Thermodynamics

System and Surrounding and Boundaries

- A **system** is a certain portion of universe selected for investigation. Usually, the word system refers to a collection that makes thinking about a problem more convenient.
- Everything else/outside the system is known as the **surrounding.**

System+Surronding→Universe

For example, if the system being studied is a house, the surrounding would be everything else that is not the house (other houses, the neighbourhood, the general environment around the house, etc.).

- Systems can be described in three different ways:

1. **Isolated:** This is a system in which *no matter or energy* is being exchanged with the surroundings.
2. **Closed:** This is a system in which *only energy* is being exchanged with the surroundings.
3. **Open:** This is a system in which *both matter and energy* is being exchanged with the surroundings.

Examples of Systems

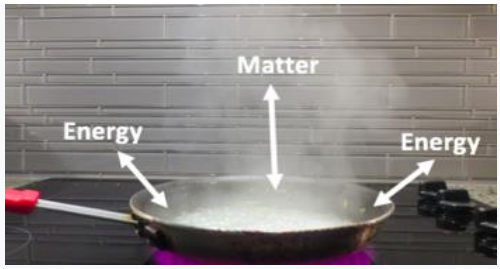

Figure 1. This is an open system. The system is the pan and the surrounding is the kitchen.

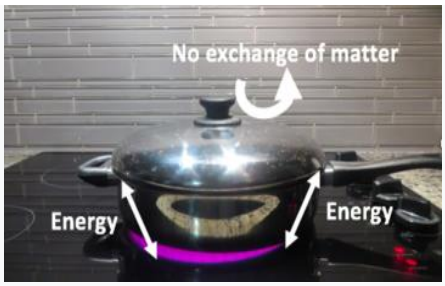

Figure 2. This is a closed system. The system is the pan/lid and the surrounding is the kitchen.

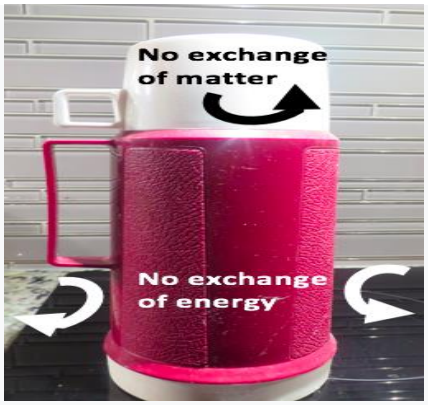

Figure 3. This **is an isolated system. The system is the thermos and the surrounding is the kitchen**.N

Boundary: The envelope which encloses a system separate it from its surroundings is called the **boundary** of the system.

Note: The exchange of energy can take place either by doing work on/by the system (mechanical energy) or thermally (Thermal energy-heat), e.g. Compression or Magnetization belong to former category (mechanical energy) whereas heating belongs to later category (Thermal energy-heat).

- A boundary which prevents thermal interaction/exchange of heat with the surroundings is known as **adiabatic boundary** and the system is known as thermally isolated.
- A boundary through which exchange of heat with surroundings can take place is known as **diathermic boundary**. Obviously, a system with diathermic boundary will be in thermal contact with its surroundings.

State of a System

A thermodynamic state of system at any instant represents its condition at that time. It is specified by a set of experimentally measurable quantities and sufficient to determine all other properties and are known as thermodynamic variables or variables of state, such as **temperature, pressure, volume**, density, electric field, surface area etc. These are independent of its surroundings or history.

Intensive and Extensive Variables

The variables of a system which are independent of its mass or number of particles in the system (depends on the nature of the system) are called **intensive variables** e.g. pressure, temperature, density, specific heat, viscosity, electric field etc. These are not additive.

The variables of a system which are dependent of its mass or number of particles are called **extensive variables** e.g. Volume, Mass, area, electric dipole moment etc. These are not additive.

Specific variables are extensive variable per unit mass. For example:

$$\text{specific volume} = V/m = v.$$

Specific properties are intensive because they do not depend on the mass of the system.

Equilibrium :

An equilibrium state is a particularly simple condition of a system in which variable characterizing it do not change with time.

It is important to note that variable/properties ***describe states only*** when the system is in equilibrium.

Steady states (Dynamic Equilibrium)

It is important not to confuse an equilibrium state with a **steady state**, a state that is constant during a time period during which the system exchanges matter or energy with the surroundings.

Processes

When the values of thermodynamic variables associated with a system change from one equilibrium state to another equilibrium state, the system is said to undergo a thermodynamic process.

Quasi-static Process

A process in which the deviation from thermodynamic equilibrium is infinitesimally small and all the states through which the system possese can be considered equilibrium states, is known as a Quasi-static Process**.**

Reversible and Irreversible Processes

A reversible process is one which can be reversed in such a way that all changes taking place in the direct process are exactly repeated in the reverse order and opposite sense, and no changes are left in any of the bodies taking part in the process or in the surrounding.

Any process which is not reversible exactly is an irreversible process.

All natural processes - conduction, radiation, radioactive decay etc. are irreversible processes.

Condition for reversibility: The process must be carried out quasi-statically and without dissipation of energy (e.g. without friction, viscosity etc).

Cycle

When a system in a given state goes through a series of different processes and finally returns to its initial state, the system is said to have undergone a cycle.

At the end of a cycle all properties have the same value as they had at the beginning.