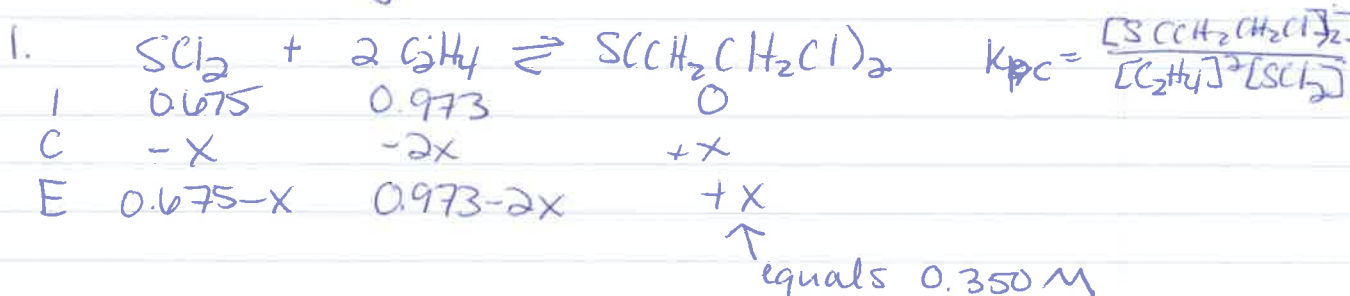


homework 10 key



$[\text{SCl}_2]_{\text{eq}} = 0.675 - 0.350 = 0.325 \text{ M}$
 $[\text{C}_2\text{H}_4]_{\text{eq}} = 0.973 - 2(0.350) = 0.273 \text{ M}$
 $[\text{S}(\text{C}_2\text{H}_4\text{CH}_2\text{Cl})_2]_{\text{eq}} = 0.350 \text{ M}$

$K_c = \frac{0.350}{(0.273)^2 (0.325)} = 14.45$

$K_p = K_c \left(\frac{c^0 RT}{p^0} \right)^{\Delta n}$ $\Delta n = \nu_{\text{S}(\text{C}_2\text{H}_4\text{CH}_2\text{Cl})_2} - \nu_{\text{SCl}_2} - \nu_{\text{C}_2\text{H}_4}$

$K_p = 14.45 \left(\frac{1 \frac{\text{mol}}{\text{L}} \cdot 0.08314 \frac{\text{L} \cdot \text{bar}}{\text{mol} \cdot \text{K}} \cdot 293 \text{K}}{1 \text{ bar}} \right)^{1-1-2}$

$K_p = 0.024$

$\nu_{\text{S}(\text{C}_2\text{H}_4\text{CH}_2\text{Cl})_2} = 1$
 $\nu_{\text{SCl}_2} = 1$
 $\nu_{\text{C}_2\text{H}_4} = 2$
 $c^0 = 1 \text{ mol/L}$
 $R = 0.08314 \frac{\text{L} \cdot \text{bar}}{\text{mol} \cdot \text{K}}$
 $T = 293 \text{ K}$
 $p^0 = 1 \text{ bar}$

2. a) shift in equilibrium position to favor reactants (K_p decreases)
 b) shift in equilibrium position to favor products (no change in K_p)
 c) No change to equilibrium position or K_p



I	n_0	0	0	
C	-2ξ	$+2\xi$	$+\xi$	total # moles: $n_0 - 2\xi + 2\xi + \xi$
E	$n_0 - 2\xi$	$+2\xi$	$+\xi$	$= n_0 + \xi$

$K_p = \frac{P_{\text{NO}}^2 P_{\text{Cl}_2}}{P_{\text{NOCl}}^2} = \frac{(X_{\text{NO}}^2 P_{\text{tot}})^2 X_{\text{Cl}_2} P_{\text{tot}}}{X_{\text{NOCl}}^2 P_{\text{tot}}^2}$

$X_{\text{NO}} = \frac{2\xi}{n_0 + \xi}$
 $X_{\text{Cl}_2} = \frac{\xi}{n_0 + \xi}$
 $X_{\text{NOCl}} = \frac{n_0 - 2\xi}{n_0 + \xi}$

3 (cont)

$$K_p = \left(\frac{2\xi}{n_0 + \xi} \right)^2 \left(\frac{\xi}{n_0 + \xi} \right) \left(\frac{n_0 + \xi}{n_0 - 2\xi} \right)^2 P_{\text{tot}}$$

$$= \frac{4\xi^2 \cdot \xi}{(n_0 + \xi)(n_0 - 2\xi)^2} P_{\text{tot}}$$

$$= \frac{4\xi^3}{n_0(n_0 + \xi)(n_0 - 2\xi)^2} P_{\text{tot}}$$

$$= \frac{4\xi^3}{(n_0 + \xi)(n_0 - 2\xi)^2} P_{\text{tot}}$$

4.



$$\begin{aligned} \Delta G^\circ &= 2 \Delta G_f^\circ(\text{NO}_2) - \Delta G_f^\circ(\text{N}_2\text{O}_4) \\ &= 2(51.258) - 97.787 \\ &= 4.729 \text{ kJ/mol} = 4729 \text{ J/mol} \end{aligned}$$

$$K_p = e^{-\Delta_r G^\circ / RT} \quad T = 298 \text{ K}, R = 8.314 \text{ J/mol}\cdot\text{K}$$

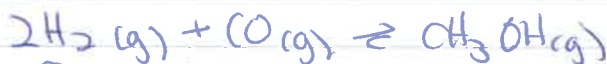
$$= 0.148$$



$$\begin{aligned} \Delta_r G^\circ &= 2 \Delta G_f^\circ(\text{HI}) - \Delta G_f^\circ(\text{I}_2) - \Delta G_f^\circ(\text{H}_2) \\ &= 2(1.500) - 19.325 - 0 \\ &= -16.205 \text{ kJ/mol} = -16205 \text{ J/mol} \end{aligned}$$

$$K_p = e^{-\Delta_r G^\circ / RT} = 692$$

5.

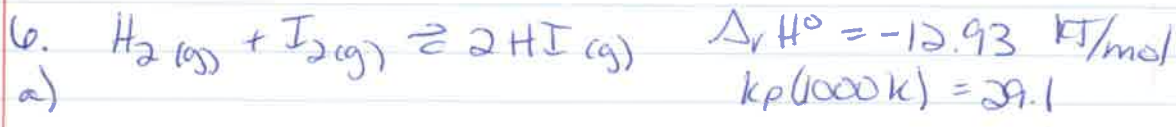


$$Q = \frac{P_{\text{CH}_3\text{OH}}}{P_{\text{CO}} P_{\text{H}_2}^2} = \frac{10.0 \text{ bar}/1 \text{ bar}}{\left(\frac{0.005 \text{ bar}}{1 \text{ bar}} \right) \left(\frac{0.10 \text{ bar}}{1 \text{ bar}} \right)^2} = 2 \times 10^5$$

$$K_p = 2.21 \times 10^4$$

$Q > K_p$ Rxn will proceed toward left (make more $\text{H}_2 + \text{CO}$)

Also $\Delta_r G = RT \ln(Q/K_p)$, here $\Delta_r G > 0$ so rxn isn't spontaneous as written



van't Hoff Eq

$$\ln\left(\frac{K_p(T_2)}{K_p(T_1)}\right) = -\frac{\Delta_r H^\circ}{R} \left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$\ln\left(\frac{29.1}{K_p(700)}\right) = -\frac{-12.93 \times 1000 \text{ J/mol}}{8.314 \text{ J/mol}\cdot\text{K}} \left(\frac{1}{1000} - \frac{1}{700}\right)$$

$$\ln\left(\frac{29.1}{K_p}\right) = 0.664$$

$$\frac{29.1}{K_p} = e^{0.664}$$

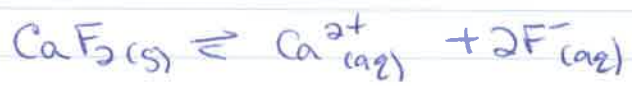
$$K_p = 26.7 \text{ @ } 700 \text{ K}$$

b) K_p decreases as a function of increasing temperature because this is an exothermic reaction.

$$K_p = \frac{[HI]^2}{[H_2][I_2]} \Rightarrow \text{so more HI when } K_p \text{ is bigger... more HI at } 700 \text{ K.}$$

c) $K_p(1000 \text{ K})$ is bigger for endothermic rxn.

7.



$$K_{sp} = a_{Ca^{2+}} a_{F^-}^2 = C_{Ca^{2+}} C_{F^-}^2 \gamma_{\pm}^3 = 3.9 \times 10^{-11}$$

$$\text{so } C_{Ca^{2+}} C_{F^-}^2 = \frac{3.9 \times 10^{-11}}{\gamma_{\pm}^3}$$

Step 1 let $\gamma_{\pm} = 1$ and $S = C_{Ca^{2+}}$
 so $C_{F^-} = 2S$

$$(S)(2S)^2 = 3.9 \times 10^{-11} / \gamma_{\pm}^3$$

$$4S^3 = 3.9 \times 10^{-11} \quad S = 2.136 \times 10^{-4} \text{ M}$$

Step 2 Ionic Strength

$$I_c = \frac{1}{2} (z_+^2 c_{c_+} + z_-^2 c_{c_-})$$

$$= \frac{1}{2} (2^2 \cdot s + (-1)^2 \cdot 2s) \quad s = 2.136 \times 10^{-4} M$$

$$+ 2^2 \cdot 0.015 + (-2)^2 \cdot 0.015 \quad \text{MgSO}_4$$

$$= 0.0606 M$$

Step 3 Extended Debye-Huckel for γ_{\pm}

$$\ln \gamma_{\pm} = \frac{-1.173 |z_+ z_-| I_c^{1/2}}{1 + I_c^{1/2}}$$

$$I_c = 0.0606 M$$

$$z_+ = 2$$

$$z_- = -1$$

$$= -0.463$$

$$\gamma_{\pm} = 0.629$$

Step 4 Repeat Step 1 w/ $\gamma_{\pm} = 0.629$

$$4s^3 = 3.9 \times 10^{-11} / (0.629)^3 \quad s = 3.396 \times 10^{-4} M$$

Step 5 Repeat Step 2 w/ new $s = 3.396 \times 10^{-4} M$

$$I_c = \frac{1}{2} (2^2 s + (-1)^2 \cdot 2s + 2^2 \cdot 0.015 + (-2)^2 \cdot 0.015)$$
$$= 0.0610 M$$

Step 6 Repeat Step 3 w/ new I_c

$$\ln \gamma_{\pm} = \frac{-1.173 |z_+ z_-| I_c^{1/2}}{1 + I_c^{1/2}} = -0.4647$$

$$\gamma_{\pm} = 0.628$$

Repeat Cycle (steps 1-3)

$$\text{w/ new } \gamma_{\pm}, \quad s = 3.402 \times 10^{-4} M$$

$$\text{w/ new } s, \quad I_c = 0.0610 M$$

$$\text{w/ new } I_c, \quad \gamma_{\pm} = 0.628$$

$$\text{w/ } \gamma_{\pm}, \quad s = 3.402 \times 10^{-4} M \quad \boxed{\text{converged}}$$

Without using activities, s was $2.14 \times 10^{-4} M$ but it really is $3.40 \times 10^{-4} M$!