Chem 130 **Name**_____
Exam 3, Ch 7, 19, 14 **November 9, 2016**
100 Points

Please follow the instructions for each section of the exam. Show your work on all mathematical problems. Provide answers with the correct units and significant figures. Be concise in your answers to discussion questions.

Part 0: Warmup. 4 points each

1. Reactions with a positive ΔH^o and a negative ΔS^o are
   a. spontaneous at all temperatures.
   b. non-spontaneous at all temperatures.
   c. spontaneous at low temperatures but non-spontaneous at high temperatures. Answer _____
   d. non-spontaneous at low temperatures but spontaneous at high temperatures.
2. Which of the processes below DOES NOT result in an increase in entropy?
   a. $2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O(g)$
   b. $H_2O(s) \rightarrow H_2O(\ell)$ (The melting of ice.)
   c. $CO_2(s) \rightarrow CO_2(g)$ (The sublimation of dry ice.) Answer _____
   d. $NH_4NO_3(s) \rightarrow N_2O(g) + 2\ H_2O(\ell)$
3. Consider the reaction below. If hydrogen chloride gas is being produced at 1.2 moles per liter per minute (M min^{-1}), at what rate is hydrogen gas being consumed?

   $$2ICl(g) + H_2(g) \rightarrow I_2(g) + 2HCl(g)$$

   a. 1.2 M min^{-1}
   b. 0.60 M min^{-1}
   c. 2.4 M min^{-1} Answer _____
   d. Not enough information to determine.

Part I: Complete all of problems 4-8

4. Describe what is meant when we call something a “state function”. How do the properties of a state function aid us in determining thermodynamic parameters and in predicting thermodynamic behavior? (6 points)

5. Concisely discuss the validity of each of the following statements. Clearly justify your reasoning. A few sentences should be sufficient. (14 points)
   a. Reactions with a positive ΔH^o and a positive ΔS^o can never be product-favored.

   b. Free energy changes provide a good indication of which reactions are favorable and fast, as well as those that are unfavorable and slow.

6. Consider a first order reaction B → Products. An experiment is performed and it is determined that, given a starting [B] = 0.100 M, it requires 56.2 seconds for the concentration to fall to 0.029 M. What is the rate constant for the reaction? How long would it take for the concentration to fall from 0.100 M to 0.0010 M? (14 points)

Answer: Rate constant_____ **Time to 0.0010 M**_____

7. How much heat energy is produced when 0.100 kg of gaseous ethane (C_2H_6) undergoes a combustion reaction with excess oxygen gas to produce gaseous carbon dioxide and liquid water? (14 points)

Species	ΔH^o_f, kJ mol^{-1}	Species	ΔH^o_f, kJ mol^{-1}
O(g)	+249.2	$H_2O(\ell)$	-285.8
$O_2(g)$	0	$H_2O(g)$	-241.8
H(g)	+218.0	$C_2H_6(g)$	-84.7
$H_2(g)$	0	$CO_2(g)$	-393.5

Answer_____

Part II. Answer three (3) of problems 8-11. Clearly mark the problem you do not want graded. 14 points each.

8. Determine ΔH^o for the reaction $N_2H_4(\ell) + 2H_2O_2(\ell) \rightarrow N_2(g) + 4H_2O(\ell)$ from these data:

Reaction	ΔH^o
$N_2H_4(\ell) + O_2(g) \rightarrow N_2(g) + 2H_2O(\ell)$	-622.2 kJ
$H_2(g) + ½\ O_2(g) \rightarrow H_2O(\ell)$	-285.8 kJ
$N_2(g) + O_2(g) \rightarrow 2NO(g)$	+173.1 kJ
$H_2(g) + O_2(g) \rightarrow H_2O_2(\ell)$	-187.8 kJ

Answer_____

9. A coffee-cup calorimeter contains 100.0 mL of 0.300 M HCl at 20.3°C. When 1.82 g zinc metal also at 20.3°C is added and is allowed to react via the net ionic equation below, the temperature rises to 30.5°C. What is the heat of reaction per mole of Zn? Assume no heat is lost to the environment during the course of the reaction and that the heat capacity and the density of the solution is the same as that of pure water (1.00 g/mL and 4.184 J/g°C, respectively).

$$Zn(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + H_2(g)$$

Answer_____

10. The reaction $I^-(aq) + OCl^-(aq) \rightarrow IO^-(aq) + Cl^-(aq)$ was studied and the data below were obtained. Determine the rate law and the value of the rate constant for this reaction.

$[I^-]_0$(mol/L)	$[OCl^-]_0$(mol/L)	Initial Rate (mol/Ls)
0.12	0.18	0.0791
0.060	0.18	0.0395
0.030	0.090	0.00988
0.24	0.090	0.0791

Answer_____

11. Consider the reaction $N_2O(g) + 2H_2O(\ell) \rightarrow NH_4NO_3(s)$ at 298K.

Species	ΔH^o_f, kJ mol^{-1}	S^o_f, J mol^{-1} K^{-1}	ΔG^o_f, kJ mol^{-1}
$O_2(g)$	0	205.1	0
$H_2(g)$	0	130.7	0
$NH_4NO_3(s)$	-365.6	151.1	-183.9
$N_2O(g)$	82.05	219.9	104.2
$H_2O(\ell)$	-285.8	69.91	-237.1
$H_2O(g)$	-241.8	188.8	-228.6

a. Is the forward reaction exothermic or endothermic? (5 points)

b. What is the value of ΔG^o at 298 K? (5 points)

c. Does the reaction occur spontaneously at temperatures above 298 K, below 298 K, both, or neither? Justify your answer. (4 points)

Possibly Useful Information

$R = 0.08206\ L\ atm\ mol^{-1}\ K^{-1}$ $R = 8.314\ J\ mol^{-1}\ K^{-1}$	$K = {}^{o}C + 273.15$	$slope = m = \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}$
$q = mc\Delta T$	$q = n_{LR}\Delta H_{rxn}$	$q = m\Delta H$
$\Delta S_{universe} = \Delta S_{system} - \Delta S_{surr}$	$\Delta G = \Delta H - T\Delta S$	$\Delta S_{surr} = -\Delta H_{sys}/T$
$rate = k[A]^0$	$[A]_t = -kt + [A]_0$	$t_{1/2} = [A]_0/2k$
$rate = k[A]^1$	$\ln[A]_t = -kt + \ln[A]_0$	$t_{1/2} = 0.693/k$
$rate = k[A]^2$	$\frac{1}{[A]_t} = kt + \frac{1}{[A]_0}$	$t_{1/2} = 1/(k[A]_0)$

To save some calculation time, you may round all atomic masses to two (2) decimal points.

1 1A												13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1 H 1.00794	2 2A																2 He 4.00260
3 Li 6.941	4 Be 9.01218											5 B 10.811	6 C 12.011	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.1797
11 Na 22.9898	12 Mg 24.3050	3 3B	4 4B	5 5B	6 6B	7 7B	8	9 8B	10	11 1B	12 2B	13 Al 26.9815	14 Si 28.0855	15 P 30.9738	16 S 32.066	17 Cl 35.4527	18 Ar 39.948
19 K 39.0983	20 Ca 40.078	21 Sc 44.9559	22 Ti 47.88	23 V 50.9415	24 Cr 51.9961	25 Mn 54.9381	26 Fe 55.847	27 Co 58.9332	28 Ni 58.693	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.61	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.9059	40 Zr 91.224	41 Nb 92.9064	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.906	46 Pd 106.42	47 Ag 107.868	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.757	52 Te 127.60	53 I 126.904	54 Xe 131.29
55 Cs 132.905	56 Ba 137.327	57 *La 138.906	72 Hf 178.49	73 Ta 180.948	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.967	80 Hg 200.59	81 Tl 204.383	82 Pb 207.2	83 Bi 208.980	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra 226.025	89 †Ac 227.028	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (277)	109 Mt (268)	110 Ds (271)	111 Rg (272)							

*Lanthanide series	58 Ce 140.115	59 Pr 140.908	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.965	64 Gd 157.25	65 Tb 158.925	66 Dy 162.50	67 Ho 164.930	68 Er 167.26	69 Tm 168.934	70 Yb 173.04	71 Lu 174.967
†Actinide series	90 Th 232.038	91 Pa 231.036	92 U 238.029	93 Np 237.048	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (262)