MULTIPLE CHOICE (2 pts each): Write the 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) Which of the following would be the strongest oxidizing agent? 1) _____

a) Fe^{3+} b) Cr^{3+} c) Al^{3+} d) Au^{3+}

2) What is the oxidation number on chromium in the dichromate ion ($Cr_2O_7^{2-}$)? 2) _____

a) +7 b) +3 c) +6 d) +12

3) What is the entropy of a process that has a $\triangle H$ of 326J/mol at 18°C? 3) _____

a) 18.1 J/mol K b) 2.24 J/mol K

c) 5868 J/mol K d) 1.12 J/ mol K

4) Which of the following statements are true? 4) _____

I: electrons move toward the cathode

II: electrons move toward the anode

III: cations move toward the cathode

IV: anions move toward the cathdoe

a) I & IV b) II & III c) II & IV d) I & III

5) What is the equilibrium constant for a process with a stadard Gibbs Free Energy value of 0.0654kJ at 28°C? 5) _____

a) 0.974 b) 0.755 c) 1.32 d) 1.03

6) What is the maximum electrical work that can be done when 3 moles of Cl_2 are reduced to Cl^- in a system will a cell potential of +2.20V? 6) _____

a) -3.18×10^5 J b) -1.06×10^6 J c) -1.27×10^6 J d) -6.37×10^5 J

7) Which of the following cations would be reduced in aqueous solution? 7) _____

a) Ba^{2+} b) Pb^{2+} c) Li^+ d) Na^+

8) Which of the following processes would lead to greater entropy? 8) _____

a) synthesizing aspirin

b) growing a tree

c) organizing your dorm room

d) turining your chemistry notes into confetti

SHORT ANSWER (14 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) Given the overall cell reaction: $Co^{2+}(aq) + Fe(s) \rightarrow Fe^{2+}(aq) + Co(s)$

a.) Write the cell diagram. Answer a: _____

b.) What is the 1/2 reaction at the anode? Answer b: _____

c.) What is the 1/2 reaction at the cathode? Answer c: _____

d.) Calculate the standard cell potential for this cell. Answer d: _____

e.) Would Fe(s) spontaneously reduce Co^{2+} to the free metal? Answer e:_____

f.) Is this a Galvanic cell? Answer f: _____

2) Balance the following equation: $Br_2 + SO_2 \rightarrow Br^- + SO_4^{2-}$

a.) In acidic solution:

Answer a:_____

b.) In basic solution:

Answer b:_____

c.) What element was oxidized in the reaction? Answer c:_____

d.) What element was reduced in the reaction? Answer d: _____

e.) How many electrons were transferred in the balanced equation? Answer e: _____

3) Given the following reaction: $Li_2S \rightarrow 2Li^+ + S^{2-}$ Use the table on the cover sheet to:

a.) Calculate $\triangle H$

Answer a:_____

b.) Calcuate $\triangle S$

Answer b:_____

c.) Calculate $\triangle G$ at 25°C

Answer c: _____

d.) At what temperature (°C) does this reaction transition between spontaneous & nonspontaneous?

Answer d:_____

4) A cell uses the following reaction: $Al^{3+}(aq) + Cr(s) \rightarrow Cr^{3+}(aq) + Al(s)$

a.) What is the E_{cell} under standard conditions? Answer a: _____

b.) What is the E_{cell} at 25°C if $[Al^{3+}] = 0.50M$ and $[Cr^{3+}] = 0.75M$?

Answer b:_____

c.) What is $\triangle G$ under standard conditions?

Answer c: _____

d.) What is $\triangle G$ under the conditions described in part b?

Answer d:_____

5) For the reaction $A(aq) + 2B(aq) \rightarrow C(aq)$ $\triangle G° = -3.974$ kJ/mol

a.) What is the value of K at 25°C? Answer a:_____

b.) What is the value of $\triangle G$ at 100°C? Q = 1.63 at this temperature.

Answer b:_____

c.) What is the value of $\triangle G$ at 25°C if [A] = 0.200M, [B] = 0.150M, [C] = 1.20M?

Answer c:_____

6) A 0.368 A current is passed through molten $NiCl_3$ for 45 minutes.

a.) What is the reduction 1/2 reaction? Answer a: _____

b.) How many electrons are transferred in this process? Answer b: _____

d.) How many moles of Ni(s) would be produced? Answer c: _____

e.) What mass of Ni(s) would be produced? Answer d: _____

MULTIPLE CHOICE (2 pts each): Write the 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) Which of the following would be the strongest oxidizing agent? 1) D

a) Fe^{3+} b) Cr^{3+} c) Al^{3+} d) Au^{3+}

2) What is the oxidation number on chromium in the dichromate ion ($Cr_2O_7^{2-}$)? 2) C

a) +7 b) +3 c) +6 d) +12

$-2(7) = -14$ $-14 + 2Cr = -2$ $2Cr = +12$ $Cr = +6$

3) What is the entropy of a process that has a ΔH of 326J/mol at 18°C? 3) D

a) 18.1 J/mol K b) 2.24 J/mol K

c) 5868 J/mol K d) 1.12 J/ mol K

$S = \frac{\Delta H}{T} = \frac{326\ J/mol}{291.15\ K} = 1.12\ J/mol\,K$

4) Which of the following statements are true? 4) D

I: electrons move toward the cathode

II: electrons move toward the anode

III: cations move toward the cathode

IV: anions move toward the cathdoe

a) I & IV b) II & III c) II & IV d) I & III

5) What is the equilibrium constant for a process with a stadard Gibbs Free Energy value of 0.0654kJ at 28°C? 5) A

a) 0.974 b) 0.755 c) 1.32 d) 1.03 $K = e^{-0.026120?}$

$\Delta G = -RT \ln K$ $65.4\ J = -(8.314\ J/mol\,K)(301.15\ K) \ln K$ $\ln K = -0.026120?$

6) What is the maximum electrical work that can be done when 3 moles of Cl_2 are reduced to Cl^- in a system will a cell potential of +2.20V? 6) C

$3\ mol\ Cl_2 \left(\frac{2e^-}{Cl_2}\right) = 6\ mole^-$

a) -3.18×10^5 J b) -1.06×10^6 J c) -1.27×10^6 J d) -6.37×10^5 J

$W = -nFE = -(6\ mol)(96{,}485\ J/v.mol)(2.20V)$

7) Which of the following cations would be reduced in aqueous solution? 7) B

a) Ba^{2+} b) Pb^{2+} c) Li^+ d) Na^+

8) Which of the following processes would lead to greater entropy? 8) D

a) synthesizing aspirin

b) growing a tree

c) organizing your dorm room

d) turining your chemistry notes into confetti

SHORT ANSWER (14 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) Given the overall cell reaction: $Co^{2+}(aq) + Fe(s) \rightarrow Fe^{2+}(aq) + Co(s)$

a.) Write the cell diagram. Answer a: $Fe(s)|Fe^{2+}(aq)||Co^{2+}(aq)|Co(s)$

b.) What is the 1/2 reaction at the anode? Answer b: $Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$

c.) What is the 1/2 reaction at the cathode? Answer c: $Co^{2+}(aq) + 2e^- \rightarrow Co(s)$

d.) Calculate the standard cell potential for this cell. Answer d: $+0.16V$

$-0.28V - (-0.44V) = 0.16V$

e.) Would Fe(s) spontaneously reduce Co^{2+} to the free metal? Answer e: yes

f.) Is this a Galvanic cell? Answer f: yes

2) Balance the following equation: $Br_2 + SO_2 \rightarrow Br^- + SO_4^{2-}$

a.) In acidic solution:

Answer a: $Br_2 + SO_2 + 2H_2O \rightarrow 2Br^- + SO_4^{2-} + 4H^+$

$Br_2 + 2e^- \rightarrow 2Br^-$ $\quad 2H_2O + SO_2 \rightarrow SO_4^{2-} + 4H^+ + 2e^-$

$+4OH^-$ $\quad +4OH^- \rightarrow 4H_2O$

b.) In basic solution:

Answer b: $Br_2 + SO_2 + 4OH^- \rightarrow 2Br^- + SO_4^{2-} + 2H_2O$

c.) What element was oxidized in the reaction? Answer c: sulfur

d.) What element was reduced in the reaction? Answer d: bromine

e.) How many electrons were transferred in the balanced equation? Answer e: $2e^-$

J/mol K ΔS 63 14 22

kJ/mol ΔH -447 -278.5 41.8

3) Given the following reaction: $Li_2S \rightarrow 2Li^+ + S^{2-}$ Use the table on the cover sheet to:

a.) Calculate ΔH

$[2(-278.5\ kJ/mol) + (41.8\ kJ/mol)] - [-447\ kJ/mol]$

$-557\ kJ/mol + 41.8\ kJ/mol$

$-515.2\ kJ/mol - (-447\ kJ/mol) = -68.2\ kJ/mol$

Answer a: $-68.2\ kJ/mol$

b.) Calcuate ΔS

$[2(14\ J/mol K) + (22\ J/mol K)] - [63\ J/mol K]$

$28\ J/mol K + 22\ J/mol K$

$50\ J/mol K - 63\ J/mol K = -13\ J/mol K = -0.013\ kJ/mol K$

Answer b: $-0.013\ kJ/mol K$

c.) Calculate ΔG at 25°C

$\Delta G = \Delta H - T\Delta S$

$= (-68.2\ kJ/mol) - [298.15\ K(-0.013\ kJ/mol K)$

$= -68.2\ kJ/mol + 3.876\ kJ/mol = -64.324\ kJ/mol$

Answer c: $-64.3\ kJ/mol$

d.) At what temperature (°C) does this reaction transition between spontaneous & nonspontaneous?

$0 = -68.2\ kJ/mol - T(-0.013\ kJ/mol K)$

$\frac{68.2\ kJ/mol}{0.013\ kJ/mol K} = \frac{T(0.013\ kJ/mol K)}{0.013\ kJ/mol K}$

$T = 5246.15\ K - 273.15 = 4973°C$

Answer d: 4973°C

4) A cell uses the following reaction: $Al^{3+}(aq) + Cr(s) \rightarrow Cr^{3+}(aq) + Al(s)$

a.) What is the E_{cell} under standard conditions?

$-1.66V - (-0.74) = -0.92V$

Answer a: $-0.92V$

b.) What is the E_{cell} at 25°C if $[Al^{3+}] = 0.50M$ and $[Cr^{3+}] = 0.75M$?

$E = E^0 - \frac{RT}{nF} \ln Q$

$Q = \frac{[Cr^{3+}]}{[Al^{3+}]} = \frac{0.75}{0.50} = 1.5$

$E = -0.92V - \frac{(8.314\ J/mol K)(298.15K)}{(3)(96,485\ J/V\text{-}mol)} \ln(1.5)$

$= -0.92V - [(0.00856374\ 6V)(0.405465)]$

$= -0.92V - 0.0034723 = -0.9235V$

Answer b: $-0.9235V$

c.) What is ΔG under standard conditions?

$\Delta G = -nFE = -(3)(96,485\ J/V\text{-}mol)(-0.92V) = +266298.6\ J/mol$

Answer c: $+266\ kJ/mol$

d.) What is ΔG under the conditions described in part b?

$\Delta G = -(3)(96,485\ J/V\text{-}mol)(-0.9235V)$

$= +267312\ J/mol$

Answer d: $+267\ kJ/mol$

5) For the reaction $A(aq) + 2B(aq) \rightarrow C(aq)$ $\Delta G° = -3.974$ kJ/mol

a.) What is the value of K at 25°C? Answer a: 4.9689

$\Delta G = -RT\ln K$

$-3.974\ kJ/mol = -(8.314\times10^{-3}\ kJ/mol\,K)(298.15\,K)\ln K$ (−2.4788 kJ/mol)

$\ln K = 1.603195 \quad K = e^{1.603195} = 4.9689$

b.) What is the value of ΔG at 100°C? Q = 1.63 at this temperature.

$\Delta G = \Delta G° + RT\ln Q$ Answer b: −2.458 kJ/mol

$\Delta G = -3.974\ kJ/mol + [(8.314\times10^{-3}\ kJ/mol\,K)(373.15K)\ln(1.63)]$ (0.48858)

$= -3.974\ kJ/mol + 1.51576\ kJ/mol = -2.458\ kJ/mol$

c.) What is the value of ΔG at 25°C if [A] = 0.200M, [B] = 0.150M, [C] = 1.20M?

$Q = \frac{[1.20]}{[0.200][0.150]^2} = 266.67$ Answer c: +9.873 kJ/mol

$\ln 266.67 = 5.58601$

$\Delta G = -3.974\ kJ/mol + [(8.314\times10^{-3}\ kJ/mol\,K)(298.15K)(5.58601)]$

$= -3.974\ kJ/mol + 13.8467\ kJ/mol = +9.8727\ kJ/mol$

6) A 0.368 A current is passed through molten $NiCl_3$ for 45 minutes.

a.) What is the reduction 1/2 reaction? Answer a: $Ni^{3+} + 3e^- \rightarrow Ni$

b.) How many electrons are transferred in this process? Answer b: 3

d.) How many moles of Ni(s) would be produced? Answer c: 0.00343 mol

$45\,min\left(\frac{60s}{min}\right) = 2700s$

$n = \frac{(2700s)(0.368A)}{96{,}485\ \frac{A\cdot s}{mol}} = 0.010299774\,e^-\left(\frac{1\,mol\,Ni}{3\,mole^-}\right) = 0.00343265 8\,mol\,Ni\left(\frac{58.693}{mol}\right)$

$= 0.20147g$

e.) What mass of Ni(s) would be produced? Answer d: 0.201g