First Law of Thermodynamics

1.01. THERMAL EQUILIBRIUM AND TEMPERATURE

Two systems are said to be in thermal equilibrium with each other, if they are at the same temperature.

Thus, the temperature is a property, which determines whether the two systems will be in thermal equilibrium or not. In other words, temperature is a thermodynamic property of all the systems, such that any two systems having the same temperature must be in thermal equilibrium.

1.02. ZEROTH LAW OF THERMODYNAMICS

It states that if two systems A and B are in thermal equilibrium with a third system C, then A and B must be in thermal equilibrium with each other.

Fig. 1.01 shows two systems A and B separated by an ***adiabatic wall*** (a wall which does not allow heat flow). The two systems are placed in contact with a third system C with a ***diathermic wall*** (a wall which permits heat flow) in between.

Suppose that the system A, B and C are at different temperatures. Obviously, the three systems will not be in thermal equilibrium with one another. However, the systems A and C ; and the systems B and C will exchange heat and after certain time, they will attain thermal equilibrium separately. If the adiabatic wall between the systems A and B is removed at that time, it will be found that there is no exchange of heat between the systems A and B. Therefore, the systems A and B also acquire thermal equilibrium, when the systems A and B are allowed to attain thermal equilibrium separately with the system C.

1.03. A FEW DEFINITIONS

(*i*) Thermodynamic system. *An assembly of extremely large number of particles having a certain value of pressure, volume and temperature is called a thermodynamic system.* For example, a large collection of gas molecules is a thermodynamic system.

(*ii*) Thermodynamic variables. *The variables which determine the thermodynamic behaviour of a system are called thermodynamic variables.* The quantities like pressure (P), volume (V) and temperature (T) are thermodynamic variables. There are some other thermodynamic variables, such as internal energy (U), entropy (S), etc. All other thermodynamic variables can be expressed in terms of P, V and T.

(*iii*) Equation of state. *A relation between pressure, volume and temperature for a system is called its equation of state.* The state of a system is completely known in terms of its pressure, volume and temperature.

For example, for 1 mole of an ideal gas, the equation of state is

$$PV = RT$$

In a simple system, such as a gas contained in a cylinder, any two variables out of the three variables P, V and T determine the state of the system. The third variable can be known by using the equation of state.

(*iv*) Thermodynamic process. *A thermodynamic process is said to be taking place, if the thermodynamic variables of the system change with time.*

In practice, the following types of thermodynamic processes can take place :

(*a*) *Isothermal process.* *A thermodynamic process that takes place at constant temperature is called isothermal process.*

(b) *Isobaric process.* *A thermodynamic process that takes place at constant pressure is called isobaric process.*

(c) *Isochoric process.* *A thermodynamic process that takes place at constant volume is called isochoric process.*

(d) *Adiabatic process.* *A thermodynamic process in which no heat enters or leaves the system is called adiabatic process.*

(e) *Cyclic process.* *A thermodynamic process in which the system returns to its original state is called a cyclic process.*