Assignment 5, 2011 – Sample Solutions April 4, 11

(1) concentration cell

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

$E^\circ = 0$

$n = 1$

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

$E = -0.070V$

(2) (a) $Fe^{3+} + e^- \rightarrow Fe^{2+}$ $n_a = 1$ $E^\circ(a) = 0.771V$

(b) $Fe^{2+} + 2e^- \rightarrow Fe$ $n_b = 2$ $E^\circ(b) = -0.447V$

$$\Delta G^\circ(a) = -n_a F E_0(a)$$

$$\Delta G^\circ(b) = -n_b F E_0(b)$$

for (c) $Fe^{3+} + 3e^- \rightarrow Fe$ $n_c = 3$

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

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

$$= -0.041V$$

(3) $\ln K = \frac{nF}{RT} E^\circ$ { I forgot to provide a T, so assume $T = 298.15K$

$n = 2$

$\Rightarrow \ln K = 85.63$

$K = 1.55 * 10^{37}$

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

(fit...)

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

$\Delta G^\circ_R = -nFE^\circ$

$n = 1$

$= \underline{-6.880} * \underbrace{10^3 \, VC mol^{-1}}_{kJ\,mol^{-1}}$

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

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

$\Delta S^\circ_R = nF \frac{dE^\circ}{dT} = \underline{-48.1} \, J \, K^{-1} mol^{-1}$

$\Delta H^\circ_R = \Delta G^\circ_R + T\Delta S^\circ = \underline{-21.2} \, kJ \, mol^{-1}$

b) use full formula : $T = 323 \, K$

$E^\circ = 0.05668 \, V$

$\Delta G^\circ_R = -nFE^\circ = -\underline{5.469} \, kJ \, mol^{-1}$

April 2, 12

Q5

$$\pi = \frac{n_B RT}{V} \qquad n_B = \frac{m_B}{M_B}$$

$$\Rightarrow M_B = \underbrace{\left(\frac{m_B}{V}\right)}_{290.0\,g/L} \frac{RT}{\pi} \qquad \pi = 2.17\ atm,\quad T = 298.15\ K$$

$$290.0\,g/L = 290.0\,\frac{kg}{m^3}$$

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

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

Clausius-Clapeyron, integrated:

Q6 a)

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

$T_1 = 373.15K$

$T_2 = 375.15K$

$$\Rightarrow \ln\frac{P_2}{P_1} = 0.0698 \ ; \quad P_1 = 1.00\ atm$$

$$\Rightarrow P_2 = 1.07\,atm = 1.09 \ast 10^5\ Pa$$

(86)

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

b) b.p. elevation

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

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

$\Rightarrow x_B = 0.0701$

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

$n_B = 0.0754\ mol$

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

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