South Pasadena • AP Chemistry

Name _____
Period ___ Date ___/___/___

16 • Chemical Equilibria

PROBLEM SET #1

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. $N_2g) + 3\ H_2(g) \leftrightarrows 2\ NH_3(g)$

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

2. $HF(aq) \leftrightarrows H^+(aq) + F^-(aq)$

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

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

   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) $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$

   b) $Ni(s) + 4CO(g) \rightleftharpoons Ni(CO)_4(g)$

   c) $5CO(g) + I_2O_5(s) \rightleftharpoons I_2(g) + 5CO_2(g)$

   d) $Ca(HCO_3)_2(aq) \rightleftharpoons CaCO_3(s) + H_2O(l) + CO_2(g)$

   e) $AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq)$

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:

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

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

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

(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:**
$SO_3(g) \leftrightarrows SO_2(g) + \frac{1}{2}\ O_2(g)$
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:
$H_2S(aq) \leftrightarrows H^+(aq) + HS^-(aq)$
$HS^-(aq) \leftrightarrows H^+(aq) + S^{2-}(aq)$

(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)?