Partial molar Properties

The thermodynamic properties U, H, S, A and G named internal energy (U), enthalpy (H), entropy (S), Work function A and Gibbs free energy (G) are extensive properties, its value change with change in number of moles.

$$\text{let} \quad X = f(T, P, n_1, n_2 \cdots n_i \cdots n_j) \quad \text{—— (1)}$$

$$\text{where } n_1 + n_2 + n_3 + \cdots + n_j = N \quad (i \neq j)$$

no. of moles of the Component.

For small change in temp, pressure and no. of moles of the Component.

$$dx = \left(\frac{\partial x}{\partial T}\right)_{P,N} dT + \left(\frac{\partial x}{\partial P}\right)_{T,N} dP + \left(\frac{\partial x}{\partial n_1}\right)_{P,T,n_2,n_3 \cdots n_j} dn_1 + \text{------} \quad (2)$$

The quantity $\left(\frac{\partial x}{\partial n_1}\right)_{T,P,n_2,n_3 \cdots n_i}$ is called the partial molar properties of 1st Component and represented by $\overline{X}_1$

Similarly for the ith Component:-

$$\left(\frac{\partial x}{\partial n_i}\right)_{T,P,n_1,n_2,n_3 \cdots} = \overline{X}_i = \text{Partial molar Properties}$$

$$\left(\frac{\partial U}{\partial n_i}\right)_{T,P,n_1,n_2 \cdots} = \overline{U}_i = \text{Partial molar internal energy}$$

$$\left(\frac{\partial H}{\partial n_i}\right)_{T,P,n_1,n_2 \cdots} = \overline{H}_i = \text{Partial molar enthalpy}$$

$$\left(\frac{\partial S}{\partial n_i}\right)_{T,P,n_1,n_2,n_3 \cdots} = \overline{S}_i = \text{Partial molar entropy}$$

$$\left(\frac{\partial V}{\partial n_i}\right)_{T,P,n_1,n_2 \cdots} = \overline{V}_i = \text{Partial molar Volume}$$

Chemical Potential: — The Partial molar free energy is designated as Chemical Potential and represented by Symbol μ.

$$\left(\frac{\partial G}{\partial n_i}\right)_{T,P,n_1,n_2,n_3 \cdots} = \overline{G}_i = \mu_i \quad \text{——} ③$$

For infinitesimal Change in free energy, We can write the following equation

$$dG = \left(\frac{\partial G}{\partial T}\right)_{P,N} dT + \left(\frac{\partial G}{\partial P}\right)_{T,n_1,n_2 \cdots n_i} dP + \left(\frac{\partial G}{\partial n_1}\right)_{T,P,n_2,n_3 \cdots n_i \cdots} dn_1 + \left(\frac{\partial G}{\partial n_2}\right)_{T,P,n_1,n_3 \cdots n_i \cdots} dn_2 + \text{------}$$

$$\text{or, } dG = \left(\frac{\partial G}{\partial T}\right)_{P,N} + \left(\frac{\partial G}{\partial P}\right)_{T,n_1,n_2 \cdots n_i \cdots} dP + \mu_1 dn_1 + \mu_2 dn_2 + \text{----} + \mu_i dn_i \text{ —(}$$

where μ_1, μ_2, μ_3 ------ μ_i are chemical Potential of 1, 2, 3, 4 --- i Component respectively.

If T and P remains constant then $(dG)_{T,P} = \mu_1 dn_1 + \mu_2 dn_2 + \text{----} + \mu_i dn_i$ —(

If a system has a definite Composition having $n_1, n_2, n_3 \cdots n_i$ moles of Constituents 1, 2, 3 --- i ..respectively, then integrating eqn (5) we h

$$(G)_{T,P,N} = n_1 \mu_1 + n_2 \mu_2 + \text{-----} + n_i \mu_i \quad \text{——} ⑥$$

For one mole of Pure Substance $G = \mu$

i.e Free energy is identical with chemical Potential.

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