

# Chapter 16 - Kinetics

# Warm Up!

- You are trying to boil water to make some pasta. What are some ways you can make the water boil faster?
- Iron in nails react with oxygen to form rust. Octane reacts with oxygen to create energy as fuel. Which reaction happens at a faster rate?

# Today's Agenda

- QOTD: What makes some reactions happen faster than others?
- Rate of reactions
- Energy diagrams to illustrate reaction profiles and rates
- Factors that affect rate
- Homework: Problem Set 1 and 2

# Reaction Rates

- How does your speedometer measure how fast your car is driving? What are the units?

$$\text{Rate} = \frac{\Delta \text{ distance or quantity}}{\Delta \text{ time}}$$

# Reaction Rates

- Chemists measure the change in concentration (mol/L) over a certain time interval.
- Usually some form of M/s (M = molar)

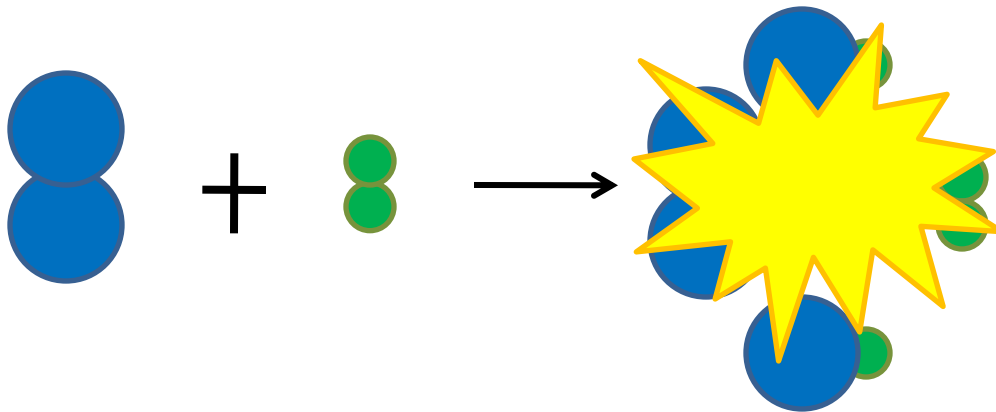
For  $A \rightarrow B$

[A] notates the concentration of A so,

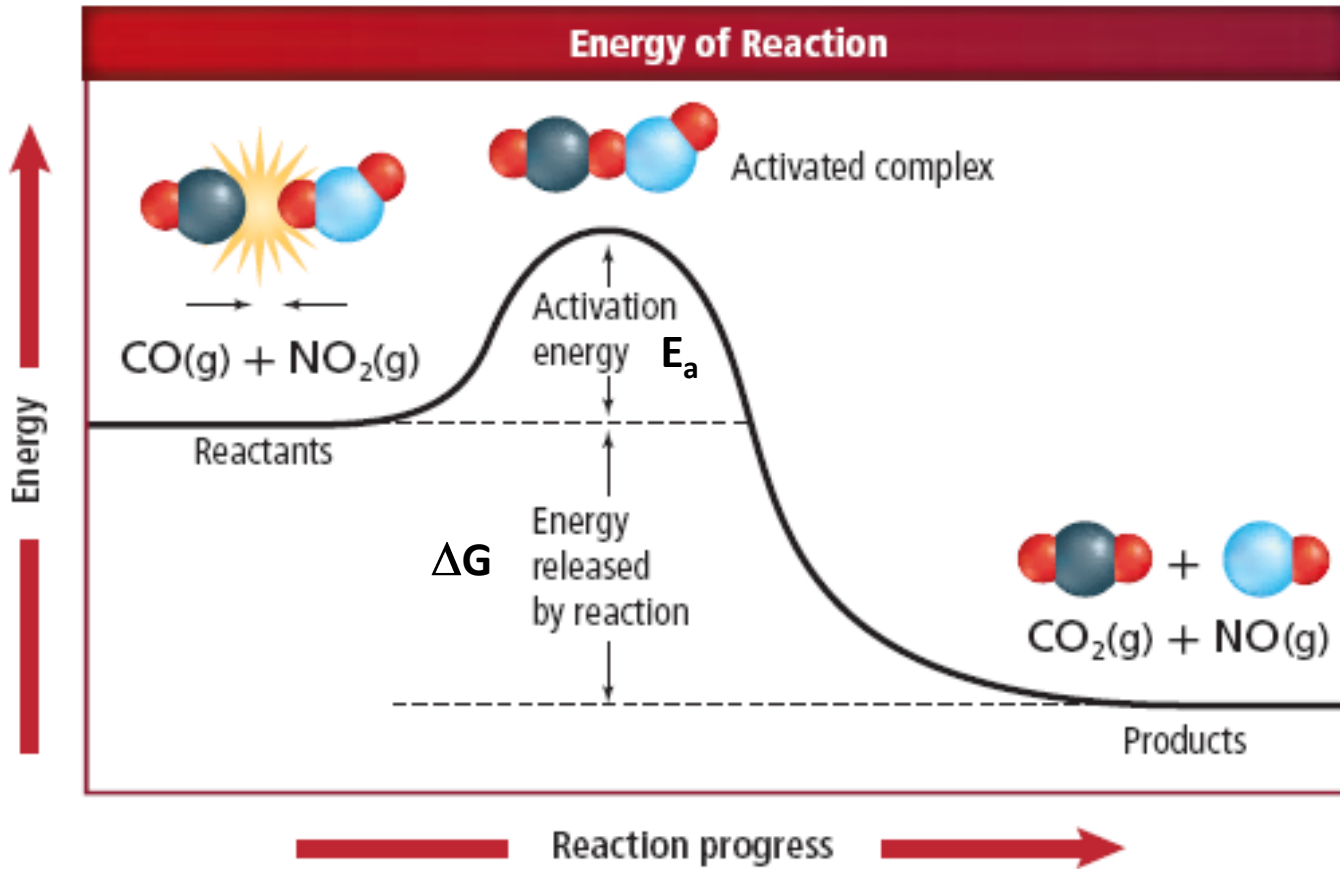
$$\text{Decay Rate} = \Delta[A]/\Delta t$$

# How do molecules react anyways?

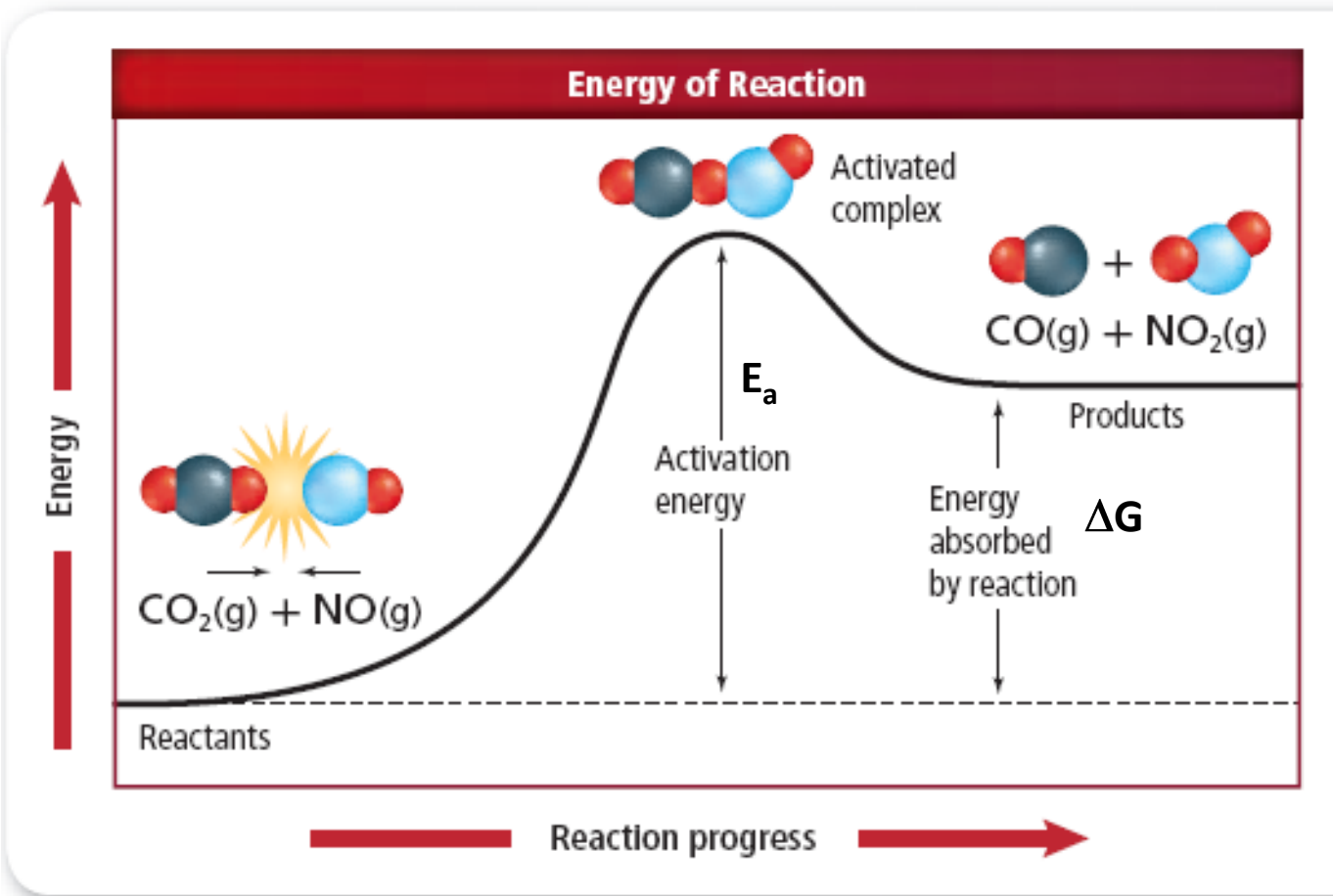
- Basically they bump into one another...
- Collision theory – atoms or molecules must collide with one another in a specific orientation in order to form products.



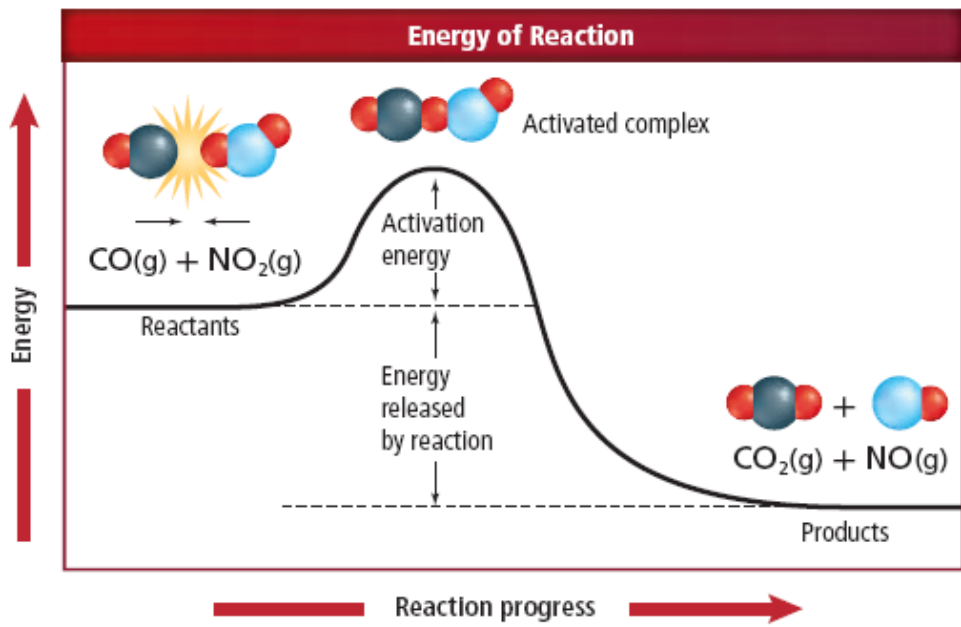
# Energy Diagrams



# Energy Diagrams





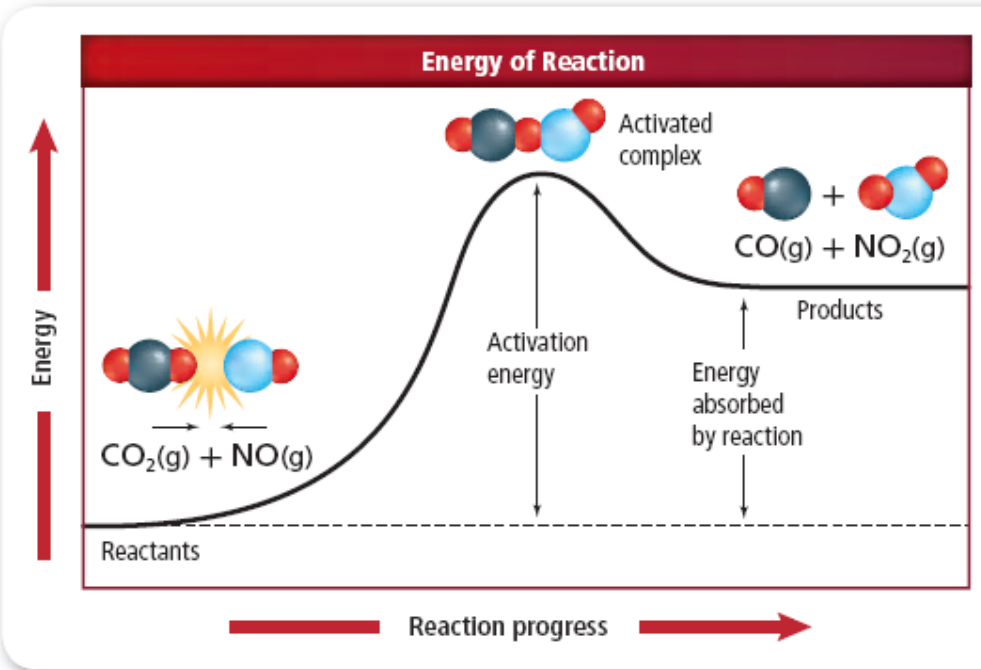


**EXOTHERMIC**

Products are lower in energy than reactants

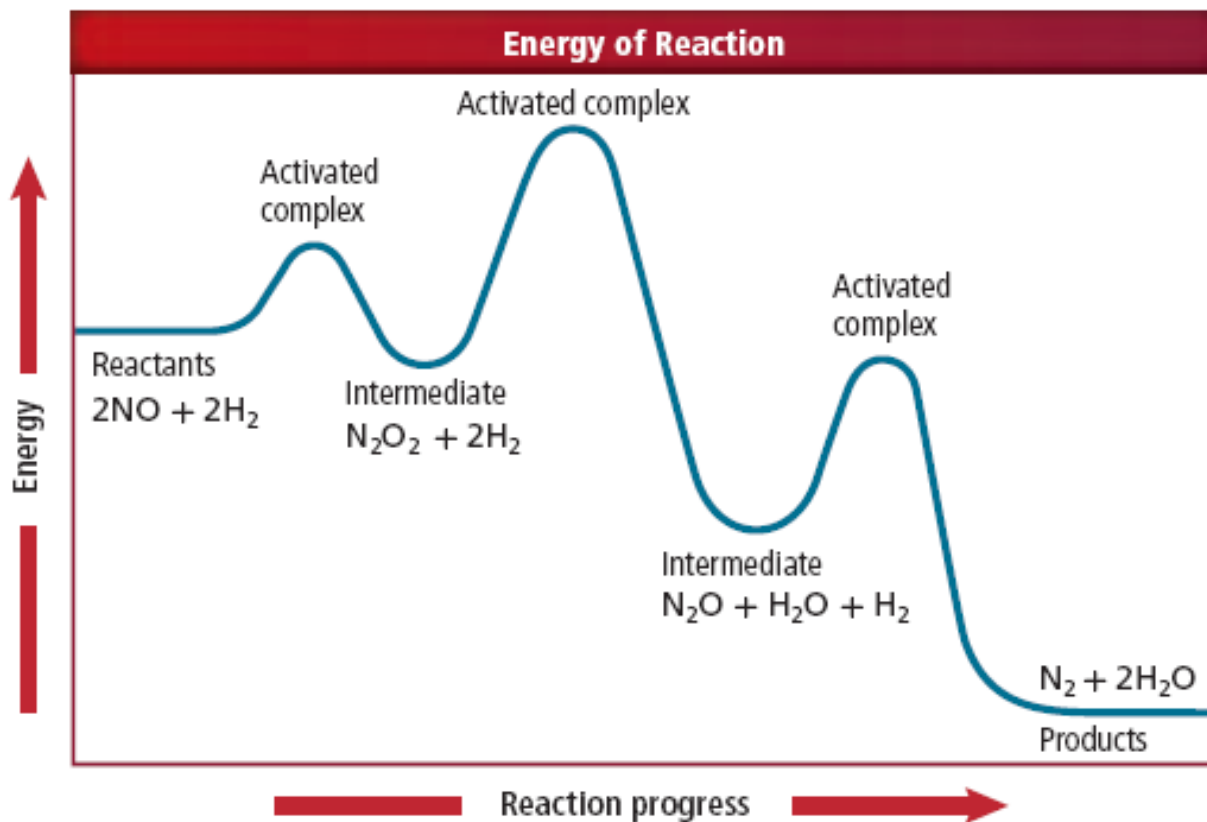
**ENDOTHERMIC**

Products are higher in energy than reactants



# Rate Determining Step

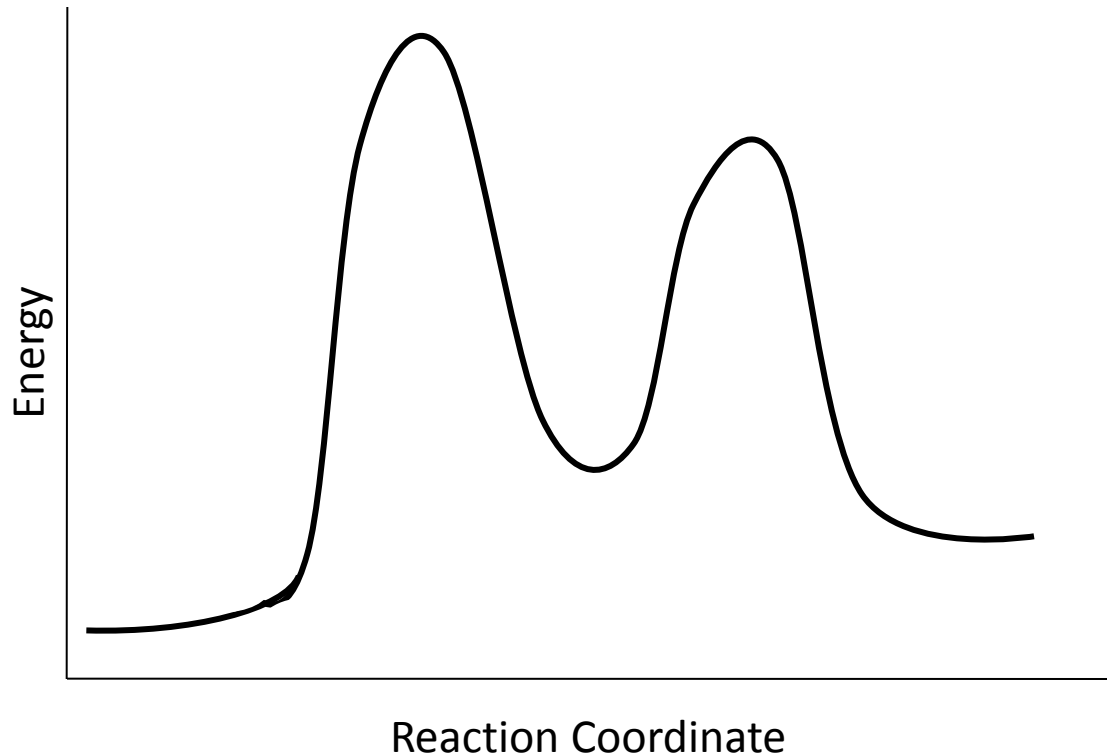
In a multi-step reaction, the slowest step determines the overall rate. The Rate Determining Step (RDS) has the highest  $E_a$



# Practice

- Draw an energy diagram of an exothermic process. Label axes, reactants, products activation energy, and  $\Delta G$ .
- How is this different than if the reaction was endothermic?
- Sketch a multi step reaction and label the intermediates and the rate determining step

# Warm Up



Label  $E_a$  for each step, reactants, products,  $\Delta G$ , and the RDS.

Is the reaction endo or exothermic? Why?

What two things have to happen for a chemical reaction to be successful?

# Today's Agenda

- QOTD: What factors affect the rate of a reaction?
- Temperature and Pressure
- Catalysts
- Inhibitors
  
- Finish work from Friday due Wednesday.  
Copper Calorimetry Lab in notebook due Tuesday.

# Factors Affecting Reaction Rate

- What is DOING the reacting?
  - Some elements/compounds just are more reactive and react faster than others.
  - Elements that are not very reactive are referred to as **INERT**.

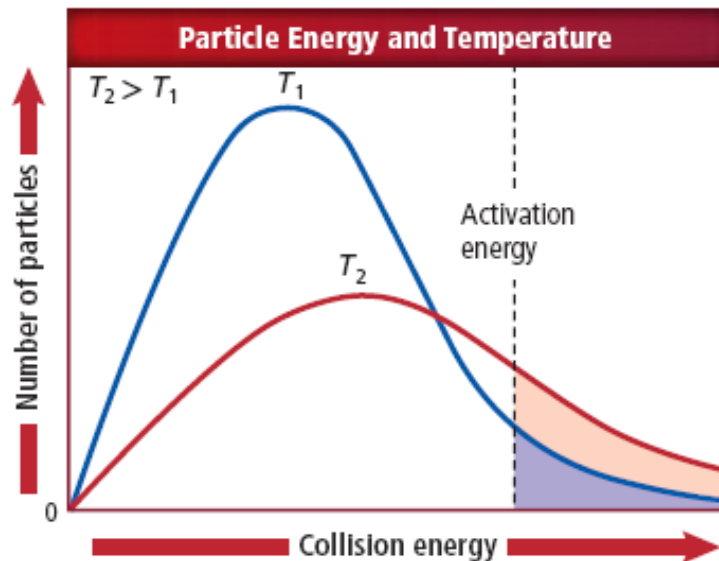
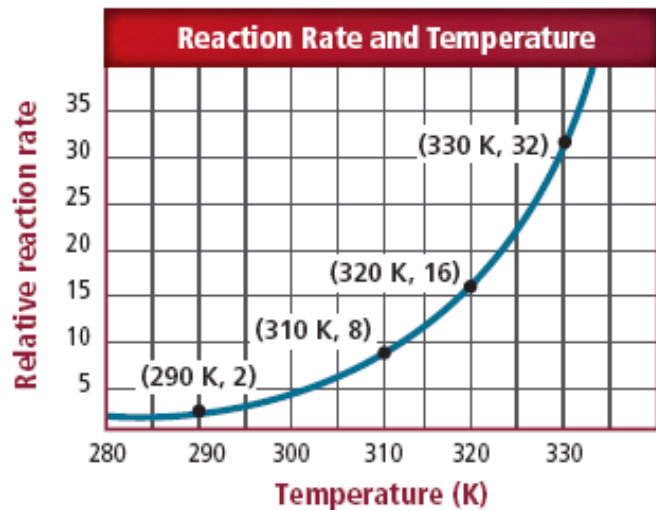
# Factors Affecting Reaction Rate

- Concentration
  - How much is available to react?
  - The **more molecules** that are present, the **higher the chance of collisions** and the **faster the rate!**
- Surface Area
  - If the reaction only happens on the surface of a metal, the more open surface for reacting the faster the reaction

More “stuff” = more collisions = faster chemistry!

# Factors Affecting Reaction Rate

- Temperature
  - Higher temperatures = faster reactions
  - Temperature is a measure of kinetic energy and therefore, collisions!
  - Also, a greater % of reactants have enough energy to overcome the  $E_a$



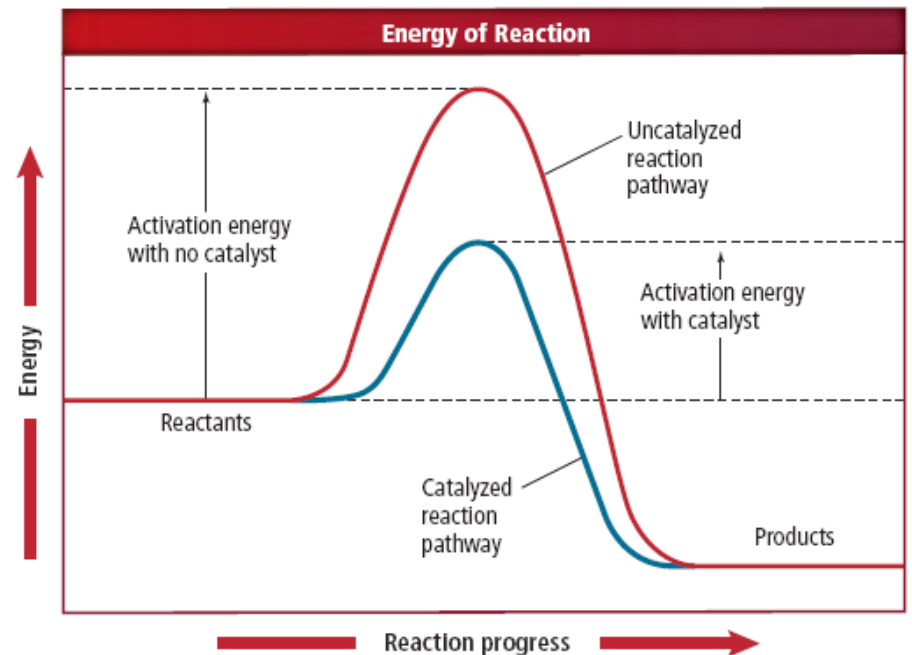


# Factors Affecting Reaction Rate

- Catalysts

- Catalysts – used to lower  $E_a$  but are not used up in the reaction.

- Enzymes are catalysts that increases chemical reactions in biological systems. They are neither transformed nor consumed in the reaction.



# Factors Affecting Reaction Rate

- Inhibitor
  - Substance that slows down a reaction or prevents a reaction from happening at all!
    - Utilized extensively in biological systems and in pharmaceutical research!
  - Sometimes they block a low energy pathway, or they bind to a reactant so that it cannot react with anything else, or they get in the way of natural catalysts!
    - Food preservatives are inhibitors that are safe to eat but inhibit bacterial growth! Yum...

**Table 16.2****Experimental Initial Rates  
for  $aA + bB \rightarrow \text{products}$** 

Trial	Initial [A](M)	Initial [B](M)	Initial Rate (mol/(L · s))
1	0.100	0.100	$2.00 \times 10^{-3}$
2	0.200	0.100	$4.00 \times 10^{-3}$
3	0.200	0.200	$16.00 \times 10^{-3}$

Consider the reaction and the following rate data:



- i. Determine the reaction order for NO and H<sub>2</sub>.

Experiment	P <sub>NO</sub> (M)	P <sub>H<sub>2</sub></sub> (M)	Initial Rate (mmHg/sec)
1	400	150	0.66
2	400	300	1.34
3	150	400	0.25
4	300	400	1.03

# Review Questions

- How do reactants interact with one another to form products?
- When can two reactants collide and NOT form products?
- If you were making pasta sauce and you added wine to react with the tomato acid, how could you make your sauce react faster?
- Why does Mg react faster with HCl than Fe?