

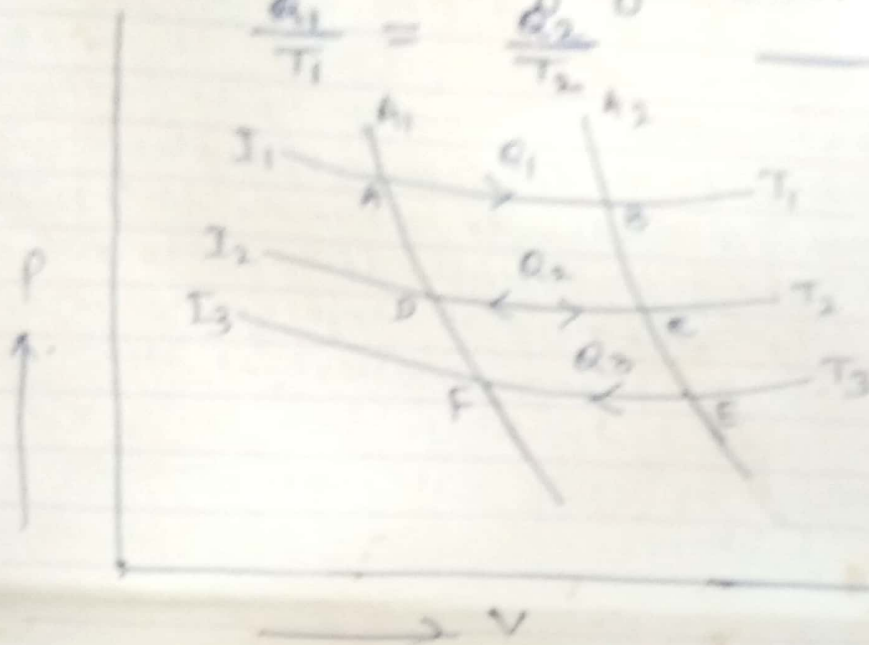
Concept of Entropy

The concept of entropy was first introduced by Clausius in 1854 while working on the formulation and application of the second law of thermodynamics. The exact meaning of entropy is transformation. It is a very important thermodynamic quantity and has proved very useful in the study of the behaviour of heat engines.

Considering the isothermals I_1, I_2 & I_3 at temperatures T_1, T_2 & T_3 on a P-V indicator diagram. Let A_1 and A_2 be two adiabats which intersect these isothermals at A and B, C and D, E and F respectively. The all along the adiabats A_1 and A_2 , there is a change in volume and temperature with change in pressure. Let ABCD and DCEF represent the Carnot's reversible cycle. Considering the cycle ABCD, Let Q_1 be the

heat absorbed from A to B at temperature T_1 , and let Q_2 be the heat rejected from C to D at temperature T_2 , then from the theory of a Carnot engine,

$$\frac{Q_1}{T_1} = \frac{Q_2}{T_2} \quad \text{--- (1)}$$



Similarly, considering the cycle DCEF, Q_2 heat be absorbed at T_2 and Q_3 heat be rejected at T_3 then

$$\frac{Q_2}{T_2} = \frac{Q_3}{T_3} \quad \text{--- (2)}$$

From (1) and (2)

$$\frac{Q_1}{T_1} = \frac{Q_2}{T_2} = \frac{Q_3}{T_3} = \dots = \text{a constant}$$

In going from one adiabatic to the other, heat energy is either absorbed or rejected.

The amount of heat absorbed or rejected is not constant but depends upon the temperature.

Higher the temperature, more is the heat absorbed or rejected and vice-versa.

In general, if Q be the heat absorbed or rejected at a temperature T in going from one adiabatic to the other, then

$$\frac{Q}{T} = \text{constant}$$

This constant ratio is called the change in entropy between the states represented by the two adiabatics. Let S_1 and S_2 be respectively the entropy for the adiabatics A_1 and A_2 then,

$$S_2 - S_1 = \frac{Q}{T} = \text{Constant} \quad (2)$$

If the adiabatics lie very close to each other and dQ is the quantity of heat absorbed or rejected at a temperature T in going from one adiabatic to the other, then

$$\text{Change in entropy, } ds = \frac{dQ}{T}$$

Hence in general, the change in entropy (4)

$$\int_{S_1}^{S_2} ds = S_2 - S_1 = \int_{A_1}^{A_2} \frac{dQ}{T} \quad (5)$$

The expression $\int_{A_1}^{A_2} \frac{dQ}{T} = \int_{S_1}^{S_2} ds$ is a function

of the thermodynamic coordinates of a system. This integral refers to the value of the function at the final state minus its value at the initial state. This function is called entropy and is represented by S .

Hence entropy of a system is a function of the thermodynamical coordinates defining the state of the system. Moreover, ds is an exact differential since it is the differential of an actual function.

All along the adiabatic, neither heat is given nor heat is rejected from the system.

Therefore, $dQ = 0$

$$\text{change in entropy} = \frac{dQ}{T} = 0$$

It means that entropy all along the adiabatic

is constant. Therefore, the entropy of a substance is that physical quantity which remains constant when the substance undergoes a reversible adiabatic process.