Practice Questions Section 2.1

The Equilibrium Constant

1. Write equilibrium expressions for the following reversible reactions:

   a. $2\ NO_{2\,(g)} \leftrightarrow N_2O_{4\,(g)}$

   b. $N_{2\,(g)} + 3\ H_{2\,(g)} \leftrightarrow 2\ NH_{3\,(g)}$

   c. $2\ SO_{2\,(g)} + O_{2\,(g)} \leftrightarrow 2\ SO_{3\,(g)}$

2. For the equilibrium system described by $2\ SO_{2\,(g)} + O_{2\,(g)} \leftrightarrow 2\ SO_{3\,(g)}$

   at a particular temperature the equilibrium concentrations of SO_2, O_2 and SO_3 were 0.75 M, 0.30 M, and 0.15 M, respectively. At the temperature of the equilibrium mixture, calculate the equilibrium constant, K_{eq}, for the reaction.

3. For the equilibrium system described by: $PCl_{5\,(g)} \leftrightarrow PCl_{3\,(g)} + Cl_{2\,(g)}$

   K_{eq} equals 35 at 487°C. If the concentrations of the PCl5 and PCl3 are 0.015 M and 0.78 M, respectively, what is the concentration of the Cl_2?

4. The following table gives some values for reactant and product equilibrium concentrations (in moles/L; M) at 700 K for the Shift reaction, an important method for the commercial production of hydrogen gas:

   $CO_{(g)} + H_2O_{(g)} \leftrightarrow CO_{2\,(g)} + H_{2\,(g)}$

Trial	$[CO_2]$	$[H_2]$	$[CO]$	$[H_2O]$
1	0.600	0.600	0.266	0.266
2	0.600	0.800	0.330	0.286
3	2.00	2.00	0.877	0.877
4	1.00	1.50	0.450	0.655
5	1.80	2.00	0.590	1.20

   Calculate K_{eq} for each of the five trials. How do the answers compare with each other? Why?

Practice Questions Section 2.1

The Equilibrium Constant Answers

1. Write equilibrium expressions for the following reversible reactions:

Answers

a. $2\ NO_{2\,(g)} \leftrightarrow N_2O_{4\,(g)}$ $K_{eq} = \dfrac{[N_2O_4]}{[NO_2]^2}$

b. $N_{2\,(g)} + 3\ H_{2\,(g)} \leftrightarrow 2\ NH_{3\,(g)}$ $K_{eq} = \dfrac{[NH_3]^2}{[N_2]\ [[H_2]^3}$

c. $2\ SO_{2\,(g)} + O_{2\,(g)} \leftrightarrow 2\ SO_{3\,(g)}$ $K_{eq} = \dfrac{[SO_3]^2}{[SO_2]^2[O_2]}$

2. For the equilibrium system described by $2\ SO_{2\,(g)} + O_{2\,(g)} \leftrightarrow 2\ SO_{3\,(g)}$

at a particular temperature the equilibrium concentrations of SO_2, O_2 and SO_3 were 0.75 M, 0.30 M, and 0.15 M, respectively. At the temperature of the equilibrium mixture, calculate the equilibrium constant, K_{eq}, for the reaction.

Solution:

Begin by setting up the equilibrium constant expression for the balanced equation:

$$K_{eq} = \frac{[SO_3]^2}{[SO_2]^2[O_2]}$$

Next, substitute in the known values, and solve for the unknown, which is Keq for this question. Don't forget to use the exponents!

$$K_{eq} = \frac{[SO_3]^2}{[SO_2]^2[O_2]} = \frac{(0.15)^2}{(0.75)^2(0.30)} = 0.13$$

3. For the equilibrium system described by: $PCl_{5\,(g)} \leftrightarrow PCl_{3\,(g)} + Cl_{2\,(g)}$

   K_{eq} equals 35 at 487°C. If the concentrations of the PCl5 and PCl3 are 0.015 M and 0.78 M, respectively, what is the concentration of the Cl_2?

   Solution:

   Again begin by setting up the equilibrium constant for the equation and then substitute in the know values. But in this case, K_{eq} is one of our known values; one of the concentrations is the unknown.

$$K_{eq} = \frac{[PCl_3]\ [Cl_2]}{[PCl_5]}$$

   Let χ = the unknown, $[Cl_2]$. Substitute in known values and solve for χ:

$$35 = \frac{(0.78)\ (\chi)}{(0.015)}$$

$$35 \times 0.015 = 0.78 \times (\chi)$$

$$\chi = [Cl_2] = 0.67M$$

4. The following table gives some values for reactant and product equilibrium concentrations (in moles/L; M) at 700 K for the Shift reaction, an important method for the commercial production of hydrogen gas:

   $CO_{(g)} + H_2O_{(g)} \leftrightarrow CO_{2\,(g)} + H_{2\,(g)}$

Trial	$[CO_2]$	$[H_2]$	[CO]	$[H_2O]$
1	0.600	0.600	0.266	0.266
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4	1.00	1.50	0.450	0.655
5	1.80	2.00	0.590	1.20

   Calculate K_{eq} for each of the five trials. How do the answers compare with each other? Why?

Solution:

Set up the equilibrium constant expression and solve for Keq for each trial. $K_{eq} = \frac{[CO_2]\ [H_2]}{[CO]\ [H_2O]}$

Trial	$[CO_2]$	$[H_2]$	$[CO]$	$[H_2O]$	K_{eq}
1	0.600	0.600	0.266	0.266	5.09
2	0.600	0.800	0.330	0.286	5.09
3	2.00	2.00	0.877	0.877	5.09
4	1.00	1.50	0.450	0.655	5.09
5	1.80	2.00	0.590	1.20	5.09

Keq = 5.09 for all trials.

Keq is a constant and will not change unless the temperature of the system is changed (there are often minor variations resulting from experimental measurements, however).