KEY

THE STRENGTH OF ACIDS AND BASES

→ molecules

Acids ionize when placed in water. The polar water molecule pulls the hydrogen ion from the acid molecule. $H{:}\ddot{\underset{..}{Cl}}{:} \rightarrow H^+ + {:}\ddot{\underset{..}{Cl}}{:}^-$

Strong Bases dissociate when dissolved in water. $NaOH \rightarrow Na^+ + OH^-$

→ made of ions (metal and OH^-)

The extent to which the acids and bases ionize/dissociate determines the relative strength of the acid or base.

Classification as a strong or weak acid has <u>nothing</u> to do with corrosive properties. HF is a weak acid, but it has the ability to etch glass.

<u>Strong Acids</u>

Write the balanced equation for the ionization of HCl in water:

$$HCl_{(aq)} + H_2O_{(l)} \xrightarrow{100\%} H_3O^+_{(aq)} + Cl^-_{(aq)}$$

Write an equilibrium expression for this reaction:

$$K_a = \frac{[H_3O^+][Cl^-]}{[HCl]}$$

very small (indeterminate)

The equilibrium constant is called the **<u>acid dissociation constant</u>** and is represented by **K_a.**

(eq. constant)

→ for strong acids, K_a = very large

<u>Strong Bases</u>

Write the balanced equation for the dissociation of NaOH in water:

$$NaOH_{(s)} \rightarrow Na^+_{(aq)} + OH^-_{(aq)}$$

Write an equilibrium expression for this reaction:

$$K_b = [Na^+][OH^-]$$

The equilibrium constant is called the **<u>base dissociation constant</u>** and is represented by **K_b.**

(eq. constant)

<u>Weak Acids</u>

less than 100% ionization – reaches an equilibrium

Write the equation for the ionization of $HC_2H_3O_2$ in water:

$$HC_2H_3O_{2(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + C_2H_3O_2^-{}_{(aq)}$$

Write the equilibrium expression for this reaction:

$$K_a = \frac{[H_3O^+][C_2H_3O_2^-]}{[HC_2H_3O_2]}$$

K_a for acetic acid $= 1.8 \times 10^{-5}$

<u>Weak Bases</u>

Write the equation for the reaction of ammonia in water:

$$NH_{3(g)} + H_2O_{(l)} \rightleftharpoons NH_4^+{}_{(aq)} + OH^-_{(aq)}$$

Write the equilibrium expression for this reaction:

$$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]}$$

THE AUTOIONIZATION OF WATER

Pure water ionizes to a very slight extent!!!!!! (1/500 million molecules will ionize.)

$$H_2O_{(l)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$$

H+

Self-ionización of water.

In pure water, the concentration of H_3O^+ will always equal the concentration of OH^-. Careful measurements have shown that in pure water at 25°C,

$$[H_3O^+] = [OH^-] = 1\times10^{-7}\,M$$

→ 1/500 million molecules

You can write an equilibrium expression for the autoionization of water:

$$K_w = [H_3O^+][OH^-]$$

$$\left.\begin{aligned} K_w &= [H_3O^+][OH^-] \\ &= (1\times10^{-7})(1\times10^{-7}) \\ &= 1\times10^{-14} \end{aligned}\right\} \text{at } 25°C$$

K_w is called the ion product constant for water and is equal to 1 x 10^{-14} for water at 25°C.

The pH scale is a log scale based on 10, where **$pH = -\log [H_3O^+]$**

The pH of pure water is

at 25°C

$$pH = -\log[1\times10^{-7}]$$
$$= 7$$

The pH scale ←0 ——— 7 ——— 14→

0	7	14
Acid solutions	Neutral solutions	Base solutions
$[H_3O^+]>[OH^-]$	$[H_3O^+]=[OH^-]$	$[H_3O^+]<[OH^-]$

Similar log scales are used for representing other quantities:

$pOH = -\log[OH^-]$

$pK = -\log K$

Can also solve for

$[H_3O^+] = 10^{-pH}$

$pH + pOH = 14$

$Kw = [H_3O^+][OH^-] = 1 \times 10^{-14}$

$Kw = [H_3O^+][OH^-] = 1 \times 10^{-14}$ This expression is true for pure water <u>and</u> for dilute aqueous solutions at 25°C.

$\xleftarrow{\text{shift}}$

- If add HCl to water

$H_2O + H_2O \rightleftharpoons H_3O^+ + OH^-$

$\uparrow \quad \downarrow \qquad \uparrow\downarrow \qquad \downarrow$

net ↑

$K_w = [H_3O^+][OH^-]$

↳ stays the same

- If add NaOH to water

$H_2O + H_2O \rightleftharpoons H_3O^+ + OH^-$

$\uparrow \qquad \uparrow\downarrow$

net up

$K_w = [H_3O^+][OH^-]$

$\downarrow \qquad \uparrow$

↳ stays the same

<u>Must follow the sig fig rule for working with logarithms!</u>

The rule is that the number of decimal places in the log is equal to the number of significant figures in the original number.

* *The pH changes by 1 for every power of 10 change in $[H^+]$. Remember this because it will allow you to predict pH without a calculator.*

EASY pH PROBLEMS

1. What is the $[H_3O^+]$ of a 0.02 M HCl solution? What is the pH?

$HCl + H_2O \rightarrow H_3O^+ + Cl^-$

.02M $\qquad$ .02M

$ph = -\log .02 = 1.7$

2. What is the $[H_3O^+]$ of a 0.02 M NaOH solution? What is the pH?

$NaOH \rightarrow Na^+ + OH^-$

.02M $\qquad$ .02M

$K_w = [H_3O^+][OH^-]$

$[H_3O^+] = \frac{1 \times 10^{-14}}{.02} = 5 \times 10^{-13} M\ H_3O^+$

$pH = -\log 5 \times 10^{-13} = 12.3$

$pOH = -\log .02 = 1.7$

$pH = 14 - 1.7 = 12.3$

3. Calculate the $[H_3O^+]$ and $[OH^-]$ of the following:

A. Lemon juice (pH = 2.2)

$[H_3O^+] = 10^{-2.2} = .006\ M\ H_3O^+$

$[OH^-] = \frac{1 \times 10^{-14}}{.006} = 2 \times 10^{-12} M\ OH^-$

B. Household ammonia (pH = 11.9)

$[H_3O^+] = 10^{-11.9} = 1 \times 10^{-12} M\ H_3O^+$

$[OH^-] = \frac{1 \times 10^{-14}}{1 \times 10^{-12}} = 1 \times 10^{-2} M\ OH^-$

4. Calculate the hydroxide ion concentration of 0.022 M hydrochloric acid solution.

$$HCl + H_2O \rightleftharpoons H_3O^+ + Cl^-$$

$.022 \qquad .022$

$$[OH^-] = \frac{K_w}{[H_3O^+]} = \frac{1\times10^{-14}}{.022} = 4.5\times10^{-13}\ M\ OH^-$$

5. The pH of canned soda was measured with a pH meter and determined to be 3.5. What is the $[H_3O^+]$?

$$[H_3O^+] = 10^{-pH}$$
$$= 10^{-3.5} = 3\times10^{-4}\ M\ H_3O^+$$

6. What is the pH, $[H_3O^+]$, and $[OH^-]$ of a solution made by dissolving 750.0g of HI gas in a 4.5 liter container of water?

$$\frac{750.0g\ HI}{4.5L} \times \frac{1\ mole}{127.91g} = 1.3\ mol/L$$

$$HI \rightarrow H^+ + I^-$$

$1.3 \qquad 1.3$

$pH = -\log 1.3$
$= -.11$

$pOH = 14 - pH$
$= 14.11$

$[H_3O^+] = 1.3M$

$$[OH^-] = \frac{1\times10^{-14}}{1.3} = 7.7\times10^{-15}\ M$$