Chemistry 102 Winter 2010

Announcements

1. Key for Exam 2 posted outside of PS 158.
2. Final exam on Mar. 15, Monday.

Today

1. Chemical equilibrium.

Chemical equilibrium

Chemical equilibrium is a dynamic equilibrium between reactants and products in which their concentrations remain constant.

dynamic equilibrium: forward and reverse processes occur simultaneously and at the same rates; no visible change on the macroscale.

The vaporization-condensation equilibrium in a capped water bottle is an example of physical equilibrium between liquid molecules and gas molecules in which their numbers remain constant.

What about equilibrium on different days?

<u>warm day</u>:

<u>hot day</u>:

<u>cold day</u>:

Similarly for chemical processes,

cis-2-butene trans-2-butene (p. 465)

(Fig. 13.2, at 500K)

Using chemical kinetics and the rate law, we can derive a mathematical expression as a measure of equilibrium. This process is 1st order.

forward rate = reverse rate rate = k[conc.]

$$k_{\text{forward}}[\textit{cis}] = k_{\text{reverse}}[\textit{trans}]$$

$$\frac{k_{\text{forward}}}{k_{\text{reverse}}} = \frac{[\textit{trans}]}{[\textit{cis}]} = K_c = \text{equilibrium constant}$$

By measuring the concentrations at 500 K, the equilibrium constant, K_c is 1.65 at 500 K.

At 600 K: $K_c = 1.47$

At 700 K: $K_c = 1.36$

<u>equilibrium constant</u>: the ratio of concentrations of products to reactants at equilibrium; has a constant value at a given temperature; K_c.

Writing equilibrium constant expressions

Ratio of concentrations of products to reactants.

Include only gases and dissolved substances because their concentrations can change during a reaction. Pure liquids and solids have a constant mass to volume ratio, so their concentrations do not change during a reaction, and they are not included in equilibrium constant expressions.

Use the stoichiometric coefficients as exponents (unlike the rate law for the overall reaction).

<u>Examples</u>:

$2Pb(s) + 3O_2(g) \quad\quad 2PbO(s) + 2SO_2(g)$

$AgI(s) \quad\quad Ag^+(aq) + I^-(aq)$

Practice: Write the equilibrium constant expression for the following reactions.

$H_2(g) + I_2(g)$ $2HI(g)$

$SiO_2(s) + 3C(s)$ $SiC(s) + 2CO(g)$

$HF(aq) + H_2O(l)$ $H_3O^+(aq) + F^-(aq)$

What does the magnitude of K_c tell us?

If $K_c >> 1$

If K_c nearly 1

If $K_c << 1$

For *cis*-2-butene ⇌ *trans*-2-butene,

K_c	T (K)
1.65	500
1.47	600
1.36	700

K_c can answer three important questions (p.466).

1. Are products or reactants favored?

2. Given initial concentrations of reactants and products, which direction of the reaction (forward or reverse) will be favored to reach equilibrium?

Consider K_c = [*trans*]/[*cis*] = 1.65 at 500 K.

If initial [*trans*] = 0 M, what direction is favored (or required) to reach equilibrium?

If initial [*cis*] = 0 M, what direction favored?

3. What are the equilibrium concentrations of reactants and products?

Next class we will work on answering 2 and 3 in more depth.

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OWL HW deadlines

Due Date	Assignment
3/15/10	Chapters 9-13

Before next class,

1. Study Chapter 13, pp.461-468, and Sec. 13.3.
2. Work on OWL HW.