# Chemistry 122- Acid Base Unit
## Chapter 19.2, Water Equilibrium Notes

**Date:**

***Objective***: *Describe how $[H^+]$ and $[OH^-]$ are related in an aqueous solution. Classify the solution as neutral, acidic or basic given the $[H^+]$ or $[OH^-]$. Convert the $[H^+]$ and $[OH^-]$ into pH and pOH values.*

About 2 molecules out of every billion water molecules have enough energy when they collide to transfer a $H^+$ ion from one water molecule to the other.

When water ionizes, or falls apart into ions: it is called the self ionization of water

$H_2O \leftrightarrow H^+ + OH^-$ Arrhenius

The proton or hydrogen ion usually attaches to another water molecule, creating the hydronium ion. $H_2O_{(l)} + H_2O_{(l)} \leftrightarrow H_3O^+_{(aq)} + OH^-_{(aq)}$ ] Bronsted-Lowry

The self-ionization of water occurs to a small *extent*:

$[H^+] = [OH^-] = 1 \times 10^{-7}\ mol/L$

Since they are equal, a neutral solution results from water

$K_w = [H^+][OH^-] = 1 \times 10^{-14}\ mol^2/L^2$

$K_w$ is called the "ion product constant" for water

**For all aqueous solutions, the product of the hydrogen-ion concentration and the hydroxide-ion concentration equals $1.0 \times 10^{-14}$**

$K_w$ is constant in every aqueous solution:

$$[H^+] \times [OH^-] = 1 \times 10^{-14}\ mol^2/L^2$$

If we know one, other can be determined by inputting the value of the known concentration and using the kw constant value. We can also determine the acidity or basicity of the solution.

- If $[H^+] > 10^{-7}$, it is acidic and $[OH^-] < 10^{-7}$
- If $[H^+] < 10^{-7}$, it is basic and $[OH^-] > 10^{-7}$

Example 1

Calculate the $OH^-$ concentration of a 0.20M solution of $HNO_3$

$HNO_{3(aq)} \rightarrow H^+_{(aq)} + NO_3^-{}_{(aq)}$

0.20M 0.20M 0.20M

ACIDIC

$K_w = [H^+][OH^-]$ $\quad [OH^-] = \frac{K_w}{[H^+]} = \frac{1.0 \times 10^{-14}\ mol^2/L^2}{0.20\ mol/L} = 5.0 \times 10^{-14}\ \frac{mol}{L}$

Example 2
Calculate the $H^+$ ion concentration in a solution of 0.32 mol/L $Ba(OH)_2$.

Step 1: Write the balanced Ionization equation

$Ba(OH)_{2(aq)} \rightarrow Ba^{2+}_{(aq)} + 2OH^-_{(aq)}$

0.32M 0.32M 0.64M

Step 2: Calculate the concentration of each entity.

$[OH^-] = 0.64M$ $[H^+] = \frac{1.0 \times 10^{-14} mol^2/L^2}{0.64 \frac{mol}{L}} = 1.6 \times 10^{-14}$ $[H^+]$

$\therefore$ A BASE

Step 3: Use $K_w$ to calculate the $[H^+]$ or $[OH^-]$

Problems!

1. What is the hydroxide ion concentration in a solution that has a hydrogen ion concentration of $6.8 \times 10^{-10}$M? Is the solution acidic or basic?
2. If the hydroxide ion concentration in a solution is $5.67 \times 10^{-3}$M, calculate the hydrogen ion concentration. Is the solution acidic or basic.
3. A 0.15M solution of hydrochloric acid at 25°C is found to have a hydrogen ion concentration of 0.15M. Calculate the concentration of hydroxide ions.
4. Calculate the hydrogen ion concentration in a 0.25M solution of barium hydroxide.
5. Determine the hydrogen and hydroxide ion concentrations in 500. mL of an aqueous solution containing 2.6 grams of sodium hydroxide.
6. The hydrogen ion concentration in an industrial effluent is 4.40 mmol/L ($4.40 \times 10^{-3}$ mol/L). Determine the concentration of hydroxide ions in the effluent.
7. The hydroxide ion concentration in a household cleaner is 0.299mmol/L. Calculate the hydrogen ion concentration in the cleaner.
8. Calculate the hydroxide ion concentration in a solution prepared by dissolving 0.37g of hydrogen chloride in 250ml of water.
9. Calculate the hydrogen ion concentration in a saturated solution of calcium hydroxide that has a solubility of 6.9 mmol/L.
10. What is the hydrogen ion concentration in a solution made by dissolving 20.0g of potassium hydroxide in water to form 500ml of solution?

Ex 5. 2.6g in 500.mL $[H^+]$ & $[OH^-]$?

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

0.13M 0.13M 0.13M

$n = \frac{m}{M} = \frac{2.6g}{40.0g/mol} = 0.065mol$ $c = \frac{n}{V} = \frac{0.065mol}{0.500L} = 0.13M$

$[OH^-] = 0.13M$ $[H^+] = \frac{K_w}{[OH^-]} = \frac{1.0 \times 10^{-14} mol^2/L^2}{0.13 \frac{mol}{L}} = 7.7 \times 10^{-14} mol/L$

$\therefore$ BASE!