Exam 4

MULTIPLE CHOICE (3pts each): Write the ONE letter corresponding to the correct answer on the line next to each question. The LETTER ASSOCIATED WITH THE CORRECT ANSWER MUST BE WRITTEN ON THE LINE NEXT TO THE QUESTION in order to receive full credit.

1.) If an aqueous solution of magnesium chloride is electrolyzed, which of the following would be a reduction product? 1.) B

a.) Mg(s) (b.) $H_2(g)$ c.) Cl(g) d.) $O_2(g)$

2.) 50.0mL of $Ba(NO_3)_2$ and 25.0mL of Na_2SO_4 are combined in an erlenmeyer flask and a precipitate forms. Which of the following compounds is most likely to be the precipitate? 2.) A

(a.) $BaSO_4$ $Na(NO_3)_2$ c.) $NaNO_3$ d.) $Ba(SO_4)_2$

3.) Which of the following options would be the best oxidizing agent? 3.) D

a.) Al^3+ b.) Ni^2+ c.) Cr^3+ (d.) Cu^2+

4.) Which of the following would be more soluble in a solution of HCl? 4.) B

a.) $C_7H_{14}COOH$ (b.) $C_7H_{14}NH_2$ c.) NaCl d.) $PbCl_2$

5.) For a cell based on the reaction Al^3+(aq) + Cr(s) --> Cr^3+(aq) + Al(s), how much work would be needed for 0.500 moles of Aluminum to be plated out? 5.) A

(a.) 130kJ b.) 44kJ c.) 350kJ d.) 270kJ

$0.500\,mol\ Al\left(\frac{3e^-}{Al}\right) = 1.5\,mole^-$ $w = -(1.5)(96,485)(-0.92)$

6.) Which of the following metals would be the best choice to protect iron from corrosion? 6.) A

(a.) zinc b.) cobalt c.) lead d.) tin

7.) Which of the following would spontaneously oxidize metallic gold to the Au^3+ ion? 7.) D

a.) solid lithium b.) aqueous silver ions c.) liquid bromine (d.) fluorine gas

8.) A complex was formed by dissolving a slightly soluble ionic compound in ammonia. The Ksp for the ionic compound was 4.56x10^-8, and the Kf for the complex formation was 2.97x10^5. What is the Keq for the overall process? 8.) D

a.) 6.51x10^12 b.) 2.97x10^5 c.) 1.54x10^-13 (d.) 1.35x10^-2

$(4.56\times10^{-8})(2.97\times10^{5})$

9.) Which of the following compounds is the least soluble? The values listed in parenthesis are the K_{sp} values for each compound. 9.) B

a.) $Mn(OH)_2$ (1.9x10^-13) (b.) $Fe(OH)_2$ (8.0x10^-16)

c.) Pb(OH)2 (1.2x10^-15) d.) $Cd(OH)_2$ (2.5x10^-14)

10.) What is the potential for a two electron concentration cell at 298K where one half cell has a concentration of 0.589M and the other half cell has a concentration of 2.98x10^-4M? 10.) B

a.) -0.0974V (b.) +0.0974V c.) -0.758V d.) +0.758V

$$E = 0 - \left(\frac{(8.314\ J/mol\,K)(298\,K)}{(2)(96485\ J/V\cdot mol)}\right)\ln\left(\frac{2.98\times10^{-4}}{0.589}\right)$$

SHORT ANSWER (10 pts each): Completely answer all of the following questions. Read all questions carefully!!! SHOW ALL WORK. Make sure to include units and report all mathematical answers to the correct number of significant figures. Write final answers in designated locations when indicated.

1. $PbNO_3)_2$ is added to 0.250M NaOH.

   a.) What is the formula of the potential solid product? Answer: $Pb(OH)_2$

   $NaNO_3$ would be soluble

   $Pb(OH)_2$ would be only slightly soluble

   b.) What concentration of $Pb(NO_3)_2$ is needed to start precipitation? The K_{sp} of the solid product is 1.2×10^{-15}.

   $Pb(OH)_2(s) \rightleftharpoons \underset{x}{Pb^{2+}(aq)} + \underset{2x}{2OH^-(aq)}$ Answer: $1.92 \times 10^{-14} M$

   $1.2 \times 10^{-15} = [x][2x]^2$

   $1.2 \times 10^{-15} = [x][0.250]^2$

   $1.2 \times 10^{-15} = [x][0.0625]$

   $x = 1.92 \times 10^{-14} M$

2. Given the reaction $2Al^{3+}(aq) + 3Be(s) \rightarrow 3Be^{2+}(aq) + 2Al(s)$ at 298K

   a.) Write the half reaction at the anode: Answer: $Be(s) \rightarrow Be^{2+}(aq) + 2e^-$

   b.) Write the half reaction at the cathode: Answer: $Al^{3+}(aq) + 3e^- \rightarrow Al(s)$

   c.) Calculate E° Answer: $+0.19V$

   $-1.66V - (-1.85V) = +0.19V$

   d.) Calculate the value of E when the concentrations are $[Al^{3+}]=0.550M$ and $[Be^{3+}]=0.620M$.

   $E = 0.19V - \left[\frac{(8.314)(298)}{(6)(96,485)}\right] \ln\left(\frac{(0.620)^3}{(0.550)^2}\right)$ Answer: $0.191V$

   $= 0.19V - [(0.004279972)(-0.2384334)]$

   $= 0.19V + 0.001020428V$

   $= 0.19102V$

3. The compound QF_3 (MW = 139.462g/mol) has a solubility of 2.838g/L.

a.) What is the molar solubility of this compound?

Answer: 0.02035 M

$$\frac{2.838g}{L} \times \frac{1mol}{139.4629}$$

$$= 0.0203496\ mol/L$$

b.) Calculate the K_{sp} for this compound.

Answer: 4.630×10^{-6}

$$QF_3(s) \rightleftharpoons Q^{3+}(aq) + 3F^-(aq)$$
$$\quad\quad\quad\quad\quad\quad X \quad\quad\quad 3X$$

$K_{sp} = [X][3X]^3 \quad X = 0.0203496$

$K_{sp} = [0.0203496][3 \times 0.0203496]^3 = 4.630087 \times 10^{-6}$

4. Calculate the mass, in grams, of solid metal that can be produced when 2.5amps of current is passed through molten $CrCl_3$ for 30.0 minutes.

$30.0min\left(\frac{60.0s}{min}\right) = 1800s$

Answer: 0.81g

$$n = \frac{At}{F} = \frac{(2.5)(1800)}{96,485} = 0.0466394\ mol\ e^-$$

$$0.0466394\ mol\ e^-\left(\frac{1\ mol\ Cr}{3\ mol\ e^-}\right)$$

$$= 0.01554646\ mol\ Cr\left(\frac{51.996g}{mol}\right)$$

$$= 0.808354g\ Cr$$

5. Balance the reaction $CrO_4^{2-} + W^{1+} \rightarrow WO_2^{1-} + Cr^{3+}$. You do not need to include phases.

a.) In acidic solution:

Answer: $2CrO_4^{2-} + 3W^{+} + 4H^{+} \rightarrow 2Cr^{3+} + 3WO_2^{-} + 2H_2O$

$2\left(CrO_4^{2-} + 8H^{+} \xrightarrow{+3e^-} Cr^{3+} + 4H_2O\right)$ $\qquad$ $3\left(W^{+} + 2H_2O \rightarrow WO_2^{-} + 4H^{+} + 2e^-\right)$

$2Cr_2O_4^{2-} + \overset{4}{16}H^{+} + 6e^- \rightarrow 2Cr^{3+} + \overset{2}{8}H_2O$

$3W^{+} + 6H_2O \rightarrow 3WO_2 + 12H^{+} + 6e^-$

$2Cr_2O_4^{2-} + 3W^{+} + 4H^{+} \rightarrow 2Cr^{3+} + 3WO_2^{-} + 2H_2O$

b.) Convert your answer in part a so that the reaction is balanced in basic solution.

Answer: $2CrO_4^{2-} + 3W^{+} + 2H_2O \rightarrow 2Cr^{3+} + 3WO_2^{-} + 4OH^{-}$

$2Cr_2O_4^{2-} + 3W^{+} + \overset{2}{4}H_2O + 4H^{+} + 4OH^{-} \rightarrow 2Cr^{3+} + 3WO_2^{-} + 2H_2O + 4OH^{-}$

6. The K_{sp} of MgF_2 is 3.7×10^{-8} $\qquad$ $MgF_2(s) \rightleftharpoons \underset{x}{Mg^{2+}(aq)} + \underset{2x}{2F^{-}(aq)}$

a.) Calculate the molar solubility in water.

Answer: $2.1 \times 10^{-3}\ M$

$3.7 \times 10^{-8} = [x][2x]^2$

$3.7 \times 10^{-8} = 4x^3$

$\sqrt[3]{x^3} = \sqrt[3]{9.25 \times 10^{-9}}$

$x = 2.099168 \times 10^{-3} M$

b.) Calculate the molar solubility in 0.125M NaF.

Answer: $2.4 \times 10^{-6}\ M$

$3.7 \times 10^{-8} = [x][0.125]^2$

$3.7 \times 10^{-8} = [x][1.5625 \times 10^{-2}]$

$x = 2.368 \times 10^{-6} M$

7. Given a 3 electron system at 298.15K where $K_{eq} = 6.82 \times 10^2$

a.) Calculate E° Answer: +0.0559V

$$E^\circ = \frac{(8.314\ J/mol\,K)(298.15\ K)}{(3)(96485\ J/V\cdot mol)} \ln(6.82 \times 10^2)$$

$$= (8.563746 \times 10^{-3}\ V)(6.52503) = 0.55879V$$

b.) Calculate ΔG° Answer: -1.62×10^4 J
−16.4 kJ

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

$$= (-3\ mol)(96.485\ J/V\cdot mol)(0.055879V)$$

$$= -16174.37\ J$$

c.) Is this process favored in the forward direction? Answer: Yes

d.) Briefly explain your answer to part c.

ΔG is negative
E is positive