Medical Physics

The First Stage

Second Term – First Lecture

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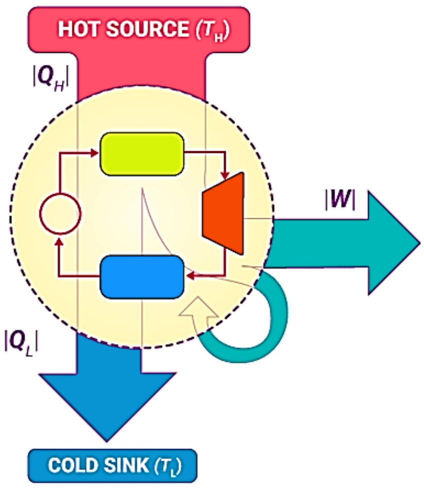
Introduction to Thermodynamic

Difination

Thermodynamics in physics is a branch that deals with heat, work and temperature, and their relation to energy, radiation and physical properties of matter.

To be specific, it explains how thermal energy is converted to or from other forms of energy and how matter is affected by this process. Thermal energy is the energy that comes from heat. This heat is generated by the movement of tiny particles within an object, and the faster these particles move, the more heat is generated.



Distinction Between Mechanics and Thermodynamics

The distinction between mechanics and thermodynamics is worth noting. In mechanics, we solely concentrate on the motion of particles or bodies under the action of forces and torques. On the other hand, thermodynamics is not concerned with the motion of the system as a whole. It is only concerned with the internal macroscopic state of the body.

Different Branches of Thermodynamics

Thermodynamics is classified into the following four branches:

1- Classical Thermodynamics
2- Statistical Thermodynamics
3- Chemical Thermodynamics
4- Equilibrium Thermodynamics

1. Classical Thermodynamics

   In classical thermodynamics, the behaviour of matter is analysed with a macroscopic approach. Units such as temperature and pressure are taken into consideration, which helps the individuals calculate other properties and predict the characteristics of the matter undergoing the process.

2. Statistical Thermodynamics

   In statistical thermodynamics, every molecule is under the spotlight, i.e. the properties of every molecule and how they interact are taken into consideration to characterise the behaviour of a group of molecules.

3. Chemical Thermodynamics

   Chemical thermodynamics is the study of how work and heat relate to each other in chemical reactions and in changes of states.

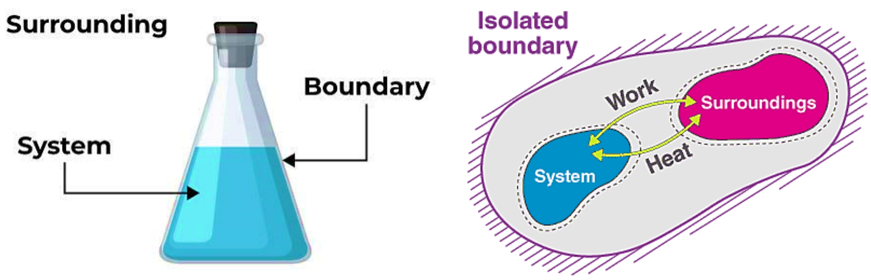
4. Equilibrium Thermodynamics

Equilibrium thermodynamics is the study of transformations of energy and matter as they approach the state of equilibrium.

Basic Concepts of Thermodynamics – Thermodynamic Terms

Thermodynamics has its own unique vocabulary associated with it. A good understanding of the basic concepts forms a sound understanding of various topics discussed in thermodynamics preventing possible misunderstandings.

Thermodynamic Systems



System

A System is a region containing energy and/or mater that is separated from its surroundings by arbitrary imposed walls or boundaries.

System boundary

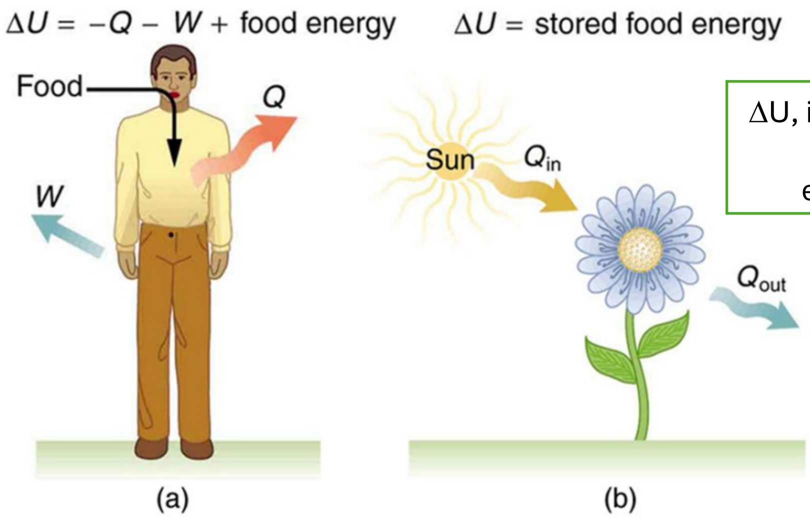
A boundary is a closed surface surrounding a system through which energy and mass may enter or leave the system.

Surroundings

Everything that interacts with the system.

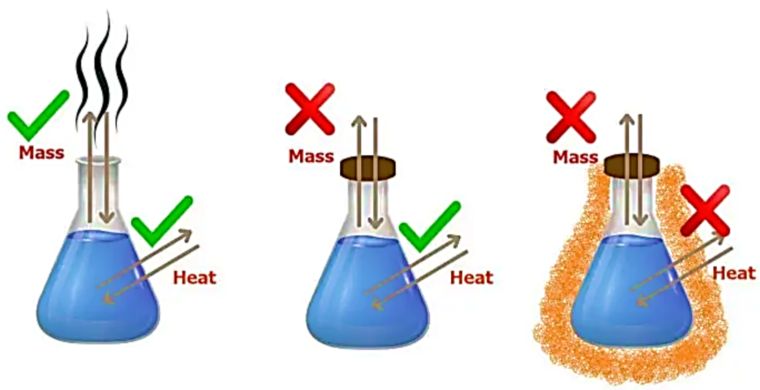
Thermodynamic systems

A thermodynamic system is a specified region of interest. That region can encompass a quantity of matter or a space with fixed or moveable boundaries.



ΔU, internal energy; Q quantity of energy; W, work

The body of a creature, such as a human body or plants, are a thermodynamic systems. Applying the conservation of energy to such a system, we observe that the energy into the body minus the energy out of the body is equal to the energy stored in the body. For this reason, we can manage our weight, which indicates energy storage, by balancing energy intake with energy usage. So, summarizes the three types of thermodynamic systems as describe in next figure.



Open system	Closed system	Isolated system
Mass transfer (yes)	Mass transfer (No)	Mass transfer (No)
Heat transfer (yes)	Heat transfer (Yes)	Heat transfer (No)

Open system (control volume): A thermodynamic system defined by a volume in space of interest. Both matter and energy can enter or exit an open system.

Closed system (control mass): A thermodynamic system consisting of a fixed amount of mass (matter). No mass (matter) enters or exits a closed system. Energy can cross the boundary of a closed system

Isolated system: A completely sealed thermodynamic system or a physical system so far removed from other systems that it does not interact with them. Neither matter nor heat can transfer to or from the system.

Microscopic and macroscopic views:

The term ***microscopic*** refers to anything that is invisible to the naked eye. Therefore, ***microscopic*** properties refer to the properties of matter at microscopic level. However, the term macroscopic refers to the things we can see with the naked eye. Thus, macroscopic properties are the properties of matter in the visible level. Moreover, the units of measurement are different for these two types of properties.

Macroscopic properties of matter are the properties in bulk matter. These properties arise according to how the constituents of matter are arranged in the matter and how the particles are held together.

Microscopic properties are properties of the constituents of bulk matter. That means; these are the properties of atoms, ions or molecules of matter which build up the matter.

Energy exists at all scales, from the smallest subatomic scale to the grandest scale of the universe. At human scales we sense that fast-moving objects have lots of kinetic energy, and that heavy objects up high, springs wound up, or charged capacitors have lots of potential energy. We also sense that a very hot object has much energy, in modern terminology referred to as internal energy (not heat, which in modern term inology refers to a mechanism of energy transfer and not to energy content).

At microscopic scales, internal energy is nothing more than the kinetic and potential energy of the molecules, which we cannot see in detail at our human macroscopic scale.

The energy in the electronic bonds that hold molecules together is another form of internal energy. When a macroscopic object is moving quickly, there is a high degree of organization in the motion of the molecules. In contrast, the object could be motionless but contain the same energy, this time in randomly oriented, disorganized molecular motions (internal energy).

Often an engineer's job is to find some way to convert microscopically disorganized energy (internal energy) into microscopically organized energy (kinetic or potential energy) so that we can produce a macroscopic motion or effect. There is a limit on the ability of macroscopic systems to produce microscopic order. The Second Law of Thermodynamics is the great principle of science that reflects this limit.

Quick Quiz:

(Q1) What is the thermodynamic science, and application in pharmacy?

(Q2) What is the different types of thermodynamic branches?

(Q3) What is the meaning of system, surrounding and system boundary "you can draw diagram to describe your answer"?

(Q4) Explain the macroscopic and microscopic meaning in the system.