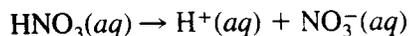


18B**Acids and Bases**

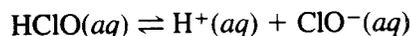
Extra Practice Problems

Using Dissociation Constants

What is the difference between a strong acid and a weak acid? We say that a solution with a lower pH is more acidic than a solution with a higher pH. Since pH is a measure of hydrogen ion concentration, it should make sense that a strong acid is one that gives more hydrogen ions in solution than a weak acid. Nitric acid, HNO_3 , is an example of a strong acid. It completely ionizes in aqueous solution to form hydrogen ions and nitrate ions.



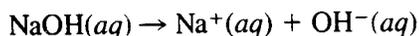
Hypochlorous acid, HClO , is an example of a weak acid. A weak acid ionizes only slightly in water and an equilibrium is established between the unionized form and the ionized form of the acid.



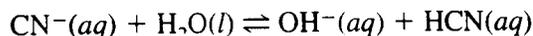
As in any equilibrium, we can write an expression for the equilibrium constant for this reaction. It is called the acid dissociation and has a value of 3.2×10^{-8} mol/L.

$$K_a = \frac{[\text{H}^+][\text{ClO}^-]}{[\text{HClO}]} = 3.2 \times 10^{-8}$$

We could also write an equilibrium constant expression for the strong acid, nitric acid. We normally don't so this because K_a is so large that it cannot be measured. The basicity of a solution is a measure of the hydroxide ion concentration. As with acids, the difference between a strong and a weak base also depends on the degree of ionization or reaction with water to produce hydroxide ion. A strong base, such as sodium hydroxide, NaOH , completely dissociates into a cation and the anion, the hydroxide ion.



A weak base only partially reacts with water producing hydroxide ion. An aqueous solution of cyanide ion, CN^- , is a weak base.



An equilibrium constant, called the base dissociation constant, can be written for this reaction.

$$K_b = \frac{[\text{OH}^-][\text{HCN}]}{[\text{CN}^-]} = 2.0 \times 10^{-5}$$

Example A

Rank these compounds in order of increasing hydrogen ion concentration: weak acid, strong base, weak base. 18·8

Solution The strong base will have the lowest $[\text{H}^+]$; strong base, weak base, weak acid.

You Try It

1. Rank these compounds in order of increasing hydroxide ion concentration: weak base, weak acid, strong base, strong acid. 18·8

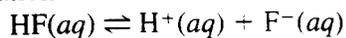
Your Solution

Example B

Write the expression for the acid dissociation constant of the strong acid hydrofluoric acid, HF.

18·8

Solution First write the equation.



$$K_a = \frac{[\text{H}^+][\text{F}^-]}{[\text{HF}]}$$

You Try It

2. Write the expression of for the base dissociation constant for hydrazine, N_2H_4 , a weak base. Hydrazine reacts with water to form the N_2H_5^+ ion.

18·8

Your Solution

Problems For You to Try

3. Use Table 18·5 in your text to rank these acids from weakest to strongest: $\text{H}_2\text{C}_2\text{O}_4$, HCO_3^- , H_2PO_4^- , HCOOH .

18·8

4. Write the equilibrium equation and the acid dissociation constant for the following weak acids:

18·8

- H_2S
- NH_4^+
- $\text{C}_6\text{H}_5\text{COOH}$

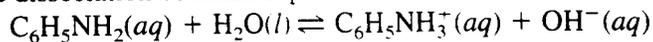
5. Match each solution with its correct description.

18·8

- | | |
|------------------------------|--|
| a. dilute, weak acid | (1) 18M $\text{H}_2\text{SO}_4(aq)$ |
| b. dilute, strong base | (2) 0.5M $\text{NaOH}(aq)$ |
| c. concentrated, strong acid | (3) 15M $\text{NH}_3(aq)$ |
| d. dilute, strong acid | (4) 0.1M $\text{HC}_2\text{H}_3\text{O}_2(aq)$ |
| e. concentrated, weak base | (5) 0.1M $\text{HCl}(aq)$ |

6. Write the base dissociation constant expression for the weak base analine, $\text{C}_6\text{H}_5\text{NH}_2$.

18·8

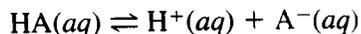


18C**Acids and Bases**

Extra Practice Problems

Dissociation Constants for Weak Acids and Bases

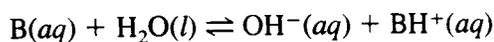
An equilibrium between the unionized and ionized forms is established when a weak acid, HA, is dissolved in water.



The dissociation constant expression for the weak acid, HA, takes the general form

$$K_a = \frac{[\text{H}^+] \times [\text{A}^-]}{[\text{HA}]}$$

The value of K_a can be calculated from the experimentally measured pH of a solution of known acid concentration. Conversely, if the K_a of a weak acid is known, the extent of its dissociation, and therefore, the pH of the solution can be calculated. A similar expression can be written for the dissociation constant of a weak base, B.



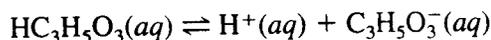
$$K_b = \frac{[\text{OH}^-] \times [\text{BH}^+]}{[\text{B}]}$$

Example A

When 0.20 mol of lactic acid, $\text{HC}_3\text{H}_5\text{O}_3$, is added to enough water to make 1.0 L of solution the equilibrium hydrogen ion concentration is $5.3 \times 10^{-3}M$. What is the K_a of lactic acid?

18·9

Solution Write the equation for the equilibrium.



Write the dissociation constant expression.

$$K_a = \frac{[\text{H}^+] \times [\text{C}_3\text{H}_5\text{O}_3^-]}{[\text{HC}_3\text{H}_5\text{O}_3]}$$

At equilibrium, $[\text{H}^+] = 5.3 \times 10^{-3}M = [\text{C}_3\text{H}_5\text{O}_3^-]$

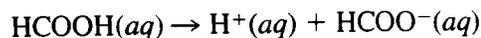
$$[\text{HC}_3\text{H}_5\text{O}_3] = 0.20M = 5.3 \times 10^{-3}M = \sim 0.20M$$

Substitute these equilibrium concentrations into the expression for K_a .

$$K_a = \frac{(5.3 \times 10^{-3}M)(5.3 \times 10^{-3}M)}{0.20M} = 1.4 \times 10^{-4}$$

You Try It

1. A 0.10M solution of formic acid has an equilibrium $[\text{H}^+] = 4.2 \times 10^{-3}M$.



What is the K_a of formic acid?

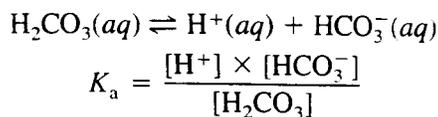
18·9

Your Solution

Example B

What is the equilibrium $[H^+]$ of a $0.10M$ solution of carbonic acid, H_2CO_3 . The K_a of $H_2CO_3 = 4.2 \times 10^{-7}$.

Solution Write the equation for the equilibrium and the acid dissociation constant expression.



At equilibrium, $[H^+] = x = [HCO_3^-]$

$$[H_2CO_3] = 0.10M = x = \sim 0.10m \text{ (since } x \ll 0.10M)$$

Substitute into the expression for K_a and solve for x .

$$K_a = \frac{(x)(x)}{0.10M} = 4.2 \times 10^{-7}$$
$$x^2 = 4.2 \times 10^{-8}$$
$$x = 2.0 \times 10^{-4} = [H^+]$$

You Try It

2. The K_a of benzoic acid, C_6H_5COOH , is 6.3×10^{-5} . What is the equilibrium $[H^+]$ in a $0.20M$ solution of benzoic acid?

Your Solution

Problems For You to Try

3. A $0.10M$ solution of hydrocyanic acid, HCN , has an equilibrium hydrogen ion concentration of $6.3 \times 10^{-6}M$. What is the K_a of hydrocyanic acid?
4. What is the equilibrium concentration of hydrogen ion in a $0.10M$ solution of propanoic acid, C_2H_5COOH ? The K_a of propanoic acid is 1.8×10^{-5} .

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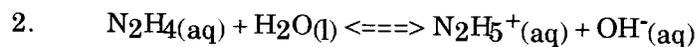
Chemistry 40S

Acid/Base Review

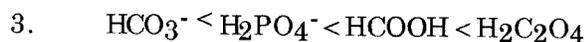
Answers

Review Sheet 18B

1. Strong acid, weak acid, weak base, strong base.



$$K_a = \frac{[\text{N}_2\text{H}_5^+][\text{OH}^-]}{[\text{N}_2\text{H}_4]}$$



4. a.
$$K_a = \frac{[\text{H}_3\text{O}^+][\text{HS}^-]}{[\text{H}_2\text{S}]}$$

b.
$$K_a = \frac{[\text{H}_3\text{O}^+][\text{NH}_3]}{[\text{NH}_4^+]}$$

c.
$$K_a = \frac{[\text{H}_3\text{O}^+][\text{C}_6\text{H}_5\text{COO}^-]}{[\text{C}_6\text{H}_5\text{COOH}]}$$

5. a. (4) b. (2) c. (1) d. (5) e. (3)

6.
$$K_b = \frac{[\text{C}_6\text{H}_5\text{NH}_3^+][\text{OH}^-]}{[\text{C}_6\text{H}_5\text{NH}_2]}$$

Review Sheet 18C

1. $K_a = 1.8 \times 10^{-4} \text{ M}$

2. $[\text{H}_3\text{O}^+] = 3.6 \times 10^{-3} \text{ M}$

3. $K_a = 4.0 \times 10^{-10}$

4. $[\text{H}_3\text{O}^+] = 1.3 \times 10^{-3} \text{ M}$

