PROBLEM SET 5

1) a) Find the equilibrium constant at298 K for the reaction

$PCI_5 \rightarrow PCI_3 + CI_{2(g)}$

b) Find the total pressure if 0.001 mol of PCI_5 is placed in a vessel with a volume of 20 L at 298 K and allowed to equilibrate. Assume ideal gas behavior.

2) a) Find ΔH^o, ΔG^o and K_p at 298 K for $I_{2(g)} \rightarrow 2I_{(g)}$
   b) Assume ΔH^o constant find temperature at which K_p=1
   c) Assume ΔH^o constant find K_p at 1000 K.
   d) Assume ΔCp constant find K_p at 1000 K.

3) A certain gas mixture held at 395 K has the following initial pressures. $P(Cl_2)$ = 351.4 torr, $P(COCl_2)$ = 0. At equilibrium total pressure is 439.5 torr is held constant. Find K at 395 K for

$CO + Cl_2 \rightarrow COCl_2$

4) For the ideal gas reaction $PCI_5 \rightarrow PCI_3 + CI_{2(g)}$
State whether equilibrium shifts to the right or left when each of the following changes is made in an equilibrium mixture at 25 ^oC

a) T is decreased at constant P
b) V is decreased at constant T
c) Some PCl5 is removed at constant T and V
d) $He_{(g)}$ is added at constant T and V
e) $He_{(g)}$ is added at constant T and P

5) For $2\,CO_{(g)} + O_{2(g)} \rightarrow 2\,CO_{2(g)}$ assume ideal gas behavior and ΔG^o_{298} = -514.382 kj/mol and ΔH^o_T (kj/mol) = $-565.968 + 0.0015(T-298) + 2.85*10^{-6}(T^2-298^2)+1448((1/T)-(1/298))$
Find an expression for $\ln K_p(T)$ and calculate K_p at 1000 K for this reaction.

6) Suppose 1.0 mol of CO_2 and 1.0 mol of COF_2 are placed in a very big vessel at 25^{o}C and a catalyst for the gas phase reaction $2\,COF_2 \leftrightarrow CO_2 + CF_4$ is added. Find the equilibrium amounts. ΔG^o_{298} = -35 kj/mol

7) For the ideal gas reaction $N_2 + 3H_2 \leftrightarrow 2\,NH_3$ suppose 1 mol of N_2 and 3 mol of H_2 react at constant T and P, no other gases are present initially. Let x be the number of moles of N_2 that have reacted when equilibrium is reached. ($x = \varepsilon_{eq}$)
Show that,

$X=1-[1-s/(s+4)]^{1/2}$, $s= (27\,K_p)^{1/2}\,P/P^*$

8) Nitrogen trioxide dissociates according to the reaction

$N_2O_{3(g)} \leftrightarrow NO_{2(g)} + NO_{(g)}$

When one mole of $N_2O_{3(g)}$ is held at 25 ^{o}C and 1 bar total pressure until equilibrium is reached, the extent of reaction is 0.30. What is $\Delta_r G^o$ for this reaction at 25 ^{o}C?

9) Calculate the molar Gibbs energy of butane isomers for extents of reaction of 0.2, 0.4, 0.6 and 0.8 for the reaction **n-butane = isobutene** at 1000 K and 1 bar.
At 1000 K $\Delta_r G^o$(n-butane)=270 kJ/mol, $\Delta_r G^o$(n-butane)=276.6 kJ/mol
Make a plot and show that the minimum corresponds to the equilibrium extent of reaction.

10) At 250 ^{o}C, PCl_5 is 80 % dissociated at a pressure of 1.013 bar, and so K=1.80. What is the extent of reaction at equilibrium after sufficient nitrogen has been added at constant pressure to produce a nitrogen partial pressure of 0.9 bar? The total pressure is maintained at 1 bar.