CHM1311 D: Principles of Chemistry (Prof. N. Goto)
Assignment #5
Due Nov 9th, at the beginning of class. Late assignments will not be accepted.

Assignments can be submitted individually, or by groups of up to 4 students.

1) Last Name: _____ First Name: _____ Student ID: _____

2) Last Name: _____ First Name: _____ Student ID: _____

3) Last Name: _____ First Name: _____ Student ID: _____

4) Last Name: _____ First Name: _____ Student ID: _____

Solutions must be written legibly, in the space provided. Adequate detail to the calculation (including units, appropriate sig figs) must be provided to make it possible for other students to understand how you arrived at the final solution. If more space is needed, use the back of the page. Do not add extra pages, as they will not be marked. Assignment pages must be stapled together.
NOTE: For each question a hint, or reference to an Office Hours video, or Interactive LearningWare (ILW) problem in WileyPLUS is given in brackets.

Question 1. (Video 14.3)
The reaction of Cl_2 gas with CO gas to give phosgene gas has been described this mechanism:

$$Cl_2 \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} 2\,Cl$$

$$Cl + CO \xrightarrow{k_2} COCl$$

$$COCl + Cl_2 \xrightarrow{k_3} COCl_2 + Cl$$

a) What is the equilibrium constant expression for this reaction? (1 mark)

b) Express the equilibrium constant in terms of rate constants for the elementary reactions. (1 mark)

Question 2. (Video 14.27)

The following exothermic gas-phase reaction is at equilibrium in a fixed volume reaction vessel:

$$PCl_5\,(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$$

Predict what happens to the amount of PCl_5 in the system when each of the following changes is made. Provide justification for your answer. In some cases this may require a calculation.

a) The temperature is raised. (2 marks)

b) More Cl_2 gas is added to the vessel. (1 mark)

c) Xenon gas is introduced to increase the pressure inside the reaction vessel. (1 mark)

Question 3. (ILW 14.31)

When 0.313 mol of C_6H_5COOH is dissolved in 0.416 L of water, proton transfer occurs.

$$C_6H_5COOH\,(aq) + H_2O\,(l) \rightleftharpoons C_6H_5COO^-\,(aq) + H_3O^+\,(aq)$$

What is K_{eq}, given that the equilibrium concentration of H_3O^+ ions is 0.00686 M. (4 marks)

Question 4. (ILW 14.35)

At 452°C, K_{eq} is 1.69×10^{-5} for the following reaction

$$A\ (s) + 2\ B\ (g) \rightleftharpoons 2\ C\ (g) + D\ (g)$$

If gas B at 0.483 bar is injected into a container at 452°C that contains excess A, what are the partial pressures of all the gases at equilibrium? (4 marks)

Question 5. (ILW 14.51)

The equilibrium constant for the association of NO_2 to form N_2O_4 gas at 515 K is 2.1×10^{-4}. If NO_2 gas at 298 K, 0.657 bar is placed in a sealed container and heated to 515 K, what is the equilibrium pressure of N_2O_4? (5 marks)

Question 6. (Additional Interactive LearnWare Problem 1)

Consider the following chemical equilibrium:

$$A\,(g) + B\,(s) \rightleftharpoons 2\,C\,(g) + D\,(s)$$

If the initial pressure of A is 3.01 bar, the total pressure at equilibrium is 5.67 bar. Use these pressures to calculate K_{eq}. (4 marks)

Question 7. (See Chapter 14 lecture slide 30, 31)

Lead chloride precipitates from solution when lead acetate (325.29 g/mol) is mixed with sodium chloride with an equilibrium constant of 5.88×10^4 at 298 K. Suppose 2.65 g of lead acetate was added to 500.0 mL of 0.500 M sodium chloride. Calculate the concentration of $Pb^{2+}(aq)$ that would remain in solution at equilibrium at 298K. (4 marks)