B.Sc, B.Sc II (H) Paper III A

Free energy

Free energy or Gibb's free energy is a thermodynamic quantity which is mathematically defined as

$$G = H - TS$$

Here G = Free energy, H = Enthalp, T = Temperature and S is entropy of system.

As H, T and S is the state function hence G is also will be also free energy. a state function. Let a isothermal process occurs at a temperature T and hence

$G_1 = H_1 - TS_1$ For initial state — (i)

$G_2 = H_2 - TS_2$ For final state — (ii)

or $G_2 - G_1 = (H_2 - TS_2) - (H_1 - TS_1)$

$= (H_2 - H_1) - T(S_2 - S_1)$.

or $\Delta G = \Delta H - T\Delta S$ — (iii)

ΔG = Change in free energy

ΔH = change in Enthalpy

ΔS = change in entropy.

From definition of entropy.

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

or $T\Delta S = q_{rev}$ — (iv)

At constant pressure

$$\Delta H = E + PV \quad \text{—— (V)}$$

From equation (V), (IV) and (III) we get

$$\Delta G = (E + PV) - Q_{rev}$$

$$= (\Delta E - Q_{rev}) + PV \quad \text{— (VI)}$$

From First law of thermodynamic

$$\therefore Q_{rev} = \Delta E + W_{max}$$

or $$\Delta G - Q_{rev} = -W_{max} \quad \text{— (VII)}$$

From (VII) and (VI)

$$\Delta G = -W_{max} + P\Delta V$$

or $$\boxed{-\Delta G = W_{max} - P\Delta V} \quad \text{— (VIII)}$$

$P\Delta V$ is work of expansion and hence $W_{max} - P\Delta V$ means maximum work other than work of expansion i.e useful work other than work of expansion is called decrease in free energy.

If ΔG is -ve, the process is spontaneous
ΔG is +ve the process is non-spontaneous
ΔG is zero, the process is called at equilibrium.

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