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Learning Objectives

- Give examples of irreversible and reversible chemical reactions.
- Describe a reversible reaction that is in equilibrium.

Irreversible Reactions

Some chemical reactions can occur in only one direction. These reactions are called irreversible reactions. The reactants can change to the products, but the products cannot change back to the reactants. These reactions are like making a cake. The ingredients of a cake—such as eggs and flour—are the reactants. They are mixed together and baked to form the cake, which is the product (see Figure 1.2). The cake can’t be “unbaked” and “unmixed” to change it back to the raw eggs, flour, and other ingredients. So making a cake is irreversible.

Combustion reactions are generally irreversible. Combustion occurs whenever a fuel burns. In this type of reaction,
the fuel may combine with oxygen (in the air) and produces carbon dioxide and water vapor. The chemical equation for a combustion reaction is:

\[ \text{Fuel} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} \]

In a complete combustion reaction, fuel and oxygen are the reactants and the products are carbon dioxide and water. These two products cannot react to reform the fuel and oxygen, so the reaction is irreversible. The one-way arrow in the equation shows that the reaction can go in only one direction.

**Reversible Reactions**

Many chemical reactions can occur in both directions. These reactions are called reversible reactions. Not only can the reactants change to the products, but the products can change back to the reactants, at least under certain conditions. Consider again the reaction in which hydrogen gas and oxygen gas combine to produce water. This reaction is reversible if an electric current is applied to the water that is produced. You can see how this is done in the Figure 1.3. The current causes the water molecules to break down to individual hydrogen and oxygen atoms. Then these atoms recombine to form molecules of hydrogen gas and oxygen gas.
Q: In a chemical equation, a reversible reaction is represented with two arrows, one pointing in each direction. This shows that the reaction can go both ways. How would you represent the reversible reaction in which hydrogen and oxygen gases combine to produce water?

A: The chemical equation would be:

\[ \text{H}_2 + \text{O}_2 \rightleftharpoons \text{H}_2\text{O} \]

**Balancing Act**

In a reversible reaction, both forward and reverse directions of the reaction generally occur at the same time. While reactants are reacting to produce products, products are reacting to produce reactants. Often, a point is reached at which forward and reverse directions of the reaction occur at the same rate. When this happens, there is no overall change in the amount of reactants and products, even though the reactions keep occurring in both directions. This point is called equilibrium. The term *equilibrium* means “state of balance,” and it is used to refer to a state of balance between any opposing changes.

**Summary**

- Irreversible chemical reactions can occur in only one direction. The reactants can change to the products, but the products cannot change back to the reactants.
- Reversible chemical reactions can occur in both directions. The reactants can change to the products, and the products can also change back to the reactants.
- Equilibrium occurs when forward and reverse directions of a reversible reaction occur at the same rate so there is no overall change in the amounts of reactants and products.

**Review**

1. What is an irreversible chemical reaction? Give an example.
2. Describe a reversible chemical reaction.
3. When is a reversible chemical reaction in equilibrium?

**Explore More**

Watch the video about chemical equilibrium below, and then answer the questions that follow.

[Click image to the left or use the URL below.]

**MEDIA**

Click image to the left or use the URL below.

**URL:** http://www.ck12.org/flx/render/embeddedobject/82369
1. What is the reversible reaction presented in the video? What type of reaction is it?
2. When does the reverse reaction start occurring? What type of reaction is the reverse reaction?
3. What shifts the point of equilibrium in this chemical reaction?

Resources

1. Ingredients: Gemma Bardsley; Cake: The Integer Club. Ingredients: http://www.flickr.com/photos/7321654@N03/3041986568/; Cake: http://www.flickr.com/photos/40231253@N05/5464503521/ . CC BY 2.0
2. Zachary Wilson; Ingredients: Gemma Bardsley; Cake: The Integer Club. CK-12 Foundation; Ingredients: http://www.flickr.com/photos/7321654@N03/3041986568/; Cake: http://www.flickr.com/photos/40231253@N05/5464503521/ . CC BY-NC 3.0; CC BY 2.0