

**Homework #10**

This homework doesn't cover all the important topics from this chapter, but I wanted to keep it relatively short given the timing with the exam and the busy time before Thanksgiving. Just note that there may be other topics on the exam not covered here.

**Chapter 26**

- A United Nations toxicologist studying the properties of mustard gas,  $S(CH_2CH_2Cl)_2$ , a blistering agent used in chemical warfare, prepares a mixture of 0.675 M  $SCH_2$  and 0.973 M  $C_2H_4$  and allows it to react at 20 °C. At equilibrium,  $[S(CH_2CH_2Cl)_2] = 0.350$  M. Calculate  $K_p$  (1 bar standard state).

$$SCH_2 + 2C_2H_4 \rightleftharpoons S(CH_2CH_2Cl)_2$$
- Consider the reaction:  $2NO_2(g) \rightleftharpoons N_2O_4(g)$   $\Delta_r \bar{H}^\circ = -58.04$  kJ/mol  
 Predict what happens at equilibrium if:

  - The temperature is raised.
  - The pressure on the system is increased.
  - A catalyst is added to the system.
- Gaseous nitrosyl chloride,  $NOCl$ , decomposes to gaseous  $NO$  and gaseous  $Cl_2$ . Assuming we start with  $n_0$  moles of  $NOCl(g)$  and no  $NO(g)$  or  $Cl_2(g)$ , derive an expression for  $K_p$  in terms of the equilibrium value of the extent of reaction,  $\xi_{eq}$ , and the total pressure,  $P_{tot}$ .
- Using the data in Table 26.1, calculate  $\Delta_r G^\circ(T)$  and  $K_p(T)$  at 25 °C for

  - $N_2O_4(g) \rightleftharpoons 2NO_2(g)$
  - $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$
- Given that  $K_p = 2.21 \times 10^4$  at 25 °C for the reaction below, predict the direction in which a reaction mixture in which  $P_{CH_3OH} = 10.0$  bar,  $P_{H_2} = 0.10$  bar, and  $P_{CO} = 0.0050$  bar proceeds to attain equilibrium. Use the reaction quotient to justify your answer.

$$2H_2(g) + CO(g) \rightleftharpoons CH_3OH(g)$$
- a) The value of  $\Delta_r H^\circ$  is -12.93 kJ/mol and  $K_p = 29.1$  at 1000 K for  
 $H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$   
 Assuming that  $\Delta_r H^\circ$  is temperature independent, calculate  $K_p$  at 700K.

b) Does value of  $K_p$  value for this reaction increase or decrease as a function of temperature? Why? Will there be more  $HI(g)$  at equilibrium at 700 K or at 1000 K?

c) Would  $K_p(800K)$  or  $K_p(1000K)$  be bigger if the reaction was *endothermic*?
- Calculate the solubility of  $CaF_2(aq)$  in a solution that is 0.0150 molar in  $MgSO_4(aq)$ . Take  $K_{sp} = 3.9 \times 10^{-11}$  for  $CaF_2(aq)$ . Compare your result to the one using only concentrations instead of activities (i.e., the  $s$  you found by assuming  $\gamma_{\pm} = 1$ ).