

## Zeroth Law of Thermodynamics:-

The zeroth law of thermodynamics states that if two bodies are in thermal equilibrium with a third body, they are also in thermal equilibrium with each other.

If  $\boxed{A}$  and  $\boxed{B}$  are in thermal equilibrium

and  $\boxed{B}$  and  $\boxed{C}$  are in thermal equilibrium,

then  $\boxed{A}$  and  $\boxed{C}$  are in thermal equilibrium.

$$T_A = T_B, \quad T_B = T_C$$

$$\therefore T_A = T_C$$

When a body is brought into contact with another body that is at a different temperature, heat is transferred from the body at higher temperature to the one at lower temperature until both bodies attain the same temperature. At that point, the heat transfer stops, and the two bodies are said

to have reached thermal equilibrium. The equality of temperature is the only requirement for thermal equilibrium.

Energy:

Energy is defined as that capacity a body or substance possesses which can result in the performance of work. From the law of conservation of energy the energy cannot be created or destroyed.

Energy can exist in numerous forms such as thermal, mechanical, kinetic, potential, electric, magnetic, chemical, and nuclear, and their sum constitutes the total energy  $E$  of a system. The total energy of a system on a unit mass basis is denoted by  $e$  and is expressed as

$$e = \frac{E}{m} \quad (\text{kJ/kg})$$

In thermodynamic analysis, it is often helpful to consider the various forms of energy that make up the total energy of a system in two groups:

macroscopic and microscopic. The macroscopic energy of a system is related to motion and the influence of some external effects such as gravity, magnetism, electricity and surface tension. The energy that a system possesses as a result of its motion relative to some reference frame is called kinetic energy (KE). When all parts of a system move with same velocity, the kinetic energy is expressed as

$$KE = m \frac{V^2}{2} \quad (\text{kJ})$$

Or, on a unit mass basis,

$$ke = \frac{V^2}{2} \quad (\text{kJ/kg})$$

where  $V$  denotes the velocity of the system relative to some fixed reference frame.

The energy that a system possesses as a result of its elevation in a gravitational field is called potential energy (PE) and is expressed as

$$PE = mgz$$

or on a unit mass basis,

$$Pe = g z$$

where

$g$  is the gravitational acceleration.

$z$  is the elevation of the center of gravity of a system relative to some arbitrarily selected reference level.

The microscopic forms of energy are those related to the molecular structure of a system and the degree of the molecular activity, and they are independent of outside reference frames. The sum of all the microscopic forms of energy is called the internal energy of a system and is denoted by  $U$ .

The magnetic, electric, and surface tension effects are significant in some specialized cases and are usually ignored. In the absence of such effects, the total energy of a system consists of the kinetic, potential, and internal energies and is expressed as

$$E = U + KE + PE = U + m \frac{V^2}{2} + mgz \quad (\text{kJ})$$

or, on a unit mass basis,

$$e = u + ke + pe = u + \frac{V^2}{2} + gz \quad (\text{kJ/kg})$$

The first law of Thermodynamics:-

The first law of thermodynamics can be stated as follows:-

When a system undergoes a thermodynamics cycle then net heat supplied to the system from the surroundings is equal to net work done by the system on its surroundings.

$$\oint dQ = \oint dW$$

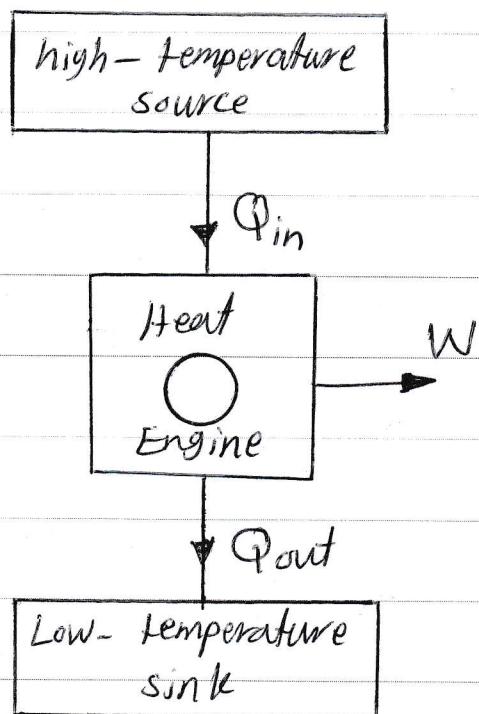
where  $\oint$  represents the sum for a complete cycle.

The second Law of Thermodynamics:-

The second law of thermodynamics indicates that, although the net heat supplied in a cycle is equal to the net work done, the gross heat supplied must be greater than the net work done, some heat must always be rejected by the system.

## Heat Engine:-

A heat engine is a system that converts heat or thermal energy to mechanical energy, which can then be used to do mechanical work. The second law implies that a source of heat supply and a sink for the rejection of heat are both necessary, since some heat must always be rejected by the system.



where

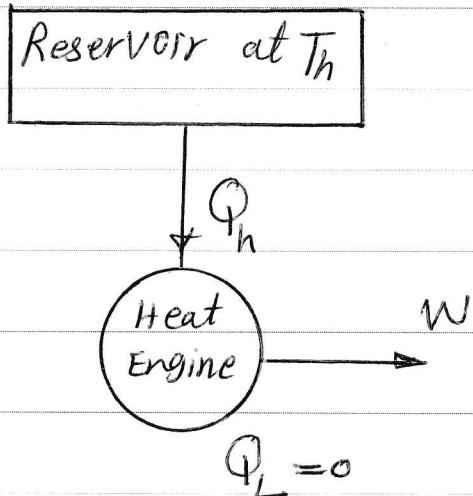
$Q_{in}$  is the heat supplied from the source

$Q_{out}$  is the heat rejected

$W$  is the work done.

Kelvin- Planck statement :-

It is impossible for any device that operates on a cycle to receive heat from a single reservoir and produce a net amount of work. Therefore, it is not possible to have the following system with  $Q_L = 0$ . We cannot convert all of the heat from reservoir to work.



Clausius statement :-

It is impossible to construct a device that operates in a cycle and produces no effect other than the transfer of heat from a lower-temperature body to a higher-temperature body. It simply states that a refrigerator cannot operate unless its compressor is driven by an external power source, such as electric motor.

By the first law of thermodynamics, in a complete cycle

Net heat supplied = Net work done

$$\sum dQ = \sum dw$$

$$Q_{in} - Q_{out} = W$$

By the second law, the gross heat supplied must be greater than the net work done,

$$Q_{in} > W$$

Thermal Efficiency:

The thermal efficiency of a heat engine is defined as the ratio of the net work done in the cycle to the gross heat supplied in the cycle.

$$\text{Thermal efficiency, } \eta = \frac{W}{Q_{in}}$$

$$= \frac{Q_{in} - Q_{out}}{Q_{in}} = 1 - \frac{Q_{out}}{Q_{in}}$$

## Entropy:-

The first law of thermodynamics deals with the property energy and the conservation of it. The second law leads to the definition of a new property called entropy.

Entropy is a function of a quantity of heat which shows the possibility of conversion of that heat into work. The increase in entropy is small when heat is added at a high temperature and is greater when heat addition is made at a lower temperature. Thus for maximum entropy, there is minimum availability for conversion into work and for minimum entropy

there is maximum availability for conversion into work. The term 'entropy' was first introduced by Clausius.

Entropy can be viewed as a measure of molecular disorder, or molecular randomness. As a system becomes more disordered, the positions of the molecules become less predictable and the entropy increases. Thus, it is surprising that the entropy of a substance is lowest in the solid phase and highest in the gas phase. In the solid phase, the molecules of a substance continually