Chemistry 145, Fall 1998 Final
Prof. Shattuck Name________________________________

Note: Here are some typical problems from a previous longer final. The Colby portion of the 2014 final will be one hour.

Part 1: 8 points each.

1\. . The change in entropy for the phase transition PCl_5 (s) → PCl_5(g) is
(a) positive (b) negative c) about zero

6\. Will NO_3^- oxidize Cu to Cu^{2+} under standard conditions? Show your work for credit. Note:
$NO_3^- + 4H^+ + 3\,e^- = NO + 2\,H_2O$ E° = 0.96 V reduction at the cathode
$Cu^{2+} + 2\,e^- = Cu(s)$ E° = 0.34 V oxidation of Cu at the anode

$E°_{cell} = E_R - E_L = E_{cathode} - E_{anode} = 0.96\text{ V} - 0.34\text{ V} = 0.62\text{ V} > 0$ so yes

7\. Name the following compounds or supply the formula:

a. KNO_2 __potassium nitrite____
b. $NaClO_3$ ___sodium chlorate________
c. phosphorous acid ____H_3PO_3________

8\. The reaction $3Cd(s) + 2\,Al^{3+} = 3Cd^{2+} + 2\,Al(s)$ has a negative standard cell voltage. Is the equilibrium constant
(a) greater than 1 (b) less than 1 (c) can't tell from the information given

from $\Delta G° = -nFE°_{cell}$ and $\Delta G° = -RT \ln K_{eq}$ or $E°_{cell} = \frac{RT}{nF} \ln K_{eq}$

10\. For the reaction $Cd(s) + 2\,Fe^{3+} = Cd^{2+} + 2\,Fe^{2+}$ the standard cell potential is E° = 0.371 V. Calculate the cell potential if $[Fe^{3+}]$ = 0.100M and $[Cd^{2+}] = [Fe^{2+}]$ = 0.010 M.

$$E° = E°_{cell} - \frac{RT}{nF} \ln K_{eq} \quad \text{or} \quad E° = E°_{cell} - \frac{0.0592\text{ V}}{n} \log Q \quad \text{with } n = 2$$

$$E° = 0.371\text{ V} - \frac{0.0592\text{ V}}{2} \log\left(\frac{[Cd^{2+}]\,[Fe^{2+}]^2}{[Fe^{3+}]^2}\right) = 0.371\text{ V} - \frac{0.0592\text{ V}}{2} \log\left(\frac{(0.010)(0.010)^2}{(0.100)^2}\right)$$

$E° = 0.371\text{ V} - (-0.1184\text{ V}) = 0.4894\text{ V} = 0.489\text{ V}$

15\. In the electrolysis of a solution containing Cd^{2+} ions, 0.500 g of Cd are plated out using a current of 0.500 amp. How much time does this take? $Cd^{2+} + 2\,e^- \rightarrow Cd\,(s)$

$n_{electrons} = 0.500\text{ g}/112.41\text{ g mol}^{-1}\,(2\text{ mol } e^-/1\text{ mol } Cd^{2+}) = 8.896\times10^{-3}\text{ mol } e^-$
$Q = It = n_{electrons} F$
$t = 8.896\times10^{-3}\text{ mol } e^-(96485\text{ C mol}^{-1})/(0.500\text{ C s}^{-1}) = 1.72\times10^3\text{ s}$

23\. Calculate ΔG for the reaction $NO(g) + O_3(g) \rightarrow NO_2(g) + O_2(g)$ at 298.2K when the pressures are as follows: $P_{NO} = 1.00\times10^{-6}$, $P_{O_3} = 1.00\times10^{-6}$, $P_{NO_2} = 1.00\times10^{-7}$, and $P_{O_2} = 1.00\times10^{-4}$. ΔG°= -198 kJ for this reaction.

$\Delta G = \Delta G° + RT \ln Q$

$$\Delta G = \Delta G^\circ + RT \ln \frac{P_{NO_2}\, P_{O_2}}{P_{NO}\, P_{O_3}}$$

$$= -198\ \text{kJ} + 8.314\ \text{J K}^{-1}\ \text{mol}^{-1}(298.2\ \text{K}) \ln\left(\frac{(1.00\text{x}10^{-7})(1.00\text{x}10^{-4})}{(1.00\text{x}10^{-6})(1.00\text{x}10^{-6})}\right) = -192\ \text{kJ}$$

Helpful Formulas and Constants

$h = 6.63\text{x}10^{-34}$ J sec $c=3.0\text{x}10^{8}$ m sec^{-1} $N_A = 6.02\text{x}10^{23}$ mol^{-1}

$R = 8.314$ J mol^{-1} K^{-1} = 0.08206 L atm mol^{-1} K^{-1} T(0°C) = 273.15 K

F = 96485 C mol^{-1} 1 L atm = 101.3 J

$\pi = MRT$ $q = mC_s\Delta T$ $w = -P\Delta V$ $\Delta H = \Delta E + \Delta(PV)$

$\ln\left(\frac{P_2}{P_1}\right) = -\frac{\Delta H_{vap}}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$ $\ln\left(\frac{k_2}{k_1}\right) = -\frac{\Delta E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$ $\ln\left(\frac{[A]}{[A]_o}\right) = -kt$ $\frac{1}{[A]} - \frac{1}{[A]_o} = kt$

$t_{1/2} = \frac{0.693}{k}$ $t_{1/2} = \frac{1}{k\,[A]_o}$ $\Delta G = \Delta G^o + RT \ln Q$

$E = E^o - \frac{RT}{nF} \ln Q$ $E = E^o - \frac{0.0257\ V}{n} \ln Q$ $E = E^o - \frac{0.0592\ V}{n} \log Q$