Name: ___________________________ Date: ______________________________

Equilibrium Summary Problems

1. In an experiment for this reaction at 2000 K:

$$H_2 (g) + CO_2 (g) \rightleftharpoons H_2O (g) + CO (g)$$

The equilibrium values of each substance are as follows:

$[H_2]$ = 0.20 M

$[CO_2]$ = 0.30 M

$[H_2O]$ = [CO] = 0.55 M

a. Calculate the value of K_c for the reaction at 2000 K.

b. Determine K_p for this system.

c. When the system is cooled from 2000 K to a lower temperature, 30% of the CO is converted back to CO_2. Determine K_c at this temperature. Is this reaction endothermic or exothermic?

d. In a different experiment, 0.50 mol of H_2 is mixed with 0.50 mole of CO_2 in a 3.0 L reaction vessel at 2000 K. Calculate the equilibrium concentration of CO at this temperature.

2. For the reaction:

$$C (s) + CO_2 (g) \rightleftharpoons 2 CO (g)$$

Solid carbon and carbon dioxide gas at 1160 K were placed in a rigid 2.00 L container, and the reaction shown above occurred. As the reaction proceeded, the total pressure in the container was monitored. When equilibrium was reacted, there was still some carbon remaining in the container. Results are:

Time (hours)	**Total Pressure of Gasses (atm)**
0.0	5.00
2.0	6.26
4.0	7.09
6.0	7.75
8.0	8.37
10.0	8.37

a. Write the K_p expression.

b. Use ideal gas law to determine the initial number of moles of CO_2 placed in the vessel.

c. If the value of K_p is 27.87, determine the partial pressure of each gas in the system at equilibrium.

d. In another experiment involving the same reaction, a rigid 2.00 L container initially contains 10.0 g of C (s), plus CO (g) and CO_2 (g), each at a partial pressure of 2.00 atm at 1160 K. Determine whether the partial pressure of CO_2 will increase, decrease or remain the same as the system approaches equilibrium.

Name: ________________________ Date: ___________________________

3. Determine the effect of each stress on the reaction system:

$$CaCO_3 (s) + CO_2 (g) + H_2O (l) + heat \rightleftharpoons Ca^{2+} (aq) + 2\ HCO_3^- (aq)$$

a. Adding $CaCO_3$ (s)
b. Removing Ca^{2+} (aq)
c. Removing CO_2 (g)
d. Adding $NaHCO_3$ (s)
e. Adding Ne (g)
f. Increasing temperature
g. Decreasing volume
h. Adding a catalyst

4. A saturated solution is prepared by adding excess PbI_2 (s) to distilled water to form 1.0 L of solution at 25°C. The concentration of Pb^{2+} (aq) in the saturated solution is found to be 1.3×10^{-3} M.
   a. Write the dissociation equation for lead(II) iodide.
   b. Write the equilibrium constant expression for the equation.
   c. Calculate the molar concentration of I^- (aq) in the solution.
   d. Calculate the value of the equilibrium constant, K_{sp}.
   e. If 2.0 L of a saturated solution is prepared at 25°C, what would be the molar concentrations of Pb^{2+} (aq) and I^- (aq)?
   f. Solid NaI is added to the saturated solution of PbI_2. Assuming the volume is constant, will the concentration of Pb^{2+} increase, decrease or stay the same?

5. The value of K_{sp} for $BaCrO_4$ is 1.2×10^{-10}. Determine if a precipitate will form when a 0.500 L sample of 8.2×10^{-6} M of $Ba(NO_3)_2$ is added to 0.500 mL of 8.2×10^{-6} M Na_2CrO_4 (aq).

6. A solution is made so that $[Zn^{2+}] = 0.00250$ M and $[Ag^+] = 0.0570$ M. K_{sp} for ZnF_2 is 4.8×10^{-7} and for AgF is 7.6×10^{-8}.
   a. Which will precipitate first? At which $[F^-]$ will it begin to precipitate?
   b. What is the maximum $[F^-]$ that can be made to precipitate almost all of one and none of the other?
   c. What is the concentration of the less soluble ion under the conditions specified in b.?

Solutions

1a. 5.0
1b. 5.0
1c. 0.87; endothermic
1d. 0.12 M

2a. $K_p = P^2_{CO}/P_{CO2}$
2b. 0.105 mol
2c. $P_{CO2} = 1.63$ atm
2d. decrease

3a. no change
3b. right
3c. left
3d. left
3e. no change
3f. right
3g. right
3h. no change

4a. $PbI_2 (s) \rightleftharpoons Pb^{2+} (aq) + 2I^- (aq)$
4b. $K_{sp} = [Pb^{2+}][I^-]^2$
4c. 2.6×10^{-3} M
4d. 8.8×10^{-9}
4e. the same (1.3×10^{-3} M and 2.6×10^{-3} M)
4f. decrease (adding I^-)

5. no

6a. AgF; 1.3×10^{-6} M
6b. 1.4×10^{-2} M
6c. 5.5×10^{-6} M