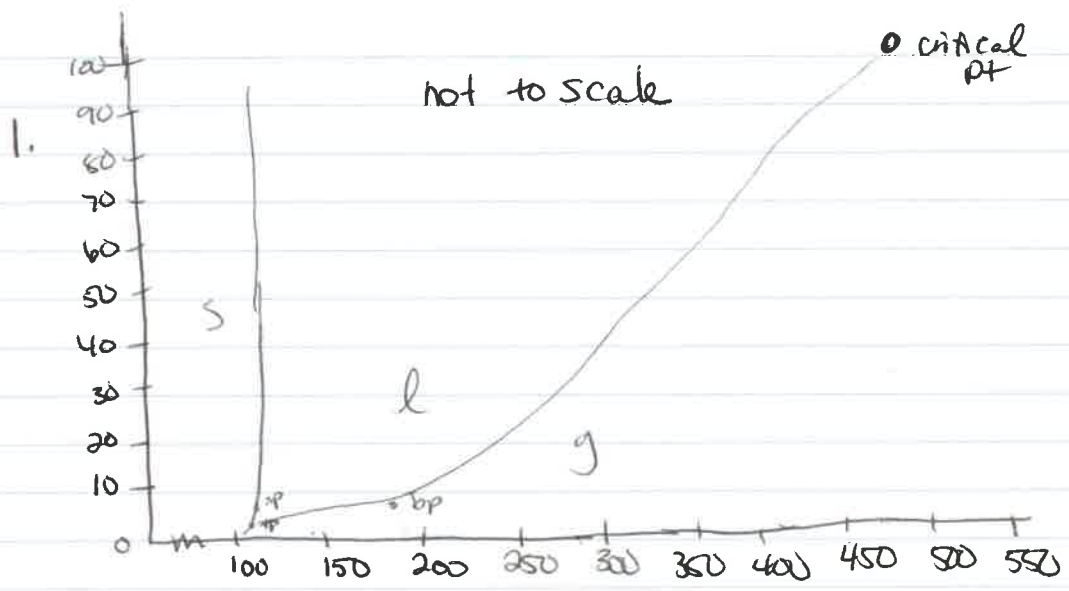


Exam 3 Review Problems Key

1



2.

$x_{\text{ethanol}}$	real $P_{\text{ethanol}}/\text{torr}$	ideal $P_{\text{ethanol}}/\text{torr}$	real $P_{\text{water}}/\text{torr}$	ideal $P_{\text{water}}/\text{torr}$
0	0.00	0.00	23.78	23.78
0.10	17.65	5.92	21.70	21.40
0.50	36.86	21.60	17.29	11.89
0.90	53.45	53.28	5.38	2.38
1.00	59.20	59.20	0.00	0.00

Real partial pressures are greater than ideal (ie positive deviations). Thus there are more molecules of ethanol + water in gas phase than predicted by Raoult's Law and repulsive forces dominated in the solution.

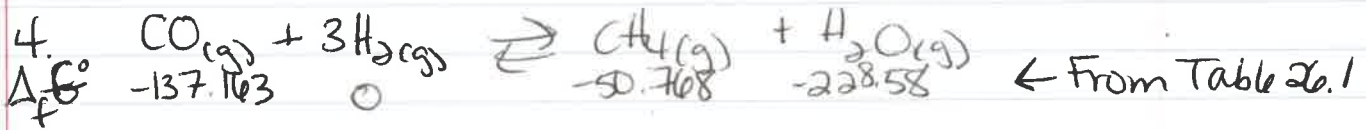
$$3. a_2 = a_+ a_- = a_{\pm}^2 = (m_+)(m_-) \gamma_{\pm}^2 = m^2 \gamma_{\pm}^2$$

if  $m_+ = m_{\text{Cu}^{2+}} = m$   
 then  $m_- = m_{\text{SO}_4^{2-}} = m$

2

~~WPS~~

~~WPS~~



$$\Delta_r G^\circ = -50.768 - 228.58 - (-137.163) - 0$$

$$= -142.185 \text{ kJ/mol} = -142185 \text{ J/mol}$$

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

$$-\Delta_r G^\circ / RT = \ln K_p \quad \text{or} \quad K_p = e^{-\Delta_r G^\circ / RT}$$

$$K_p = 8.38 \times 10^{24}$$

This  $K_p$  is very large, so this reaction goes nearly to completion (i.e. it favors products to a high extent).

5. If the  $K_p$  of a reaction increases with increasing temperature, the reaction is endothermic. Using the van't Hoff equation...

$$\ln \left( \frac{K_p(T_2)}{K_p(T_1)} \right) = -\frac{\Delta H_r}{R} \left( \frac{1}{T_2} - \frac{1}{T_1} \right) \quad K_p(T_2) = 2 K_p(T_1)$$

$$\ln \left( \frac{2K_p(T_1)}{K_p(T_1)} \right) = -\frac{\Delta H_r}{R} \left( \frac{1}{400} - \frac{1}{300} \right)$$

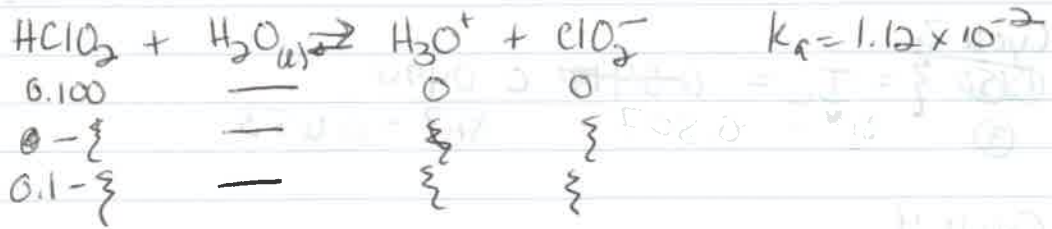
$$\ln 2 = -\Delta H_r / R \left( -8.3 \times 10^{-4} \right)$$

$$+831.78 = \Delta H_r / R$$

$$\Delta H_r = 6915 \text{ J/mol or } 6.915 \text{ kJ/mol}$$

(3)

In Concentration  
I  
C  
E



$$K_a = \frac{a_{\text{H}_3\text{O}^+} a_{\text{ClO}_2^-}}{a_{\text{HClO}_2}} = \frac{C_{\text{H}_3\text{O}^+} C_{\text{ClO}_2^-} \gamma_{\pm}^2}{C_{\text{HClO}_2}} = 1.12 \times 10^{-2}$$

At eq.  $\frac{\xi^2}{0.1 - \xi} \gamma_{\pm}^2 = 1.12 \times 10^{-2}$

$$\xi^2 = \frac{1.12 \times 10^{-2}}{\gamma_{\pm}^2} (0.1 - \xi)$$

$$\xi^2 + \frac{1.12 \times 10^{-2}}{\gamma_{\pm}^2} \xi - 1.12 \times 10^{-3} = 0$$

cycle 1 ① Let  $\gamma_{\pm}^2 = 1$

$$\xi^2 + 1.12 \times 10^{-2} \xi - 1.12 \times 10^{-3} = 0$$

$$\xi = 0.0354$$

② Find  $I_c$

$$I_c = \frac{1}{2} ((1)^2 \xi + (-1)^2 \xi) = \xi = 0.0354$$

③ Find  $\gamma_{\pm}$

$$\ln \gamma_{\pm} = \frac{-1.173 |z_1 z_2| I_c^{1/2}}{1 + I_c^{1/2}}$$

$$\gamma_{\pm} = 0.831 \quad \gamma_{\pm}^2 =$$

cycle 2

$$\textcircled{1}/\textcircled{2} \xi^2 + \frac{1.12 \times 10^{-2}}{(0.831)^2} \xi - \frac{1.12 \times 10^{-3}}{(0.831)^2} = 0$$

$$\xi = I_c = 0.0476$$

$$\textcircled{3} \gamma_{\pm} = 0.820 \quad 0.810 \quad \gamma_{\pm}^2 = 0.657$$

Cycle 3

$$\begin{matrix} \textcircled{1}/\textcircled{2} \\ \textcircled{3} \end{matrix} \left. \vphantom{\begin{matrix} \textcircled{1}/\textcircled{2} \\ \textcircled{3} \end{matrix}} \right\} = I_c = \cancel{0.0417} \quad 0.0494$$

$$\delta_{\pm} = 0.807 \quad \delta_{\pm}^2 = 0.653$$

Cycle 4

$$\begin{matrix} \textcircled{1}/\textcircled{2} \\ \textcircled{3} \end{matrix} \left. \vphantom{\begin{matrix} \textcircled{1}/\textcircled{2} \\ \textcircled{3} \end{matrix}} \right\} = I_c = 0.0497$$

$$\delta_{\pm} = 0.808 \quad \delta_{\pm}^2 = 0.652$$

Cycle 5

$$\begin{matrix} \textcircled{1}/\textcircled{2} \\ \textcircled{3} \end{matrix} \left. \vphantom{\begin{matrix} \textcircled{1}/\textcircled{2} \\ \textcircled{3} \end{matrix}} \right\} = I_c = 0.0497$$

$$\delta_{\pm} = 0.808 \quad \delta_{\pm}^2 = 0.652 \quad \left. \vphantom{\begin{matrix} \textcircled{1}/\textcircled{2} \\ \textcircled{3} \end{matrix}} \right\} \text{converged}$$

$$\text{pH} = -\log(c_{\text{H}_3\text{O}^+} \delta_{\pm}) = \boxed{1.396}$$

The larger the  $K_a$ , the more acidic the solution  
(the easier to deprotonate the acid).