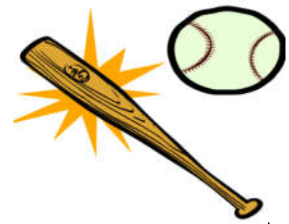
AP Chemistry
Ms. Ye

Name ___________________________________
Date ________________________Block ______

Collision Theory: What Must Happen in Order for a Chemical Reaction to Occur?



Model: In the picture, the baseball bat represents **Reactant A** and the baseball represents **Reactant B**. A reaction will only be successful if the batter hits a **homerun**. If the batter does not hit a homerun, the reaction will be considered a failure and not occur. Now, read the four scenarios below and answer the key questions that follow.

Scenario 1: The pitcher throws a fastball down the middle of the plate. The batter takes a mighty swing and totally misses the ball. The umpire yells, "Strike one!"

Scenario 2: The pitcher throws an off-speed pitch and the batter checks his swing. The batter just barely makes contact with the ball and it dribbles down in front of the batter's feet into foul territory. The umpire yells, "Foul ball; strike two!"

Scenario 3: The pitcher throws a curve ball that looks like it might catch the outside corner of the plate. The batter swings with all his strength, but the bat grazes the underside of the ball and the ball skews off to the right, flying into the crowd. The umpire yells, "Foul ball, still two strikes!"

Scenario 4: The pitcher throws another fastball down the middle of the plate. The batter swings and wallops the ball high into the air and the ball clears the center field wall that reads 410 feet. The ump yells, "Homerun!"

Key Questions:

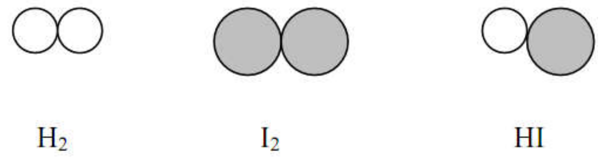
1. Did a reaction take place between Reactant A and Reactant B in Scenario 1? Why or why not? Explain your reasoning in terms of the nature of the collision (how the ball and bat were hit, how much energy was used).

2. Did a reaction take place between Reactant A and Reactant B in Scenario 2? Why or why not? Explain your reasoning in terms of the nature of the collision.

3. Did a reaction take place between Reactant A and Reactant B in Scenario 3? Why or why not? Explain your reasoning in terms of the nature of the collision.

4. Did a reaction take place between Reactant A and Reactant B in Scenario 4? Why or why not? Explain your reasoning in terms of the nature of the collision.

Exercise: Hydrogen gas and iodine vapor combine to form hydrogen iodide gas, as shown in the equation **$H_2 + I_2 \rightarrow 2\,HI$**. Use the representations for the reactants and product to the right for the following questions:



1. Draw a diagram to show an orientation for the reactant molecules that could produce an **effective collision** capable of producing two HI molecules.

2. Draw a diagram to show an orientation for the reactant molecules that would **NOT** produce an effective collision

3. What else must be true of this collision (other than proper orientation) for a chemical reaction to successfully occur between H_2 and I_2?

Multiple Choice Questions:

1. Which event must always occur in order for a chemical reaction to take place?
   A. Effective collisions between reacting particles
   B. Addition of a catalyst to the reaction system
   C. Formation of a precipitate
   D. Formation of a gas

2. A reaction is most likely to occur when reactant particles collide with
   A. Proper energy, only
   B. Proper orientation, only
   C. Both proper energy and proper orientation
   D. Neither proper energy nor proper orientation

3. Increasing the temperature increases the rate of a reaction by
   A. Lowering the activation energy
   B. Increasing the activation energy
   C. Lowering the frequency of effective collisions between reacting molecules
   D. Increasing the frequency of effective collisions between reacting molecules

Energy in Reactions

During a chemical reaction, atoms are rearranged to form new substances by breaking old bonds and forming new bonds. Bond breaking takes energy, while bond making releases energy. Even exothermic reactions, such as burning wood, need energy to get started. One explanation for this is that old bonds must be broken before new bonds form. The energy needed to get the reaction started is called the **activation energy**. It comes from the collisions between the reacting particles. Measurements show, however, that the energy needed to break the bonds during a chemical reaction is greater than the activation energy. An alternate explanation is that instead of the energy from the collisions being used to break the bonds, it is used to form an unstable, high energy **activated complex**. The high energy activated complex is so unstable, it quickly falls apart to form the products. Because the activated complex lasts only a short time, it is also called a **transition state complex**. According to transition state theory, during a chemical reaction, intermediate products, known as the transition state complex, form that exist for only brief periods of time while the atoms rearrange themselves.

A typical reaction on the molecular playground.

Answer the questions below based on the reading above.

1. Why is it necessary to supply energy in the form of a spark to ignite the gasoline in an automobile engine if gasoline releases energy when it burns?

2. According to collision theory, where does the activation energy during a reaction come from?

3. According to transition state theory, what is activation energy used for?

4. What is an activated complex?

   a. Why does it last only a short time?

   b. Why it is it unstable?

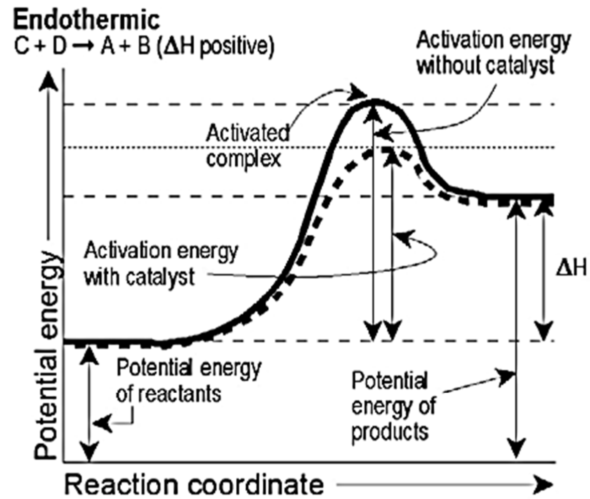
   c. What forms from the activated complex?

   d. How does the potential energy of the activated complex compare to that of the reactant or the product?

   e. What evidence is there that an activated complex forms during a reaction?

Energy Changes in a Reaction: Potential Energy Diagrams

In order for a reaction to begin, energy is needed to form an activated complex. The energy needed to form an activated complex is called activation energy. It comes from effective collisions. Activation energy is needed whether heat is absorbed or released during a chemical reaction. Heat absorbed or released during a chemical reaction is called **heat of reaction** or **enthalpy** (ΔH). Enthalpy is the difference between the potential energy of the products and the reactants ($\Delta H = H_{products} - H_{reactants}$). In exothermic reactions, ones in which energy is released, the potential energy of the products is lower than the potential energy of the reactants and ΔH is negative. For endothermic reactions, ones in which energy is absorbed, the potential energy of the products is higher than the potential energy of the reactants and ΔH is positive. Catalysts reduce the activation energy for both exothermic and endothermic reactions but have no effect on the change in enthalpy.



Answer the questions below based on the reading and the graph above.

1. Based on the graph above:
   a. Which has the highest energy–the reactants, the products, or the activated complex?

   b. Which has the lowest energy–the reactants, the products, or the activated complex?

2. If the reactants have a potential energy of 10.2 kJ/mol and the products have a potential energy of 15.7 kJ/mol, what is ΔH?

3. What effect do catalysts have on ΔH?

4. Catalysts are used to speed up chemical reactions. Based on the graph above, how do they do this?

5. What is an endothermic reaction? What information on the graph above shows that the reaction pictured is endothermic?

Reaction Rates and Potential Energy Diagrams WS

1. Chemical reactions occur when reactants collide. For what reasons may a collision fail to produce a chemical reaction?

2. What is the activation energy of a reaction, and how is this energy related to the activated complex of the reaction?

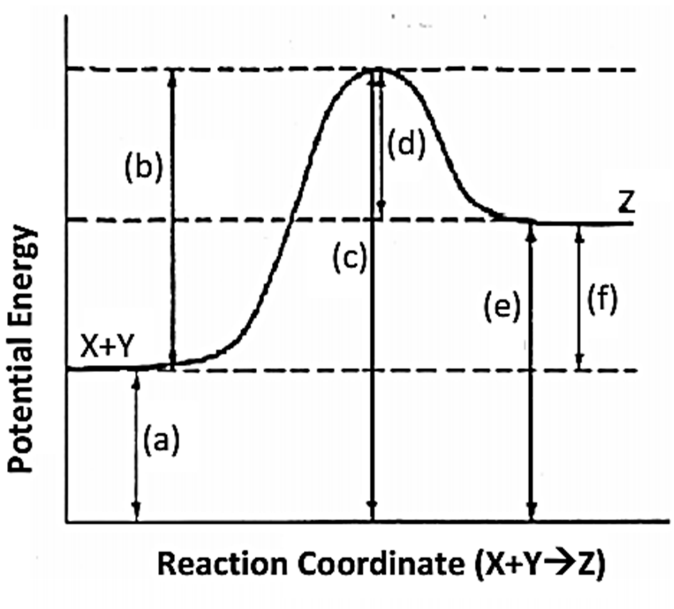
3. What happens when a catalyst is used in a reaction?

4. Name 4 things that will speed up or slow down a chemical reaction.

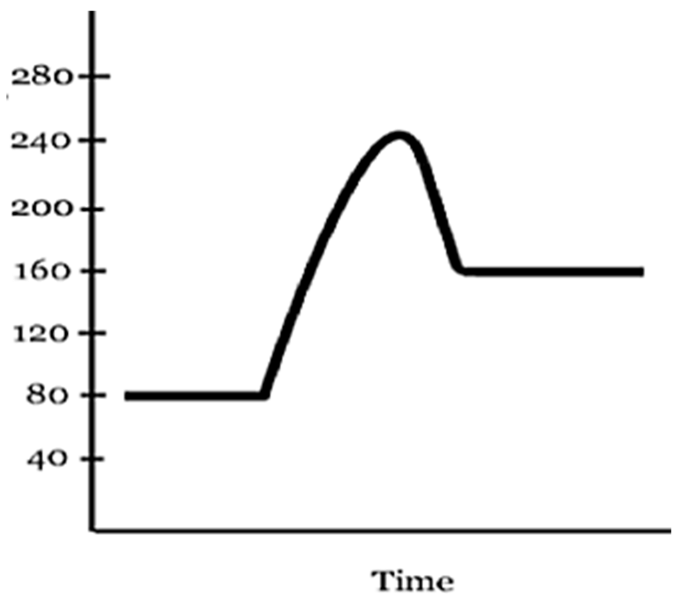
5. Draw an energy diagram for a reaction. Label the axis, PE of reactants = 350 KJ/mol, Ea = 100 KJ/mol, PE of products = 250 KJ/mol.

6. Is the reaction represented by the energy diagram you drew above exothermic or endothermic? Explain.

7. How could you lower the activation energy for the reaction you drew above?



1. Which of the letters a–f in the diagram represents the potential energy of the products? _______
2. Which letter indicates the potential energy of the activated complex? ________
3. Which letter indicates the potential energy of the reactants? ________
4. Which letter indicates the activation energy? _____
5. Which letter indicates the heat of reaction? ______
6. Is the reaction exothermic or endothermic? ______
7. Which letter indicates the activation energy of the reverse reaction? ________
8. Which letter indicates the heat of reaction of the reverse reaction? ________
9. Is the reverse reaction exothermic or endothermic? ___



1. The PE of the reactants of the forward reaction is about ____ kilojoules.

2. The PE of the products of the forward reaction is about _____ kilojoules.

3. The PE of the activated complex of the forward reaction is about ___ kilojoules.

4. The activation energy of the forward reaction is about ___ kilojoules.

5. The heat of reaction (ΔH) of the forward reaction is about ___ kilojoules.

6. The forward reaction is _________(endothermic or exothermic).

7. The PE of the reactants of the reverse reaction is about _____ kilojoules.

8. The PE of the products of the reverse reaction is about _____ kilojoules.

9. The PE of the activated complex of the reverse reaction is about ____kilojoules.

10. The activation energy of the reverse reaction is about ____ kilojoules.

11. The heat of reaction (ΔH) of the reverse reaction is about ____ kilojoules.

12. The reverse reaction is _________ (endothermic or exothermic)