Homework Set 5

CH 353, Vanden Bout, Summer 2009

Chapter 7

E7.1a,E7.3a, 7.12a, 7.14a

1. Find the equilibrium constants for the following reactions at 298 K. (balance the reactions!) For each reaction state whether it favors the products or reactants at equilibrium. All compounds can be assumed to be ideal gas. (you will need to balance the equations as K is useless w/out a balanced eqn)

PCl_5 goes to PCl_3 and Cl_2

CO and O_2 go to CO_2

O_2 goes to O_3 *

N_2 and O_2 go to NO *

For the reactions marked *, state why you might have guessed the answer.
Based on the result of your 2nd reaction why should anyone buy a CO monitor for their house?

2.

If solid Iodine (I_2) is exposed to Hydrogen gas (H_2) in the presence of UV light at room temperature it reacts to form HI gas. An equilibrium mixture of these three components is found to be 39% (by mole) HI and 61% H_2 with some solid I_2 in the container at a temperature of 300 K and a constant pressure of 1 bar. What is the Gibbs' energy of formation ($\Delta_R G°$) for HI at 300 K?

Starting with a half mole each of solid I_2 and H_2 you find that after you reached equilibrium 6.62 kJ of heat has been absorbed the system (in order to keep the temperature constant). Using this information what is $\Delta_R H°$ for HI? What is $\Delta_R S°$ for this reaction?

3.

For the reaction

$$H_2(g) + CO_2(g) \longrightarrow H_2O(g) + CO(g)$$

Find the values for $\Delta_R G°$, $\Delta_R H°$, and K at 298 and 1000 K

Using the $\Delta_R H°$ (1000) as assuming $\Delta_R H°$ is ind. of T, take the value of K at 1000 K and find the value at 1259 K.

How do each of these methods compare with the experimental value of K = 1.60

4.

Alchemists used to decompose mercury oxide to mercury as a demonstration of their powers. The reaction

$$2\ HgO\ (s, red) \ \text{------}\rightarrow\ 2\ Hg\ (l) + O_2\ (g)$$

was performed by heating HgO, a red colored powder, to produced mercury vapor which upon condensation produced bright silvery mercury. Seemingly worthless red powdered transformed into shiny metal liquid. Ohh…Ahhh….

Using the thermodynamic data you (from the book, the internet, …) determine the equilibrium constant for this reaction at room temperature.

We have talked about the fact that most reaction will never be pure reactants or pure products at equlibrium because there is some entropy gained from mixing even when the energetics strongly favor either reactants or products. However for this reaction in *air*, you can wait the rest of your life and none of the HgO will decompose. Why? (it's not kinetics).

5.

The **A** reacts with the **B** by the following chemical reaction to form the two compounds **C** and **D**.

$$\mathbf{A}\ (s) + 2\mathbf{B}\ (g) \ \text{-------}\!\!\rightarrow\ \mathbf{C}\ (g) + 3\ \mathbf{D}\ (g)$$

Initially the system has 3 moles of **A**, 4 moles of **B**, and 1 mole of **C** in a container that is held at a constant pressure of 3 bar and a temperature of 300 K. The mixture reacts and the system evolves until all four compounds are found to be at equilibrium. At equilibrium it is found that the partial pressures of **C** and **D** are the same.

What is the equilibrium constant for this reaction?

What is $\Delta_R G°$ for this reaction?

If $\Delta_R H°$ for this reaction is +2 kJ mol^{-1}, what is the heat for the process of the system going from the initial conditions to equilibrium?

What is the work for this process?

What is the change in internal energy for this process?