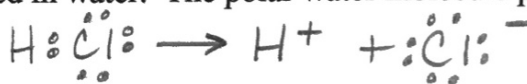


KEY

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.



Strong Bases dissociate when dissolved in water.



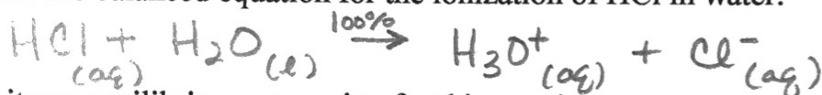
made of ions (metal and OH⁻)

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 nothing to do with corrosive properties. HF is a weak acid, but it has the ability to etch glass.

Strong Acids

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



Write an equilibrium expression for this reaction:

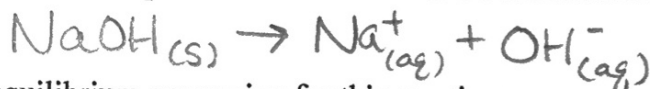
$$K_a = \frac{[H_3O^+][Cl^-]}{[HCl]}$$

very small (indeterminate)

The equilibrium constant is called the acid dissociation constant and is represented by K_a.
(eq. constant)

Strong Bases

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



Write an equilibrium expression for this reaction:

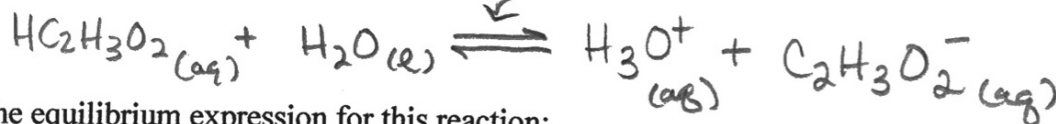
$$K_b = [Na^+][OH^-]$$

The equilibrium constant is called the base dissociation constant and is represented by K_b.
(eq. constant)

for strong acids, K_a = very large

Weak Acids

Write the equation for the ionization of HC₂H₃O₂ in water:



less than 100% ionization - reaches an equilibrium

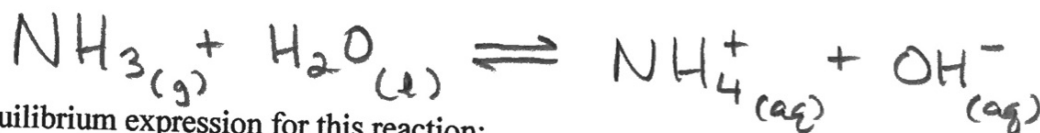
Write the equilibrium expression for this reaction:

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

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

Weak Bases

Write the equation for the reaction of ammonia in water:

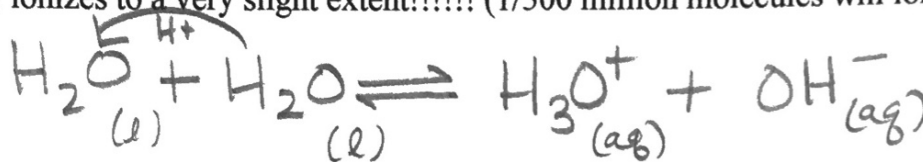


Write the equilibrium expression for this reaction:

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

THE AUTOIONIZATION OF WATER

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



Self-ionization 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 ,

$$[\text{H}_3\text{O}^+] = [\text{OH}^-] = 1 \times 10^{-7} \text{ M} \quad \rightarrow \text{1/500 million molecules}$$

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

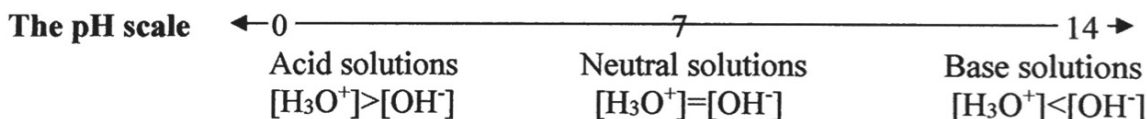
$$K_w = [\text{H}_3\text{O}^+][\text{OH}^-] \quad \left. \begin{aligned} K_w &= [\text{H}_3\text{O}^+][\text{OH}^-] \\ &= (1 \times 10^{-7})(1 \times 10^{-7}) \\ &= 1 \times 10^{-14} \end{aligned} \right\} \text{at } 25^\circ\text{C}$$

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

The pH scale is a log scale based on 10, where **$\text{pH} = -\log [\text{H}_3\text{O}^+]$**

The pH of pure water is at 25°C

$$\text{pH} = -\log [1 \times 10^{-7}] = 7$$



Similar log scales are used for representing other quantities:

$$\text{pOH} = -\log[\text{OH}^-]$$

$$\text{pK} = -\log K$$

Can also solve for

$$[\text{H}_3\text{O}^+] = 10^{-\text{pH}}$$

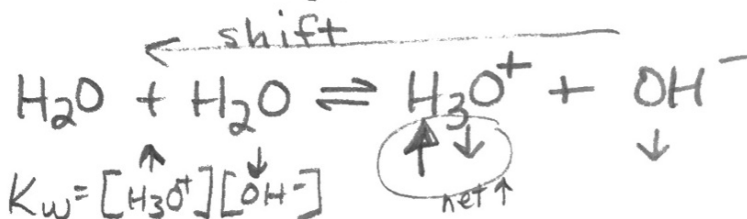
$$\text{pH} + \text{pOH} = 14$$

$$K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 1 \times 10^{-14}$$

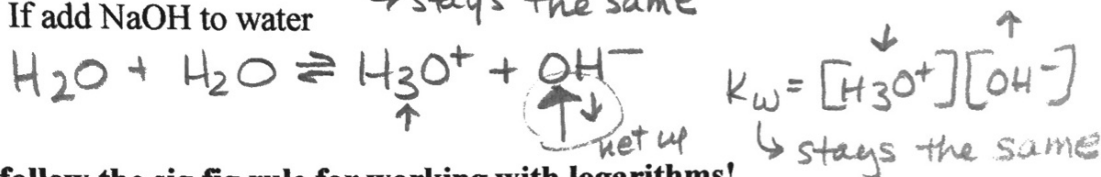
$$K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$$

This expression is true for pure water and for dilute aqueous solutions at 25°C.

- If add HCl to water



- If add NaOH to water



Must follow the sig fig rule for working with logarithms!

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.)

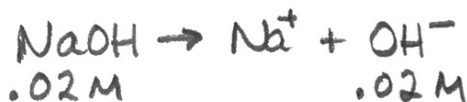
EASY pH PROBLEMS

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



$$pH = -\log .02 = 1.7$$

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



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

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

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

$$pOH = -\log .02 = 1.7$$

$$pH = 14 - 1.7 = 12.3$$

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

A. Lemon juice (pH = 2.2)

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

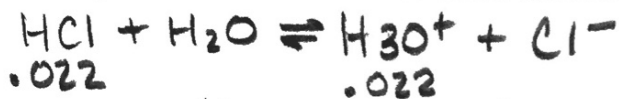
$$[OH^-] = \frac{1 \times 10^{-14}}{.006} = 2 \times 10^{-12} \text{ M } OH^-$$

B. Household ammonia (pH = 11.9)

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

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

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



0.022

0.022

$$[\text{OH}^-] = \frac{K_w}{[\text{H}_3\text{O}^+]} = \frac{1 \times 10^{-14}}{0.022} = 4.5 \times 10^{-13} \text{ M OH}^-$$

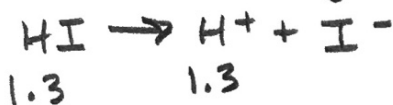
5. The pH of canned soda was measured with a pH meter and determined to be 3.5. What is the $[\text{H}_3\text{O}^+]$?

$$[\text{H}_3\text{O}^+] = 10^{-\text{pH}}$$

$$= 10^{-3.5} = 3 \times 10^{-4} \text{ M H}_3\text{O}^+$$

6. What is the pH, $[\text{H}_3\text{O}^+]$, and $[\text{OH}^-]$ of a solution made by dissolving 750.0g of HI gas in a 4.5 liter container of water?

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



$$\text{pH} = -\log 1.3$$
$$= -0.11$$

$$\text{pOH} = 14 - \text{pH}$$
$$= 14.11$$

$$[\text{H}_3\text{O}^+] = 1.3 \text{ M}$$

$$[\text{OH}^-] = \frac{1 \times 10^{-14}}{1.3} = 7.7 \times 10^{-15} \text{ M}$$