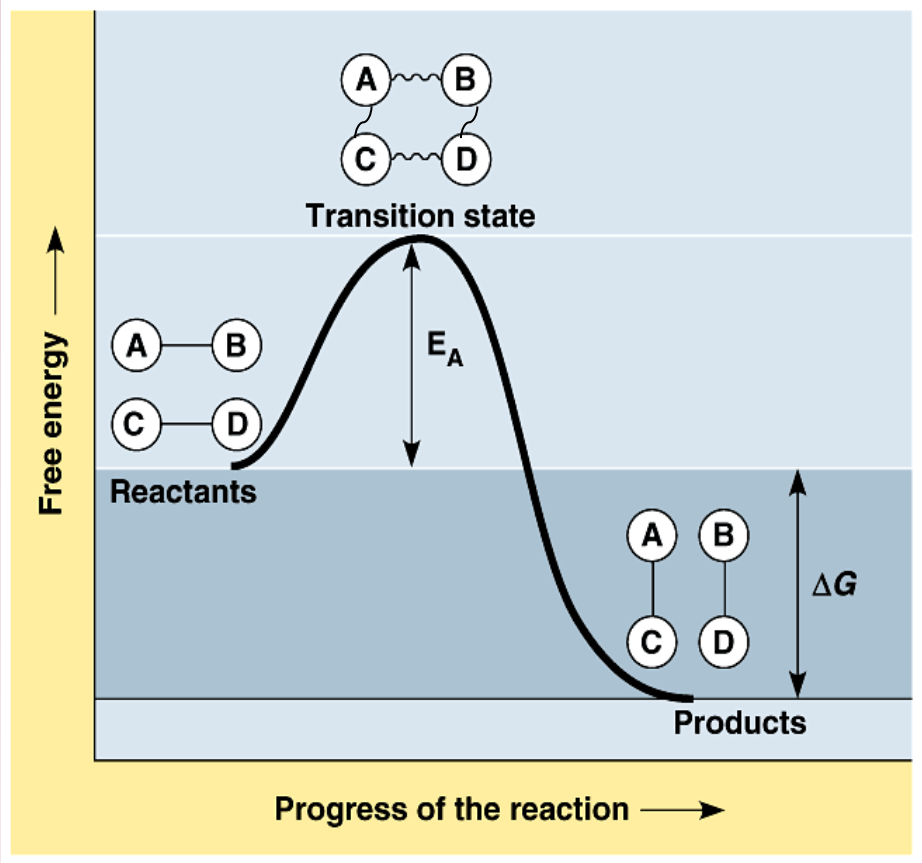


The transition state complex (bonds break and form at the same time)

RATE THEORIES

TRANSITION STATE THEORY:

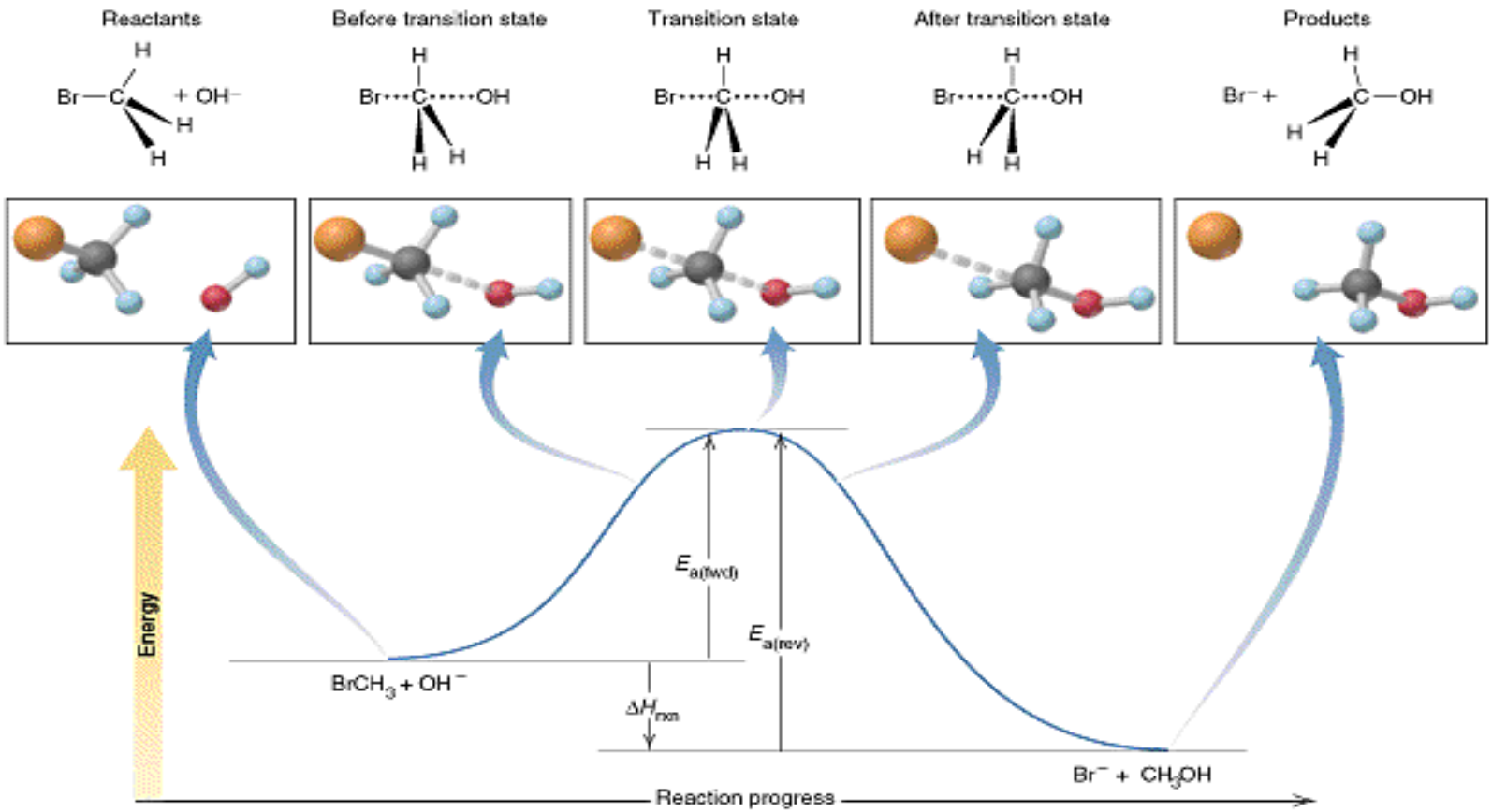
The transition state complex (bonds break and form at the same time)



RATE THEORIES

TRANSITION STATE THEORY:

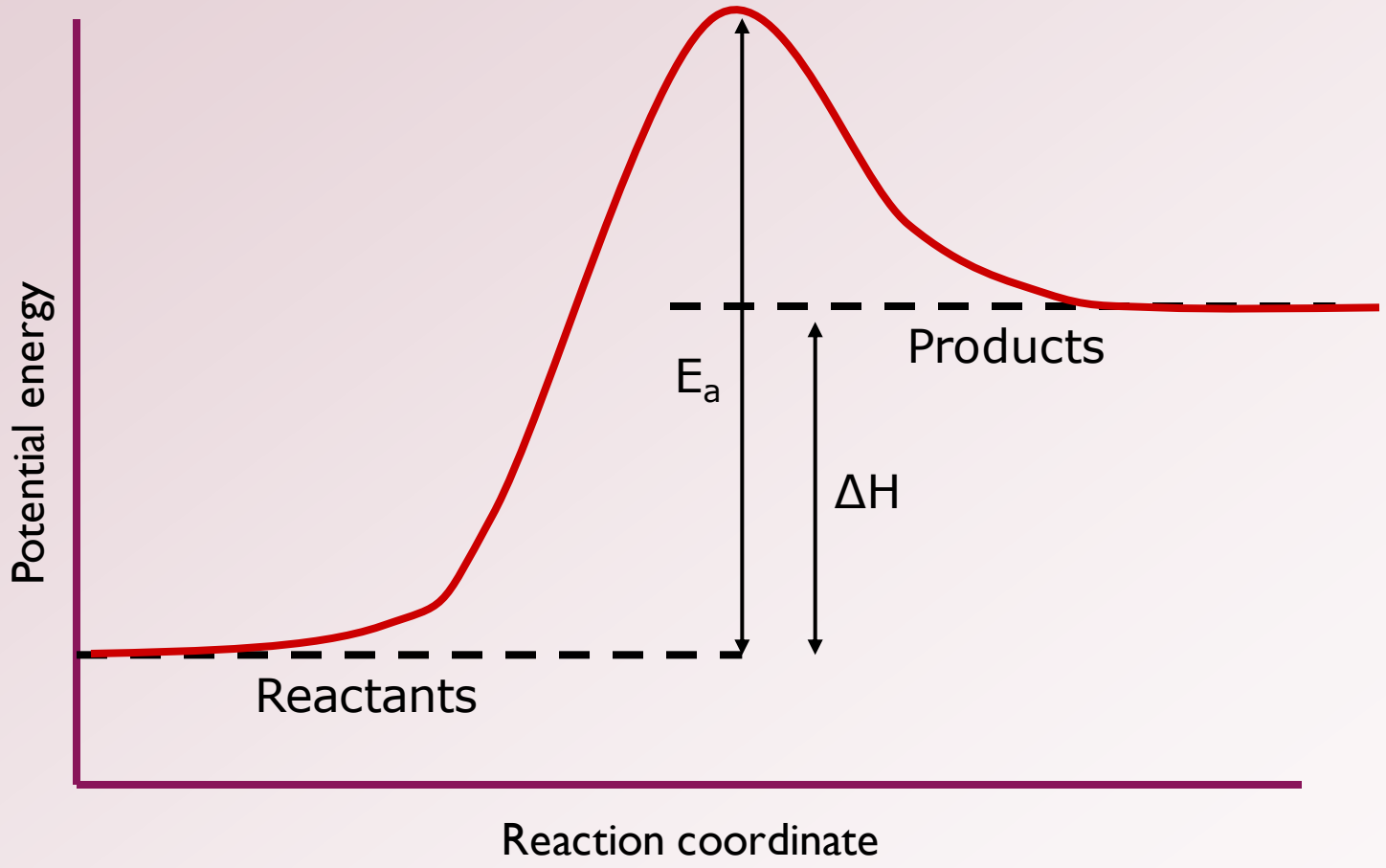
Potential energy diagrams



RATE THEORIES

TRANSITION STATE THEORY:

Draw the potential energy diagram for the reverse reaction



RATE THEORIES

TRANSITION STATE THEORY:

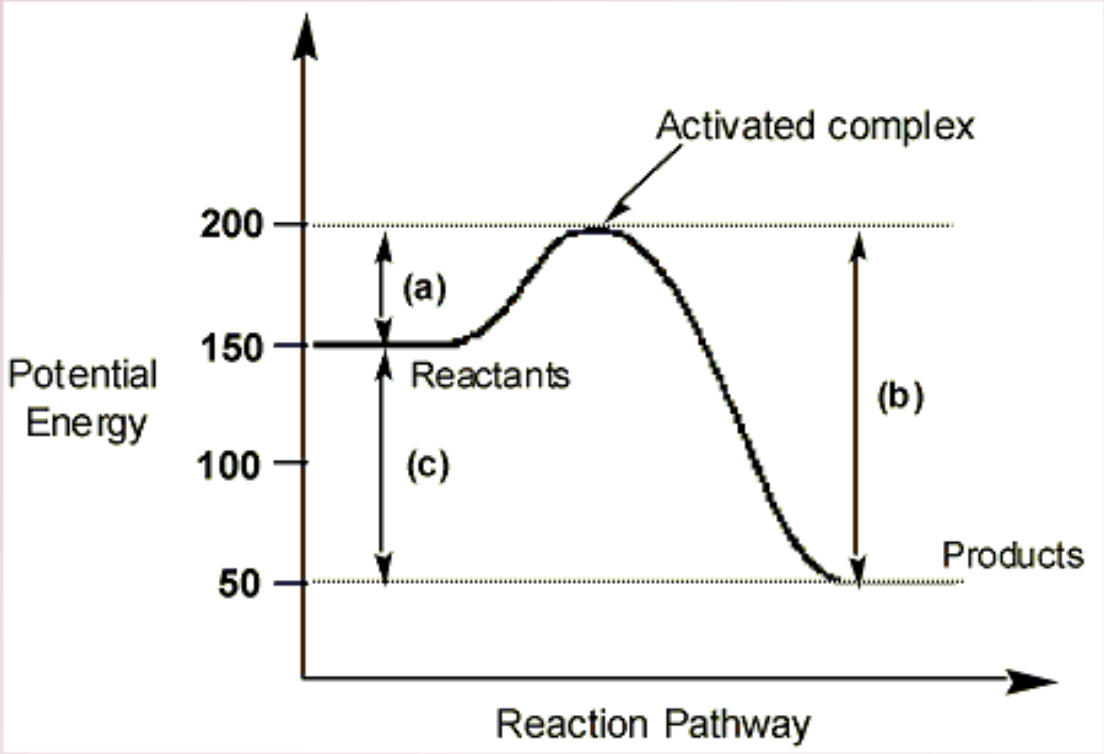
Examine the E_a for both reactions. What does that suggest?

E_a is different between the forward and reverse directions of a given reaction.

Generally, endothermic reactions are slower than exothermic reactions due to a higher E_a.

RATE THEORIES

TRANSITION STATE THEORY:



1. Identify E_a, ΔH and transition state.
2. What are the values of E_a and ΔH?
3. Endothermic or exothermic?
4. What are E_a and ΔH for the reverse rxn?

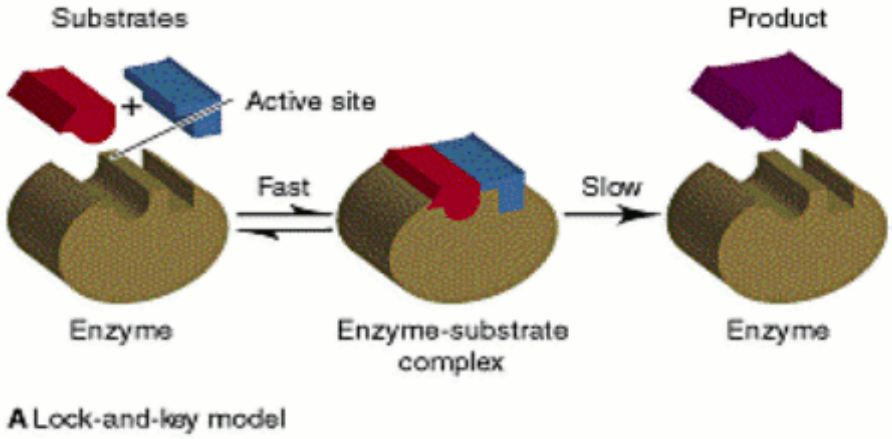
RATE THEORIES

CATALYST:

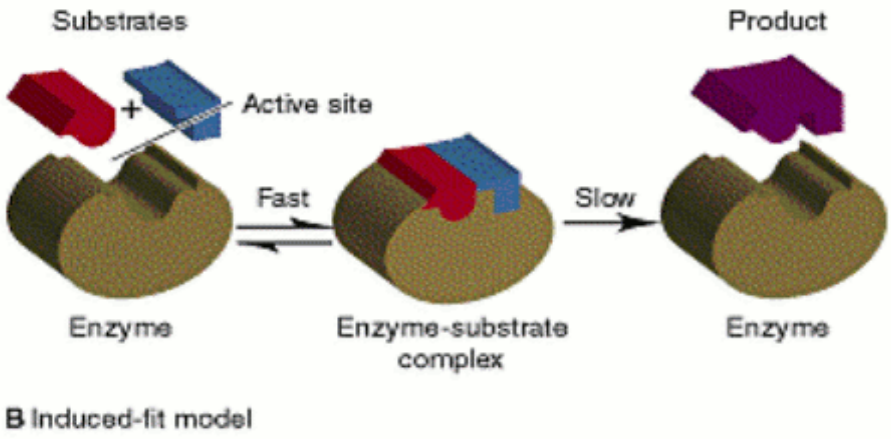
catalyst - a substance that increases the rate of a chemical reaction without being consumed

homogeneous catalyst - exist in the same phase as the reactants

heterogeneous catalyst - exist in a different phase as the reactants



A Lock-and-key model

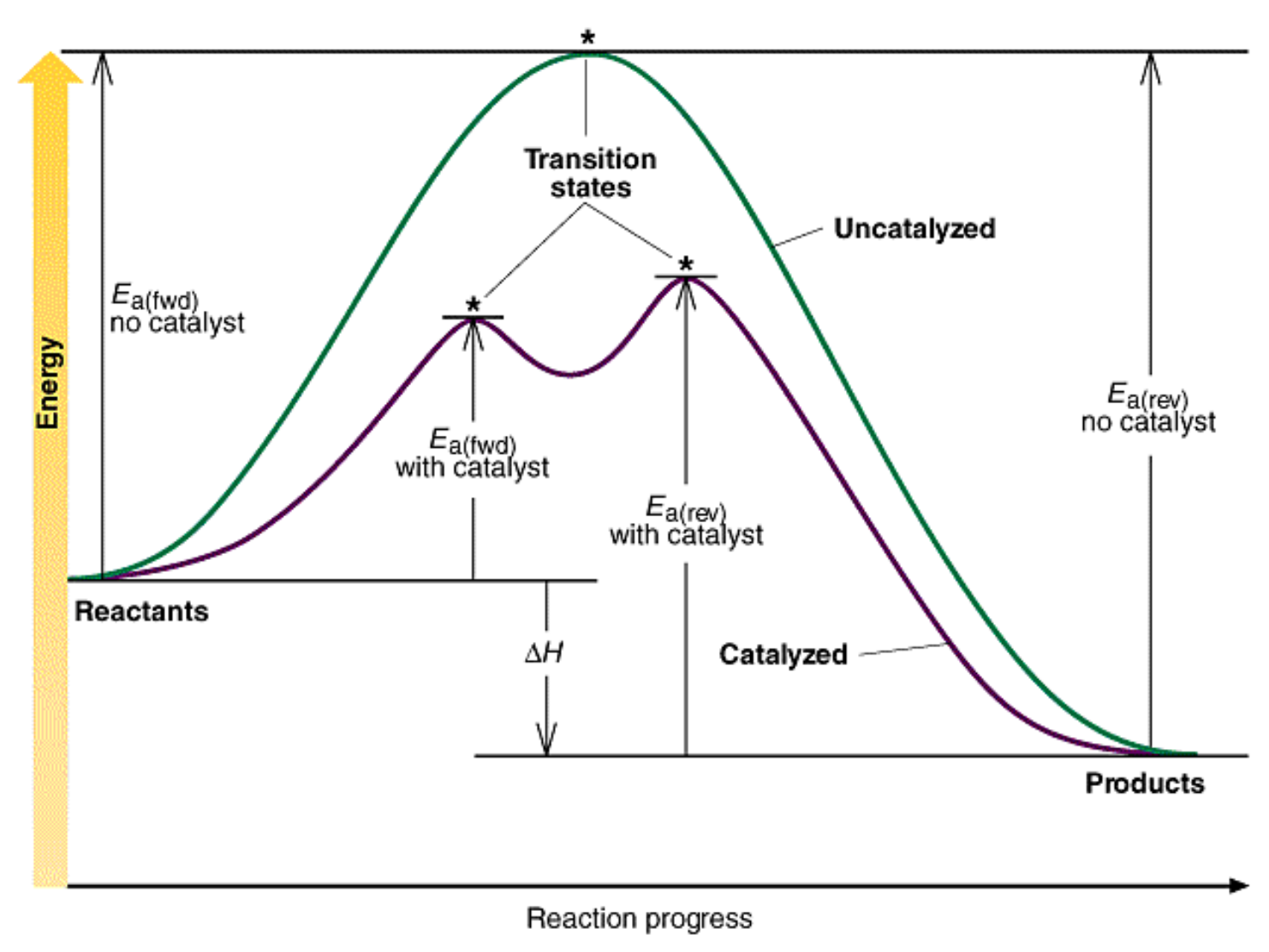


B Induced-fit model

RATE THEORIES

CATALYST:

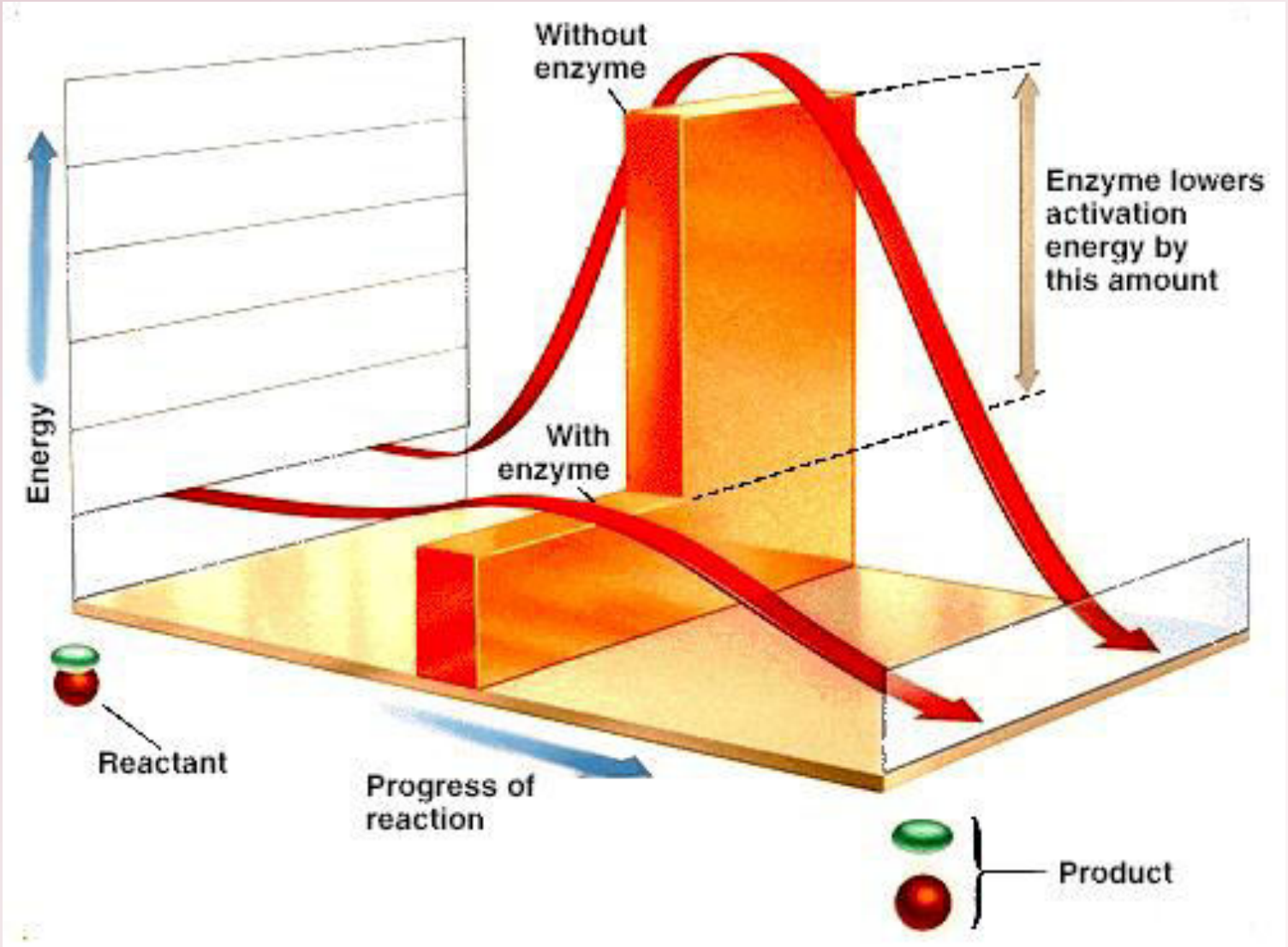
Catalysts lower the E_a of a reaction



RATE THEORIES

CATALYST:

Catalysts lower the E_a of a reaction

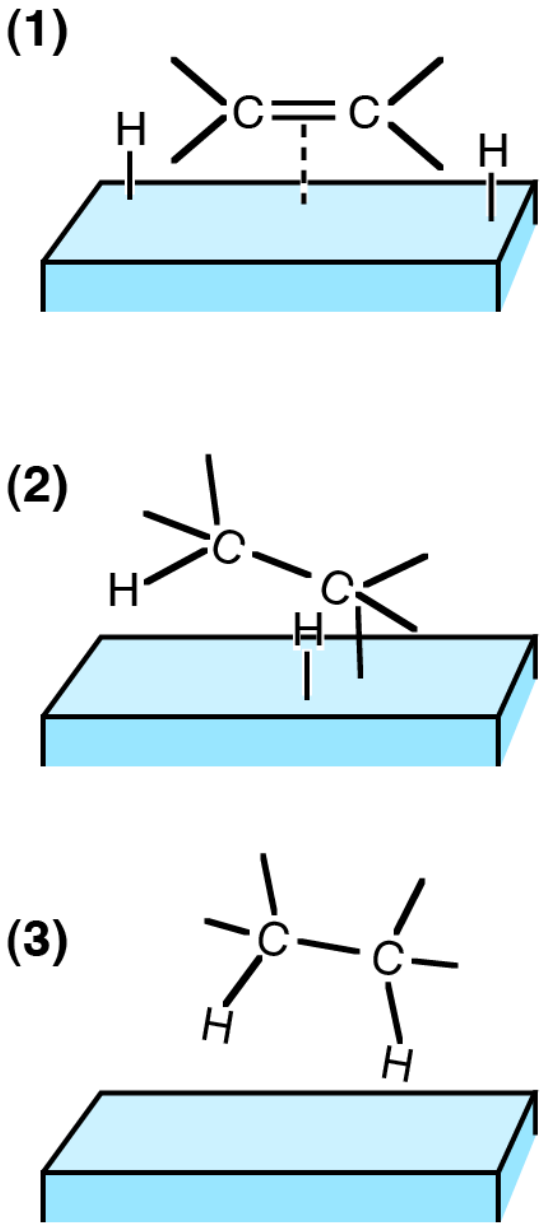


RATE THEORIES

CATALYST:

Catalysts:

- bend or stretch bonds to make them easier to break / react
- reduce E_A (make transition state easier)
- bring two reactants close together
- provide a microenvironment for reactions



RATE THEORIES

CATALYST:

Inhibitors - bind with the reactant or the catalyst to prevent the reaction from occurring and reducing reaction rate