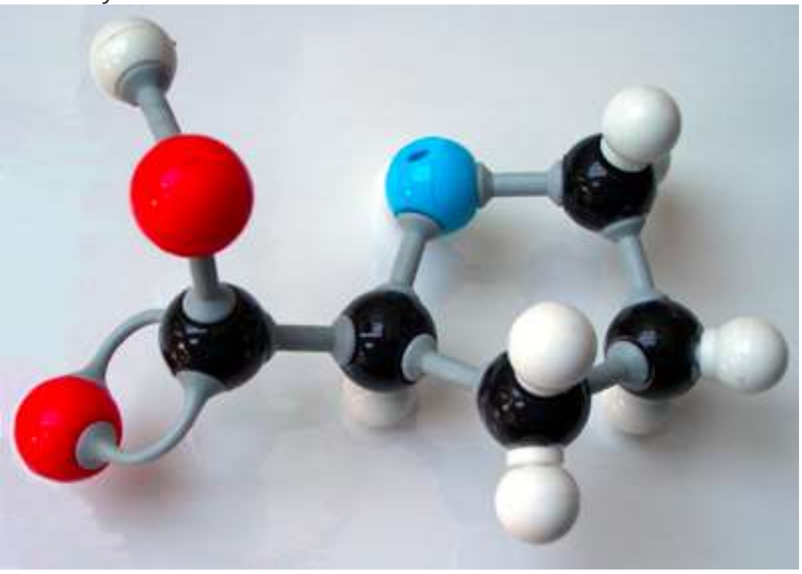
Chemical reactions

Chemical reactions and how they break and form bonds between atoms. Balanced reactions, reversibility, and equlibrium.

Introduction

Molecules—like the ones that make up your body—are just collections of atoms held together by chemical bonds. In many ways, they're a lot like Tinkertoy® building projects. In fact, if you take organic chemistry, you'll most likely buy a model set that looks suspiciously similar to Tinkertoys®:



Ball-and-stick model of the atom proline made using a modeling kit.

Image credit: "Proline model," by Peter Murray-Rust (CC BY-SA 2.5.

Just as you can put Tinkertoy® wheels together in different ways using different stick connectors, you can also put atoms together in a different ways by forming different sets of chemical bonds. The process of reorganizing atoms by breaking one set of chemical bonds and forming a new set is known as a chemical reaction.

Chemical reactions

Chemical reactions occur when chemical bonds between atoms are formed or broken. The substances that go into a chemical reaction are called the **reactants**, and the substances produced at the end of the reaction are known as the **products**. An arrow is drawn between the reactants and products to indicate the direction of the chemical reaction, though a chemical reaction is not always a "one-way street," as we'll explore further in the next section.
For example, the reaction for breakdown of hydrogen peroxide (H_2O_2) into water and oxygen can be written as:

$2H_2O_2$ (hydrogen peroxide)

In this example hydrogen peroxide is our reactant, and it gets broken down into water and oxygen, our products. The atoms that started out in hydrogen peroxide molecules are rearranged to form water molecules (H_2O) and oxygen molecules (O_2).

You may have noticed extra numbers in the chemical equation above: the 2s in front of hydrogen peroxide and water. These numbers are called **coefficients**, and they tell us how many of each molecule participate in the reaction. They must be included in order to make our equation **balanced**, meaning that the number of atoms of each element is the same on the two sides of the equation.

Equations must be balanced to reflect the **law of conservation of matter**, which states that no atoms are created or destroyed over the course of a normal chemical reaction. You can learn more about balancing reactions in the balancing chemical equations tutorial.

Reversibility and equilibrium

Some chemical reactions simply run in one direction until the reactants are used up. These reactions are said to be **irreversible**. Other reactions, however, are classified as reversible. **Reversible reactions** can go in both the forward and backward directions.

In a reversible reaction, reactants turn into products, but products also turn back into reactants. In fact, both the forward reaction and its opposite will take place at the same time. This back and forth continues until a certain relative balance between reactants and products is reached—a state called **equilibrium**. At equilibrium, the forward and backward reactions are still happening, but the relative concentrations of products and reactants no longer change.

Each reaction has its own characteristic equilibrium point, which we can describe with a number called the **equilibrium constant**. To learn where the equilibrium constant comes from and how to calculate it for a specific reaction, check out the equilibrium topic.

When a reaction is classified as reversible, it is usually written with paired forward and backward arrows to show it can go both ways. For example, in human blood, excess hydrogen ions ($H+$) bind to bicarbonate ions (HCO_3), forming carbonic acid (H_2CO_3):

Since this is a reversible reaction, if carbonic acid were added to the system, some of it would be turned into bicarbonate and hydrogen ions to restore equilibrium. In fact, this buffer system plays a key role in keeping your blood pH stable and healthy.