Chemical equilibrium $\quad \checkmark\ 2H_2 + O_2 \rightarrow 2H_2O$

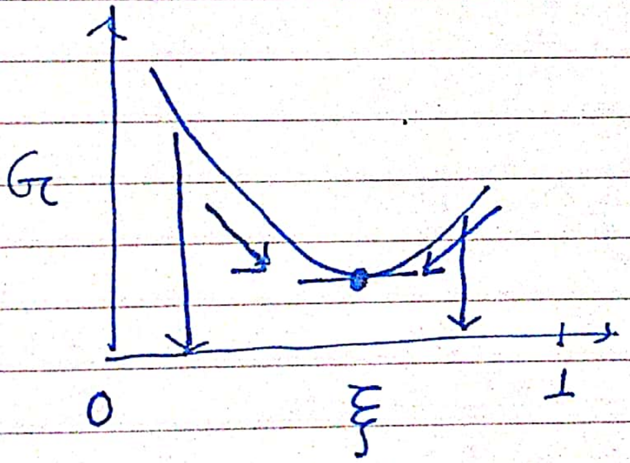
$$\boxed{\nu_A A + \nu_B B \rightleftharpoons \nu_C C + \nu_D D}$$

ξ (xi) : reaction extent

$$\Delta_r G = \left(\frac{\partial G}{\partial \xi}\right)_{P,T}$$

$P, T, \underbrace{n_A, n_B, n_C, n_D}$

$$\cancel{\left(\frac{\partial G}{\partial n_A}\right)_{P,T,n_C,n_D,n_B}}$$



$$(A+B) \rightarrow (C+D)$$
$\downarrow \qquad \uparrow$

$$\underbrace{(\nu_C\mu_C + \nu_D\mu_D)}_{\text{products}} - \underbrace{(\nu_A\mu_A + \nu_B\mu_B)}_{\text{reactants}}$$

$$= \sum_J \nu_J \mu_J$$

$$= \sum_J \nu_J \left(\mu_J^\circ + RT \ln \frac{P_J}{P^\circ}\right)$$

$$= \sum (\nu_J \mu_J^\circ) + RT \sum \nu_J \ln \frac{P_J}{P^\circ} \quad (1)$$

$$\Delta_r G = \underbrace{\sum_J \nu_J \mu_J^\circ}_{} + RT \sum_J \nu_J \ln p_J/p^\circ \equiv \left(\frac{\partial G}{\partial \xi}\right)_{p,T}$$

$$= \Delta_r G^\circ + RT \ln \underbrace{\prod \left(p_J/p^\circ\right)^{\nu_J}}_{Q}$$

$a \ln b = \ln b^a$

$\ln c + \ln d$

$= \ln (c \times d)$

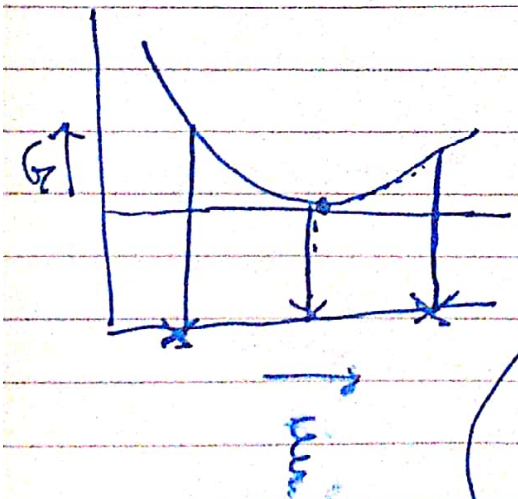
$$\nu_A A + \nu_B B \rightarrow \nu_C C + \nu_D D$$

$$Q = \prod_J \left(\frac{p_J}{p^\circ}\right)^{\nu_J}$$

$$= \left(\frac{p_A}{p^\circ}\right)^{-\nu_A} \left(\frac{p_B}{p^\circ}\right)^{-\nu_B} \left(\frac{p_C}{p^\circ}\right)^{\nu_C} \left(\frac{p_D}{p^\circ}\right)^{\nu_D}$$

$K_p \,|\, K_c$

$$= \frac{\left(p_C/p^\circ\right)^{\nu_C} \left(p_D/p^\circ\right)^{\nu_D}}{\left(p_A/p^\circ\right)^{\nu_A} \left(p_B/p^\circ\right)^{\nu_B}}$$

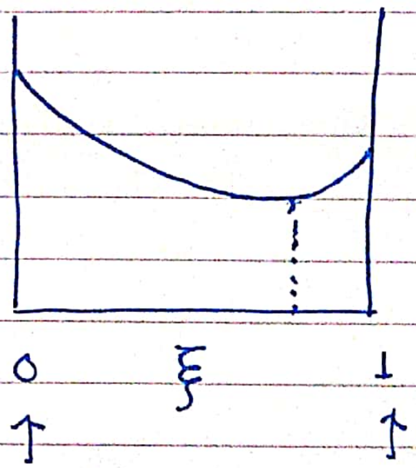


$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

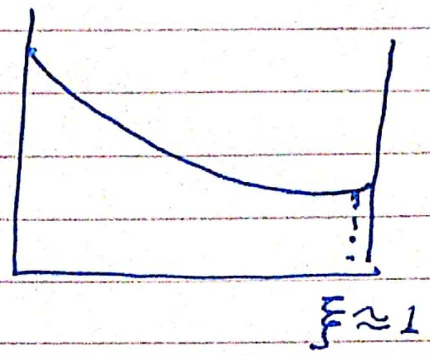
$$\Delta_r G = \Delta_r G^\circ + RT \ln Q$$

At eqm $\quad 0 = \Delta_r G^\circ + RT \ln \underbrace{Q|_{eq}}_{K_{eq}}$

$$\Delta_r G = \underbrace{-RT \ln K_{eq}}_{} + RT \ln Q$$



$2H_2 + O_2 \rightarrow 2H_2O$



P, T $\qquad K_{eq} \equiv K_p$

$$\left\{ \begin{aligned} \frac{\partial (G_2/T)}{\partial T} &= -\frac{H_2}{T^2} \\ \frac{\partial (G_1/T)}{\partial T} &= -\frac{H_1}{T^2} \end{aligned} \right.$$

Gibbs - Helmholtz eqn:

$$\boxed{\frac{\partial (G/T)}{\partial T} = -\frac{H}{T^2}} \Rightarrow \frac{\partial (\Delta G/T)}{\partial T} = -\frac{\Delta H}{T^2}$$

$K = K(T)$?

$$\Delta_r G^\circ = -RT \ln Q|_{eq} = -RT \ln K_{eq}$$

$$-R \frac{\partial \ln K_{eq}}{\partial T} = \frac{\partial}{\partial T}\left(\Delta_r G^\circ / T\right)$$

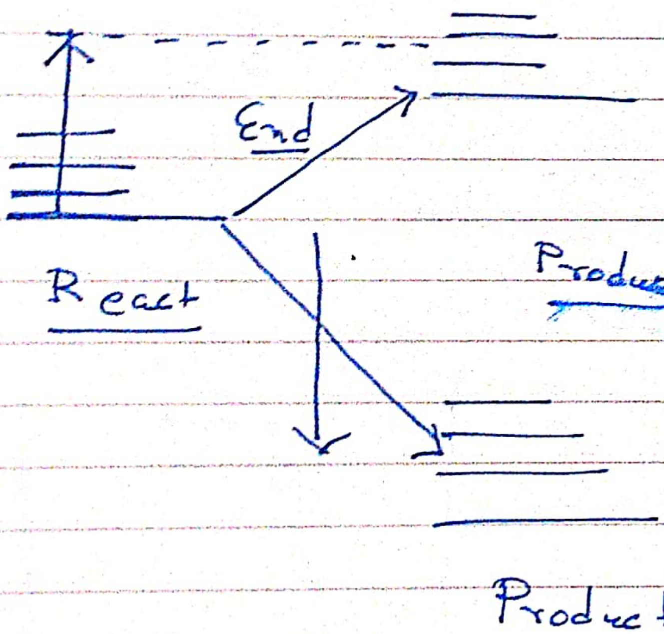
$$\boxed{\frac{d \ln K_{eq}}{dT} = \frac{\Delta_r H^\circ}{RT^2}}$$

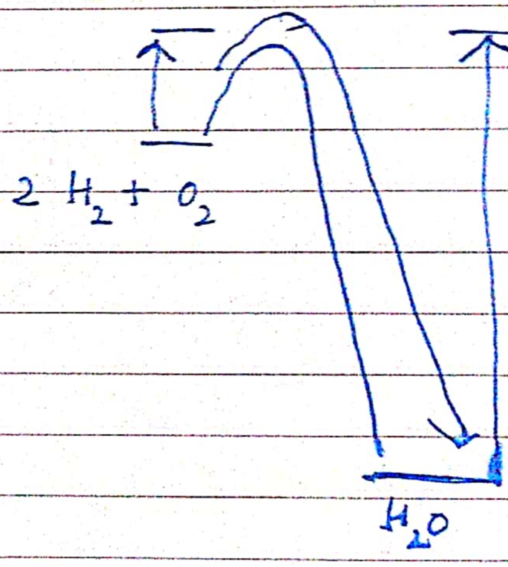
$\Delta_r H^\circ > 0$ endo

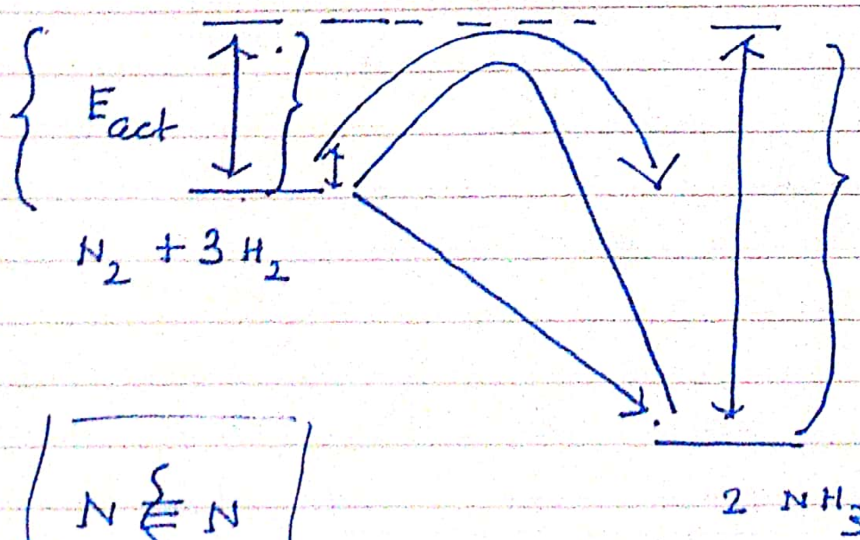
$\Delta_r H^\circ < 0$ exo

$N_2 + 3H_2 \rightleftharpoons 2NH_3 \qquad \Delta_r H^\circ < 0$

$T \downarrow \qquad K_{eq} \uparrow$







$\Delta E \approx RT$

$\Delta \varepsilon \approx k_B T$

Optimal temp

$\boxed{N \equiv N}$

Fe

$\sim 550°C$

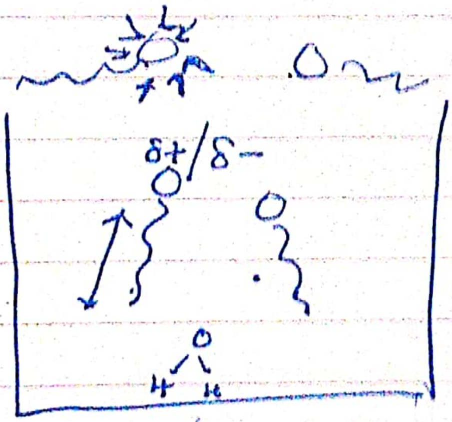
$$\boxed{\Delta G = \underbrace{\Delta H} - \underbrace{T\Delta S}}$$ at const T

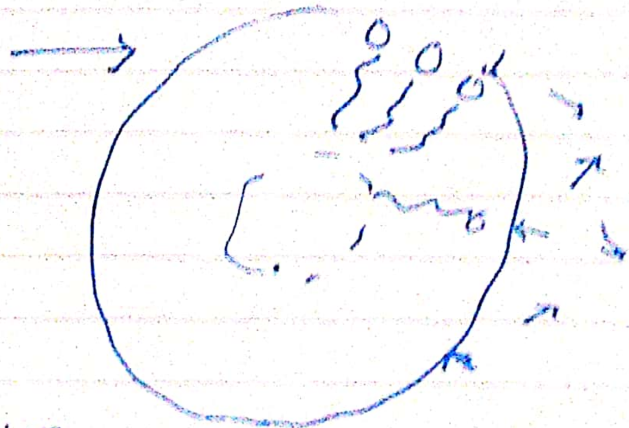
$$OO + O \rightarrow OOOO$$

$$\Delta G = nRT \underbrace{\sum x_i \ln x_i}$$

$$\Delta S = -nR \sum x_i \ln x_i$$

1978





Self-assembly

micelles $\Delta S = -ve$

water $\Delta S = +ve$ ✓

solvent

$\Delta S > 0$