1. (10) a) (5) Write an expression for the reaction quotient for the reaction

\[ 4\text{NH}_3 (g) + 3 \text{O}_2 (g) \rightleftharpoons 2\text{N}_2 (g) + 6 \text{H}_2\text{O} (g) \]

b) (5) Consider the following reaction

\[ \text{NH}_2\text{COONH}_4 (s) \rightleftharpoons 2\text{NH}_3 (g) + \text{CO}_2 (g) \]

You place an amount of NH\textsubscript{2}COONH\textsubscript{4} in a closed, empty container and after the reaction comes to equilibrium you measure the partial pressure of CO\textsubscript{2} to be 41.6 atm. What is the value of K\textsubscript{P} for this reaction?
2. (10) The Kc for the reaction

\[ 2\text{NOCl (g)} \rightleftharpoons 2\text{NO (g)} + \text{Cl}_2 \text{(g)} \]

is \(4.3 \times 10^{-4}\). The initial concentration of NOCl in an otherwise empty vessel is 1.00 M. Calculate the concentration of NO after the system comes to equilibrium.

3. (10) Consider the conversion of sulfur dioxide to sulfur trioxide

\[ 2\text{SO}_2 \text{(g)} + \text{O}_2 \text{(g)} \rightleftharpoons 2\text{SO}_3 \text{(g)} \quad \Delta H^\circ = -197 \text{ kJ} \]

How will the equilibrium yield of sulfur trioxide be affected by

a) compression

b) increase in temperature?

4. (10) Calculate the pH in the following solutions:

a) (5) \(2.1 \times 10^{-3}\) M NaOH

b) (5) 0.15 M HNO\(_3\)
5. (10) Circle the stronger acid in each of the following pairs.
   a) PH$_4^+$ or PH$_3$
   b) H$_2$S or HS$^-$
   c) HPO$_4^{2-}$ or H$_2$PO$_4^-$
   d) HClO$_2$ or HClO$_3$

6. (10) A 0.0010 M solution of formic acid is 34% ionized. Use this information to calculate a) the pH of the solution, b) the Ka of formic acid.

7. (10) Benzoic acid has an acid ionization constant of 6.46X10$^{-5}$.  
   a) (5) Calculate the pH of a 0.100 M benzoic acid solution
   b) (5) How many moles of sodium benzoate must be added to 1.00 L of the above solution to bring the pH up to 4.00?
8. (10) a 25.0-mL sample of 0.100 M acetic acid is mixed with 10.0 mL of 0.100 M NaOH. Calculate the pH of the resulting buffer. (Hint: we are mixing acid and base. pKa of acetic acid is 4.754)

9. (10) HA is a weak acid with acid ionization constant Ka and B a weak base with base ionization constant Kb. They react as follows:

\[ \text{HA} + \text{B} \rightleftharpoons \text{HB}^+ + \text{A}^- \quad (1) \]

Show that the Kc for the above reaction is equal to KaKb/Kw

10. (10) Barbituric acid has a Ka of 9.8X10^{-5}. How many moles of sodium barbiturate should you add to 1L of a 0.10 M solution of barbituric acid to make a buffer of pH 4.5?