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.) A 1M solution of SnF_2 is electrolyzed. What are the products? 1.) C
a.) Sn(s), F_2(g) b.) O_2(g), H_2(g) (c.) Sn(s), O_2(g), H^+(aq) d.) F_2(g), H_2(g)

2.) Which of the following would be the best reducing agent? 2.) D
a.) tin b.) iron c.) sodium (d.) potassium

3.) Which of the following would have the highest molar solubility? 3.) A
(a.) BaF_2 ($K_{sp} = 1.0\times10^{-6}$) b.) CaF_2 ($K_{sp} = 5.3\times10^{-9}$)
c.) PbF_2 ($K_{sp} = 2.7\times10^{-8}$ d.) MgF_2 ($K_{sp} = 3.7\times10^{-8}$)

4.) What is the cell voltage for the following cell: $Pb(s)|Pb^{2+}(aq)||Cr^{3+}(aq)|Cr(s)$ 4.) B
a.) +0.61V (b.) −0.61V c.) +0.87 d.) −0.87
$-0.74V-(-0.13V) = -0.61V$

5.) Which of the following would be the best choice to prevent the oxidative corrosion of chromium? 5.) B
a.) Copper (b.) Aluminum c.) Lead d.) Cobalt

6.) A galvanic cell is set up using a Co^{2+}/Co ($-0.28V$) electrode and a Zn^{2+}/Zn (-0.76) electrode. 6.) D
Which response best describes the Co^{2+}/Co electrode?
a.) It is the anode and undergoes oxidation b) It is the anode and undergoes reduction
c.) It is the cathode and undergoes oxidation (d.) It is the cathode and undergoes reduction
→ spontaneous so E_{cell} is positive

7.) Which of the following would create a spontaneous cell with an Fe/Fe^{2+} ($-0.44V$) cathode? 7.) D
↳ need pos E_{cell}
a.) Pb/Pb^{2+} ($-0.13V$) Ni/Ni^{2+} ($-0.25V$) c.) Cu/Cu^{2+} ($+0.16V$) (d.) Ba/Ba^{2+} ($-2.90V$)

8.) If a solution of Na_2SO_4 was combined with a solution of $Sr(NO_3)_2$, what would be the most likely precipitate? 8.) A
(a.) $SrSO_4$ b.) $NaNO_3$ c.) Sr_2SO_4 d.) $Na(NO_3)_2$

9.) Which of the following would have increased solubility in a solution of NaOH? 9.) B
Acids are more soluble in basic solutions
a.) $CH_3CH_2NH_2$ (b.) $CH_3CH_2CH_2COOH$ c.) $Ca(OH)_2$ d.) CaF_2

10.) What is the Cell Voltage for a cell with a Sn^{2+}/Sn cathode and an Be^{2+}/Be anode? 10.) C
a.) +2.85V b.) −2.85V (c.) +1.71V d.) −1.71V

$-0.14V-(-1.85V) =$

SHORT ANSWER (10 pts each): Completely answer all of the following questions. Read all questions carefully!!! SHOW ALL WORK. If your work is in a different location, you must make a note of this in the given work area for the problem in order for the work to be considered for partial credit. 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.) Given 550mL of a 5.00×10^{-4}M solution of $Co(NO_3)_2$

a.) What mass, in grams, of KOH would need to be added to start precipitation? The K_{sp} value for the product is 1.6×10^{-15}.

$56.10654\ g/mol$ = molar mass KOH

Insoluble product: $Co(OH)_2$

$Co(OH)_2(s) \rightleftharpoons Co^{2+}(aq) + 2OH^-(aq)$ ← 5.00×10^{-4}M

$K_{sp} = [Co^{2+}][OH^-]^2$

$\frac{1.6\times10^{-15}}{5.00\times10^{-4}} = \frac{[5.00\times10^{-4}][OH^-]^2}{5.00\times10^{-4}}$

$\sqrt{[OH^-]^2} = \sqrt{3.2\times10^{-12}}$

$[OH^-] = 1.788854\times10^{-6}\ \frac{mol}{L} \times 0.550L$

$= 9.8387\times10^{-7}\ mol\left(\frac{56.10654\ g}{mol}\right)$

$= 5.52015\times10^{-5}\ g$

Answer: $5.5\times10^{-5}\ g$

$[OH^-] = [KOH]$

b.) What is the formula of the product?

Answer: $Co(OH)_2$

2.) a.) How many grams of solid gold will be produced in an electrolytic cell of molten $AuCl_3$ if a current of 0.496A is passed through the cell for 3.0hrs?

$nF = At \quad n = \frac{At}{F}$

$3.0hr\left(\frac{60min}{hr}\right)\left(\frac{60s}{min}\right) = 10800s$

$n = \frac{(0.496A)(10800s)}{96,485\ \frac{A\cdot s}{mol}}$

$= 0.0555195\ mol\ e^-\left(\frac{1\ mol\ Au}{3\ mol\ e^-}\right)$

$= 0.0185065\ mol\ Au\left(\frac{196.967\ g}{mol}\right)$

$= 3.645179\ g$

Answer: $3.6\ g$

a.) How much work is done by this system?

$2Au^{3+} + 6Cl^- \rightarrow 2Au + 3Cl_2$

$w = -nFE$

$E^\circ_{cell} = E^\circ_{cathode}(Au) - E^\circ_{anode}(Cl) = 1.50V - 1.36V = 0.14V$

$w = -(0.0555195\ mol\ e^-)(96,485\ J/V\cdot mol)(0.14V) = -749.95J$

Answer: $-750\ J$

3.) The K_{sp} value for CdS is 8.0×10^{-28}

a.) What is the molar solubility in water? Answer: 2.8×10^{-14} M

$CdS(s) \rightleftharpoons Cd^{2+}(aq) + S^{2-}(aq)$

$X \quad X$

$8.0 \times 10^{-28} = X^2$

$X = 2.8284 \times 10^{-14}$ M

b.) What is the molar solubility in 1.50M NH_3? K_f for the complex $[Cd(NH_3)_4]^{2+}$ is 1.3×10^7

$CdS(s) \rightleftharpoons Cd^{2+}(aq) + S^{2-}(aq)$

$Cd^{2+}(aq) + 4NH_3(aq) \rightleftharpoons [Cd(NH_3)_4]^{2+}(aq)$ Answer: 2.3×10^{-10} M

$CdS(s) + 4NH_3(aq) \rightleftharpoons [Cd(NH_3)_4]^{2+}(aq) + S^{2-}(aq)$

$K_{eq} = \frac{[Cd(NH_3)_4]^{2+}[S^{2-}]}{[NH_3]^4} = 1.04 \times 10^{-20} = \frac{[X][X]}{[1.50]^4}$

$K_{eq} = K_{sp} \times K_f$

$= (8.0 \times 10^{-28})(1.3 \times 10^7)$

$= 1.04 \times 10^{-20}$

$1.04 \times 10^{-20} = \frac{X^2}{5.0625}$ $\quad X^2 = 5.265 \times 10^{-2}$

$X = 2.29456 \times 10^{-10}$ M

c.) What is the K_{eq} for the overall process? Answer: 1.04×10^{-20}

$K_{eq} = K_{sp} \times K_f$

4.) Given the following Redox reaction: $ClO_3^-(aq) + Sn(s) \rightarrow Cl_2(g) + Sn^{2+}(aq)$

a.) Balance the reaction in acidic solution:

$2[ClO_3^- + 5e^- \rightarrow Cl_2]$ $\quad 5[Sn \rightarrow Sn^{2+} + 2e^-]$

$2ClO_3^- + 10e^- + 12H^+ \rightarrow 2Cl_2 + 6H_2O$ $\quad 5Sn \rightarrow 5Sn^{2+} + 10e^-$

$5Sn \rightarrow 5Sn^{2+} + 10e^-$

$2ClO_3^- + 5Sn + 12H^+ \rightarrow Cl_2 + 5Sn^{2+} + 6H_2O$

b.) Take your answer for the reaction balanced in acidic solution and convert it so that it is balanced in basic solution.

$2ClO_3^- + 5Sn + \overbrace{12H^+ + 12OH^-}^{6\ +12H_2O} \rightarrow Cl_2 + 5Sn^{2+} + 6H_2O + 12OH^-$

$2ClO_3^- + 5Sn + 6H_2O \rightarrow Cl_2 + 5Sn^{2+} + 12OH^-$

c.) How many electrons are transferred in the balanced equation?

Answer: $10e^-$

5.) The K_{sp} value for SrF_2 is 2.5×10^{-9}

a.) What is the molar solubility in water? Answer: $8.5 \times 10^{-4}\ M$

$SrF_2(s) \rightleftharpoons Sr^{2+}(aq) + 2F^-(aq)$

$X \qquad 2X$

$\frac{2.5 \times 10^{-9}}{4} = [X][2X]^2 = \frac{4X^3}{4}$

$\sqrt[3]{X^3} = \sqrt[3]{6.25 \times 10^{-10}}$

$X = 8.54988 \times 10^{-4}\ M$

b.) What is the molar solubility in 0.020M NaF? Answer: $6.2 \times 10^{-6}\ M$

$SrF_2(s) \rightleftharpoons Sr^{2+}(aq) + 2F^-(aq)$

$X \qquad 0.020$

$2.5 \times 10^{-9} = [X][0.020]^2$

$\frac{2.5 \times 10^{-9}}{0.0004} = \frac{[X][0.0004]}{0.0004}$

$X = 6.25 \times 10^{-6}\ M$

6.) Given the reaction: $3Sn^{2+}(aq) + 2Al(s) \leftrightarrow 2Al^{3+}(aq) + 3Sn(s)$

a.) Write the ½ reaction at the anode. (oxidation) Answer: $Al(s) \leftrightarrow Al^{3+}_{(aq)} + 3e^-$

b.) Write the ½ reaction at the cathode. (reduction) Answer: $Sn^{2+}(aq) + 2e^- \leftrightarrow Sn(s)$

c.) What is the value of $E°_{cell}$? Include the sign with your answer.

$E°_{cell} = E°_{cathode} - E°_{anode}$ Answer: $+1.52V$

$-0.14V - (-1.66V) = +1.52V$

d.) What is the value of K at 25°C?

$E°_{cell} = \frac{RT}{nF} \ln K$

$1.52V = \frac{(8.314\ J/mol\,K)(298.15K)}{(6)(96,485\ J/V \cdot mol)} \ln K$

$\frac{1.52V}{4.281873 \times 10^{-3}V} = \frac{4.281873 \times 10^{-3}V \ln K}{4.281873 \times 10^{-3}V}$

$\ln K = 354.985$

$K = e^{354.985} =$

Answer: $K = e^{355}$

(since value is too large for many calculators to process it can be reported in terms of e)

7.) A cell uses the following reaction: $Cu^{2+}(aq) + 2Ag(s) \leftrightarrow 2Ag^{+}(aq) + Cu(s)$

b.) What is the value of E°_{cell} under standard conditions?

Cu = cathode Ag = anode

$E^{\circ}_{cell} = 0.34V - 0.80V = -0.46eV$

Answer: $-0.46eV$

b.) What is the value of E_{cell} at 298K when Cu^{2+} = [0.062M] and Ag^{+} = [0.0054M]

$E = E^{\circ}_{cell} - \left(\frac{RT}{nF}\right) \ln Q$

Answer: $-0.36eV$

$Q = \frac{[0.0054]^2}{[0.062]} = \frac{2.916 \times 10^{-5}}{0.062} = 4.7032 \times 10^{-4}$

$E = -0.46eV - \left(\frac{(8.314\ J/mol\cdot K)(298K)}{(2)(96,485\ J/V\cdot mol)}\right) \ln(4.7032 \times 10^{-4})$

$E = -0.46eV - [(1.2839 \times 10^{-2}V)(-7.6621)]$

$E = -0.46eV + 9.8374 \times 10^{-2}$

$E = -0.361623V$