ENTROPY

Entropy Change :- The equation (...) of Carnot cycle may be rearrange as

$$1 - \frac{q_1}{q_2} = 1 - \frac{T_1}{T_2}$$

$$\text{or } \frac{q_1}{q_2} = \frac{T_1}{T_2}$$

$$\text{or } \frac{q_1}{T_1} = \frac{q_2}{T_2} \quad \text{——— (a)}$$

In General form equation (10) may be written as $\frac{q_{rev}}{T} = \text{Constant}$ ——— (b)

The quantity $\frac{q_{rev}}{T}$ represents a definite quantity or state function viz. the entropy change of the system -

Entropy is defined as

$$ds = \int \frac{dq_{rev}}{T}$$

$$\Delta S = \frac{q_{rev}}{T}$$

(a) Entropy S is a thermodynamic function and it can be expressed in terms of P, V and T.

(b) Entropy change value depends only on the final and initial state of the system, not on the Path of change.

(c) Entropy is an extensive properties, its value depends upon the amount of substance involved.

(d) Absorption of heat increases the entropy of the system and loss of heat decreases entropy of the system.
In adiabatic process $dq = 0$, so entropy change is zero.

Entropy Change in Carnot Cycle : —

For each Carnot cycle

$$\frac{q_1}{T_1} + \frac{q_2}{T_2} = 0 \quad \text{——— (1)}$$

For reversible cycle,

$$\sum \frac{q}{T} = 0 \quad \text{——— (2)}$$

If change is infinitesimal

$$\sum \frac{dq}{T} = 0 \quad \text{——— (3)}$$

If cycle is performed in two steps i.e A to B and Back from B to A.

$$\sum \frac{dq}{T} = \int_A^B \frac{dq}{T} + \int_B^A \frac{dq}{T} = 0 \quad \text{——— (4)}$$

Now, $\int_A^B \frac{dq}{T}$ is the summation of all the change in $\frac{dq}{T}$ along Path I.

and $\int_B^A \frac{dq}{T}$ is the summation of all the change in $\frac{dq}{T}$ along Path II.

Now eqn (4) can be written as

$$\int_A^B \frac{dq}{T} = -\int_B^A \frac{dq}{T}$$

$$\text{or} \quad \int_A^B \frac{dq}{T} \text{ (Path I)} = \int_B^A \frac{dq}{T} \text{ (Path II)} \qquad (5)$$

It follows from above that $\int_A^B \frac{dq}{T}$ is a definite quantity independent of the Path.

If S_A is the entropy in initial state A.

and S_B is the entropy in final state B.

Then change in entropy

$$\Delta S = S_B - S_A = \int_A^B \frac{dq}{T} \qquad (6)$$

for infinitesimally small change

$$dS = \frac{dq}{T} \qquad (7)$$

At constant temperature for a finite change dS becomes ΔS and dq becomes q.

$$\therefore \quad \Delta S = \frac{q}{T} \qquad (8)$$

The change of entropy (ΔS) for state A to B will invariably be the same whether the change is reversible or not.

$$\text{i.e.} \quad \Delta S = \int_A^B \frac{dq}{T} \qquad (9)$$

The entropy change for a finite change of state at constant Temperature is given by.

$$\Delta S = \frac{q_{rev}}{T}$$

Unit of entropy: —

The unit of entropy is Joules per degree Kelvin i.e ($J K^{-1}$)

This is known as entropy unit (e.u.)

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