Chemistry 210 Exam 4

Be sure to put your name on each page. This page can be removed from your exam so that you will have a Periodic Table handy throughout the exam, it does not need to be turned in. Show all your work for problems which require any sort of calculation, no credit will be given for answers without work shown. If you have shown a significant amount of work or multiple drawings for a problem, draw a box around what you consider your final answer.

Avogadro's Number = 6.022×10^{23} $^{\text{units}}/_{\text{mol}}$
$32.00^{\circ}F = 0.000^{\circ}C = 273.15K$
Density of Water = $1.000\ ^{g}/_{mL}$
$R = 0.08206\ ^{L \cdot atm}/_{mol \cdot K} = 8.314\ ^{J}/_{mol \cdot K}$
1atm = 760torr = 760mmHg = 101.325kPa
$PV=nRT$
$\Delta T_{fp/bp} = k_{fp/bp} \bullet m \bullet i$
For water: $k_{fp} = -1.86\ ^{\circ C}/_{m}$
$k_{bp} = 0.512\ ^{\circ C}/_{m}$
$P_1 = X_1 P_1^{\circ}$
$\Pi = MRTi$
$C_1V_1 = C_2V_2$

Integrated Rate Laws:

0^{th}	$[A]_t$	$= -kt + [A]_o$
1^{st}	$\ln[A]_t$	$= -kt + \ln[A]_o$
2^{nd}	$1/[A]_t$	$= kt + 1/[A]_o$

$k = Ae^{-Ea/RT}$

$$\ln(k) = \left(\frac{-E_a}{R}\right)\left(\frac{1}{T}\right) + \ln(A)$$

$$\ln\left(\frac{k_1}{k_2}\right) = \frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

$$pH = pK_a + \log\left(\frac{[\text{conjugate base}]}{[\text{conjugate acid}]}\right)$$

$E_{cell} = E^{o}_{cell} - {}^{RT}/_{nF}\ ln Q$
$E^{o}_{cell} = {}^{RT}/_{nF}\ ln K^{o}$
$K^{o} = e^{\wedge}({}^{nF}/_{RT}\ E^{o}_{cell})$
$F = 96485\ ^{J}/_{V \bullet mol\ of\ electrons}$
$\Delta G^{o} = \Delta H^{o}_{system} - T\Delta S^{o}_{system}$
$\Delta G^{o} = -nFE^{o}_{cell} = -RT ln K^{o}$
$\Delta G = \Delta G^{o} + RT ln Q$
$F = 96485\ ^{C}/_{mol\ electrons}$
1A = 1 C / sec

Quadratic formula:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

1 **H** 1.0079																	2 **He** 4.0026
3 **Li** 6.941	4 **Be** 9.0122											5 **B** 10.811	6 **C** 12.011	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.180
11 **Na** 22.990	12 **Mg** 24.305											13 **Al** 26.982	14 **Si** 28.086	15 **P** 30.974	16 **S** 32.066	17 **Cl** 35.453	18 **Ar** 39.948
19 **K** 39.098	20 **Ca** 40.078	21 **Sc** 44.956	22 **Ti** 47.88	23 **V** 50.942	24 **Cr** 51.996	25 **Mn** 54.938	26 **Fe** 55.847	27 **Co** 58.933	28 **Ni** 58.69	29 **Cu** 63.546	30 **Zn** 65.39	31 **Ga** 69.723	32 **Ge** 72.61	33 **As** 74.922	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.80
37 **Rb** 85.468	38 **Sr** 87.62	39 **Y** 88.906	40 **Zr** 91.224	41 **Nb** 92.906	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.76	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	71 **Lu** 174.97	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.84	75 **Re** 186.21	76 **Os** 190.23	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** 226.03	103 **Lr** (260)	104 **Rf** (261)	105 **Db** (262)	106 **Sg** (263)	107 **Bh** (262)	108 **Hs** (265)	109 **Mt** (266)	110 (269)	111 (272)	112 (277)		114		116		

57 **La** 138.91	58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** (145)	62 **Sm** 150.36	63 **Eu** 151.97	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.94	70 **Yb** 173.04
89 **Ac** 227.03	90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** 237.05	94 **Pu** (244)	95 **Am** (243)	96 **Cm** (247)	97 **Bk** (247)	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (258)	101 **Md** (258)	102 **No** (259)

Score

Multiple Choice (5pts each): Circle the letter of the most correct response.

1. A large negative change in free energy means:
   a. The reaction is very slow
   b. The system is becoming more disordered
   c. The reaction is spontaneous
   d. The reaction is exothermic
   e. The reaction is not spontaneous

2. A reaction will be spontaneous at relatively high temperature and non-spontaneous at relatively low temperature if:
   a. $\Delta H^{o}_{system} > 0$ and $\Delta S^{o}_{system} > 0$
   b. $\Delta H^{o}_{system} > 0$ and $\Delta S^{o}_{system} < 0$
   c. $\Delta H^{o}_{system} < 0$ and $\Delta S^{o}_{system} < 0$
   d. $\Delta H^{o}_{system} < 0$ and $\Delta S^{o}_{system} > 0$
   e. $\Delta H^{o}_{system} > 0$ and $\Delta S^{o}_{system} = 0$

3. For a reaction with a small negative ΔS:
   a. Heat is liberated by the reaction
   b. The disorder of the system is increasing
   c. The reaction proceeds very quickly
   d. The system is becoming more ordered
   e. The reaction is not spontaneous

4. If the change in enthalpy for a reaction is positive and the change in entropy is negative:
   a. The system is becoming more disordered
   b. The reaction will be non-spontaneous at all temperatures
   c. The reaction will be spontaneous only at low temperatures
   d. The reaction releases heat
   e. The reaction will be spontaneous at all temperatures

5. A reaction will be product-favored/spontaneous if:
   a. $\Delta G^{o} < 0$
   b. $\Delta S^{o} < 0$
   c. $E^{\circ}_{cell} < 0$
   d. $K_{eq} < 1$
   e. $\Delta H > 0$

6. How are the change in Gibb's Free Energy and the equilibrium constant for a reaction related?
   a. As K approaches zero, ΔG approaches zero
   b. They're not.
   c. As ΔG gets more negative, K gets very large
   d. The value of ΔG is equal to (-logK)
   e. As ΔG gets more positive, K approaches 1

7. In a spontaneous electrochemical voltaic cell, which of the following is ***true***?
   a. The cell potential is zero
   b. Cations flow through the salt bridge from the cathode to the anode
   c. The metal cathode gains mass as the cell reaction proceeds
   d. Oxidation occurs at the cathode
   e. Electrons flow from the cathode to the anode

Score

8. For a spontaneous redox reaction, which of the following is ***false***?
   a. Oxidation is the process of losing electrons
   b. Water molecules are added to balance any extra oxygen atoms
   c. ΔG is negative.
   d. Gaining electrons is reduction
   e. Electrons appear on the left side of the oxidation half reaction

9. Give the oxidation number for each atom in the following formulas. (15pts)

   $LiBrO_3$ P_2O_5 PH_3

10. For each of the following reactions, predict whether the sign if ΔS^o will be positive or negative and explain your answer. (15pts)

$$Ca(NO_3)_2(aq) + Na_3PO_4(aq) \leftrightarrows Ca_3(PO_4)_2(s) + 2\ NaNO_3(aq)$$

$$2\ NO(g) + O_2(g) \leftrightarrows 2\ NO_2(g)$$

$$H_2SO_3(aq) \leftrightarrows H_2O(l) + SO_2(g)$$

11. Why is the standard reduction potential for $Ca^{+2}|Ca$ ($E°_{red}$ = -2.868V) more negative than the standard reduction potential for $Mg^{+2}|Mg$ ($E°_{red}$ = -2.371V)? (5pts)

Score

12. You are studying a process for which $\Delta H° = +41.63^{kJ}/_{mol}$ and $\Delta S° = +318.7^{J}/_{mol\cdot K}$. What is $\Delta G°$ for this process at 25.00°C? Will the reaction be more or less spontaneous at 20.00°C? (10pts)

13. Ethane {$C_2H_6(g)$} can burn in oxygen to form carbon dioxide and water. How much {Gibb's Free} energy can be liberated by burning 39.618g of ethane in an unlimited supply of oxygen? (10pts)

14. You are studying the reaction of acetic acid {$CH_3CO_2H(l)$} with methyl amine {$CH_3NH_2(l)$} to produce N-methylacetamide {$C_3H_7NO(l)$} and water. When you run the reaction at 23.61ºC, you find that ΔG for this reaction is $+51.03^{kJ}/_{mol}$ and $\Delta S = +61.37\ ^{J}/_{mol\cdot K}$ (10pts)
    a. Is the reaction endothermic or exothermic? (*Explain your answer with explicit calculations.*)
    b. Over what temperature range is this reaction spontaneous?

15. You have burned 72.612g of ethene {$C_2H_4(g)$} in oxygen to form carbon dioxide and water. If all of the Gibb's Free Energy liberated by this reaction is used to decompose calcium fluoride to calcium metal and fluorine gas, how many grams of calcium metal will be formed? (15pts)

Score

16. For each of the following pairs of half-reactions/half-cells, determine the voltage of the spontaneous reaction/cell and write a balanced equation for the spontaneous reaction, identifying the oxidation and reduction half-reactions. (10pts each)

$Au^{3+}(aq)|Au^{+1}(aq)$ and $Cr^{3+}(aq)|Cr(s)$

$PbO_2(s)|Pb^{2+}(aq)$ and $I_2(s)|I^{-1}(aq)$

$HSO_4^{-1}(aq)|H_2SO_3(aq)$ and $MnO_4^{-1}(aq)|MnO_2(s)$

Thermodynamic Values at 25°C:

Substance	**ΔH^o_f ($^{kJ}/_{mol}$)**	**S^o ($^{J}/_{mol \cdot K}$)**	**ΔG^o_f ($^{kJ}/_{mol}$)**
$C_2H_6(g)$	-84.69	+229.5	-32.9
$O_2(g)$	0	+205.138	0
$CO_2(g)$	-393.5	+213.8	-394.4
$H_2O(g)$	-241.8	+188.8	-228.6
$H_2O(l)$	-285.8	+69.91	-237.2
$C_2H_4(g)$	+52.3	+219.5	+68.1
$CaF_2(s)$	-1228.0	+68.5	-1175.6
$Ca(s)$	0	+41.6	0
$F_2(g)$	0	+202.8	0

Standard Reduction Potentials at 25°C:

Half cell	**E^o_{red} (volts)**	**Half cell**	**E^o_{red} (volts)**
$Au^{3+}(aq)|Au^{+1}(aq)$	+1.361	$I_2(g)|I^{-1}(aq)$	+0.536
$Cr^{3+}(aq)|Cr(s)$	-0.913	$HSO_4^{-1}(aq)|H_2SO_3(aq)$	+0.167
$PbO_2(s)|Pb^{+2}(aq)$	+1.455	$MnO_4^{-1}(aq)|MnO_2(s)$	+1.673

Score