Chemical Equilibrium Part 1 Review

1. Write the concentration equilibrium constant (K_c) for each of the following chemical reactions.
   (a) $2CH_{4(g)} \Leftrightarrow H_2C_{2(g)} + 2H_{2(g)}$
   (b) $Ni_{(s)} + 4CO_{(g)} \Leftrightarrow Ni(CO)_{4\,(g)}$
   (c) $2HgO_{(s)} \Leftrightarrow 2Hg_{(l)} + O_{2(g)}$
   (d) $4HCl_{(g)} + O_{2(g)} \Leftrightarrow 2H_2O_{(l)} + 2Cl_{2(g)}$
   (e) $2HCl_{\,(g)} + O_{2(g)} \Leftrightarrow H_2O_{(g)} + Cl_{2(g)}$
   (f) $Ag^{+}_{(aq)} + Cl^{-}_{(aq)} \Leftrightarrow AgCl_{(s)}$
   (g) $CO_{2\,(aq)} + 2H_2O_{\,(l)} \Leftrightarrow HCO_3^{-}{}_{(aq)} + H_3O^{+}{}_{(aq)}$

2. Which side of the equilibrium is favored, products or reactants, for each of the following where, A $\Leftrightarrow$ B.
   (a) $K_{eq} = 1.375 \times 10^{-3}$
   (b) $K_{eq} = 1375$
   (c) $K_{eq} = 1.00$

3. In your own words, paraphrase Le Châtelier's Principle.

4. Given the equilibrium, $N_{2(g)} + 3H_{2(g)} \Leftrightarrow 2NH_{3(g)}$ $\Delta H = -386$ KJ/mol, predict the direction the equilibrium will shift (forward, reverse, no shift) if:
   (a) N_2 is added.
   (b) H_2 is removed.
   (c) NH_3 is added.
   (d) NH_3 is removed.
   (e) the volume of the container is decreased.
   (f) the pressure is increased by adding Argon gas.
   (g) the reaction is cooled.
   (h) equal number of moles of H_2 and NH_3 are added.

5. Predict what will happen when the reaction volume is decreased in each of the following reactions.
   (a) $6CO_{2(g)} + 6H_2O_{(l)} \Leftrightarrow C_6H_{12}O_{6(s)} + 6O_{2(g)}$
   (b) $PCl_{5(g)} \Leftrightarrow PCl_{3(g)} + Cl_{2(g)}$
   (c) $H_{2(g)} + CO_{2(g)} \Leftrightarrow H_2O_{(g)} + CO_{(g)}$

6. Given the following equilibrium: $2NO_{2(g)} \Leftrightarrow N_2O_{4(g)}$ $\Delta H = -58.0$ kJ, predict the effect of each of the following changes on this he equilibrium (forward, reverse, no shift)
   (a) add N_2O_4
   (b) remove NO_2
   (c) increase the volume
   (d) decrease the temperature
   (e) add N_2

7. The equilibrium constant for the following reaction is 5.0 at 400 °C.

$$CO_{(g)} + H_2O_{(g)} \Leftrightarrow CO_{2(g)} + H_{2(g)}$$

Determine the direction of the reaction if the following amount (in moles) of each compound is placed in a 1.0 L flask.

	$CO_{(g)}$	$H_2O_{(g)}$	$CO_{2(g)}$	$H_{2(g)}$
(a)	0.50	0.40	0.80	0.90
(b)	0.01	0.02	0.03	0.04
(c)	1.22	1.22	2.78	2.78
(d)	0.61	1.22	1.39	2.39

8. Given the equilibrium concentrations of $[O_2] = 0.21$ mol/L and $[O_3] = 6.0 \times 10^{-8}$ mol/L, calculate the value of K_c for the reaction: $2O_{3\,(g)} \Leftrightarrow 3O_{2(g)}$.

9. At a particular temperature a 2.0 L flask contains 2.0 mol H_2S, 0.40 mol H_2, and 0.80 mol S_2. Calculate K_c at this temperature for the reaction: $2H_{2(g)} + S_{2(g)} \Leftrightarrow 2H_2S_{(g)}$

10. Consider the following equilibrium: $2CH_{4(g)} \Leftrightarrow H_2C_{2(g)} + 2H_{2(g)}$.
If the initial concentration of CH_4 is 0.0300 mol/L and the equilibrium concentration of H_2C_2 is 0.01375 mol/L
(a) calculate the equilibrium concentrations of CH_4 and H_2
(b) calculate the numerical value of K_c.

11. Consider the following equilibrium: $H_{2(g)} + I_{2(g)} \Leftrightarrow 2HI_{(g)}$ $K_c = 54.5$ at 425 °C.
If 0.020000 mol/L $HI_{(g)}$ is allowed to reach equilibrium, predict the concentrations of $H_{2(g)}$, $I_{2(g)}$, and $HI_{(g)}$.

12. The equilibrium constant, K_c, is 0.1764 at 1500 °C for $CO_{(g)} + 3H_{2(g)} \Leftrightarrow CH_{4(g)} + H_2O_{(g)}$.
If the initial concentration of CO is 0.1000 mol/L and the initial concentration of $H_{2(g)}$ is 0.300 mol/L, what are the equilibrium concentrations of all species?

13. At a certain temperature, 4.0 mol NH_3 is introduced into a 2.0 L container, and the NH_3 partially dissociates by the reaction: $NH_{3(g)} \Leftrightarrow N_{2(g)} + H_{2(g)}$. At equilibrium, 2.0 mol NH_3 remains. What is the value of K_c for this reaction?

14. At a particular temperature, $K_c = 1.00 \times 10^2$ for the reaction: $H_{2(g)} + F_{2(g)} \Leftrightarrow HF_{(g)}$.
(a) In an experiment, 2.00 mol H_2 and 2.00 mol F_2 are introduced into a 1.00 L flask. Calculate the concentration of all species at equilibrium.
(b) An additional 0.50 mol H_2 is added to the equilibrium mixture in part (a). Calculate the new equilibrium concentrations of all gases.