Spring 2007 CH 302 Worksheet 3

Below are listed various reactions, stresses, and reaction components. Indicate how the amount of the indicated component changes when the stress is applied.

	Reaction	Stress	Component
1.	$3\ H_2\ (g) + N_2\ (g) \leftrightarrow 2\ NH_3\ (g)$	Addition of N_2 gas	H_2
2.	$CH_3OH\ (g) + 2\ O_2\ (g) \leftrightarrow CO_2\ (g) + 2\ H_2O\ (g)$	Addition of heat	CH_3OH
3.	$CH_3OH\ (g) + H_2\ (g) \leftrightarrow CH_4\ (g) + H_2O\ (l)$	Addition of pressure	CH_3OH
4.	$N_2\ (g) + O_2\ (g) \leftrightarrow 2\ NO\ (g)$	Reduction of pressure	O_2

Give the equation for K_c for the equations given in problems 5-8.

5. $2\ H_2\ (g) + 2\ O_2\ (g) \leftrightarrow 2\ H_2O\ (g)$

6. $HCl\ (aq) + H_2O\ (l) \leftrightarrow H_3O^+\ (aq) + Cl^-\ (aq)$

7. $NaCl\ (s) \leftrightarrow Na^+\ (aq) + Cl^-\ (aq)$

8. $C_8H_{18}\ (g) + 25/2\ O_2\ (g) \leftrightarrow 8\ CO_2\ (g) + 9\ H_2O\ (g)$

9. Consider the following reaction at 25°C:

   $$H_2 + I_2 \leftrightarrow 2\ HI$$

   The reaction mixture is initially prepared with $C_{H2} = 0.1$, $C_{I2} = 0.1$, $C_{HI} = 0.5$. What is Q for this initial reaction mixture?

10. Which direction will the reaction in number 7 shift?

11. For the reaction

    $$N_2\ (g) + 3\ H_2\ (g) \leftrightarrow 2\ NH_3\ (g)$$

    the equilibrium constant with respect to concentration, $K_c = 3.8$. Calculate K_p at 298 K, the equilibrium constant with respect to pressure in atm. (Note: This hasn't been covered in class yet and won't be on Tuesday's quiz.)

12. For the reaction

    $$NH_3\ (g) + HCl\ (g) \leftrightarrow NH_4Cl\ (s)$$

    $\Delta H = -176$ kJ/mol and $\Delta S = -305$ J/mol K. What is K for this reaction a 300 K? At 600 K?

13. Calculate ΔG for the formation of ammonia at 298 K, given $K_c = 3.8$.

14. Assume that at some temperature, the reaction given below has an equilibrium constant K_p of 7.5. $C_6H_{12}O_6$, O_2, CO_2, and H_2O are places in a reaction vessel, each with an initial concentration of 1 atm. What are the equilibrium pressures?

$$C_6H_{12}O_6\ (g) + 6\ O_2\ (g) \leftrightarrow 6\ CO_2\ (g) + 6\ H_2O\ (g)$$

a. $P_{C6H12O6} = 1.017$, $P_{O2} = 1.108$, $P_{CO2} = 0.892$, $P_{H2O} = 0.891$
b. $P_{C6H12O6} = 0.898$, $P_{O2} = 0.387$, $P_{CO2} = 1.613$, $P_{H2O} = 1.613$
c. $P_{C6H12O6} = 0.981$, $P_{O2} = 0.887$, $P_{CO2} = 1.112$, $P_{H2O} = 1.112$
d. $P_{C6H12O6} = 1.465$, $P_{O2} = 1.465$, $P_{CO2} = 0.535$, $P_{H2O} = 0.535$

15. Write an expression for K_p for the reaction in problem 14 above, in terms of x = the magnitude of the change in pressure of $C_6H_{12}O_6$.

16. Assume that the reaction below has an equilibrium constant of 105 at some temperature. If you start out with 1 M CO_2 and 1 M H_2 in 3 kg of water, what is the equilibrium concentration of CO?

$$CO\ (aq) + H_2O\ (l) \leftrightarrow CO_2\ (aq) + H_2\ (aq)$$

17. For the same reaction as in number 14, imagine you have some mixture of CO, CO_2, and H_2 in water. You know that initially $C_{CO} = 0.0025$ M and $C_{H2} = 0.5$ M. The equilibrium concentration of CO_2 ends up being 0.005. What are the initial and final concentrations of CO in this reaction?

18. One mole of acetic acid is dissolved in one liter of water, following the reaction below. K for this process, known as the "acid dissociation constant" for acetic acid, is about 1.8×10^{-5}. Given that the pH of a solution is defined by
$pH = -\log_{10}([H_3O^+])$, what is the pH of this solution at equilibrium?

$$HC_2H_3O_2\ (aq) + H_2O\ (l) \leftrightarrow C_2H_3O_2^-\ (aq) + H_3O^+\ (aq)$$

19. Imagine some reaction A ↔ A*, which converts some species A between two forms. The reaction takes place in solution. If 1 mole of each of A and A* is placed in 1 L of water, and K for the reaction as written is 1.5, what is the equilibrium concentration of A*?

20. Once the reaction in problem 19 has reached equilibrium, 90% of the A* is removed from the mixture, and equilibrium is reestablished. What is the new concentration of A*?