$$(dG)_{T,P} < 0 \qquad (dA)_{T,V} < 0$$

$$(dG)_{T,P,n} = 0 \qquad (dA)_{T,V} = 0$$

$$dG(T, P, n_1, n_2, \ldots) = V\,dp - S\,dT + \sum_{i=1}^{m} \mu_i \, dn_i$$

$$\mu_i \equiv \left(\frac{\partial G(T, P, n_1, \ldots, n_m)}{\partial n_i}\right)_{T, P, \{n_{j \neq i}\}}$$

species "i"

Intensive Property

G extensive property, 1st order extensive.

$$\lambda^1 G(T, P, n_1, n_2, \ldots, n_m) = G(T, P, \lambda n_1, \lambda n_2, \ldots, \lambda n_m)$$

At T, P constant,

Take derivative wrt $\underline{\lambda}$

$$G(T, P, n_1, n_2, \dots, n_m) = \frac{\partial}{\partial \lambda}\left[G(T, P, \lambda n_1, \lambda n_2, \dots, \lambda n_m\right]$$

$$= \sum_{i=1}^{m} \left(\frac{\partial(\lambda n_i)}{\partial \lambda}\right)\left(\frac{\partial G}{\partial(\lambda n_i)}\right)_{T, P, \{\lambda n_{j \neq i}\}}$$

$$= \sum_{i=1}^{m} (n_i)\left(\frac{\partial(\lambda G(T, P, n_1, \dots, n_m))}{\partial(\lambda n_i)}\right)_{T, P, \{\lambda n_{i \neq j}\}}$$

$$= \sum_{i=1}^{m} (n_i)\left(\frac{\cancel{\lambda}}{\cancel{\lambda}}\right)\left(\frac{\partial G(T, P, n_1, n_2, \dots, n_m)}{\partial n_i}\right)_{T, P, \{n_{j \neq i}\}}$$

$$= \sum_{i=1}^{m} (n_i)\, \mu_i$$

m component system at T, P constant

$$\boxed{G(T, P, n_1, \dots, n_m) = \sum_{i=1}^{m} \mu_i n_i} \quad !!!$$

$$dG(T,p,\{n_i\}) = Vdp - SdT + \sum_{i=1}^{m} \mu_i dn_i$$

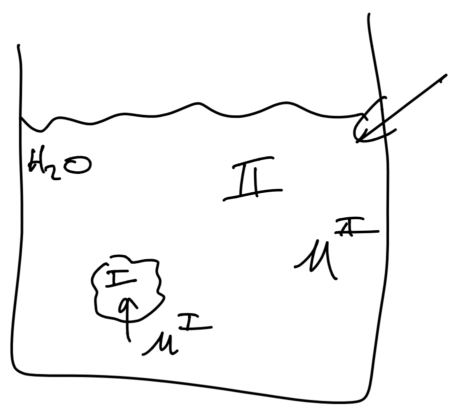
T, p constant.

$$dG = \sum_{i=1}^{m} \mu_i dn_i$$

$$dG = \mu\, dn \quad \leftarrow 1 \text{ component}$$

T, p

Equil.



$$(dG)_{T,p,\{n\}} = 0 \quad @ \text{ Equil.}$$

$$dG = \mu\, dn = 0$$

$$dn^{I}, \quad dn^{II}$$

$$dn^{I} = -dn^{II}$$

$$dn^{I} + dn^{II} = 0 = dn$$

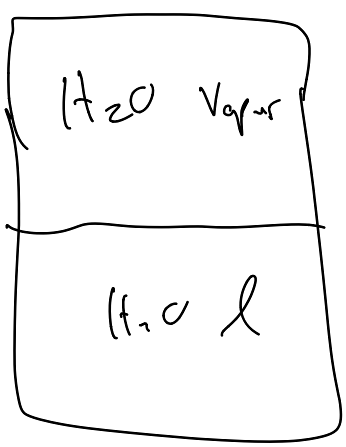
$$dG = \mu^{I}\,dn^{I} + \mu^{II}\,dn^{II}$$

$$\Rightarrow \quad dn^{I} = -dn^{II}$$

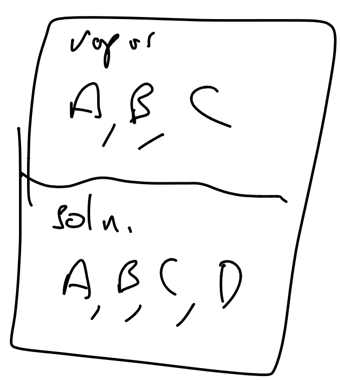
$$dG = (\mu^{I} - \mu^{II})\,\underbrace{dn^{I}}_{\text{non-zero}} = 0$$

$$\therefore \quad \mu^{I} - \mu^{II} = 0$$

$$\boxed{\mu^{I} = \mu^{II}} \quad !!!$$

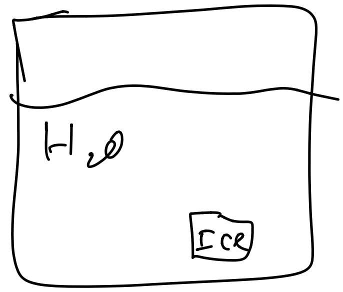


$$\mu^{vapor}_{H_2O} = \mu^{liquid}_{H_2O}$$



$$\mu_A^{soln} = \mu_A^{vapor}$$

$$\mu_B^{soln} = \mu_B^{vapor}$$



$$\mu_{H_2O}^{l} = \mu_{H_2O}^{ice}$$

@ equilibrium

Pure Species

$$G = \mu n$$

$$dG = d(\mu \underline{\underline{n}}) = V\,dp - S\,dT$$

$$\boxed{d\mu = \underset{\text{molar}}{\bar{V}}\,dp - \underset{\text{molar}}{\bar{S}}\,dT}$$

at Constant T:

$$d\mu = \bar{V}\,dp$$

$$\bar{V}^{ig} = \frac{RT}{P}$$

$$d\mu = RT\frac{dP}{P} = RT\,d(\ln P)$$

T = constant, vary P

$$\mu_2 - \mu_1 = RT\int_{P_1}^{P_2} d(\ln P)$$

$$\mu_2 - \mu_1 = RT \ln\left(P_2/P_1\right)$$

$$\mu_2 = \mu_1(T, P_1) + RT \ln\left(P_2/P_1\right)$$

$$P_1 = 1\ \text{bar} = P^\circ$$

$$\mu_2 = \mu_1(T, P^\circ) + RT \ln\left(P_2/P^\circ\right)$$

$$= \mu_1(T, P^\circ) + RT \ln\left(P_2/1\ \text{bar}\right)$$

$$\mu_2(T, P_2) = \mu_1(T, P^\circ) + RT \ln\left(P_2\right)$$