Day-9

→ $aA + bB \longrightarrow cC + dD$

a, b, c, d are stoichiometric coefficients

Criterion for chemical equilibrium

$$c\bar{g}_C + d\bar{g}_D - a\bar{g}_A - b\bar{g}_B = 0$$

Equilibrium constant for ideal gas mixtures

$$K_p = \frac{(P_c/P_0)^c (P_d/P_0)^d}{(P_a/P_0)^a (P_B/P_0)^b}$$

$$\Delta G^\circ = -R_u T \ln K_p$$

$$\Rightarrow K_p = \exp\left(\frac{-\Delta G^\circ(T)}{R_u T}\right)$$

$$= \exp\left(\frac{a\bar{g}^\circ_A(T) + b\bar{g}^\circ_B(T) - c\bar{g}^\circ_C(T) - d\bar{g}^\circ_D(T)}{R_u T}\right)$$

$$\Rightarrow K_p = \frac{N_C^c N_D^d}{N_A^a N_B^b} \left(\frac{P_{mix}}{P^\circ N_{TOTAL}}\right)^{c+d-a-b}$$

→ $N_2 \longrightarrow 2N$ (25°C and 4700 K)

Find K_p.

Do the same for $H_2 \longrightarrow 2H$.

Ans:) $N_2 \rightleftharpoons 2N$

at 298 K

$$K_p = \exp\left[\frac{1\times 0 - 2\times 455504}{8.314\times 298}\right]$$

$\simeq 2.03 \times 10^{-160}$

≈ 0

at 4700K

$$K_p = \exp\left(\frac{1\times 0 - 2\times 162730}{8.314 \times 4700}\right)$$

$$= 2.4114 \times 10^{-4}$$

$H_2 \rightleftharpoons 2H$

At 1000 K

$$K_p = \exp.\left(\frac{1\times 0 - 2\times 165528}{8.314 \times 1000}\right)$$

$$= 5.091 \times 10^{-18}$$

At 4700 K

$$K_p = \exp.\left(\frac{1\times 0 - 2\times -58545}{8.314 \times 4700}\right)$$

$$= 20.015$$

→ 2 kmol CO + 3 kmol O_2 heated to 2600K, P = 304 kPa. Find eq. comp., mixture has $CO + CO_2 + O_2$.

Ans.) $CO + 1/2\, O_2 \rightleftharpoons CO_2$

$$K_p = \exp\left(\frac{1\times -335389 + 1/2\times 0 - 1\times -396061}{8.314 \times 2600}\right)$$

$= 16.5485$

Now, $2CO + 3O_2 \rightleftharpoons xCO_2 + yO_2 + zCO$

$2 = x + z$, $2 + 3\times2 = 2x + 2y + z$

$\Rightarrow x + y + z/2 = 4$

$$K_p = \frac{x^1}{(2-x)^1(3-x/2)^{1/2}} \left(\frac{304\times10^3}{101.325\times10^3\times(5-x/2)}\right)^{-0.5}$$

$= 16.5485$

$\Rightarrow x = 1.906$

$+ 0.094\ CO + 2.047\ O_2$