

### 6.3 - Ionization of Water

*pages 608-609 in Matter and Change*

*pages 572-573 in Health*

## **Ionization of Water**

**In this reaction, the vast majority of the water remains as H<sub>2</sub>O.**

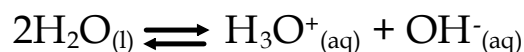
**Only about 1 water molecule in 500 million is ionized.**



### 6.3 - Ionization of water and Kw

Water is considered a non-electrolyte (will not conduct electricity)

However, a few water molecules will dissociate to form ions as represented by:



Because this system is in equilibrium, the equilibrium constant for water can be determined.

$$K_{eq} = \frac{[\text{H}_3\text{O}^+][\text{OH}^-]}{[\text{H}_2\text{O}][\text{H}_2\text{O}]} = [\text{H}_3\text{O}^+][\text{OH}^-] \quad \text{H}_2\text{O is not included}$$

**because it is liquid and therefore constant**

This is called the ion product constant for water or  $K_w$

-At 25°C,  $K_w$  has been experimentally determined to be  $1.0 \times 10^{-14}$

Water has many hydronium and hydroxide ions; therefore:

$$1.00 \times 10^{-14} = [\text{H}_3\text{O}^+][\text{OH}^-] = x^2$$

$$\sqrt{1.00 \times 10^{-14}} = \sqrt{x^2}$$

$$1.00 \times 10^{-7} = x = [\text{H}_3\text{O}^+] = [\text{OH}^-]$$

Solutions can be classified as acidic, basic or neutral according to:

$$[\text{H}_3\text{O}^+] > [\text{OH}^-] \quad \text{acidic}$$

$$[\text{H}_3\text{O}^+] = [\text{OH}^-] \quad \text{neutral}$$

$$[\text{H}_3\text{O}^+] < [\text{OH}^-] \quad \text{basic}$$

#### Calculating $[\text{H}_3\text{O}^+]$ in STRONG Acids and $[\text{OH}^-]$ in STRONG Bases

We will consider strong acids as those that have a  $K_a > 1$ .

-You can use **Table 14** to determine if you are working with a strong acid or weak acid. Recall that a strong acid is one that completely ionizes.

When working with a strong acid or a strong base we will calculate the concentration of hydrogen ions or hydroxide ions in the same fashion we have in the past.

Ex) Calculate  $[\text{H}_3\text{O}^+]$  for a 0.050 M solution of Perchloric acid.

Ex) NaOH is a strong base. Calculate  $[\text{OH}^-]$  for a 0.010 M solution of sodium hydroxide.

### Calculating $[\text{OH}^-]$ in STRONG Acids and $[\text{H}_3\text{O}^+]$ in STRONG Bases

When we are determining the ion concentrations for an acid, we are generally concerned with  $[\text{H}_3\text{O}^+]$ .

Likewise, when determining the ion concentrations for a base, we are concerned about  $[\text{OH}^-]$ .

However, we may be asked to find  $[\text{OH}^-]$  in an **acid** or the  $[\text{H}^+]$  in a **base**.

Remember that we are calculating the ion concentrations for acid/base **solutions**, which means they are mixed with water.

If we mix an acid with water, we are adding  $\text{OH}^-$  to the acid because water does ionize a bit. Therefore, we can use  $K_w$  to calculate  $[\text{OH}^-]$ .

ex: What are the hydronium ion and hydroxide ion concentrations in a 0.050 mol/L aqueous solution of hydrochloric acid at 25°C? Is the solution acidic or basic?

## 6.3 - Ionization of water and Kw

### 6.3 Ionization of Water Assignment

**1. The concentration of either the  $\text{H}^+$  ion or  $\text{OH}^-$  ion is given for 3 aqueous solutions at 298K. For each solution, calculate  $[\text{H}^+]$  or  $[\text{OH}^-]$ . State whether solution is acidic, basic or neutral.**

a)  $[\text{H}^+] = 1.0 \times 10^{-13}\text{M}$

b)  $[\text{OH}^-] = 1.0 \times 10^{-7}\text{M}$

c)  $[\text{OH}^-] = 1.0 \times 10^{-3}\text{M}$

**2. What is the  $[\text{H}_3\text{O}^+]$  in a 0.025M solution of NaOH. Is this solution acidic, basic or neutral?**

