FIGURE 2 Colorless hydrogen iodide gas, HI, decomposes into colorless hydrogen gas and violet iodine gas. Some of the hydrogen gas and iodine gas will reform HI.

Although only the net chemical change is directly observable for most chemical reactions, experiments can often be designed that suggest the probable sequence of steps in a reaction mechanism. Each reaction step is usually a simple process. The equation for each step represents the *actual* atoms, ions, or molecules that participate in that step. Even a reaction that appears from its balanced equation to be a simple process may actually be the result of several simple steps.

For many years, the formation of hydrogen iodide, as shown in **Figure 2,** was considered a simple one-step process. It was thought to involve the interaction of two molecules, H_2 and I_2, in the forward reaction and two HI molecules in the reverse reaction. Experiments eventually showed, however, that a direct reaction between H_2 and I_2 does not take place.

Alternative mechanisms for the reaction were proposed based on the experimental results. The steps in each reaction mechanism had to add together to give the overall equation. Note that two of the species in the mechanism steps—I and H_2I—do not appear in the net equation. *Species that appear in some steps but not in the net equation are known as* **intermediates.** (Notice that they cancel each other out in the following mechanisms.) The first possible mechanism has the following two-step pathway.

Step 1: $I_2 \rightleftarrows 2I$

Step 2: $2I + H_2 \rightleftarrows 2HI$

$I_2 + H_2 \rightleftarrows 2HI$

The second possible mechanism has a three-step pathway.

Step 1: $I_2 \rightleftarrows 2I$

Step 2: $I + H_2 \rightleftarrows H_2I$

Step 3: $H_2I + I \rightleftarrows 2HI$

$I_2 + H_2 \rightleftarrows 2HI$

The reaction between hydrogen gas and iodine vapor to produce hydrogen iodide gas is an example of a **homogeneous reaction,** *a reaction whose reactants and products exist in a single phase*—in this case, the gas phase. This reaction system is also an example of a homogeneous chemical system because all reactants and products in all intermediate steps are in the same phase.

Collision Theory

In order for reactions to occur between substances, their particles (molecules, atoms, or ions) must collide. Furthermore, these collisions must result in interactions. *The set of assumptions regarding collisions and reactions is known as* **collision theory.** Chemists use this theory to interpret many of their observations about chemical reactions.