Dougherty Valley HS AP Chemistry
Equilibrium – Chemical Equilibrium
Problem Set 1

WORKSHEET #3

Name: **Date:** **Period:** **Seat #:**

For the following three reactions,

a) write the K_{eq} expression in terms of concentration, K_c.
b) given the equilibrium concentrations, state whether each equilibrium is product-favored, reactant-favored, or fairly even ([products] ≈ [reactants]).
c) calculate the value of K_c.

1. N_2g) + 3 H_2(g) ⇆ 2 NH_3(g)

   At equilibrium:
   $[N_2]$ = 1.50 M
   $[H_2]$ = 2.00 M
   $[NH_3]$= 0.01 M

2. HF(aq) ⇆ H^+(aq) + F^-(aq)

   At equilibrium:
   [HF] = 0.55 M
   $[H^+]$ = 0.001 M
   $[F^-]$= 0.001 M

3. Fe^{3+}(aq) + SCN^-(aq) ⇆ $FeSCN^{2+}$(aq)

   At equilibrium:
   $[Fe^{3+}]$ = 0.55 M
   $[SCN^-]$ = 0.001 M
   $[FeSCN^{2+}]$= 0.001 M

Summarize:
Fill in the blanks with product-favored, reactant-favored, and approximately equal

K_c	state of equilibrium
$K_c >> 1$	
$K_c << 1$	
$K_c \approx 1$	

4. Knowing that pure water has a density of 1g/1mL calculate the mass of 1.00 Liter of water.

   Calculate the number of moles in 1.00 L of H_2O.

   What is the concentration (M) of water in water?

   At this temperature, can you get more moles of water into this Liter of water?

   The $[H_2O]$ ________ (is / is not) constant.

Important Note:
Since the concentrations of solids and liquids are constant, they are incorporated into the equilibrium constant, K_{eq}. That means, just leave them out of the K_c or K_p expression. Only include (g) and (aq)!

5. Write equilibrium expressions for each of the following reactions:
   a) $CaCO_3$(s) ⇌ CaO(s) + CO_2(g)
   b) Ni(s) + 4CO(g) ⇌ $Ni(CO)_4$(g)
   c) 5CO(g) + I_2O_5(s) ⇌ I_2(g) + 5CO_2(g)
   d) $Ca(HCO_3)_2$(aq) ⇌ $CaCO_3$(s) + H_2O(l) + CO_2(g)
   e) AgCl(s) ⇌ Ag^+(aq) + Cl^-(aq)

6. Write the equilibrium expression in terms of partial pressures (K_p) for each of the following reactions. Rate the reactions in order of their increasing tendency to proceed toward completion:

___ ___ ___ ___

(a) $4NH_3(g) + 3O_2(g) \rightleftharpoons 2N_2(g) + 6H_2O(g)$ K_p = 1×10^{228} atm

(b) $N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$ K_p = 5×10^{-31}

(c) $2HF(g) \rightleftharpoons H_2(g) + F_2(g)$ K_p = 1×10^{-13}

(d) $2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g)$
$K_p = 4.7 \times 10^{-4}$ atm

A Question That You Should Be Able To Answer:
Why don't the K_p's in (b) and (c) have units?

7. (a) Write the K_c expression for
$$2\,SO_2(g) + O_2(g) \leftrightarrows 2\,SO_3(g)$$

Calculate the value of K_c:

At equilibrium: $[SO_2] = 1.50$ M
$[O_2] = 1.25$ M
$[SO_3] = 3.50$ M

(b) If we **reverse** the equation, it is:
$$2\,SO_3(g) \leftrightarrows 2\,SO_2(g) + O_2(g)$$
Write the K_c expression for this equation and calculate the new value of K_c:

How does the expression and the value of K_c in 7(b) compare with those in 7(a)?

(c) If we now **multiply all of the coefficients by ½:**
$$SO_3(g) \leftrightarrows SO_2(g) + \tfrac{1}{2}\,O_2(g)$$
Write the K_c expression for this equation and calculate the new value of K_c:

How do they compare with 7(b)?

(d) What would happen to the K_c expression and its value if we **doubled** the coefficients?

Summarize:

Equation	K_c expression & Value
doubled	
reversed	
halved	

8. Consider an equilibrium that occurs in two steps:
$$H_2S(aq) \leftrightarrows H^+(aq) + HS^-(aq)$$
$$\underline{HS^-(aq) \leftrightarrows H^+(aq) + S^{2-}(aq)}$$

(a) Write the overall reaction.
(b) How do the K_c's for the two steps (K_{c1} & K_{c2}) relate to the K_c of the overall reaction (K_c)?