

Assignment 45, 2011 - Sample Solutions

April 4, 11

① concentration cell

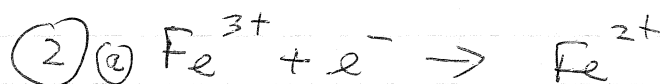
$$E = E^{\circ} - \frac{RT}{nF} \ln Q$$

$$E^{\circ} = 0$$

$$n = 1$$

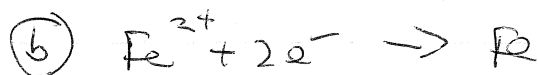
$$Q = \frac{0.2}{3} \quad (\text{assuming ideal solution})$$

$$E = -0.070 \text{ V}$$



$$n_a = 1$$

$$E^{\circ}(a) = 0.771 \text{ V}$$

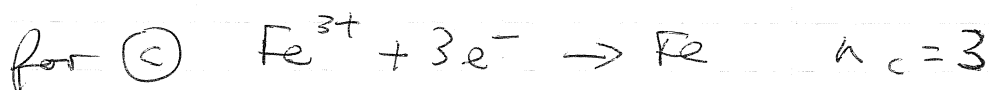


$$n_b = 2$$

$$E^{\circ}(b) = -0.44 \text{ V}$$

$$\Delta G^{\circ}(a) = -n_a F E^{\circ}(a)$$

$$\Delta G^{\circ}(b) = -n_b F E^{\circ}(b)$$



$$\Delta G^{\circ}(c) = \Delta G^{\circ}(a) + \Delta G^{\circ}(b)$$

$$E^{\circ}(c) = \frac{-\Delta G^{\circ}(c)}{n_c F} = \frac{n_a E^{\circ}(a) + n_b E^{\circ}(b)}{n_c}$$

$$= -0.041 \text{ V}$$

$$\textcircled{3} \quad \ln K = \frac{nF}{RT} E^{\circ}$$

{ I forgot to provide a T,
so assume $T = 298.15 \text{ K}$

$$n = 2$$

$$\Rightarrow \ln K = 85.63$$

$$K = 1.55 \times 10^{37}$$

④

$$E^{\circ}(V) = a - b \left(\frac{T}{K} - 298 \right) - c \left(\frac{T}{K} - 298 \right)^2$$

(fit A....)

(a) At $T = 298 K$, only "a" term remains for E° :
 $E^{\circ} = 0.07131 V$

$$\Delta G_R^{\circ} = -nFE^{\circ}$$

$$n = 1$$

$$= -\underline{6.880} \times 10^3 \text{ J mol}^{-1}$$

kJ mol^{-1}

$$\frac{dE^{\circ}}{dT} = -b - 2c(T - 298) \quad \left(\text{units } \frac{V}{K} \right)$$

At $T = 298 K$: $\frac{dE^{\circ}}{dT} = -b = -4.99 \times 10^{-4} V K^{-1}$

$$\Delta S_R^{\circ} = nF \frac{dE^{\circ}}{dT} = \underline{-48.1} \text{ J K}^{-1} \text{ mol}^{-1}$$

$$\Delta H_R^{\circ} = \Delta G_R^{\circ} + T \Delta S^{\circ} = \underline{-21.2} \text{ kJ mol}^{-1}$$

⑥ use full formula : $T = 323 K$

$$E^{\circ} = 0.05668 V$$

$$\underline{\Delta G_R^{\circ} = -nFE^{\circ} = -5.469 \text{ kJ mol}^{-1}}$$

April 2, 12

Q5

$$\bar{J}_U = \frac{n_B RT}{V}$$

$$n_B = \frac{m_B}{M_B}$$

$$\Rightarrow M_B = \left(\frac{m_B}{V} \right) \frac{RT}{\bar{J}_U}$$

$\frac{290.0 \text{ g}}{1}$
 $\frac{290.0 \text{ kg}}{\text{m}^3}$

$$\bar{J}_U = 2.17 \text{ atm}$$

$$T = 298.15 \text{ K}$$

$$M_B = 3.27 \text{ kg mol}^{-1}$$

(I simply made up the numbers ... this may or may not be an actual macromolecule)

Clausius-Clapeyron, integrated:

Q6a

$$\ln \frac{P_2}{P_1} = \frac{\Delta H_{\text{vap}}}{R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)$$

$$T_1 = 373.15 \text{ K}$$

$$T_2 = 375.15 \text{ K}$$

$$\Rightarrow \ln \frac{P_2}{P_1} = 0.0698$$

$$P_1 = 1.00 \text{ atm}$$

$$\Rightarrow P_2 = 1.07 \text{ atm} = 1.09 \times 10^5 \text{ Pa}$$

(86)

- using K_B from text gives 4.13g;
 - using $x_B = \frac{n_B}{n_W}$ (or molality) gives 4.10g

⑤ b. p. elevation

$$\Delta T_{BP} = \frac{RT_{BP}^2}{\Delta H_{\text{vap}}} x_B \quad \text{or} \quad K_B = \frac{\Delta H_{\text{vap}}}{RT_{BP}^2} \Delta T_{BP}$$

$$\Delta T_{BP} = 2 \text{ K} ; T_{BP} = 373.15 \text{ K}$$

$$\Rightarrow x_B = 0.0701$$

$$x_B = \frac{n_B}{n_W + n_B} \Rightarrow n_B = \frac{x_B}{1 - x_B} n_W \quad \text{where } n_W = 1.00 \text{ mol (water)}$$

$$n_B = 0.0754 \text{ mol}$$

$$M(\text{NaCl}) = 58.443 \text{ g mol}^{-1} \Rightarrow m(\text{NaCl}) = 4.41 \text{ g}$$

There is a somewhat subtle issue here (not included in marking): NaCl is fully dissociated, i.e. we have 2 moles of insoluble solute