Quantitative Changes in Equilibrium Systems

Chapter 7.5

Reaction Quotient

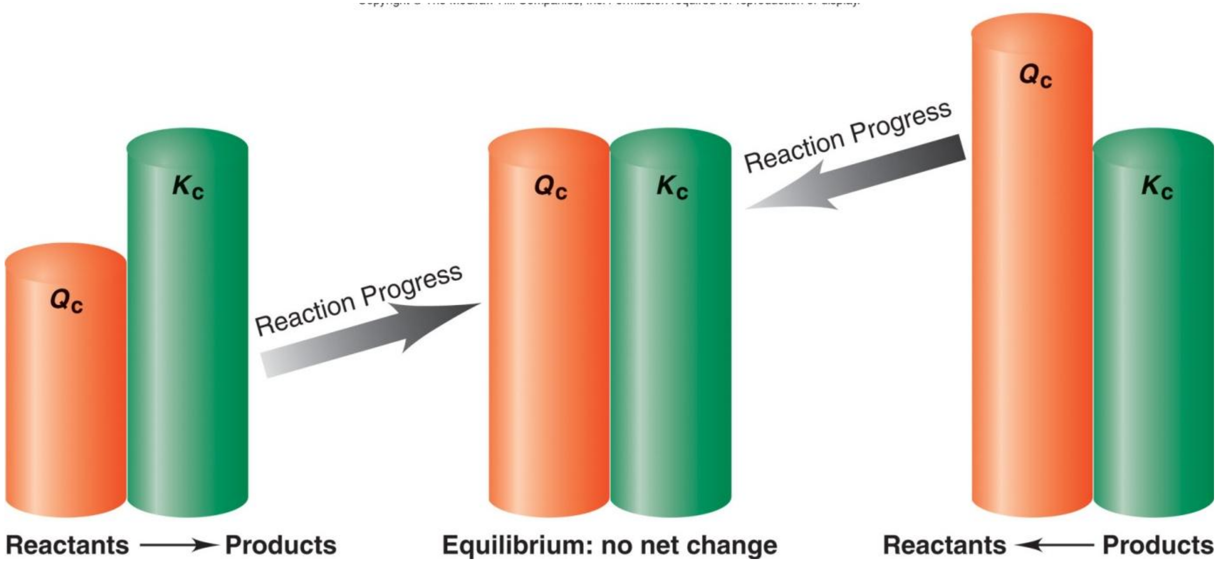
- The **reaction quotient (Q)** is the product of the concentrations of the products, divided by the product of the concentrations of the reactants, for a chemical reaction that is not necessarily at equilibrium

$$\mathbf{aA + bB \Leftrightarrow dD + eE}$$

$$Q = \frac{[D]^d[E]^e}{[A]^a[B]^b}$$

Uses for the Reaction Quotient

- Q can be compared to K to determine if equilibrium has been reached



Q < K

Q = K

Q > K

Example

- At 2000K the equilibrium constant, K, for the formation of NO is 4.0×10^{-4}. If the reaction vessel is sampled and $[N_2] = 0.50$, $[O_2] = 0.25$, $[NO]=4.2 \times 10^{-3}M$, has the reaction reached equilibrium?

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

Practice

Consider the following reaction:

$PCl_5(g) \Leftrightarrow PCl_3(g) + Cl_2(g)$ @ 250°C $K_c = 4.0 \times 10^{-2}$

- If $[Cl_2]$ and $[PCl_3]$ = 0.30M and $[PCl_5]$ = 3.0M, is the system at Equilibrium? If not, which direction will it proceed?

Calculating Equilibrium Concentrations

- We saw in section 7.1 that an ICE chart could be used to calculate equilibrium concentrations using initial concentrations and one equilibrium concentration
- We saw in section 7.2 that the equilibrium constant, K, could be calculated using equilibrium concentrations
- Today we will calculate equilibrium concentrations using initial concentrations, an ICE chart and the equilibrium constant

  (and math…Yay!)

Perfect Square Method

$H_{2(g)} + I_{2(g)} \Leftrightarrow 2HI_{(g)}$ @ 699K $K_{eq} = 55.17$

- In an experiment, 1.00 mol of each H_2 and I_2 are placed in a 0.500 L flask and the system is allowed to reach equilibrium. Find the concentration of products and reactants at equilibrium.

Quadratic Equation Method

- If the equilibrium expression is not a perfect square the quadratic equation must be used to find x

$$\mathbf{ax^2 + bx + c = 0}$$

$$\mathbf{x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}}$$

Quadratic Equation Method

$H_{2(g)} + I_{2(g)} \Leftrightarrow 2HI_{(g)}$ @ $458^{o}C$ $K_{eq} = 47.9$

- In an experiment, 1.00 mol of H_2 and 2.00 mol of I_2 are placed in a 1 L flask and the system is allowed to reach equilibrium. Find the concentration of products and reactants at equilibrium.

Simplification Method

$2CO_{2(g)} \rightleftharpoons 2CO_{(g)} + O_{2(g)}$ $K=6.40\times10^{-7}$ at $2000^{o}C$

In an experiment, 0.25M of $CO_{2(g)}$ is placed in reaction vessel and the system is allowed to reach equilibrium. Find the concentration of products and reactants at equilibrium.

Calculating Equilibrium Concentrations Summary

1. Write the balanced equation
2. Convert all amounts given to mol/L or M
3. Set up an ICE chart
4. Write out the equilibrium law expression
5. Sub in the given value for K and the equilibrium concentrations from the ICE chart
6. Solve for x (Using the appropriate method: perfect square, quadratic formula, or simplification method)
7. Sub x in to solve for the equilibrium concentrations

HOMEWORK

Required Reading:

p. 447-459

(remember to supplement your notes!)

Questions:

p. 452 #1-3

p. 454 #1-3

p. 458 #1-3

p. 459 #1-8