CH 223 Worksheet 8

1. A voltaic cell is based on a Co^{2+} / Co half-cell and an AgCl / Ag half-cell. (a) What reaction occurs at the anode? (b) What is the standard cell potential?

$Co^{2+} + 2e^- \rightarrow Co(s)$ -0.277 ~~vs~~ more negative ∴ anode

$2AgCl(s) + 2e \rightarrow 2Ag(s) + 2Cl^-(aq)$ $+0.222$ more positive ∴ cathode

$E^\circ_{cell} = E^\circ_{red}(\text{cathode}) - E^\circ_{cell}(\text{anode})$

$= 0.222\,V - (-0.277\,V) = \boxed{0.499\,V}$

2. Using the standard reduction potentials listed in Appendix E (see attached), determine if the following reaction is spontaneous under standard conditions:

gain ∴ Cath lose ∴ anode

$Hg^{2+}(aq) + 2\,I^-(aq) \rightarrow Hg(l) + I_2(s)$

$Hg^{2+}(aq) + 2e^- \rightarrow Hg(l)$ $+0.854\,V$ ∴ gain ∴ cathode

$I_2(s) + 2e^- \rightarrow 2I^-(aq)$ $+0.536\,V$ lose e⁻ ∴ anode

$E^\circ_{cell} = E^\circ_{red}(\text{cathode}) - E^\circ_{cell}(\text{anode})$

$= 0.854\,V - 0.536\,V = \boxed{0.318\,V}$ yes spontaneous

E° positive ∴

3. For the reaction

$3\,Ni^{2+}(aq) + 2\,Cr(OH)_3(s) + 10\,OH^-(aq) \rightarrow 3\,Ni(s) + 2\,CrO_4^{2-}(aq) + 8\,H_2O(l)$

gain +3 +6 (−2)4 = −8

(a) What is the value of n? (b) Use the data in Appendix E to calculate ΔG°. (c) Calculate K at T = ~~298 K.~~ 426 K

(a) $6e^-$

$\Delta G^\circ = -nFE^\circ = -RT\ln K$

$3Ni^{2+}(aq) + 6e^- \rightarrow 3Ni(s)$ $-0.28\,V$ ~~cathode~~ anode

$2CrO_4^{2-}(aq) + 8H_2O(l) + 6e^- \rightarrow 2Cr(OH)_3(s) + 10OH^-$ $-0.13\,V$

$E^\circ_{cell} = E^\circ_{cathode} - E^\circ_{(anode)} = -0.28\,V - (-0.13\,V) = -0.15\,V$

$V = \frac{J}{C}$

$\Delta G = -6\left(96485\,\frac{C}{mol}\right)\left(-0.15\,\frac{J}{C}\right)$

$= 86{,}837\,\frac{J}{mol}$

$K = e^{\frac{-\Delta G}{RT}} = e^{\frac{-(86837\,\frac{J}{mol})}{(8.314\,\frac{J}{mol\,K})(426\,K)}} = \boxed{2.25 \times 10^{-11}}$

4. A voltaic cell utilizes the following reaction and operates at 310 K.

$$3\,Ce^{4+}(aq) + Cr(s) \rightarrow 3\,Ce^{3+}(aq) + Cr^{3+}(aq)$$

(a) What is the emf of this cell under standard conditions?

$3\,Ce^{4+} + 3e^- \rightarrow 3\,Ce^{3+}$ $\quad + 1.61\ V$ $\quad$ Cathode

$Cr(s) \rightarrow Cr^{3+}_{(aq)} + 3e^-$ $\quad -0.74\ V$ $\quad$ anode

$$E^o_{cell} = E^o_{red}(\text{cathode}) - E^o_{red}(\text{anode}) = (1.61V) - (-0.74V)$$
$$\boxed{= 2.35\,V}$$

(b) What is the emf of this cell when $[Ce^{4+}] = 3.0$ M, $[Ce^{3+}] = 0.10$ M and $[Cr^{3+}]$ 0.010 M?

310 K and $V = \frac{J}{C}$

$$E = E^o - \frac{RT}{nF}\ln Q = 2.35V - \frac{8.314\frac{J}{mol\cdot K}\ 310\,K}{(3e^-)\ 96,485\frac{C}{mol}} \underbrace{\ln\frac{(0.10)^3(0.01)}{(3.0)^3}}_{-14.81}$$

$$Q = \frac{[Ce^{3+}]^3[Cr^{3+}]}{[Ce^{4+}]^3} \qquad = 2.35V - (-0.132V)$$

$$\boxed{= 2.48V}$$

5. An aqueous cadmium (Cd) solution is electrolyzed using a current of 7.60 A. How many grams cadmium will be plated out after 2.00 days?

$A = \frac{C}{s}$ $\qquad$ $Cd^{2+}_{(aq)} + 2e^- \rightarrow Cd(s)$

$$\text{Mass} = \frac{i\ t\ MM}{n\ F}$$

$2e^-$

$$= \frac{\left(7.60\frac{C}{s}\right)(2.00\ \text{days})\left(\frac{24\ hrs}{1\ day}\right)\left(\frac{60\ min}{1\ hr}\right)\left(\frac{60\ s}{1\ min}\right)\left(\frac{112.4g\ Cd}{1\ mol}\right)}{2\quad 96485\frac{C}{mol}}$$

$$\boxed{= 765\,g\ Cd}$$