B-Sc. II (H) – PAPER – III A.

Entropy and Entropy change of Ideal gas

Entropy: – Entropy of a system is an extensive properties which provides a measure of disorder or randomness. It is denoted by S. It is state function and not measured directly but only change in entropy of the system is measured.

Mathematically change in entropy of a reversible system is defined as

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

where q_{rev} is change in heat of system reversively at temperature T. Entropy unit is $JK^{-1}mol^{-1}$

If system changes from A to B reversibly then the entropy change is given as $\Delta S_{syst} = \frac{q_{rev}}{T}$ and corresponding entropy change in surroundings $\Delta S_{surr} = -\frac{q_{rev}}{T}$

For reversible process.

$$\Delta S_{system} + \Delta S_{surround} = 0$$

Irreversible process $\Delta S_{system} + \Delta S_{surrou} > 0$.

As all the natural process are spontaneous i.e irreversible, The entropy of Universe is always increasing.

Entropy change in an ideal gas :-

The change in entropy of system is defined as

$$ds = \frac{\delta q_{rev}}{T} \quad \text{--- (i)}$$

or, $\delta q_{rev} = T ds$

From First law of thermodynamics

$$dq_{rev} = dE + Pdv \quad \text{--- (ii)}$$

or From equation (i) and (ii)

$$ds = \frac{dE + Pdv}{T}$$

$$= \frac{dE}{T} + \frac{Pdv}{T} \quad \text{--- (iii)}$$

We know $C_V = \frac{dE}{dT}$ or $dE = C_V \cdot dT$

$$\therefore ds = C_V \cdot \frac{dT}{T} + \frac{Pdv}{T} \quad \text{--- (iv)}$$

For one mole of gas $PV = RT$ or $P = \frac{RT}{V}$ --- (v)

From equation (iv) and (v)

$$ds = C_V \cdot \frac{dT}{T} + \frac{Rdv}{V} \quad \text{--- (vi)}$$

On Integrating we get

$$S = C_V \ln T + R \ln V + S_0 \quad \text{--- (vii)}$$

S_0 = constant.

For Initial state (1)

$$S_1 = C_V \ln T_1 + R \ln V_1 + S_0$$

and final state (2)

$$S_2 = C_V \ln T_2 + R \ln V_2 + S_0$$

or, $\boxed{\Delta S = S_2 - S_2 = C_v \ln \frac{T_2}{T_1} + R \ln \frac{V_2}{V_1}}$ — (viii)

This is required relation between change of entropy of ideal gas when temperature and volume of initial state and final state is know

1. Alternative form of equation (iii)

$C_p - C_v = R$ or $C_v = C_p - R$ — (IX)

and $PV = RT$ and $V = \frac{RT}{P}$ — (X)

Puting value of eq (IX) and (X) in eq (VII) we get

$$S = (C_p - R)\ln T + R \ln \frac{RT}{P} + S_0$$

$$S = C_p \ln T - R\ln T + R\ln R + R\ln T - R\ln p + S_0$$

or $S = C_p \ln T - R\ln p + [R\ln R + S_0]$

or $S = C_p \ln T - R\ln p + S_0'$ — (XII)

S_0' = another integration constant

then entropy change can be written

$$\boxed{\Delta S = S_2 - S_1 = C_p \ln \frac{T_2}{T_1} - R \ln \frac{P_2}{P_1}}$$

—X—

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