Chemistry 210 Exam 2

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 = $1.000 ^{g}/_{mL}$
$R = 0.08206 \ ^{L\bullet atm}/_{mol\bullet K} = 8.314 \ ^{J}/_{mol\bullet K}$
$PV=nRT$
$\Delta T_{fp/bp} = k_{fp/bp} \bullet m \bullet i$
For water, $k_{fp} = -1.86 ^{oC}/_{m}$; $k_{bp} = 0.52 ^{oC}/_{m}$
$P_1 = X_1 P_1^{o}$
$P = cRTi$
$C_1V_1 = C_2V_2$
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 $1/[A]_t = kt + 1/[A]_o$
$k = Ae^{-Ea/RT}$

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

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

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

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

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

Chem 210 – Exam 2 *Name:* ______________________________
Summer 2010

Multiple Choice (7pts each): Circle the letter of the most correct response.

1. For a reaction at equilibrium:
   a. The reactants and products must be in the gas phase.
   b. The concentration of reactants is equal to the concentration of products.
   c. The reaction has stopped.
   d. The mass of reactants is equal to the mass of products.
   e. The rate of the forward reaction is equal to the rate of the reverse reaction.

2. Which of the following is ***true*** regarding equilibrium reactions?
   a. If K = 1, the reaction has stopped.
   b. If K < 0, the reaction reaches equilibrium very quickly.
   c. If K > 1, the reaction is reactant-favored.
   d. If K < 1, the reaction is product-favored.
   e. If K is very large, the limiting reactant is very nearly used up.

3. Which of the following is ***false*** regarding equilibrium?
   a. Equilibrium can usually be shifted by changing pressure or temperature
   b. The rates of the forward and reverse reactions are equal
   c. Equilibrium concentrations do not depend upon whether you approach equilibrium from the left or the right
   d. The forward and reverse reactions stop when a system reaches equilibrium
   e. The concentrations of products and reactants does not change once the reaction has reached equilibrium

4. Which of the following equilibrium constant expressions is correct for the given reaction:

$$2\ HNO_3(g) + NO(g) \leftrightarrow 2\ NO_2(g) + H_2O(g)$$

   a. $K_c = \dfrac{2[NO_2]_{eq}[H_2O]_{eq}}{2[HNO_3]_{eq}[NO]_{eq}}$

   b. $K_c = \dfrac{[NO_2]_{eq}^2 + [H_2O]_{eq}}{[HNO_3]_{eq}^2 + [NO]_{eq}}$

   c. $K_c = \dfrac{[NO_2]_{eq}^2[H_2O]_{eq}}{[HNO_3]_{eq}^2[NO]_{eq}}$

   d. $K_c = \dfrac{[HNO_3]_{eq}^2[NO]_{eq}}{[NO_2]_{eq}^2[H_2O]_{eq}}$

   e. $K_c = \dfrac{[NO_2]_{eq}^2}{[HNO_3]_{eq}^2[NO]_{eq}}$

5. All of the following can be explained by LeChatelier's Principle except:
   a. Removing a gaseous product will shift the equilibrium right.
   b. Adding more of an aqueous reactant will shift the equilibrium right.
   c. Increasing the temperature of an endothermic reaction will shift the equilibrium right.
   d. Increasing the pressure will shift an equilibrium toward the side that has more gas particles.
   e. Removing a gaseous reactant will shift the equilibrium left.

Score

6. Considering the reaction given, all of the following stresses will shift the equilibrium to the left except:

$$CO(g) + H_2O(g) \leftrightarrow CO_2(g) + H_2(g) \qquad \Delta H_{rxn} = 131\ ^{kJ}/_{mol}$$

   a. Decreasing the pressure on the system
   b. Adding carbon dioxide to the system
   c. Adding hydrogen to the system
   d. Decreasing the temperature of the system
   e. Removing carbon monoxide from the system

7. The reaction quotient for a reaction:
   a. Tells you how fast the reaction happens
   b. Is usually a negative number
   c. Is a constant
   d. Tells you what direction the reaction must shift to reach equilibrium
   e. Is the concentration of reactants divided by the concentration of products

8. Which of the following statements is ***false*** regarding the reaction quotient, *Q*?
   a. It tells the direction that the reaction must shift to reach equilibrium
   b. If $Q<K_c$, the system needs to shift toward the products to reach equilibrium
   c. If $Q=K_c$, the system is at equilibrium
   d. If $Q>K_c$, the system needs to shift toward the products to reach equilibrium
   e. It has the same mathematical form as the equilibrium constant

Problems:

9. You have been studying the reaction of $N_2O(g)$ with $O_2(g)$ to form $NO_2(g)$. After your system has reached equilibrium, you find that the concentrations of all species are: $[N_2O]_{eq} = 0.142M$, $[O_2]_{eq} = 0.216M$, $[NO_2]_{eq} = 1.85M$. What is the value of the equilibrium constant for this reaction? (12pts)

$$2\ N_2O(g) + 3\ O_2(g) \Leftrightarrow 4\ NO_2(g)$$

$$K = \{ [NO_2]_{eq}^4 \} / \{ [N_2O]_{eq}^2 [O_2]_{eq}^3 \} = (1.85)^4 / \{ (0.142)^2 (0.216)^3 \} = 5.76 \times 10^4$$

10. A saturated potassium bromide solution is prepared by dissolving KBr in pure water and has a potassium ion concentration of 4.137M at some temperature. What is the K_{sp} of potassium bromide at this temperature? (16pts)

	KBr(s) ⇔	$K^+(aq)$ +	$Br^-(aq)$
Initial	--	0	0
Δ	--	+x	+x
@Equilibrium	--	x M	x M

$$K_{sp} = [K^+]_{eq}[Br^-]_{eq} = (x)(x) = x^2 = (4.137)^2 = 17.11$$

Score

11. What are the concentrations of strontium ions (Atomic # = 38) and hydroxide ions in a saturated solution of strontium hydroxide prepared from strontium hydroxide solid in water ($K_{sp} = 3.84x10^{-3}$)? (16pts)

	$Sr(OH)_2(s)$ ⇔	$Sr^{+2}(aq)$ +	2 $OH^-(aq)$
Initial	--	0	0
Δ	--	+x	+2x
@Equilibrium	--	x M	2x M

$$K_{sp} = [Sr^{+2}]_{eq}[OH^-]_{eq}^2 = (x)(2x)^2 = 4x^3 = 3.84x10^{-3}$$

$$x = 0.0986$$

$$[Sr^{+2}]_{eq} = x = 0.0986M$$

$$[OH^-]_{eq} = 2x = 0.197M$$

12. $NH_3(g)$ reacts with ClO(g) to form $NO_3(g)$ and HCl(g) with an equilibrium constant of $7.16x10^{-7}$. In a 2.00L reaction vessel, you have combined 0.372mols of NH_3 with 0.546mols of ClO. What are the concentrations of all reactants and products when this reaction reaches equilibrium? (25pts)

	$NH_3(g)$ +	3 ClO(g) ⇔	$NO_3(g)$ +	3 HCl(g)
Initial	0.372mol/2.00L = 0.186M	0.546mol/2.00L = 0.273M	0	0
Δ	-x	-3x	+x	+3x
@Equilibrium	(0.186-x)M	(0.273-3x)M	x M	3x M

$$K_c = \frac{[NO_3]_{eq}^1[HCl]_{eq}^3}{[NH_3]_{eq}^1[ClO]_{eq}^3} = \frac{(x)(3x)^3}{(0.186-x)(0.273-3x)^3} = 7.16x10^{-7}$$

This could be ugly, but let's make some assumptions. If 3x is much less than 0.273, this simplifies to:

$$\frac{(x)(3x)^3}{(0.186)(0.273)^3} = \frac{27x^4}{0.0037844} = 7.16x10^{-7}$$

So $x = 3.17x10^{-3}$, our assumption is valid. Plugging in to the equilibrium concentrations:

$[NH_3]_{eq} = 0.183M$; $[ClO]_{eq} = 0.263M$; $[NO_3]_{eq} = 3.17x10^{-3}M$; $[HCl]_{eq} = 9.51x10^{-3}M$

13. When 0.267mols of sulfur dioxide {$SO_2(g)$} and 0.338mols of fluorine gas {$F_2(g)$} are sealed together in a 1.500L vessel, they reach equilibrium with thionyl fluoride {$SOF_2(g)$} and oxygen {$O_2(g)$}. The equilibrium concentration of $F_2(g)$ is found to be 0.193 M. (25pts)
    a. What are the equilibrium concentrations of all products and reactants?
    b. What is the value of K_c?
    c. Is the reaction product-favored or reactant-favored?

	2 $SO_2(g)$ +	2 $F_2(g)$ ⇔	2 $SOF_2(g)$ +	$O_2(g)$
Initial	0.267mol/1.500L = 0.178M	0.338mol/1.500L = 0.225M	0	0
Δ	-2x	-2x	+2x	+x
@Equilibrium	(0.178-2x)M	(0.225-2x)M	2x M	x M

The problem states that the equilibrium concentration of $F_2(g)$ is 0.193M. Plugging in…

$$0.225 - 2x = 0.193$$

$$x = 0.0162$$

Plugging in to the equilibrium concentrations:

$[SO_2]_{eq} = 0.178-2(0.0162) = 0.146M$; $[F_2]_{eq} = 0.193M$; $[SOF_2]_{eq} = 2(0.0162) = 0.0323M$; $[O_2]_{eq} = 0.0162M$

Plugging these into the equilibrium constant expression:

$$K_c = \frac{[SOF_2]_{eq}^2[O_2]_{eq}^1}{[SO_2]_{eq}^2[F_2]_{eq}^2} = \frac{(0.0323)^2(0.0162)}{(0.146)^2(0.193)^2} = 2.13x10^{-2}$$

$K_c < 1$, therefore this is reactant-favored

Score