Calculating Equilibrium Constants

Chem Worksheet 18-3

Name ________________

Symbol	Meaning
[ ]	Concentration (mol/L)
K_{eq}	Equilibrium constant

Equilibrium describes a situation in which the rate of the forward reaction is equal to the rate of the reverse reaction. In other words, products are made from reactants at the same speed that reactants are formed from products. When a reaction has reached these conditions the ratio of the concentration of products to concentration of reactants is equal to a value called the **equilibrium constant** (*K*).

A small value for an equilibrium constant indicates that the concentration of products is small and the concentration of reactants is large. We say that **equilibrium lies to the left** because there are more reactants. If the equilibrium constant is large, this indicates that there is a high concentration of products and a low concentration of reactants. In this situation we say the **equilibrium lies to the right** because there are more products.

	Equilibrium lies to the. .	Description
Small equilibrium constant (*K*)	left	Relatively large concentration of reactants
Large equilibrium constant (*K*)	right	Relatively large concentration of products

example

Write the equilibrium expression for the following reaction. Use the equilibrium concentrations to determine the equilibrium constant (*K*). At equilibrium $[N_2O_4] = 0.65\ M$ and $[NO_2] = 0.012\ M$.

$$N_2O_4\ (g) \leftrightarrows 2NO_2\ (g)$$

- Write the equilibrium expression:

$$K_{eq} = \frac{[\text{products}]}{[\text{reactants}]} \qquad K_{eq} = \frac{[NO_2]^2}{[N_2O_4]}$$

- Insert equilibrium concentrations and calculate:

$$K_{eq} = \frac{[0.012\ M]^2}{[0.65\ M]} = 2.2\times10^{-4}\ M$$

* the units for an equilibrium constant depend on the equilibrium expression. They are often omitted altogether.

Use the information below to calculate the equilibrium constant (K_{eq}) for the following reactions.

1. $H_2\ (g) + Cl_2\ (g) \leftrightarrows 2HCl\ (g)$
   At equilibrium $[H_2] = 0.42\ M$, $[Cl_2] = 0.075\ M$, and $[HCl] = 0.95\ M$

2. $N_2\ (g) + 3H_2\ (g) \leftrightarrows 2NH_3\ (g)$
   At equilibrium $[N_2] = 0.34\ M$, $[H_2] = 0.13\ M$, and $[NH_3] = 0.19\ M$.

3. $2NO\ (g) + O_2\ (g) \leftrightarrows 2NO_2\ (g)$
   At equilibrium $[NO] = 2.4 \times 10^{-3}\ M$, $[O_2] = 1.4 \times 10^{-4}\ M$, and $[NO_2] = 0.95\ M$.

4. $C\ (s) + CO_2\ (g) \leftrightarrows 2CO\ (g)$
   At equilibrium $[CO_2] = 8.3 \times 10^{-6}\ M$, $[CO] = 5.4 \times 10^{-5}\ M$.

Find the value of the equilibrium constant (K_{eq}) and tell whether equilibrium lies to the left or the right.

5. $2NO\ (g) + Br_2\ (g) \leftrightarrows 2NOBr\ (g)$
   At equilibrium $[NO] = 0.5$ M, $[Br_2] = 0.25$ M, and $[NOBr] = 3.5$ M.

6. $2Fe\ (s) + 3H_2O\ (g) \leftrightarrows Fe_2O_3\ (s) + 3H_2\ (g)$
   At equilibrium $[H_2O] = 1.0\ M$, and $[H_2] = 4.5\ M$.

7. $CaCO_3\ (s) \leftrightarrows CaO\ (s) + CO_2\ (g)$
   At equilibrium $[CO_2] = 4.0 \times 10^{-3}\ M$.

8. $PCl_5\ (g) \leftrightarrows PCl_3\ (g) + Cl_2\ (g)$
   Equilibrium concentrations are: $[PCl_5] = 0.25$ M, $[PCl_3] = 9.7 \times 10^{-4}$ M, and $[Cl_2] = 3.2 \times 10^{-3}$ M.

9. $CO\ (g) + 3H_2\ (g) \leftrightarrows CH_4\ (g) + 3H_2O\ (g)$
   At equilibrium $[CO] = 4.0$ M, $[H_2] = 2.8$ M, $[CH_4] = 0.75$ M, and $[H_2O] = 0.12$ M.

10. $2SO_2\ (g) + 2O_2\ (g) \leftrightarrows 2SO_3\ (g)$
    At equilibrium $[SO_2] = 2.4 \times 10^{-2}\ M$, $[O_2] = 6.4 \times 10^{-2}\ M$, and $[SO_3] = 8.2 \times 10^{-8}\ M$.

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