Hydrogen Ions and Acidity

Hydrogen Ions from Water

The reaction in which water molecules produce ions is called the self-ionization of water.

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

Another self-ionization of water involves combining two water molecules.

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

water molecule + water molecule → hydronium ion + hydroxide ion

Ion Product Constant for Water

The self-ionization of water is limited. At 25°C the equilibrium concentrations of hydrogen ions (H^+) and hydroxide ions (OH^-) are the same at 1×10^{-7}M.

For aqueous solutions, the product of (H^+) and (OH^-) equals 1.0×10^{-14}. This value is called the **ion-product constant for water (K_w)**.

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

Any aqueous solution in which $[H^+]$ and $[OH^-]$ are equal is described as a neutral solution.

Not all solutions are neutral.

$$HCl_{(g)} \xrightarrow{H_2O} H^+_{(aq)} + Cl^-_{(aq)}$$

Here, $[H^+] > [OH^-]$

*hydroxide ions are present from the self ionization of water

An acidic solution is one in which $[H^+]$ is greater than $[OH^-]$. The $[H^+]$ of an acidic solution is greater than 1.0×10^{-7}M

A basic solution is one in which $[H^+]$ is less than $[OH^-]$. The $[H^+]$ of a basic solution is less than 1.0×10^{-7}M. Basic solutions are also known as **alkaline solutions**.

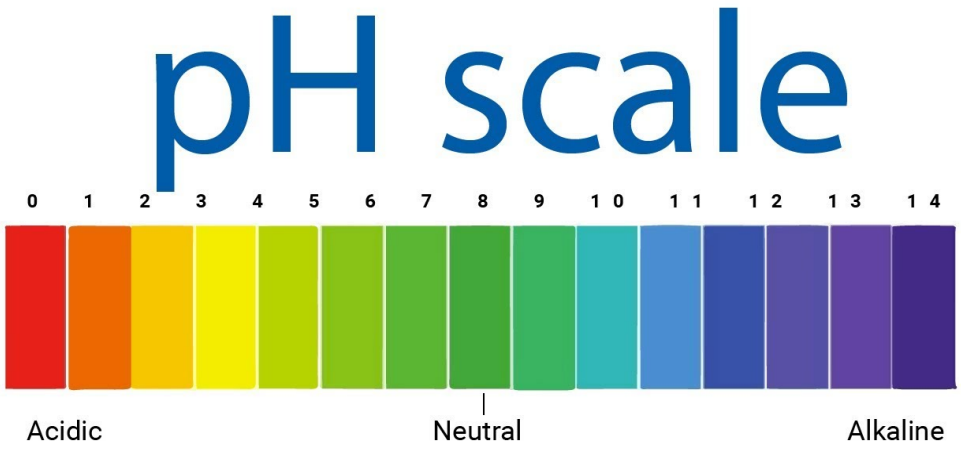
Example

Pop is slightly acidic. If the $[H^+]$ in a solution is 1.0×10^{-5}M, is the solution acidic, basic, or neutral? What is the $[OH^-]$ of this solution?

The pH Concept

A more widely used system for expressing [H^+] is the pH scale.

On the pH scale, the number range from 0 - 14. Neutral solutions have a pH of 7.



pH can be represented mathematically using logarithms.

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

Practice: In a neutral solution [H+] = 1.0×10^{-7} M

pH =

pH =

pH =

pH =

In general...

Acidic solution

$pH < 7.0$

$[H^+] > 1.0 \times 10^{-7} M$

Neutral solution

$pH = 7.0$

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

Basic solution

$pH > 7.0$

$[H^+] < 1.0 \times 10^{-7} M$

Table 19.5 on page 598 outlines some common aqueous solution.

Do you see a pattern in the pH and concentration values?

Calculating pOH is similar to $[H^+]$

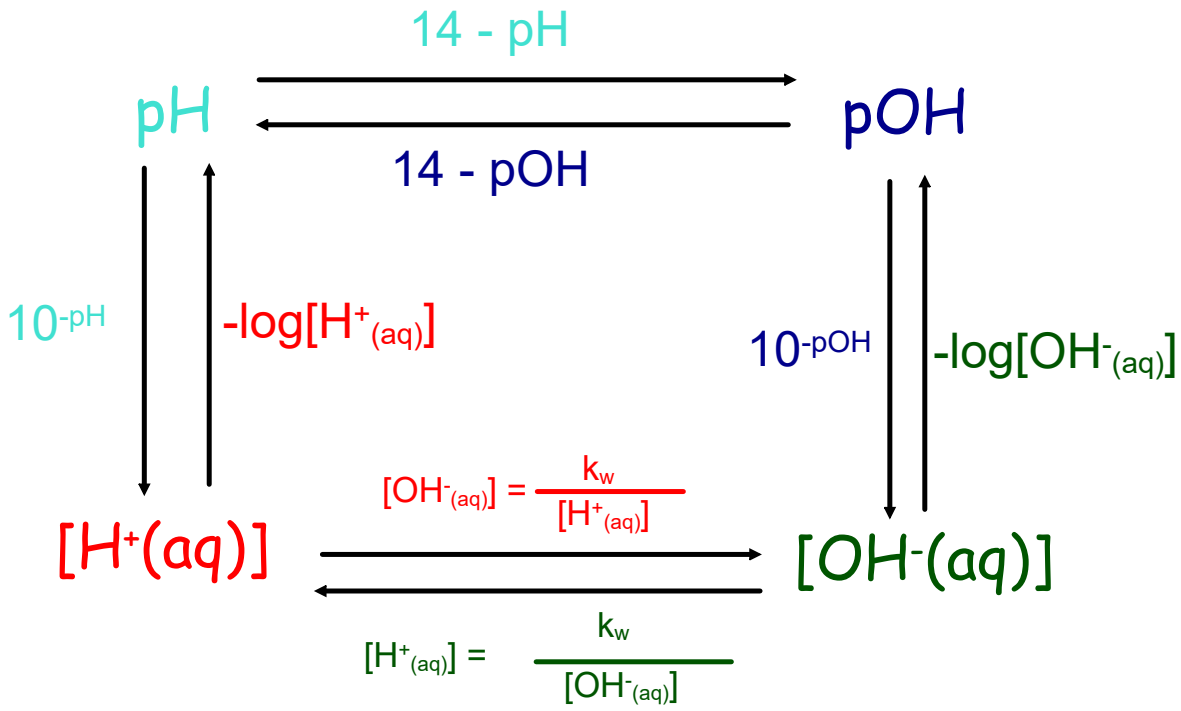
$$pOH = -\log[OH^-]$$

A neutral solution has a pOH of 7. If pOH is less than 7 it is basic. If pOH > 7 it is acidic.

We can also connect pH and pOH

$$pH + pOH = 14$$

In general...


14 - pH
pH
pOH
14 - pOH
10-pH
-log[H+(aq)]
10-pOH
-log[OH-(aq)]
[H+(aq)]
[OH-(aq)] = kw / [H+(aq)]
[OH-(aq)]
[H+(aq)] = kw / [OH-(aq)]

Example

What is the pH of a solution with a hydrogen-ion concentration of 4.2×10^{-10}M?

Example

The pH of an unknown solution is 6.35.
What is its hydrogen-ion concentration?

Example

What is the pH of a solution if $[OH^-] = 4.0 \times 10^{-11} M$?

Acid-Base indicators are valuable tools for measuring pH because its acid form and base form have different colors in solution.

See the chart on page 602. Briefly answer the 'Interpreting Graphs' section.

Try questions #9-21 on pages 596-604 as well as #1-4 on R79.

Sometimes when solving acid-base questions we will need to find the molarity first of an ion before finding the pH.

Example:

A hydrochloric acid solution was prepared by dissolving 0.37g HCl in water, giving a volume of 250 mL of solution. Determine the $[H^+_{(aq)}]$, pH, pOH, $[OH^-_{(aq)}]$. (Hint: begin by calculating the standard molarity of the solution.)