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_2O.

Only about 1 water molecule in 500 million is ionized.

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

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

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

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

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

$$K_{eq} = \frac{[H_3O^+][OH^-]}{[H_2O][H_2O]} = [H_3O^+][OH^-] \quad \mathbf{H_2O \text{ is not included}}$$

because it is liquid and therefore constant

This is called the ion product constant for water or $\mathbf{K_w}$
-At 25°C, K_w has been experimentally determined to be 1.0×10^{-14}

Water has many hydronium and hydroxide ions; therefore:

$$1.00\times10^{-14} = [H_3O^+][OH^-] = x^2$$
$$\sqrt{1.00\times10^{-14}} = \sqrt{x^2}$$
$$1.00\times10^{-7} = x = [H_3O^+] = [OH^-]$$

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

$$[H_3O^+] > [OH^-] \text{ acidic}$$
$$[H_3O^+] = [OH^-] \text{ neutral}$$
$$[H_3O^+] < [OH^-] \text{ basic}$$

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Calculating $[H_3O^+]$ in STRONG Acids and $[OH^-]$ 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 $[H_3O^+]$ for a 0.050 M solution of Perchloric acid.

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

Calculating [OH^-] in STRONG Acids and [H_3O^+] in STRONG Bases

When we are determining the ion concentrations for an acid, we are generally concerned with [H_3O^+].

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

However, we may be asked to find [OH^-] in an **acid** or the [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 OH^- to the acid because water does ionize a bit. Therefore, we can use K_w to calculate [OH^-].

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

6.3 Ionization of Water Assignment

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

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

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

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

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

6.3 Ionization of Water Assignment

3. A 2.5L solution contains 5.6 g of hydroiodic acid. What is the concentration of hydroxide ions in this solution? Is this solution acidic, basic or neutral?

4. Postassium hydroxide is a very strong base. If 6 mols are found in an 8L solution, what is the hydronium ion concentration in this solution? Is this solution acidic, basic or neutral?

5. 10.4 g of nitric acid are found in 750 mL of water. What is the hydronium concentration of this solution?

6. A 500mL (0.50M) solution of sodium hydroxide is diluted with 250mL of water. What are the final concentrations of $[H^+]$ and $[OH^-]$ in this solution? Is this solution acidic, basic or neutral?