Week 6 Concepts: Nuclear Chemistry, Energy, and

LAWS OF THERMODYNAMICS

In this section, we explore the rules of energy that we observe in the universe. We see many examples of these laws in action on a day-to-day basis. You will learn how to compare and contrast exothermic and endothermic reactions as well as the first and second laws of thermodynamics.

1. Which of these would you classify as an exothermic process?
    - Evaporation of alcohol
    - Photosynthesis
    - Wood burning
    - Ice melting
2. Which one of these processes would **NOT** be possible?
    - Energy is transferred in a chemical reaction
    - Energy is created in a chemical reaction
    - Two liquid chemicals are mixed together, and the temperature of the mixture rapidly cools
    - Energy spontaneously flows from a hot object

Energy cannot be created or destroyed in a chemical reaction.

ENERGY AND FIRST LAW OF THERMODYNAMICS

Energy takes many forms. A few of the more common forms of energy we observe are light, heat, mechanical energy, and electricity. Energy is the driving force of this universe and necessary for all life, light, and movement. Energy can be measured using various units, including calories and joules.

A good starting point in understanding the flow of energy is the First Law of Thermodynamics:

Energy in an isolated system cannot be created or destroyed, only transferred.

This law is often also known as **Conservation of Energy**, as this law tells us that energy is conserved and simply moved from one place to another and one form to another. For example, when you drive a car down the road, you are converting the chemical energy found in gasoline into heat and kinetic (movement) energy. None of this energy is destroyed or eliminated in this process.

As another example of the first law of thermodynamics in action consider a falling stone hitting the earth. The kinetic energy of this stone is converted mainly into sound, and vibration. In both of these examples, we see that energy can move from one form to another.

You may have noticed the term "isolated system" in the 1st Law of Thermodynamics. This term means a system where no matter and no energy go into or out of the system. Our universe, as we understand it, is an example of such a system, so this law applies to our universe.

SECOND LAW OF THERMODYNAMICS

The second law of thermodynamics tells us about how energy in the universe behaves in terms of flow and organization.

The amount of entropy in an isolated system irreversibly increases over time.

This law tells us that the amount of entropy, or disorder, in the universe is constantly increasing. An important reason for this is that heat spontaneously and irreversibly transfers from a hot body to a cold body. An example that illustrates both of these points is a cup of hot coffee sitting outside on a cold winter's day. At first, the heat is localized into the area of the liquid in the cup; however, the heat quickly begins to disperse into the surrounding environment spontaneously. Over time, the coffee in the cup will have the same temperature as the surrounding environment as the temperatures even out. In this way, we see that:

- Heat was spontaneously and irreversibly transferred from a higher temperature system area to the lower temperature surroundings.
- Disorder increased as the localized heat spread through the surroundings.

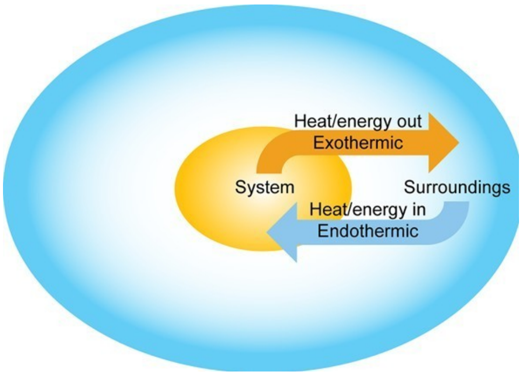
3. For each of the situations, determine if the observed behavior is a consequence of the first or second Law of Thermodynamics:

Situation	Select Law
As a rocket takes off, energy in the fuel is converted into kinetic energy, heat, and light.	1st Law of Thermodynamics
An ice cube melts on a hot day.	2nd Law of Thermodynamics
On a hot day, you turn on the oven, causing the room to become even hotter.	2nd Law of Thermodynamics
Turning on a computer results in electricity being converted into mechanical work, heat, and light.	1st Law of Thermodynamics

ENDOTHERMIC AND EXOTHERMIC REACTIONS

Energy can flow into a system from the surroundings or from the surroundings into the system. The terminology we use for these processes is:

- **Exothermic**: Energy from system to surroundings (energy released)
- **Endothermic**: Energy from surroundings to system (Energy absorbed)



The image illustrates this process. We often measure this energy in the form of heat, so heat flowing from the system to the surroundings is considered exothermic, while heat flowing into the system is considered endothermic. A good mnemonic is that exo = exit (energy exits).

An example of an exothermic process is a burning match. The burning match releases heat into the surroundings and is thus classified as exothermic. On the other hand, you may have used a chemical cooling pack to treat an injury. In a chemical cooling pack, the chemical reaction absorbs heat from the surroundings, cooling your injury. Since energy is going from the surroundings to the system, we would consider this process endothermic.