30.9: Not All Gas-Phase Chemical Reactions are Rebound Reactions

Stripping Reactions

In the previous section we showed that the reaction

$$\mathrm{D_2(g) + F(g) \longrightarrow DF(g) + D(g)}$$

is a rebound reaction because the vast majority of DF molecules bounce off from the collision with $\mathrm{D_2}$ back toward the general direction from which they came. In this section we will look at **stripping reactions**, reactions in which a majority of the product molecules continue moving on after the collision in the same direction that the precursor reactant molecules were going.

In stripping reactions, the experimental hard-sphere collision cross section is generally found to be larger than the theoretical estimate. The experimental cross-section is so large that it would be possible for two particles to remain inside the collision area and yet pass by each other without colliding. It has been determined experimentally that an electron transfer between the two particles occurs before they collide. The resulting ions are then drawn toward each other because of the Coulomb potential created by the opposite charges. One such reaction involves $\mathrm{K(g)}$ and $\mathrm{I_2(g)}$. The mechanism is:

$$\mathrm{K(g) + I_2(g) \longrightarrow K^+(g) + I_2^-(g)} \qquad \mathrm{(step\ 1)}$$

$$\mathrm{K^+(g) + I_2^-(g) \longrightarrow KI(g) + I(g)} \qquad \mathrm{(step\ 2)}$$

After the collision, the KI molecule moves off in the same general direction as the incoming K atom.

Meta-stable Intermediates

There are other bimolecular gas-phase collision reactions in which the product molecules disperse in both forward and reverse directions after the reaction. There is no explanation for these types of post-collision scattering patterns if we insist on using a simple hard-sphere collision model. However, if the colliding particles form a single atom-molecule structure that lasts long enough for the structure to undergo many rotations before splitting apart into products, it is reasonable for the newly formed products to scatter in the forward and reverse direction.

The discovery of these various reaction types was made possible by the development and use of the crossed molecular beam instruments described in Section 30.6.