Chemistry Name **KEY**

Quiz – Equilibrium # 2 KEY

DIRECTIONS: Make sure to show your work to get maximum credit.

1. Ammonium chloride is a crystalline solid that decomposes as follows:

 NH4Cl (s) ⮀ NH3 (g) + HCl (g)

a.) Some solid NH4Cl is placed in an evacuated vessel at 25 °. After equilibrium is attained, the total pressure inside the vessel is found to be .659 atm. Some solid NH4Cl remains in the vessel at equilibrium. For this decomposition, write the expression for Kp and calculate its numerical value at 25 °C.

PNH3 = PHCl NH4Cl (s) ⮀ NH3 (g) + HCl (g)

 Initial 0 0

 Change + x + x

 Equilibrium **.**329 **.**329

 If the total pressure is .659 atm., according to Dalton’s Law, each gas must be ½ of the total or .329 atm.

 K = (**.**329)2 = **.1086**

b.) Some extra NH3 gas is injected into the vessel containing the sample described in part a.) When equilibrium is reestablished at 25 °C, the partial pressure of NH3 in the vessel is twice the partial pressure of HCl. Calculate the numerical value of the partial pressure of NH3 and the partial pressure of HCl in the vessel after the NH3 has been added and equilibrium has been reestablished.

 NH4Cl ⮀ NH3 + HCl .1086 = (2x) (x) = 2x2

**x = .233 = PHCl & P­­NH3 = .4460 atm.**

c.) In a different experiment, NH3 gas and HCl gas are introduced in to an empty 1**.**00 Liter vessel at 25 °C. The initial partial pressure of each gas is **.**500 atm. Calculate the number of moles of solid NH4Cl that is present when equilibrium is established.

 NH4Cl ⮀ NH3 + HCl

 Initial 0 **.**5 **.**5 **.**1086 = (**.**5 – x)2 / 1

 Change - x - x

 Equilibrium **.**5 – x **.**5 – x x = **.**1705 atm

 PV = nRT 🡪 (**.**1705) (1) = n R (298) **n = .00697 moles** 1 to 1 ratio

2. Given the following reaction at equilibrium N2O4 (g) ⮀ 2 NO2 (g)

 Initially, **.**0400 moles of N2O4 (g) are placed in a previously evacuated 1 liter flask and heated to 100 °C. When equilibrium is established at 100 °C, the equilibrium concentration of N2O4 (g) is found to be **.**0134 M.

 a.) Calculate the equilibrium concentration of NO2

 b.) Calculate the equilibrium constant, Kc, for the reaction at 100 °C

 c.) In another experiment, equilibrium was approached from the other direction by injecting NO2 (g) into a previously evacuated flask. After equilibrium is established in this system at 100 °C, the equilibrium of N2O4 in the system.

**a.) N2O4 (g) ⮀ 2 NO2 (g)**

 **Initial .04 0**

 **Change - x + 2x x = .0266**

 **Equilibrium .0134 .0266 [ NO2 ] = .0266 x 2 = .0532**

**b.) K = (.0532)2 / .0134 = .2112**

**c.) N2O4 (g) ⮀ 2 NO2 (g)**

 **Initial**

 **Change**

 **Equilibrium x .0243**

**.2112 = (.0243)2 / x x = .0028**

3. The equilibrium constant, Kc, for the following reaction: N2 (g) + O2 (g) ⮀ 2 NO (g)

 Is 4.0 x 10-2 at a very high temperature.

 The reaction is at equilibrium at this temperature with [N2] = [O2] = **.**100 M and

 [NO] = **.**200 M in a 2**.**00 Liter flask. If **.**120 moles of NO is suddenly added to the reaction mixture, what will be the concentrations of all species when equilibrium is reestablished ? Why does it not matter that the exact temperature wasn’t specified ?

 **N2 (g) + O2 (g) ⮀ 2 NO (g)**

 **Initial .1 .1 .26**

 **Change + x + x - 2x**

 **Equilibrium .1 + x .1 + x .26 – 2x**

 **K = .04 = (.26 – 2x)2 / (.1 + x)2 🡪 .2 = .26 – 2x / .1 + x**

 **.2 (.1 + x) = (.26 – 2x) x = .1091**

**SO [N2] = [O2] = .1 + .1091 = .2091 & [NO] = .26 – 2(.1091) = .0418**

**VERIFY .04182 / .20912 = .0017 / .0437 = x x = .04 !!**

**As long as the temperature remains constant, the Keq will not change.**

4. The reaction: H2 (g) + I2 (g) ⮀ 2 HI (g)

Has an equilibrium constant, Kc = 64 at 400 °C. The reaction is at equilibrium with a [H2] = **.**040 M, [I2] = **.**040 M and [HI] = **.**320 M in a 2**.**0 Liter flask at 400 °C. If **.**15 mole of HI is added to the reaction mixture, what will be the concentration of all species when equilibrium is reestablished ?

  **H2 (g) + I2 (g) ⮀ 2 HI (g)**

 **Initial .04 .04 .395 (.32 + .15/2)**

 **Change + x + x - 2x**

 **Equilibrium .04 + x .04 + x .395 – 2x**

**64 = (.395 – 2x)2 / (.04 + x)2 🡪 8 = .395 – 2x / .04 + x 🡪 x = .0075**

 **SO [H2] = [I2] = .04 + .0075 = .0475 & [HI] = .395 – 2(.0075) = .3800**

 **VERIFY .382 / .04752 = x x = 64 which agrees with the Keq**

5. CO2 (g) ⮀ CO (g) + ½ O2 (g)

A 1**.**00 mole sample of CO2 is placed in a 1**.**00 L container and allowed to come to equilibrium at 2500 K. When equilibrium is reached at 2500 K, 17**.**6 % of the original CO­2 has decomposed to CO and O2. Calculate the value of the equilibrium constant, Kc, for the dissociation reaction at 2500 K. What difference does it make in this problem that the temperatures were given in K instead of °C ?

 **CO2 (g) ⮀ CO (g) + ½ O2 (g)**

 **Initial 1 0 0**

 **Change - .176 + .176 + .176 / 2**

 **Equilibrium .824 .176 .088**

**K = [ .176 ] [ .088 ]1/2  / [ .824 ] 🡪 K = .0634**

**There is no difference. As long as the temperature remains constant (no matter what scale is being used) the value for K will not change.**

6. An equilibrium mixture: H2 (g) + CO2 (g) ⮀ H2O(g) + CO (g)

In a 5.0 Liter container at a certain temperature was analyzed and found to contain H2 = .585 moles, CO2 = 1.585 moles, H2O = .665 moles and CO = .665 moles.

a.) Calculate the equilibrium constant

b.) How would the equilibrium quantity (moles) of H2O be affected by an increase in the total volume of the system.

**a. First change the moles to concentrations (though that is not needed)**

 **H2 (g) + CO2 (g) ⮀ H2O(g) + CO (g)**

 **.117 .317 .133 .133**

 **K = .477**

**b. The chance in volume would result in a change in pressure (decrease in this case).**

 **Therefore the system will shift to create an increase in pressure which is the side with more moles of gas. Since both sides of the equation have equal moles of gas there would be no change in the system.**

7. At 350 K, Kc is .14 for the reaction: 2 BrCl2 (g) ⮀ Br2 (g) + Cl2 (g)

 An equilibrium mixture at this temperature contains equal concentration of bromine and chlorine, .0250 M. What is the equilibrium concentration of BrCl ?

8. Kc for the reaction: 2 ICl (g) ⮀ I2 (g) + Cl2 (g)

 Is .11 at a certain temperature. Suppose the initial concentrations (mole/L) of ICl, I2 and Cl2 are **.**20 M, 0**.**00 M, and 0**.**00 M, respectively. Some of the ICl decomposes and the system reaches equilibrium. What is the equilibrium concentration of each species ?

9. The reaction: CO (g) + H2O (g) ⮀ NO (g) + H2 (g)

 Has a Kc value of 4.0 at 500 °C. Calculate the concentration of all species at equilibrium starting with:

 a. [CO] = [H2O] = .100 M and [CO2] = [H2] = 0.00 M

 b. [CO} = [H2O] = [CO2] = [H2] = .040 M

10. At 460 °C, the reaction: SO2 (g) + NO2 (g) ⮀ NO (g) + SO3 (g)

 Has Kc = 85.0 What will be the equilibrium concentrations of the four gases if a mixture of SO2 and NO2 is prepared in which they both have initial concentration of .0750 M ?