The Activated Complex

When molecules collide, some of their high kinetic energy is converted into internal potential energy within the colliding molecules. If enough energy is converted, molecules with suitable orientation become activated. New bonds can then form. In this brief interval of bond breakage and bond formation, the collision complex is in a *transition state.* Some partial bonding exists in this transitional structure. *A transitional structure that results from an effective collision and that persists while old bonds are breaking and new bonds are forming is called an* **activated complex.**

Figure 5 graphically breaks down the reaction pathway of the formation of hydrogen iodide gas into three steps. Beginning with the reactants, H_2 and I_2, a certain amount of activation energy, E_{a1}, is needed to form the activated complex that leads to the formation of the intermediates H_2 and 2I. Then more activation energy, E_{a2}, is needed to form the activated complex leading to the intermediates H_2I and I. In order to arrive at the final product, 2HI, another increase in activation energy is necessary, as seen by the highest peak labeled E_{a3}.

An activated complex is formed when an effective collision raises the internal energies of the reactants to their minimum level for reaction, as in **Figure 4.** Both forward and reverse reactions go through the same activated complex. A bond that is broken in the activated complex for the forward reaction must be re-formed in the activated complex for the reverse reaction. Observe that an activated complex occurs at a high-energy position along the reaction pathway.

The kinetic-molecular theory states that the speeds and therefore the kinetic energies of the molecules increase as the temperature increases. An increase in speed causes more collisions, which can cause an increase in the number of reactions. However, an increase in the reaction rate depends on more than simply the number of collisions, as **Figure 3** illustrates. The collisions between molecules must possess sufficient energy to form an activated complex or a reaction will not take place. Raising the temperature of a reaction provides more molecules that have this activation energy and causes an increase in the reaction rate.

In its brief existence, the activated complex has partial bonding that is characteristic of both reactant and product. It may then re-form the original bonds and separate back into the reactant particles, or it may form new bonds and separate into product particles. The activated complex, unlike the relatively stable intermediate products, is a very short-lived molecular complex in which bonds are in the process of being broken and formed.

Activation Energy Peaks in the Formation of Activated Complexes

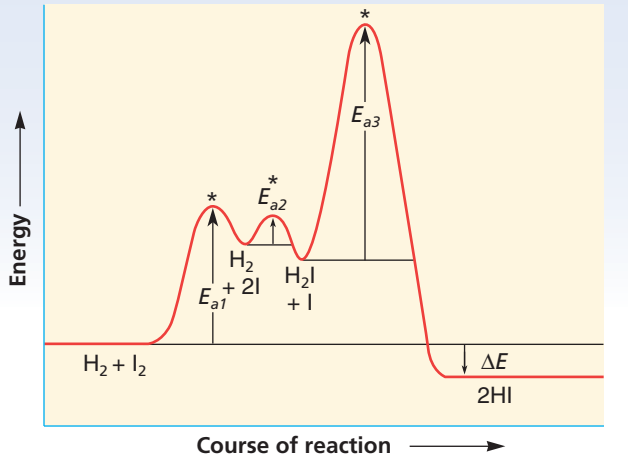

FIGURE 5 This energy profile graphically shows the formation of three activated complexes (*) during the gas-phase reaction $H_2 + I_2 \longrightarrow 2HI$.