Date: Name: Class:

Enrichment

Chapter 7

BLM 7-3

Chemical Equilibrium of Gases

Goal

Investigate the relationship between the equilibrium constants for concentration and, for gases, partial pressure

Procedure

You have learned to determine equilibrium constant (K_c) for gaseous systems using concentration data. It is also common to use the pressure of gases to determine the value for the equilibrium constant. Consider the equilibrium between the gases NO_2 and N_2O_4:

N_2O_4 (colourless) $\leftrightarrow 2NO_2$ (brown).

You can write the equilibrium expression as. $K_c = \frac{[NO_2]^2}{[N_2O_4]}$ If the pressures of NO_2 and N_2O_4 are used in the equilibrium expression, then $K_p = \frac{p_{NO_2}^2}{p_{N_2O_4}}$.

Notice that K_p is used to represent an equilibrium expression expressed in terms of pressure. The terms in the numerator and the denominator are the equilibrium partial pressures of NO_2 and N_2O_4 respectively, in units of atmospheres. Note that $K_c \neq K_p$ because the concentrations of gases (in units of mol/L) are not equal to the pressure in atmospheres at equilibrium.

Recall that pressure is related to concentration using the ideal gas law: $P = (n/v)RT$. Using this formula, you can obtain a relationship between K_c and K_p: $K_p = K_c(0.0821\ T)^{\Delta n}$

In this equation, $\Delta n = b - a$, where b represents the moles of gaseous products, and a represents the moles of gaseous reactants.

Questions

1. Write the equilibrium expression, K_p, for the reaction shown below.

   $PCl_{5\,(g)} \leftrightarrow PCl_{3\,(g)} + Cl_{2\,(g)} \quad K_c = 1.67$ (at 500 K)

2. If K_p for the reaction shown above is 1.05 at 250°C, and the partial pressures for PCl_5 and PCl_3 are 0.90 atm, and 0.45 atm respectively, determine the partial pressure of Cl_2 at equilibrium.

3. If the volume of the vessel is 3 L, determine the amount of Cl_2 present at equilibrium.

4. Determine the corresponding K_c for this reaction.