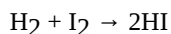


## 7.7: Reversible Reactions and Chemical Equilibrium

### Learning Objectives

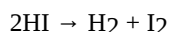
- Define chemical equilibrium.
- Recognize chemical equilibrium as a dynamic process.

Consider the following reaction occurring in a closed container (so that no material can go in or out):



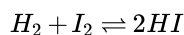
This is simply the reaction between elemental hydrogen and elemental iodine to make hydrogen iodide. The way the equation is written, we are led to believe that the reaction goes to completion, that all the  $\text{H}_2$  and the  $\text{I}_2$  react to make  $\text{HI}$ .

However, this is not the case because it is a **reversible reaction**, meaning it can go in either direction. As soon as there is enough product formed, the  $\text{HI}$  can react and the reverse chemical reaction occurs essentially "undoing" the first reaction:



Eventually, the reverse reaction proceeds so quickly that it matches the speed of the forward reaction. When that happens, the concentration of the reactants and products remains constant, there is no further change; the reaction has reached **chemical equilibrium** (sometimes just spoken as *equilibrium*; plural *equilibria*), the point at which the forward and reverse processes balance each other's progress.

Because two opposing processes are occurring at once, it is conventional to represent an equilibrium using a double arrow, like this:



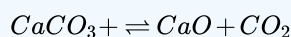
The double arrow implies that the reaction is going in both directions. Note that the reaction must still be balanced.

### ✓ Example 7.7.1

Write the equilibrium equation that exists between calcium carbonate as a reactant and calcium oxide and carbon dioxide as products.

#### Solution

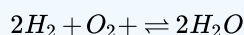
As this is an equilibrium situation, a double arrow is used. The equilibrium equation is written as follows:



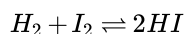
### ? Exercise 7.7.1

Write the equilibrium equation between elemental hydrogen and elemental oxygen as reactants and water as the product.

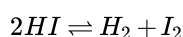
#### Answer



One thing to note about equilibrium is that the reactions do not stop; both the forward reaction and the reverse reaction continue to occur. They both occur at the same rate, so any overall change by one reaction is canceled by the reverse reaction. We say that chemical equilibrium is *dynamic*, rather than static. Also, because both reactions are occurring simultaneously, the equilibrium can be written backward. For example, representing an equilibrium as



is the same thing as representing the same equilibrium as



The reaction must be at equilibrium for this to be the case, however.

## Key Takeaways

- Chemical reactions eventually reach equilibrium, a point at which forward and reverse reactions balance each other's progress.
- Chemical equilibria are dynamic: the chemical reactions are always occurring; they just cancel each other's progress.

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