General Chemistry II
Equilibrium Practice

Instructions:

- **After practicing and studying all relevant material, test yourself using this practice exam.**
- **Place yourself in a simulated exam environment, preferably under a time constraint.**
- **Attempt to complete this practice as you would an exam, using no materials for assistance.**
- **Answers will be posted after all have had a chance to complete this trial exam. Check your answers against thy key**
- **EVALUATE: If you were able to complete problems on the trial exam, ask yourself**
    - **Had you seen the material before? If you have not, go review the relevant sections.**
    - **If you had seen the material, were you able to complete the homework and example problems? If not, review and practice until you are able to complete the problems in this situation.**
    - **If you had seen the material and were able to complete the homework and example problems, then you should do the following:**
        - **Attempt to redo the homework and example problems without assistance, in an exam environment. Continue until you can accomplish this.**
        - **Select other problems in the text that are similar and attempt to do them in an exam environment.**
        - **Continue this process until you can see a similar problem and solve it without assistance.**

1.) Consider the reaction:

$$CCl_4(g) + 3\ O_2(g) \leftrightarrow 4\ ClO(g) + CO_2(g)$$

a. Write the equilibrium constant *expression* for the reaction.
b. Using the Thermodynamic Table provided, calculate the Gibbs Free Energy change for this reaction at 298.15K. ($\Delta G^o(ClO(g)) = 97.11$ kJ/mol)
c. Calculate the equilibrium constant for this reaction.
d. Initially, 1 bar of CCl_4 and 3 bar of O_2 are added to a vessel. What is the total pressure in the system if the reaction:
    i. Goes exactly half way.
    ii. Goes to completion.
e. If the reaction vessel is compressed to a lesser volume, in which direction will this reaction shift after it has reached equilibrium?

2.) Consider the following reaction, initial conditions and equilibrium constant:

$CO(g) + 2\,H_2(g) \leftrightarrow CH_3OH(g)$ $\quad K_p = 0.00608$ at 225°C

Initial	3.0 bar	4.0 bar	0.30 bar

a. In which direction will this reaction shift?
b. Show that when an ICE diagram is prepared, the expression to be solved, given in terms of the common variable, x, is:

$$K_p = \frac{0.30 - x}{(3.0 + x)(4.0 + 2x)^2}$$

c. In this expression, give the minimum and maximum possible values for x.
d. Using the Recursion Method, or otherwise called the Successive Approximations method, solve the following equilibrium expression for x. **(Note: this would be given in advance as an exam problem)**
e. Calculate the equilibrium pressures of all species and the total pressure in the system.

3.) Consider the following reaction carried out in a 2 L pressure vessel at 500 K.

$COCl_2(g) \leftrightarrow CO(g) + Cl_2(g)$ $\quad K_p = 0.345$

a. Calculate K_c for this reaction.
b. If 2 moles of CO(g) and 1 mol of $Cl_2(g)$ are placed in the vessel and heated to 500K to initiate the reaction, fill in the ICE diagram provided.

$COCl_2(g) \leftrightarrow CO(g) + Cl_2(g)$

Initial (Molarity)			
Change			
Equilibrium			

c. Write the equilibrium constant expression for this reaction.
d. Using your results in the table and in c., produce an algebraic expression in the form of:

$$Ax^2 + Bx + C = 0$$

e. Using the quadratic equation given, calculate the correct value of x.

$$x = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$

f. Calculate the equilibrium pressures of all species.

General Chemistry II
Solubility, K_{sp} Practice

1.) CaF_2 has a K_{sp} of 3.45×10^{-11}
   a. Write the equilibrium equation for this substance in water.
   b. Calculate the solubility of this substance in water.
   c. Calculate the solubility of this substance in 0.0050 M F^{-1} solution. State any assumptions.
   d. **BONUS:** Repeat part c for a solution of 0.00050 M F^{-1}. Test any assumptions by using a recursion method.

2.) The K_{sp} values for a series of silver salts are given as follows:

   Ag_2SO_4 $K_{sp} = 1.2 \times 10^{-5}$.

   $AgCl$ $K_{sp} = 1.8 \times 10^{-10}$.

   Ag_2CO_3 $K_{sp} = 8.5 \times 10^{-12}$

   a. Place these compounds in order of increasing solubility.
   b. If a solution of Ag^+ was added, dropwise to 0.015 M solutions of SO_4^{-2}, Cl^-, and CO_3^{-2}, which solution would begin to form a precipitate first?

3.) 25.00 mL a saturated solution of $Mg(OH)_2$ was titrated with 0.000150 M HCl. A reaction occurred between the acid, HCl and the hydroxide, OH^-. 37.33 ml of the HCl solution was required to neutralize all of the OH^- produced by the $Mg(OH)_2$. Compute the K_{sp} of $Mg(OH)_2$.