HOMEWORK 12

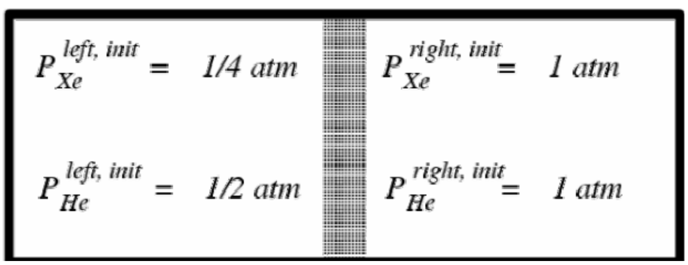
Handed out: 12th November 2007 **Due: 28st November 2007 by 5 pm**

Notes: (a) Read chapter 14 of the text from where many of these problems are extracted. (b) This homework contains many problems to allow you to practice in topics of significance to the final exam.

Problem 1: Calculate the equilibrium constant expressed as $\log_{10}K$, for $CO_2 \Leftrightarrow CO + \frac{1}{2}O_2$, at (a) 500 K, (b) 1800 ^oR. Compare with values from Table A-27.

Problem 2: Consider the gaseous reaction: $P_4 \rightarrow 2P_2$. For a system that has only gases P_4 and P_2 present, it is determined that at T = 1430K and P_{total} = 1 atm, the mole fraction of P_4 and P_2 are equal ($X_{P4} = X_{P2}$). Approximating the system as an ideal gas mixture, find the mole fractions of P_4 at the same temperature (T = 1430K) and at a total pressure P_{total} = 3/8 atm.

Problem 3: Consider a closed chamber of fixed volume that is divided into two equal parts by a rigid membrane. Initially each part contains an ideal gas mixture of Helium and Xenon with partial pressures specified in the figure below. Note that the membrane cannot move so there are always two chambers each at 1 cubic meter.



The membrane allows Helium to pass through it but does not allow Xenon to pass through it. In other words, the membrane that divides the closed chamber is permeable only to Helium. Assume the temperature is constant and that Helium and Xenon are the only species present.

What are the partial pressures of Xe and He in the left and right chambers at equilibrium?

(Hints: (a) Write equations expressing equilibrium. Only the chemical potential of He should be equal across the membrane because the amount of He is the only exchangeable extensive quantity. (b) Write equations expressing the constraint on the system, e.g. that the total number of He atoms in the system is fixed.)

Problem 4: Consider the reactions

1. $CO + H_2O \Leftrightarrow H_2 + CO_2$ (1)

2. $2CO_2 \Leftrightarrow 2CO + O_2$ (2)

3. $2H_2O \Leftrightarrow 2H_2 + O_2$ (3)

Show that $K_1 = \left(\frac{K_3}{K_2}\right)^{1/2}$.

Problem 5: For each of the following dissociation reactions, determine the equilibrium compositions:

(a) One Kmol of N_2O_4 dissociates to form an equilibrium ideal gas mixture of N_2O_4 and NO_2 at 25 ^oC, 2 atm. For $N_2O_4 \Leftrightarrow 2NO_2$, ΔG^o =5400 kJ/kmol at 25 ^oC.

(b) One kmol of CH_4 dissociates to form an equilibrium ideal gas mixture of CH_4, H_2, and C at 1000 K , 5 atm. For , $C + 2H_2 \Leftrightarrow CH_4$, $\log_{10} K = 1.011$ at 1000 K.

Problem 6: A gaseous mixture with a molar analysis of 20% CO_2, 40% CO and 40% O_2 enters a heat exchanger and is heated at constant pressure. An equilibrium mixture of CO_2, CO, and O_2 exits at 3000 K, 1.5 bar. Determine the molar analysis of the exiting mixture.

Problem 7: CO_2 gas at 25 ^oC, 5.1 atm enters a heat exchanger operating at steady state. An equilibrium mixture of CO_2, CO, and O_2 exits at 2800 K, 5 atm Determine per kmol entering:

(a) the composition of the exiting mixture (b) the heat transfer to the gas stream, in KJ

Neglect kinetic and potential energy effects.