pH Calculations

To a small but measurable degree, water undergoes self-ionization:

$$H_20(\ell) \; + \; H_20(\ell) \rightarrow H_30^+(aq) \; + \; OH^-(aq)$$

The use of brackets is a way of abbreviating "molar concentration." Thus, $[H^+]$ can be read, "the concentration of hydrogen ion in moles per liter. [OH-] can be read, "the concentration of hydroxide ion in moles per liter.

At 25°C, $[H^+] = 1.0 \times 10^{-7}$ moles H^+ per liter of solution
$[OH^-] = 1.0 \times 10^{-7}$ moles OH^- per liter of solution

Ionization Constant for Water (K_W)

1. $K_W = [H^+][OH^-] = (1.0 \times 10^{-7})(1.0 \times 10^{-7}) = 1.0 \times 10^{-14}$
2. K_W is a constant at ordinary ranges of room temperatures

pH is the negative of the common logarithm of the hydrogen ion concentration

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

pOH is the negative of the common logarithm of the hydroxide ion concentration

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

$$pH + pOH = 14.0$$

$$\begin{tikzcd}[column sep=huge, row sep=huge]
H^+ \arrow[r, shift left, "{[OH^-] = \frac{1 \times 10^{-14}}{[H^+]}}"] \arrow[d, shift left, "{pH = -\log[H^+]}"] & OH^- \arrow[l, shift left, "{[H^+] = \frac{1 \times 10^{-14}}{[OH^-]}}"] \arrow[d, shift left, "{pOH = -\log[OH^-]}"] \\
pH \arrow[u, shift left, "{[H^+] = 10^{-pH}}"] \arrow[r, shift left, "{pOH = 14 - pH}"] & pOH \arrow[u, shift left, "{[OH^-] = 10^{-pOH}}"] \arrow[l, shift left, "{pH = 14 - pOH}"]
\end{tikzcd}$$

$[H_3O^+][OH^-] = 1.0 \times 10^{-14}$

$pH + pOH = 14$

Acids $pH = -\log[H_3O^+]$ $pOH = -\log[OH^-]$ Bases

$pH = 2$ then $[H_3O^+] = 1.0 \times 10^{-2}$ M

$pOH = 12$ then $[OH^-] = 1.0 \times 10^{-12}$ M

$pH = 3.4$ then $[H_3O^+] = 10^{-3.4} = 3.98 \times 10^{-4}$ M

↳ Now find

$[OH^-] = ?$ one way: Find pOH

$pOH = 14 - 3.4 = 10.6 \quad \therefore [OH^-] = 10^{-10.6} = 2.51 \times 10^{-11}$ M

another way:

$[H_3O^+][OH^-] = 1.0 \times 10^{-14}$

$$\frac{3.98 \times 10^{-4}[OH^-]}{3.98 \times 10^{-4}} = \frac{1.0 \times 10^{-14}}{3.98 \times 10^{-4}} = 2.51 \times 10^{-11} \text{ M}$$