

Review for Exam 2, Spring 2010

Equilibrium Constants

Relating K to the rate of reaction:

When K is small, the reaction forms _____ product.

When K is large, the reaction forms _____ product.

When K is in the middle, the reaction forms _____.

When do K and Q equal each other?

When $Q < K$, the reaction proceeds toward _____.

When $Q > K$, the reaction proceeds toward _____.

Examples:

1. The reaction $\text{N}_2\text{O}_4 (\text{g}) \rightleftharpoons 2\text{NO}_2 (\text{g})$, $K_c = 0.21$. At a point during the reaction, $[\text{N}_2\text{O}_4] = 0.12 \text{ M}$ and $[\text{NO}_2] = 0.55 \text{ M}$. Is the reaction at equilibrium? If not, what direction is the reaction progressing in?

2. Chloromethane forms by the reaction $\text{CH}_4 (\text{g}) + \text{Cl}_2 (\text{g}) \rightleftharpoons \text{CH}_3\text{Cl} (\text{g}) + \text{HCl} (\text{g})$. At 1500 K, the equilibrium constant $K_p = 1.6 \times 10^4$. In the reaction mixture, $P_{\text{CH}_4} = 0.13 \text{ atm}$, $P_{\text{Cl}_2} = 0.035 \text{ atm}$, $P_{\text{CH}_3\text{Cl}} = 0.24 \text{ atm}$, and $P_{\text{HCl}} = 0.47 \text{ atm}$. Is CH_3Cl or CH_4 forming?

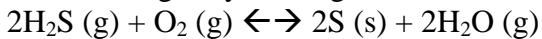
3. In a study of hydrogen halide decomposition, a researcher fills an evacuated 2.00 L flask with 0.200 mol HI gas and allows the reaction to proceed at 453 C.
 $2 \text{HI} (\text{g}) \rightleftharpoons \text{H}_2 (\text{g}) + \text{I}_2 (\text{g})$. At equilibrium, $[\text{HI}] = 0.078 \text{ M}$. Calculate K_c .

4. In a study of the conversion of methane to other fuels, a chemical engineer mixes gaseous CH_4 and H_2O in a 0.32 L flask a 1200 K. At equilibrium, the flask contains 0.26 mol CO, 0.091 mol H_2 , and 0.041 mol CH_4 . What is $[\text{H}_2\text{O}]$ at equilibrium? $K_c = 0.26$ when $\text{CH}_4 (\text{g}) + \text{H}_2\text{O} (\text{g}) \rightleftharpoons \text{CO} (\text{g}) + 3\text{H}_2 (\text{g})$

5. The research and development unit of a chemical company is studying the reaction of CH_4 and H_2S , two components of natural gas: $\text{CH}_4 (\text{g}) + 2\text{H}_2\text{S} (\text{g}) \rightleftharpoons \text{CS}_2 (\text{g}) + 4\text{H}_2 (\text{g})$
In one experiment, 1.00 mol CH_4 , 1.00 mol CS_2 , 2.00 mol H_2S , and 2.00 mol H_2 are mixed in a 250 mL vessel at 960 C. At this temperature, $K_c = 0.036$.

- In which direction will the reaction proceed to reach equilibrium?
- If $[\text{CH}_4] = 5.56 \text{ M}$ at equilibrium, what are the concentrations of the other substances?

6. To improve air quality and obtain a useful product, sulfur is often removed from coal and natural gas by treating the fuel contaminant hydrogen sulfide with O_2 .



What happens to:

- $[H_2O]$ if O_2 is added?
- $[H_2S]$ if O_2 is added?
- $[O_2]$ if H_2S is removed?
- $[H_2S]$ if sulfur is added?

Acids & Bases

Examples:

7. Write the K_a expression for each of the following:

- HCN
- HCO_3^-
- HCOOH

8. Rank the following in order of increasing acid strength: HIO_3 , HI, CH_3COOH , HF.

9. Classify each of the following as a strong or weak acid or base:

- H_3AsO_4
- $Sr(OH)_2$
- HIO
- $HClO_4$

10. What are $[H_3O^+]$, $[OH^-]$, and pOH in a solution of pH 9.78? What about a solution of pH 10.43?

11. Give the formula of the conjugate base of each of the following:

- a. HCl b. H_2CO_3 c. H_2O

12. Give the formula of the conjugate acid of each of the following:

- a. NH_3 b. NH_2^- c. H_2O

13. The weak acid HZ has a K_a of 1.55×10^{-4} . Calculate $[\text{H}_3\text{O}^+]$ of 0.075 M HZ and calculate pOH of 0.045 M HZ.

14. Choose the stronger acid in each of the following pairs:

- a. H_2SeO_3 or H_2SeO_4
b. H_3PO_4 or H_3AsO_4
c. H_2 or H_2Te

15. What are the $[\text{H}_3\text{O}^+]$ and the pH of a propanoate buffer that consists of 0.25M $\text{CH}_3\text{CH}_2\text{COONa}$ and 0.15 M $\text{CH}_3\text{CH}_2\text{COOH}$? K_a of propanoic acid = 1.3×10^{-5} .

16. What is the buffer-component ratio, $[\text{Pr}^-]/[\text{HPr}]$, of a propanoate buffer that has a pH of 5.11? K_a is in previous problem.

17. A buffer is prepared by mixing 184 mL of 0.442 M HCl and 0.500 L of 0.400 M sodium acetate. K_a acetic acid = 1.8×10^{-5}

- a. What is the pH?
- b. How many grams of KOH must be added to 0.500L of the buffer to change the pH by 0.15 units?