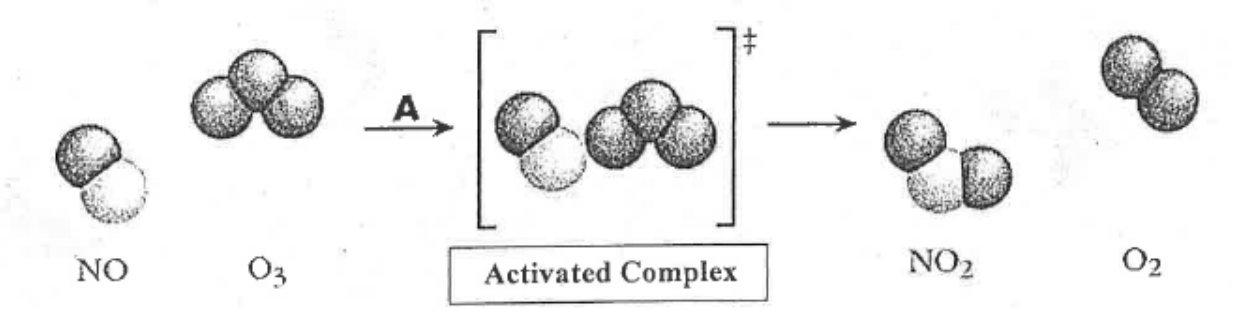
Unit 9: Chemical Kinetics & Equilibrium

#3 Collision Theory & Factors Influencing Rates of Reaction

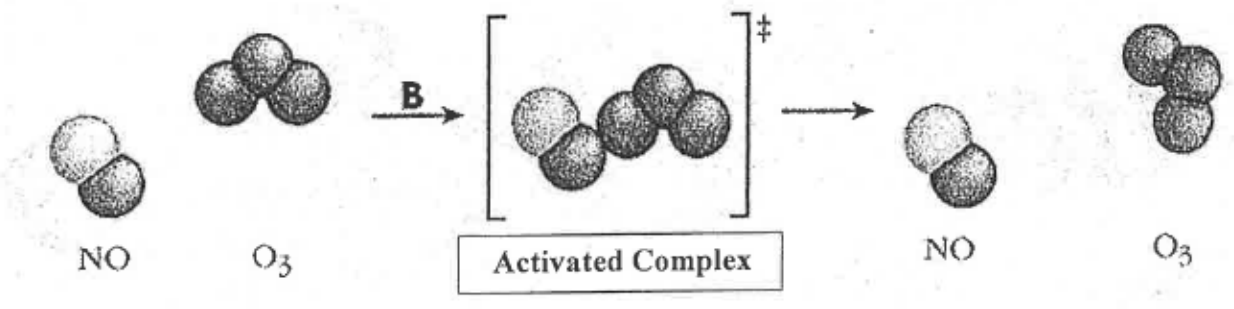
Collision Theory states that in order for a chemical reaction to occur, the reactant atoms or molecules ***must collide with each other***.

- When molecules approach one another, the valence electrons from one molecule repel the valence electrons in the other molecule and distort the existing bonds.

- If the reactant molecules collide with **sufficient energy and in the correct orientation**, the repulsion between valence electrons will break the existing bonds, allowing new (lower energy) bonds to form. This is called an **"effective collision."**



- If the reactant molecules do not collide with sufficient energy or collide in the wrong orientation, the existing bonds are not broken and no reaction occurs. This is called an "ineffective collision."



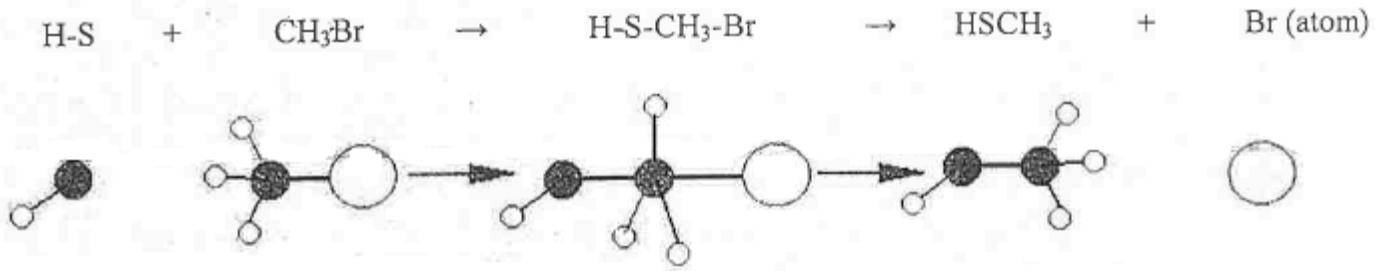
- The minimum amount of energy required for a successful collision is called **"activation energy," E_a.**

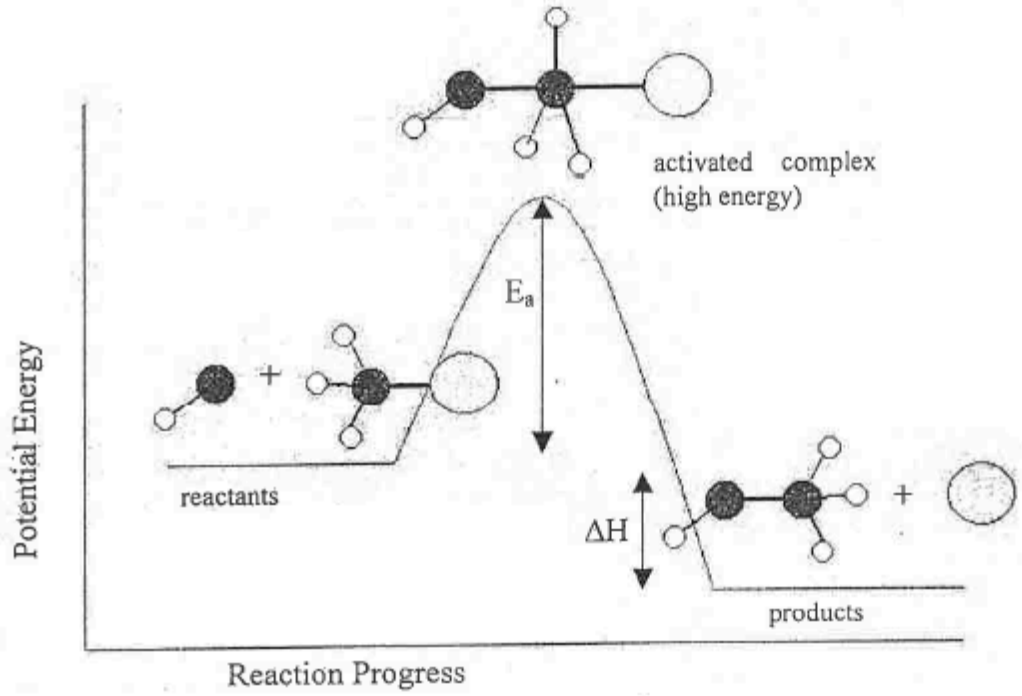
- The **"activated complex"** is a theoretical high energy particle that exists for a fraction of a second at the instant the particles collide. The activated complex can break down into either the reactants in an ineffective collision or the products in an effective collision.

- By controlling the collisions of the reactants, we can control the rate at which chemical reactions occur.

Potential Energy Changes During Chemical Reactions

The energy changes during a chemical reaction can be graphed as a "reaction pathway."





Reaction pathways show:

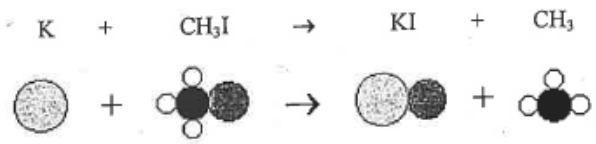
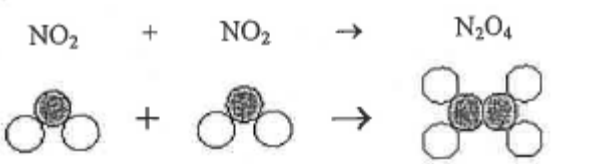
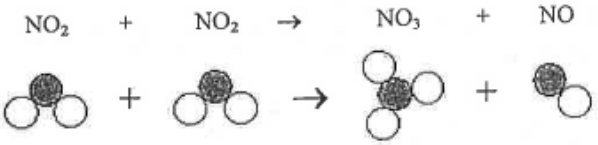
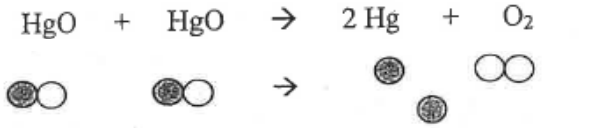
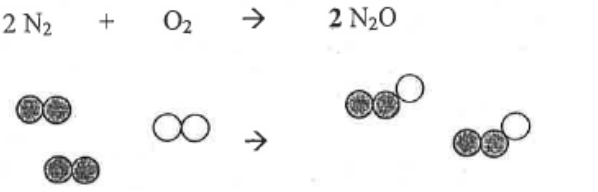
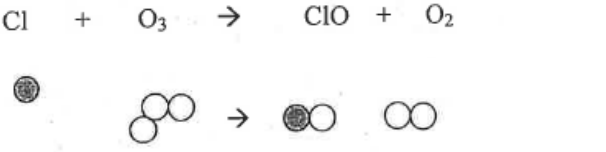
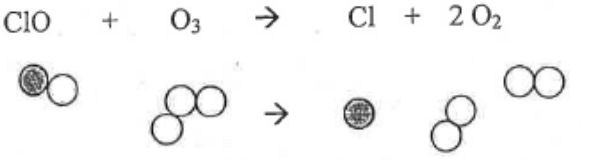
1. **<u>Activation Energy</u> (E_a)**: The minimum amount of energy that is required for a reaction to occur.
    - If the activation energy is low, the reaction will occur relatively easily.
    - If the activation is high, it is much less likely that the reaction will occur (the bonds in the reactants are too difficult to break for the reaction to proceed).
    - In general, the lower the activation energy, the faster the reaction rate.

2. **<u>ΔH</u>**: the net change in **enthalpy** (potential energy) between the reactants and products if a reaction does occur.
    - If ΔH is negative, the products are lower energy than the reactants. The reaction is exothermic and will likely occur if the activation energy can be reached.
    - If ΔH is positive, the products of the reaction are higher energy than the reactants. The reaction is endothermic and energy must be put into the system in order for the reaction to occur

Collision Theory Worksheet: Collision Theory and Potential Energy Diagrams

Collision Theory

1. For each of the following reactions, you are given a picture of the reactant molecules and the product molecule.
    a. Draw a picture that shows how the two reactant molecules must collide in order to react.
    b. In your picture of the collision draw an X through the bonds that will be broken and draw a line to show the new bonds formed.

reaction	Picture of collision
	
	
	
	
	
	
	

2. One factor that affects reaction rates is the temperature. Explain using collision theory why reactions are slower at lower temperatures.

3. Another factor that affects reaction rates in the concentrations of the reactants. Explain using collision theory why lower concentrations will slow down a reaction.

4. What do catalysts do to speed up reactions?

5. Salt is a catalyst for the reaction of iron rusting. Explain each of the following.

    a. Why is it a good idea to wash your car every couple of weeks in winter?

    b. Why is storing your car in a heated garage possibly not a good idea?

Potential Energy Diagrams

1. Define: activation energy and activated complex (aka transition state).

2. Why, in general, does a reaction with high activation energy have a low rate?

3. Why, in general, does a reaction with a low activation energy have a high rate?

4. A certain reaction has a very high activation energy and is slightly endothermic.

a. Sketch a possible potential energy diagram (reaction pathway) for the reaction.

b. On the diagram label the reactants, products, activated complex, heat of reaction (ΔH) and the activation energy (E_a) - Skip this if your diagram already has these items labeled.

5. A certain reaction has a very low activation energy and is highly exothermic.

a. Sketch a possible potential energy diagram (reaction pathway) for the reaction.

b. On the diagram label the reactants, products, activated complex, heat of reaction (ΔH) and the activation energy (E_a) - Skip this if your diagram already has these items labeled.

6. Many *exothermic* reactions (such as burning paper) require energy to get the reaction started, but they are able to sustain themselves once they start to burn. Explain in reference to collision theory, why this is true of exothermic reactions.

7. In regards to reaction rates, how might you:

a. Slow down and prevent food spoilage?

b. Slow down the rusting of metal on a car?

c. Increase the speed of combustion for a campfire?