Chem 130 **Name_____**
Exam 4 **December 6, 2017**
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 I: Complete all of problems 1-3. 4 points each.

1. For the reaction $CO\ (g) + H_2O\ (g) \rightleftarrows H_2\ (g) + CO_2(g)$ at 1000K, $K_c = 0.66$ and $\Delta H^0 = -42$ kJ. After an initial equilibrium is established in a 1.00 L container, the equilibrium amount of H_2 can be increased by
   a. adding a catalyst.
   b. decreasing the temperature.
   c. transferring the mixture to a 10.0 L container. Answer _____
   d. Decreasing the pressure

2. Expansion of a valence shell to accommodate more than eight electrons is possible with:
   a. carbon.
   b. nitrogen. Answer _____
   c. phosphorous.
   d. oxygen.

3. For the reaction $CO(g) + 2H_2\ (g) \rightleftarrows CH_3OH(g)$ $K_c = 14.5$. If 5.00 mol CO, 2.00 mol H_2O and 3.00 mol of CH_3OH are brought together and allowed to react, which of the following describes the composition of the system at equilibrium?
   a. Some CO and H_2O will have been consumed to make more CH_3OH. Answer _____
   b. Some CH_3OH will have been consumed to make more CO and H_2O
   c. The amounts of CO, H_2O, and CH_3OH will be unchanged from their initial values.
   d. There is not enough information to determine the equilibrium composition.

Part II. <u>Equilibrium</u>. Answer <u>four (4)</u> of problems 4-8. Clearly mark the problems you do not want graded. 15 points each.

4. What do we mean when we say a system has *come to equilibrium*? Describe the equilibrium condition and why we don't use a single headed arrow when we write equilibria. What does a small equilibrium constant mean in terms of thermodynamics?

5. Suppose the reaction system below has already reached equilibrium. Predict the effect of the following changes on the system. Justify your predictions with a brief statement.

$$UO_2(s) + 4HF(g) \rightleftarrows UF_4(g) + 2H_2O(g)$$

   a. More UO_2 is added to the system.

   b. The reaction is performed in a glass reaction vessel and the HF reacts with the glass.

   c. Water vapor is removed.

   d. The volume is increased.

6. You have been tasked with determining the equilibrium constant for the reaction of H_2 and S_2 gases to produce hydrogen sulfide. A mixture of 1.00 g H_2 and 1.00 g H_2S in a 0.500 L flask comes to equilibrium at 1670 K. At equilibrium, there is 8.00×10^{-6} mol of S_2 present. What are the values for K_c and K_p at this temperature?

Answer_____

7. At a certain temperature, the equilibrium constant, K_c, for this reaction is 53.3. At this temperature, 0.800 mol of H_2 and 0.400 mol of HI were placed in a 0.50 L container to react. What concentration of HI is present at equilibrium?

$$H_2\,(g) + I_2\,(g) \rightleftarrows 2HI\,(g)$$

Answer_____

8. At equilibrium, the concentrations in this system were found to be $[N_2]=[O_2]=0.100$ M and [NO]=0.500 M. If more NO is added, bringing its concentration to 0.800 M, what will the final concentration of NO be after equilibrium is re-established?

$$N_2\,(g) + O_2\,(g) \rightleftarrows 2NO\,(g)$$

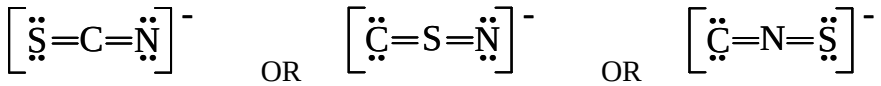
Answer_____

Part III. Bonding. Answer two (2) of problems 9-11. Clearly mark the problem you do not want graded. 15 points each.

9. Complete the table for **three (3)** of the species below.

Species	Lewis Structure (indicate resonance if necessary)	Species	Lewis Structure (indicate resonance if necessary)
H_2O		NO_2^-	
ClF_3		CS_2	

10. The Lewis structure for the thiocyanate ion (a polyatomic anion comprised of one atom each of C, N, and S) could be drawn in several ways, three of which are shown below. Which of these structures is more likely to be representative of the real structure of thiocyanate? Justify your answer.



11. Drawing the Lewis structure for carbonate ion (CO_3^{2-}) requires the use of the concept of *resonance*. Draw Lewis structures of carbonate and explain why resonance is necessary and how multiple resonance structures can be a better representation of the true structure than a single Lewis structure alone.

Possibly Useful Information

$R = 0.08206\ L\ atm\ mol^{-1}\ K^{-1}$ $R = 8.314\ J\ mol^{-1}\ K^{-1}$	$K = {}^{o}C + 273.15$	$slope = m = \frac{\Delta y}{\Delta x} = \frac{y_2 - y_1}{x_2 - x_1}$
$\Delta G = \Delta H - T\Delta S$	${}^{o}C = K - 273.15$	$K_p = K_c(RT)^{\Delta n}$
$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$	$pV = nRT$	$\Delta G = -RT\ln K$

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)