EQUILIBRIUM & WATER

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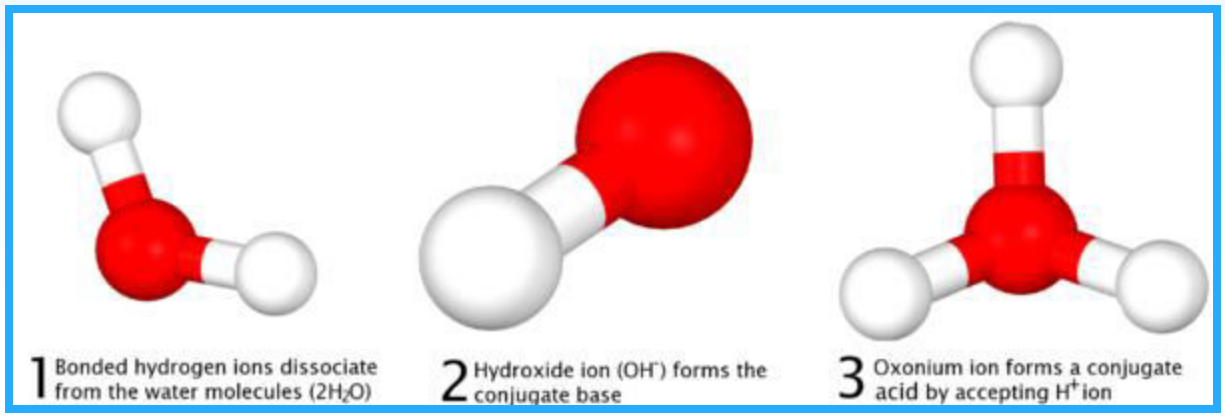
Water

$$H_2O_{(l)} <====> H_3O^+_{(aq)} + OH^-_{(aq)}$$

Is the K_w value large or small? How do you know?

$$K_w = [OH^-][H_3O^+] = 1.0 \times 10^{-14} \quad @\ 25°C$$

It is mostly water and does not conduct electricity well.



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Water

Acids and bases are determined by the relative $[H_3O^+]$ and $[OH^-]$.

1. neutral $[H_3O^+] = [OH^-]$

2. acid $[H_3O^+] > [OH^-]$

3. base $[H_3O^+] < [OH^-]$

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Water

$$K_w = 1.0 \times 10^{-14}$$

What are the concentrations of $[H^+]$ and $[OH^-]$ of pure water?

$K_w = 1.0 \times 10^{-14} = [H^+][OH^-]$

Since $[H^+] = [OH^-]$, the concentration of each is $\sqrt{1.0 \times 10^{-14}}$

$\therefore [OH-] = [H+] = 1.0 \times 10^{-7}$

What happens when NaOH is added to water? $[H^+] < [OH^-]$

HCl? $[H^+] > [OH^-]$

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Water

Interestingly, even in acidic and basic solutions.

$$K_w = 1.0 \times 10^{-14}$$

Therefore,

1. if $[H^+]$ increases, $[OH^-]$ decreases
2. if $[H^+]$ decreases, $[OH^-]$ increases

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Example #2

In one sample of blood at 25°C,

$[H^+] = 4.6 \times 10^{-8}$ M. Find the molar concentration of OH^-, and decide if the sample is acidic, basic, or neutral?

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Example #2

In one sample of blood at 25°C, $[H^+] = 4.6 \times 10^{-8}$ M. Find the molar concentration of OH^-, and decide if the sample is acidic, basic, or neutral?

$$K_w = 1.0 \times 10^{-14} = [H^+][OH^-]$$

$$1.0 \times 10^{-14} = [4.6 \times 10^{-8}][OH^-]$$

$$\frac{1.0 \times 10^{-14}}{4.6 \times 10^{-8}} = [OH^-]$$

$$2.1739 \times 10^{-7} M = [OH^-]$$

$$pH = -\log [H^+]$$

$$pH = -\log [4.6 \times 10^{-8}]$$

$$pH = -(-7.337242)$$

$$pH = 7.3$$ ← *Slightly basic*

∴ the $[OH^-] = 2.2 \times 10^{-7} M$, and the sample is slightly basic

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Example #3

A 25°C aqueous solution of sodium bicarbonate, $NaHCO_3$, has a molar concentration of OH^- of 7.8×10^{-6} M. What is its molar concentration of hydrogen ion? Is the solution acidic basic or neutral?

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Example #3

A 25°C aqueous solution of sodium bicarbonate, $NaHCO_3$, has a molar concentration of OH^- of 7.8×10^{-6} M. What is its molar concentration of hydrogen ion? Is the solution acidic basic or neutral?

$$K_w = 1.0 \times 10^{-14} = [H^+][OH^-]$$

$$1.0 \times 10^{-14} = [H^+][7.8 \times 10^{-6}]$$

$$\frac{1.0 \times 10^{-14}}{7.8 \times 10^{-6}} = [H^+]$$

$$1.28 \times 10^{-9} = [H^+]$$

$$pH = -\log [H^+]$$

$$pH = -\log [1.28 \times 10^{-9}]$$

$$pH = -(-8.89279)$$

$$pH = 8.9$$

.: the $[H^+] = 1.3 \times 10^{-9}$M, and the solution is basic

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Example #4

What is the $[H_3O^+]$ in a 0.025 M solution of NaOH at 25°C? Is this solution acidic, basic or neutral?

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Example #4

What is the $[H_3O^+]$ in a 0.025 M solution of NaOH at 25°C? Is this solution acidic, basic or neutral?

recall $[H^+] = [H_3O^+]$, and $[OH^-] = [NaOH]$

$$K_w = 1.0 \times 10^{-14} = [H^+][OH^-]$$

$$1.0 \times 10^{-14} = [H^+][0.025]$$

$$\frac{1.0 \times 10^{-14}}{0.025} = [H^+]$$

$$4.0 \times 10^{-13} = [H^+]$$

$$pH = -\log [H^+]$$

$$pH = -\log [4.0 \times 10^{-13}]$$

$$pH = -(-12.39794)$$

$$pH = 12$$

∴ the $[H_3O^+] = 4.0 \times 10^{-13}$M, and the solution is basic