Energy Changes in Chemical Reactions

As a student of chemistry, it is more interesting for you to learn how the energy changes take place during the chemical reactions. Almost all the chemical reactions involve some sort of change in energy; either they absorb energy or release energy, generally in the form of heat. **Heat** is a form of energy that always flows from an object at high temperature to an object at lower temperature, but not other way around. For instance, if you open the front door of your house in the winter time, the heat flows out but not vice verse. When you place a piece of ice on the table top, it begins to melt because the heat flows from surrounding into the ice thereby producing the melting process.

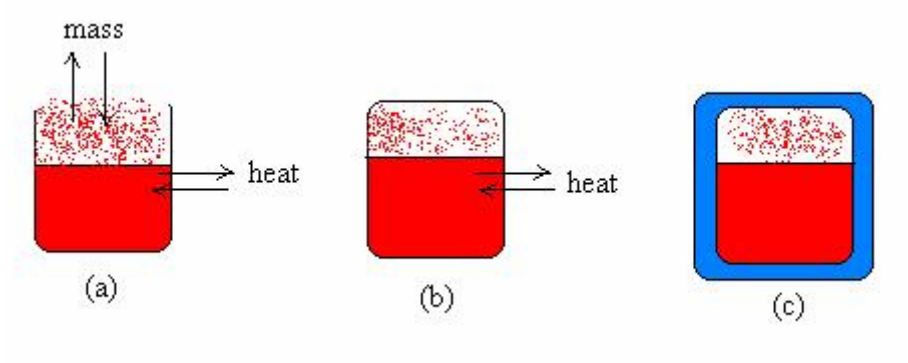
In chemistry, the energy changes in chemical reactions are studied by a special branch of chemistry known as **thermochemistry,** which is *defined as the study of heat changes in chemical reactions.*

To understand energy changes, first we must define two things, the system and the surrounding. The **system** is a specific part of the universe on which we concentrate. In chemistry for example, if you are carrying out an experiment in a beaker, the reaction mixture and the beaker constitute the system. The rest of the universe outside the system is considered as **surrounding**.

There are three types of systems:

- An open system
- A closed system
- An isolated system

An **open system** is the system that can exchange mass and energy (heat) with the surrounding, for example heating water in an open beaker. A **closed system** is the system where only the heat is exchanged with the surrounding. An **isolated system** is the system where neither heat nor mass is exchanged with the surrounding. To understand these little more thoroughly, let us set up a simple experiment. We take a certain quantity of water in an open beaker (open system) and start to heat it up. As the water begins to boil, some water converts into vapor and escapes to the surrounding above the beaker (loss of mass). At the same time, the heat also escapes to the surrounding through the opening as well as through the walls of the beaker. This system is shown below in figure (a). Now in the second experiment, we take the same beaker and close the lid and try to heat it up (closed system). Since the lid is closed, the mass cannot escape. However, the heat can still escape to the surrounding through the lid and through the walls of the beaker. This system is shown below in figure (b). In the third experiment, we completely insulate the beaker and try to heat it up (closed system). Since it is completely insulated, neither mass nor heat can escape to the surrounding. This system is shown in figure(c).



Question

Classify the following as open or closed or isolated system.

1. Human body
2. Our planet
3. Your refrigerator
4. Thermos flask
5. Coffee cup

Endothermic and exothermic processes

The process where the system gains the heat (thermal energy) from the surrounding is known as an **endothermic process**. If the chemical reaction absorbs the heat from the surrounding, it is known as an **endothermic reaction**. For instance, if you put a piece of ice on your palm, it begins to melt. Why it melts? The ice (system), gains the heat from the surrounding (palm + air) causing the ice to melt that is expressed by the following chemical reaction.

$$H_2O\ (s) + \text{energy} \rightarrow H_2O\ (l) \qquad (1)$$

On the other hand, the process where the system releases the heat to the surrounding is called **exothermic process**. If the system is the chemical reaction, it is known as an **exothermic reaction**. When you want make ice cubes, you place ice-tray filled with water in your freezer. How the water becomes ice? Here, your system is the water and the surrounding is the freezer. The water loses the heat to the surrounding thereby becoming a solid (ice), which is expressed by the following chemical equation.

$$H_2O\ (l) \rightarrow H_2O\ (s) + \text{energy} \qquad (2)$$

This process is just the opposite of the process given in Equation (1). The main purpose of the freezer/refrigerator is to extract the heat from the water or to that matter from any food to reduce the rate of spoilage or to prolong the self-life.

In endothermic reactions, the total energy of the products is more than the total energy of reactants; the difference in the energy between the products and reactants is exactly the

same amount of energy supplied by the surrounding. In exothermic reactions, the total energy of the products is less than the total energy of reactants; the difference in the energy is exactly equal to the energy released by the system to the surrounding.

Keep in mind that the above definitions of endothermic and exothermic processes are defined with respect to the system (chemical reaction). You can also define these processes with respect to surrounding. In that case, the definitions are just opposite of the above defined definitions. The first way of defining these processes is commonly accepted because almost all the time we work with the system, and besides, it is easy to manage and measure the chemical properties..