CHEM 130 **Name** ____

Quiz 10 – December 2, 2016

Complete the following problems. Write your final answers in the blanks provided.

1. Determine K_c for the reaction: $N_2(g) + O_2(g) + Cl_2(g) \rightleftharpoons 2NOCl(g)$ from the following data at 298K: (8 points)

$$\tfrac{1}{2} N_2(g) + O_2(g) \rightleftharpoons NO_2(g) \qquad K_p = 1.0 \times 10^{-9}$$
$$NOCl(g) + \tfrac{1}{2} O_2(g) \rightleftharpoons NO_2Cl(g) \qquad K_p = 1.1 \times 10^{2}$$
$$NO_2(g) + \tfrac{1}{2} Cl_2(g) \rightleftharpoons NO_2Cl(g) \qquad K_p = 0.3$$

We need to rearrange reactions to make our target reaction:

$$2(\tfrac{1}{2} N_2(g) + O_2(g) \rightleftharpoons NO_2(g)) \qquad K_p = (1.0 \times 10^{-9})^2$$
$$2(NO_2Cl(g) \rightleftharpoons NOCl(g) + \tfrac{1}{2} O_2(g)) \qquad K_p = 1/(1.1 \times 10^{2})^2$$
$$2(NO_2(g) + \tfrac{1}{2} Cl_2(g) \rightleftharpoons NO_2Cl(g)) \qquad K_p = (0.3)^2$$

So, the sum of the reactions is:

$$N_2 + \cancel{2}O_2 + 2\cancel{NO_2Cl} + \cancel{2NO_2} + Cl_2 \rightleftharpoons \cancel{2NO_2} + \cancel{2NOCl} + \cancel{O_2} + 2NO_2Cl$$
$$N_2 + O_2 + Cl_2 \rightleftharpoons 2NO_2Cl$$

$$K_p = \frac{(1.0 \times 10^{-9})^2(0.3)^2}{(1.1 \times 10^{2})^2} = 7.4\times10^{-24}$$

$$K_c = \frac{K_p}{(RT)^{\Delta n}} = \frac{7.4\times10^{-24}}{(0.08206\times298)^{-1}} = 1.81\times10^{-22}$$

2. You have been tasked with determining the equilibrium constant for the reaction of H_2 and S_2 gases to produce hydrogen sulfide. In a 0.500 L flask, a mixture that initially contains no S_2 and is 0.992 M H_2 and 0.0587 M H_2S comes to equilibrium at 1670 K. At equilibrium, there is 8.00×10^{-4} mol of S_2 present. What are the values for K_c and K_p at this temperature? (9 points)
Start with a balanced chemical reaction:

$$2H_2 + S_2 \rightleftharpoons 2H_2S$$

The equilibrium concentration of $S_2 = (8.00\times10^{-4}\text{ mol})/0.5\text{ L} = 0.00160\text{ M } S_2$

We need to determine equilibrium concentrations for the other two species. Mapping out the chemistry:

	$2H_2$	+	S_2	$\rightleftharpoons$	$2 H_2S$
i	0.992_1 M		0		0.0587 M
c	+2x		+x		-2x
e	0.992 + 2(0.00160) = 0.995_2 M		0.00160M		0.0587 – 2(0.00160) = 0.0555 M

Plugging in to K_c:

$$K_c = \frac{[H_2S]^2}{[H_2]^2[S_2]} = \frac{(0.0555)^2}{(0.995_2)^2(0.0016)} = \mathbf{1.94}$$

$$\mathbf{K_p = K_c(RT)^{\Delta n} = 1.94(0.08206\times1670)^{-1} = 0.0142}$$

3. Consider the reaction below. If the initial concentrations of H_2, F_2, and HF are 0.0100M, 1.25 M, and 2.21 M, respectively, is the system at equilibrium? If not, which way will the reaction go to achieve the equilibrium condition? Set up, but do not complete the calculation you would use to determine the equilibrium concentrations of each of the species in the reaction. You DO NOT need to arrive at a numerical answer, just get to the point where you have one algebraic expression you could solve, given additional time. **Be sure to tell me what you would do with the result of your calculation.** (8 points)

$$H_2(g) + F_2(g) \rightleftarrows 2HF(g) \qquad K = 115$$

Since we have intital concentrations of all species, we need to calculate Q first to determine the direction the reaction must go to get to equilibrium.

$$Q = \frac{[HF]^2}{[H_2][F_2]} = \frac{(2.21\ M)^2}{(0.0100\ M)(1.25\ M)} = 390$$

Since Q>K, the reaction is product heavy and more reactants will be formed on the way to equilibrium.

	H_2	+	F_2	$\rightleftarrows$	2 HF
i	0.0100 M		1.25 M		2.21 M
c	+x		+x		-2x
e	0.0100 + x		1.25 +x		2.21 – 2x

Insert these values into the equilibrium constant expression:

$$K = \frac{[HF]^2}{[H_2][F_2]} = \mathbf{\frac{(2.21 - 2x)^2}{(0.0100 + x)(1.25 + x)} = 115}$$

The boldface expression can now be solved for x, giving two possible solutions (quadratic). After choosing the chemically sensible solution, equilibrium concentrations can be calculate: [HF] = (2.21 – 2x)M, $[H_2]$ = (0.0100 + x)M, $[F_2]$ = (1.25 + x)M

Possibly Useful Information

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

1 1A	2 2A	3 3B	4 4B	5 5B	6 6B	7 7B	8 8B	9 8B	10 8B	11 1B	12 2B	13 3A	14 4A	15 5A	16 6A	17 7A	18 8A
1 H 1.00794																	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											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)