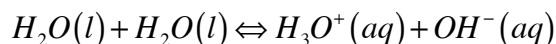


Ion Product of Water

Since water is amphoteric, it is capable of acting as both an acid and a base. As an acid, it donates an H^+ ion to become an OH^- ion. As a base, it accepts an H^+ to become an H_3O^+ ion.

It has been shown experimentally that two water molecules will react with one another to form ions according to the following equation.



In this reaction, water acts as both the acid and the base. This reaction will occur even in pure water, resulting in a small amount of ionization. In fact, it has been determined that pure water at $25^\circ C$ contains both H_3O^+ and OH^- ions at concentrations of $1.0 \times 10^{-7} \text{ mol/L}$.

Using the above equation and the known concentrations of H_3O^+ and OH^- ions, we can write an equilibrium expression for pure water and calculate the value of the ion product for water (K_w).

$$\begin{aligned} K_w &= [H_3O^+][OH^-] \\ &= (1.0 \times 10^{-7})(1.0 \times 10^{-7}) \\ K_w &= 1.0 \times 10^{-14} \end{aligned}$$

K_w is useful because it applies not only to pure water, but to every water solution at $25^\circ C$, even a solution in which the concentrations of H_3O^+ and OH^- ions are not equal.

Example 1

The concentration of H_3O^+ ions in an acid solution were measured to be $1.0 \times 10^{-2} \text{ mol/L}$. Determine the concentration of OH^- ions in the solution.

The fact that water itself ionizes to form both H_3O^+ and OH^- ions means that all acidic, basic, and neutral solutions contain both H_3O^+ and OH^- ions. It is possible to determine the nature of a water solution (acidic, basic, or neutral) by comparing the relative concentrations of these two ions.

- If $[H_3O^+] = [OH^-]$, the solution is neutral.
- If $[H_3O^+] > [OH^-]$, the solution is acidic.
- If $[H_3O^+] < [OH^-]$, the solution is basic.

Example 2

If the concentration of H_3O^+ in blood is $4.0 \times 10^{-8} \text{ mol/L}$, is blood acidic, basic, or neutral?

Worksheet

1. What is the concentration of OH^- ions in chocolate milk if $[H_3O^+] = 4.5 \times 10^{-7} \text{ mol/L}$? Is chocolate milk acidic, basic, or neutral?
2. What is the concentration of H_3O^+ ions in black coffee if $[OH^-] = 1.3 \times 10^{-9} \text{ mol/L}$? Is black coffee acidic, basic, or neutral?
3. What is the concentration of OH^- ions in saturated lime if $[H_3O^+] = 3.98 \times 10^{-13} \text{ mol/L}$? Is lime acidic, basic, or neutral?
4. What is the concentration of H_3O^+ ions in a wheat flour and water solution if $[OH^-] = 1.0 \times 10^{-8} \text{ mol/L}$? Is this solution acidic, basic, or neutral?
5. Complete the following table by determining the missing concentrations. State whether each solution is acidic, basic, or neutral.

$[H_3O^+]$	$[OH^-]$	Acidic, basic, or neutral?
	$1.0 \times 10^{-5} \text{ mol/L}$	
	$4.0 \times 10^{-9} \text{ mol/L}$	
$1.2 \times 10^{-8} \text{ mol/L}$		