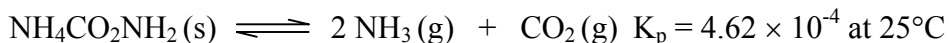
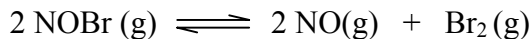


CHEM 1210
Equilibrium

- 1) Ammonium carbamate, $\text{NH}_4\text{CO}_2\text{NH}_2$, dissociates according to the exothermic reaction:



- a) If 1.00 g of ammonium carbamate is placed in a 1.00 L sealed, evacuated flask at 25°C , calculate the total pressure in the flask at equilibrium. (**$P_T = 0.146 \text{ atm}$**)
- b) What mass of ammonium carbamate will be left at equilibrium in the experiment described in part a)? (**0.84 g**)
- c) If 1.00 g of ammonium carbamate is placed in the same 1.00 L evacuated flask and some CO_2 is added so that the partial pressure of CO_2 at equilibrium is 1.00 atm, calculate the partial pressure of NH_3 when the system comes to equilibrium at 25°C . (**0.0214 atm**)
- 2) The fastest growing use of methanol is to make the octane enhancer, methyl *tert*-butyl ether. Today all methanol is produced by the reaction of carbon monoxide and hydrogen. The value of K_p for this reaction is 1.3×10^{-4} at $300.^\circ\text{C}$.
- a) Write the equilibrium reaction for the production of methanol.
(**$2\text{H}_2(\text{g}) + \text{CO}(\text{g}) \rightleftharpoons \text{CH}_3\text{OH}(\text{g})$**)
- b) What is the value of K_c at $300.^\circ\text{C}$? (**0.29**)
- c) In which direction will this reaction shift if the temperature is raised, given that the $\Delta H_{\text{rxn}} = -90.7 \text{ kJ}$. Explain! (**shifts to left because heat is a product when rxn. is exothermic, try to use up "excess" heat to re-establish eqm.**)
- d) In the industrial process, the stoichiometric ratio of CO to H_2 is used. If the reaction is carried out at an initial total pressure of 300. atm, what are the initial partial pressures of CO and H_2 ? (**100. atm CO, 200. atm H₂**)
- 3) A flask initially contains only NOBr gas. Once heated to a temperature T , 34.0 % of the original gas decomposes via the following equation to give a total pressure of 0.25 atm at equilibrium:



- a) Determine the original pressure of NOBr in the flask. (**0.21 atm**)
- b) What is the value of K_p at this temperature T ? (**9.6×10^{-3}**)
- c) If the value of K_c at this temperature T is 3.94×10^{-4} , determine the temperature T . (**298 K**)

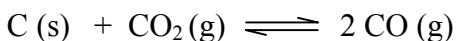
4) For the equilibrium:



At a given temperature T_1 , $K_p = 2.25$. An unknown quantity of pure $\text{PCl}_5(\text{g})$ is placed in an evacuated flask at a temperature T_1 . When equilibrium is established, the partial pressure of $\text{PCl}_5(\text{g})$ is 0.25 atm.

- What are the partial pressures of PCl_3 and Cl_2 at equilibrium? **(0.75 atm)**
- Determine the original pressure of PCl_5 (before any reaction) and the % dissociation of PCl_5 . **(1.00 atm, 75 %)**
- What is the value of K_c for the process if T_1 equals 375 °C? **(0.0423)**

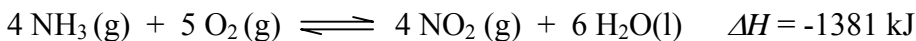
5) For the following system:



At 700. °C in a 2.00 L flask there are 0.100 moles of CO , 0.200 moles of CO_2 , and 0.400 moles of C at equilibrium. At 600. °C, an additional 0.0400 moles of C forms at equilibrium.

- The process as written is: exothermic or **endothermic**.
- Determine the value of K_c at 600. °C and 700. °C. **($K_c = 0.0250$ at 700. °C, 8.3×10^{-4} at 600. °C)**
- An additional 0.200 moles of C is added to the flask at 600. °C. What will be the effect on:
 - K_c increase decrease **no effect**
 - P_{CO} increase decrease **no effect**
 - P_{CO_2} increase decrease **no effect**

6) Consider the equilibrium:



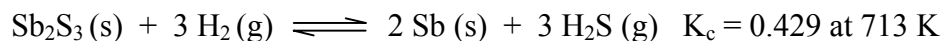
Predict whether the equilibrium amount of NH_3 will increase or decrease and the direction that the reaction will shift in order to establish a new equilibrium if:

- the volume of the system is decreased (**↓, shifts to right**)
- the temperature of the system is increased (**↑, shifts to left**)
- some O_2 is added to the container (**↓, shifts to right**)
- some He is added to the container (**no effect**)
- some NH_3 is added to the container (**↑, shifts to right**)
- some H_2O is removed from the container (**no effect as long as some water remains**)

- 7) 0.024 mole of N_2O_4 was introduced into a 0.375 L flask at 25°C . Determine the equilibrium concentrations of N_2O_4 and NO_2 at 25.0°C . ($\text{N}_2\text{O}_4 = 0.056 \text{ M}$; $\text{NO}_2 = 0.016 \text{ M}$)



- 8) 0.150 mol of antimony sulfide and 0.500 mol of H_2 were placed in a 500 mL flask and heated to 713 K. What are the equilibrium concentrations of H_2 and H_2S at 713 K?
($[\text{H}_2] = 0.570 \text{ M}$; $[\text{H}_2\text{S}] = 0.430 \text{ M}$)



- 9) 0.100 mol of H_2 and 0.100 mol of HI were placed in a 1.00 L container and heated to 445°C . Determine all equilibrium concentrations. ($[\text{H}_2] = 0.102 \text{ M}$; $[\text{I}_2] = 1.81 \times 10^{-3} \text{ M}$, $[\text{HI}] = 0.0964 \text{ M}$)

