Problems of Gas phase equilibria

1) Consider the following reaction:

$CO_{(g)} + Cl_{2(g)} \rightleftharpoons COCl_{2(g)}$

The initial partial pressures are $P(CO)$ = 2 atm and $P(Cl_2)$ = 2 atm. When the reaction reaches equilibrium the partial pressure of CO is 0.05525 atm. Determine:

a) Partial pressure (in atm) of each substance at equilibrium.

b) Equilibrium constant K_P (with partial pressures in atm).

c) Total pressure (in atm) at equilibrium.

2) In a piston the initial pressure of $SbCl_5$ is 3 atm. This substance reacts according the following reaction:

$SbCl_{5(g)} \rightleftharpoons SbCl_{3(g)} + Cl_{2(g)}$

When the reaction reaches equilibrium at 605 °C the degree of dissociation of $SbCl_5$ is 6.49 %. Calculate:

a) Partial pressure (in atm) of each substance at equilibrium.

b) Equilibrium constant K_P (with partial pressures in atm).

3) In a flask at 30 °C the N_2O_4 reacts according the following chemical equation:

$N_2O_{4(g)} \rightleftharpoons 2NO_{2(g)}$

When the reaction reaches equilibrium the total pressure is 6.509 atm and the degree of dissociation of N_2O_4 is 35.6 %. Find out:

a) Partial pressure (in atm) of each substance at equilibrium.

b) Equilibrium constant K_P (with partial pressures in atm).

c) Equilibrium constant K_C (in molarities).

4) A balloon with a volume of 4 L contains 12 mol NO that react according to the following equation:

$2NO_{(g)} \rightleftharpoons N_{2(g)} + O_{2(g)}$

When the reaction reaches equilibrium 5.733 mol N_2 are found. Calculate:

a) Moles of each substance at the equilibrium.

b) Equilibrium constant K_C (in mol/L).

c) Molarity of each substance at the equilibrium.

5) In a flask of 4 L at 205 °C we have 22.4 mol PCl_5 that react according the following reaction:

$PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$

When this reaction reaches equilibrium the degree of dissociation of PCl_5 is 8.48 %. Calculate:

a) Moles of each substance at the equilibrium.

b) Equilibrium constant K_C (in mol/L).

c) Equilibrium constant K_P (with partial pressures in atm).

Problems of Gas phase equilibria

6) Given the reaction:

$2SO_{3(g)} \rightleftharpoons 2SO_{2(g)} + O_{2(g)}$

The initial pressure of SO_3 is 3.2 atm. When the reaction reaches equilibrium the partial pressure of O_2 is 0.4445 atm. Determine:

a) Partial pressure (in atm) of each substance at equilibrium.

b) Equilibrium constant K_P (with partial pressures in atm).

c) Degree of dissociation of SO_3.

7) In a piston the following reaction occurs:

$2NO_{(g)} \rightleftharpoons N_{2(g)} + O_{2(g)}$

The initial molar concentration(s) is(are) 3 mol/L NO. The equilibrium constant is K_C = 106. Determine:

a) Molarity of each substance at the equilibrium.

b) Degree of dissociation of NO.

8) In a flask the following reaction occurs:

$PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$

The initial pressure of PCl_5 is 3 atm. The equilibrium constant is K_P = 3.3 atm. Calculate:

a) Partial pressure (in atm) of each substance at equilibrium.

b) Degree of dissociation of PCl_5.

9) Consider the following reaction at a temperature of 15 °C:

$2ICl_{(g)} \rightleftharpoons I_{2(g)} + Cl_{2(g)}$

At the equilibrium the total pressure is 5 atm and the equilibrium constant is K_P = 73.7. Determine:

a) Partial pressure (in atm) of each substance at equilibrium.

b) Degree of dissociation of ICl.

10) A piston at 485 °C contains initially 22.5 mol N_2 and 36 mol O_2 that react according the following reaction:

$N_{2(g)} + O_{2(g)} \rightleftharpoons 2NO_{(g)}$

At equilibrium the total pressure is 6.5 atm and the equilibrium constant is K_P = 0.0158. Calculate:

a) Partial pressure (in atm) of each substance at equilibrium.

b) Equilibrium constant K_C (in mol/L).

11) A flask with a volume of 9 L contains 18 mol CO_2 and 18 mol H_2S that react according the following reaction:

$CO_{2(g)} + H_2S_{(g)} \rightleftharpoons COS_{(g)} + H_2O_{(g)}$

The equilibrium constant is K_C = 0.137. Calculate:

a) Molarity of each substance at the equilibrium.

Problems of Gas phase equilibria

12) In a flask the following reaction occurs:

$$SO_2Cl_{2(g)} \rightleftharpoons SO_{2(g)} + Cl_{2(g)}$$

The initial molar concentration(s) is(are) 2.8 mol/L SO_2Cl_2. The equilibrium constant is K_C = 15.3 mol/L.
Calculate:

a) Molarity of each substance at the equilibrium.

b) Degree of dissociation of SO_2Cl_2.

Answers:

1) **a)** $P(COCl_2)$ = 1.945 atm, $P(CO)$ = 0.05525 atm and $P(Cl_2)$ = 0.05525 atm.
b) K_P = 637 atm^{-1} **c)** 2.055 atm.

2) **a)** $P(SbCl_5)$ = 2.805 atm, $P(SbCl_3)$ = 0.1947 atm and $P(Cl_2)$ = 0.1947 atm.
b) K_p = 0.0135 atm.

3) **a)** $P(N_2O_4)$ = 3.091 atm and $P(NO_2)$ = 3.418 atm.
b) K_P = 3.78 atm **c)** K_C = 0.152 mol/L.

4) **a)** 0.5338 mol NO, 5.733 mol N_2 and 5.733 mol O_2.
b) K_C = 115.
c) [NO] = 0.1334 mol/L, $[N_2]$ = 1.433 mol/L and $[O_2]$ = 1.433 mol/L.

5) **a)** 20.5 mol PCl_5, 1.9 mol PCl_3 and 1.9 mol Cl_2.
b) K_C = 0.044 mol/L **c)** K_P = 1.73 atm.

6) **a)** $P(SO_3)$ = 2.311 atm, $P(SO_2)$ = 0.889 atm and $P(O_2)$ = 0.4445 atm.
b) K_P = 0.0658 atm **c)** 27.8 %.

7) **a)** 0.1388 mol/L NO, 1.431 mol/L N_2 and 1.431 mol/L O_2.
b) 95.37 %.

8) **a)** $P(PCl_5)$ = 1.098 atm, $P(PCl_3)$ = 1.902 atm and $P(Cl_2)$ = 1.902 atm.
b) 63.4 %.

9) **a)** $P(ICl)$ = 0.2752 atm, $P(I_2)$ = 2.362 atm and $P(Cl_2)$ = 2.362 atm.
b) 94.5 %.

10) **a)** $P(NO)$ = 0.3731 atm, $P(N_2)$ = 2.313 atm and $P(O_2)$ = 3.813 atm.
b) K_C = 0.0158.

11) **a)** 1.46 mol/L CO_2, 1.46 mol/L H_2S, 0.5396 mol/L COS and 0.5396 mol/L H_2O.

12) **a)** 0.3826 mol/L SO_2Cl_2, 2.417 mol/L SO_2 and 2.417 mol/L Cl_2.
b) 86.3 %.