Name: _____

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} $^{units}/_{mol}$

$32.00^{o}F = 0.000^{o}C = 273.15K$

Density of Water = $1.000^{g}/_{mL}$

$R = 0.08206$ $^{L \cdot atm}/_{mol \cdot K} = 8.314$ $^{J}/_{mol \cdot K}$

$PV = nRT$

$\Delta T_{fp/bp} = k_{fp/bp} \cdot m \cdot i$

For water, $k_{fp} = -1.86^{o}C/_{m}$; $k_{bp} = 0.52^{o}C/_{m}$

$P_1 = X_1 P_1^{o}$

$\Pi = MRTi$

$C_1 V_1 = C_2 V_2$

Quadratic formula:

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

Integrated Rate Laws:

0th order $[A]_t = -kt + [A]_o$

1st order $\ln[A]_t = -kt + \ln[A]_o$

2nd order $1/[A]_t = kt + 1/[A]_o$

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

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

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

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

$E_{cell} = E^{o}_{cell} - $ $^{RT}/_{nF}$ lnQ

$E^{o}_{cell} = $ $^{RT}/_{nF}$ lnK^{o}

$K^{o} = e^{\wedge}($ $^{nF}/_{RT}$ $E^{o}_{cell})$

$F = 96485$ $^{J}/_{V \cdot mol\ of\ electrons}$

$\Delta G^{o} = \Delta H^{o}_{system} - T\Delta S^{o}_{system}$

$\Delta G^{o} = -nFE^{o}_{cell} = -RTlnK^{o}$

$\Delta G = \Delta G^{o} + RTlnQ$

$F = 96485$ $^{C}/_{mol\ electrons}$

$1A = 1\ C / sec$

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	57 La 138.91	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	89 Ac 227.03	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		

| 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	71 Lu 174.97
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)	103 Lr (260)

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 reaction is exothermic
   c. The reaction is not spontaneous
   d. The system is becoming more disordered
   e. The reaction is spontaneous

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

3. 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 releases heat
   c. The reaction will be spontaneous at all temperatures
   d. The reaction will be non-spontaneous at all temperatures
   e. The reaction will be spontaneous only at low temperatures

4. A reaction will be product-favored/spontaneous if:
   a. $\Delta G < 0$
   b. $\Delta S > 0$
   c. $K_{eq} < 1$
   d. $\Delta H > 0$
   e. $\Delta S < 0$

5. 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. The value of ΔG is equal to (-logK)
   c. As ΔG gets more positive, K approaches 1
   d. They're not.
   e. As ΔG gets more negative, K gets very large

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

   K_2SO_3 CO_2 CH_4

Score

7. For each of the following reactions, predict whether the sign if $\Delta S°$ will be positive or negative and explain your answer. (12pts)

$$Pb(NO_3)_2(aq) + 2\ NaCl(aq) \leftrightarrows PbCl_2(s) + 2\ NaNO_3(aq)$$

$$2\ NO_2(g) \Leftrightarrow 2\ NO(g) + O_2(g)$$
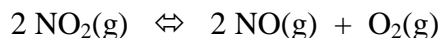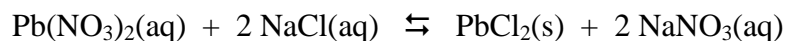
8. For liquid water $S° = +69.91\ ^J/_{mol \cdot K}$ and for gaseous water $S° = +188.825\ ^J/_{mol \cdot K}$. Explain this difference. (10pts)

9. Methane, $CH_4(g)$, burns in oxygen to form carbon dioxide and water. How much energy is released during the formation of 21.95g of water by this reaction? (20pts)

10. You are studying the reaction of benzoic acid $\{C_6H_5CO_2H(s)\}$ with methanol $\{CH_3OH(l)\}$ to produce methylbenzoate $\{C_8H_8O_2(l)\}$ and water. When you run the reaction at 17.61°C, you find that ΔG for this reaction is $-47.92\ ^{kJ}/_{mol}$ and $\Delta S = +34.18\ ^J/_{mol \cdot K}$ (20pts)
   a. Is the reaction endothermic or exothermic? (*Explain your answer with explicit calculations.*)
   b. Over what temperature range is this reaction spontaneous?

Score

11. You have burned 65.95g of ethane {$C_2H_6(g)$} in oxygen to form carbon dioxide and water. If all of the Gibb's Free Energy liberated by this reaction is used to decompose iron(III) chloride to iron metal and chlorine gas, how many grams of iron metal will be formed? (25pts)

12. For each of the following ***unbalanced*** chemical reactions, identify and write the oxidation and reduction half-reactions, and write the balanced redox reaction. (25pts)

$$Ce^{4+}(aq) + Al(s) \Leftrightarrow Ce^{3+}(aq) + Al^{3+}(aq)$$

$$Cr^{3+}(aq) + Ni^{2+}(aq) \Leftrightarrow Cr_2O_7^{2-}(aq) + Ni(s)$$
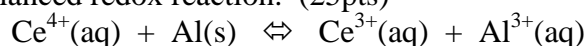
Thermodynamic Values at 25°C:

Substance	$\Delta H°_f$ ($^{kJ}/_{mol}$)	$S°$ ($^{J}/_{mol\cdot K}$)	$\Delta G°_f$ ($^{kJ}/_{mol}$)
$CH_4(g)$	-74.8	186.3	-50.8
$O_2(g)$	0	205.138	0
$CO_2(g)$	-393.509	213.74	-394.359
$H_2O(l)$	-285.83	69.91	-237.129
$H_2O(g)$	-241.818	188.825	-228.572
$C_2H_6(g)$	-84.68	229.5	-32.89
$FeCl_3(s)$	-400.39	142.3	-334.18
$Fe(s)$	0	27.15	0
$Cl_2(g)$	0	222.96	0

Score