Pearson

15.2: The Concept of Dynamic Equilibrium

Recall from Chapter 14 that reaction rates generally increase with increasing concentration of the reactants (unless the reaction order is zero) and decrease with decreasing concentration of the reactants. With this in mind, consider the reaction between hydrogen and iodine:

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

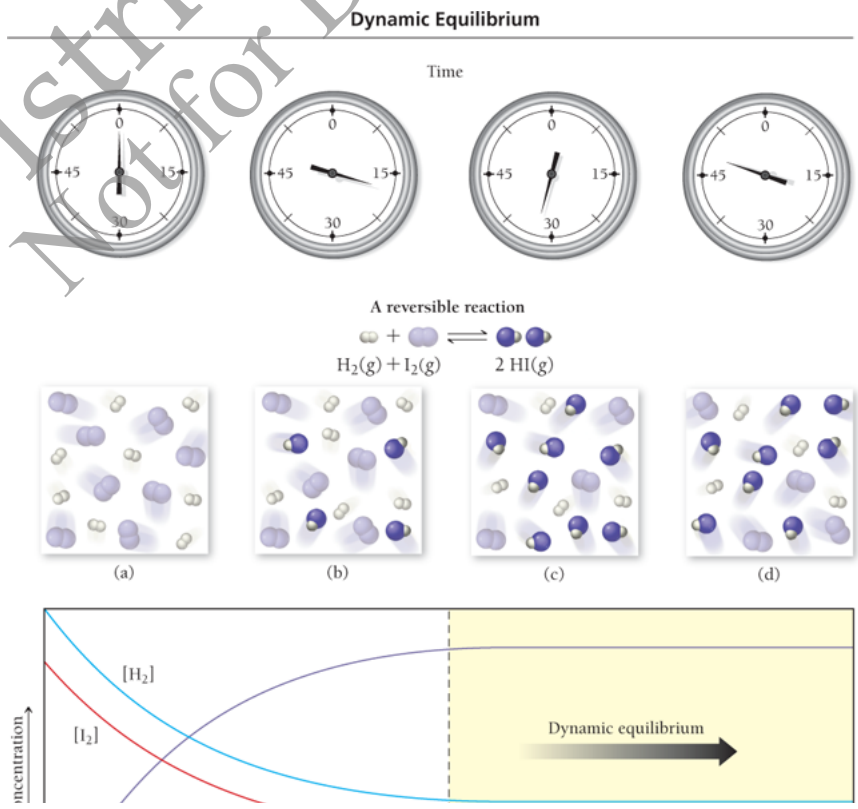
In this reaction, H_2 and I_2 react to form 2 HI molecules, but the 2 HI molecules can also react to re-form H_2 and I_2. A reaction such as this one—that can proceed in both the forward and reverse directions—is said to be **reversible**.

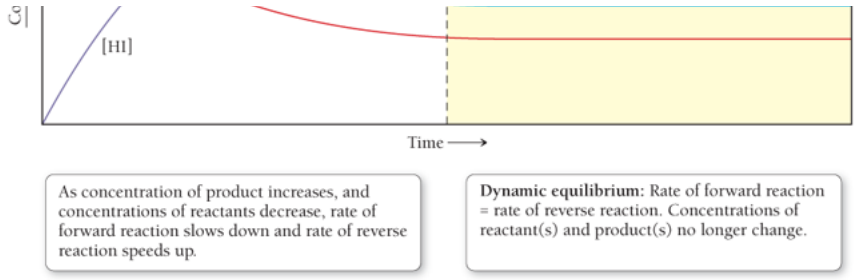
Suppose we begin with only H_2 and I_2 in a container (Figure 15.2(a)). What happens? Initially, H_2 and I_2 begin to react to form HI (Figure 15.2(b)). However, as H_2 and I_2 react, their concentrations decrease, which in turn *decreases the rate of the forward reaction*. At the same time, HI begins to form. As the concentration of HI increases, the reverse reaction begins to occur at a faster and faster rate. Eventually, the rate of the reverse reaction (which has been increasing) equals the rate of the forward reaction (which has been decreasing). At that point, **dynamic equilibrium** is reached (Figure 15.2(c, d)).

> Dynamic equilibrium for a chemical reaction is the condition in which the rate of the forward reaction equals the rate of the reverse reaction.

Figure 15.2 Dynamic Equilibrium

Equilibrium is reached in a chemical reaction when the concentrations of the reactants and products no longer change. The molecular images depict the progress of the reaction $H_2(g) + I_2(g) \rightleftharpoons 2\,HI(g)$. The graph shows the concentrations of H_2, I_2, and HI as a function of time. When equilibrium is reached, both the forward and reverse reactions continue, but at equal rates, so the concentrations of the reactants and products remain constant.





> Nearly all chemical reactions are at least theoretically reversible. In many cases, however, the reversibility is so small that it can be ignored.

Dynamic equilibrium is "dynamic" because the forward and reverse reactions are still occurring; however, they are occurring at the same rate. When dynamic equilibrium is reached, the concentrations of H_2, I_2, and HI no longer change (as long as the temperature is constant). The concentrations remain constant because the reactants and products form at the same rate that they are depleted. Note that although the concentrations of reactants and products no longer change at equilibrium, *the concentrations of reactants and products are not equal to one another* at equilibrium. Some reactions reach equilibrium only after most of the reactants have formed products; others reach equilibrium when only a small fraction of the reactants have formed products. It depends on the reaction.