Math Tutor | Using Logarithms and pH

When you work with acids and bases, you often need to state the hydronium ion concentration, $[H_3O^+]$, of a solution. One simple way is to use the negative logarithm of $[H_3O^+]$. This quantity is called *pH*. For example, pure water has a $[H_3O^+]$ of 1.00×10^{-7} M. So, the pH of pure water is $-\log (1.00 \times 10^{-7}\ M) = 7.00$. A solution of 0.1 M HCl has a pH of 1.00 or $pH = -\log (1 \times 10^{-1}) = 1.00$. The term *pOH* is also used for the negative logarithm of the hydroxide ion concentration, $[OH^-]$. The pOH of pure water is also 7.00.

Problem-Solving TIPS

- For pure water at 25°C, $[H_3O^+] = [OH^-] = 1.00 \times 10^{-7}$ M.
- The ionization constant of water, K_w, is the product of $[H_3O^+]$ and $[OH^-]$, so $K_w = [H_3O^+][OH^-] = (1.00 \times 10^{-7})(1.00 \times 10^{-7}) = 1.00 \times 10^{-14}$ at 25°C.
- If you know either $[H_3O^+]$ or $[OH^-]$, you can determine the other concentration.
- In terms of pH and pOH, pH + pOH = 14.00 for an aqueous solution at 25°C.
- Because pH calculations involve scientific notation and changes in signs, you should always check to see if answers make sense.

Sample Problem

What is the pH of a 0.0046 M solution of KOH?

KOH is completely dissociated into equal numbers of $K^+(aq)$ and $OH^-(aq)$. The concentration of OH^- is the same as the concentration of dissolved KOH, 0.0046 M. So, $[OH^-] = 4.6 \times 10^{-3}$ M, and $pOH = -\log (4.6 \times 10^{-3}\ M) = 2.34$.
For an aqueous solution at 25°C, pH + pOH = 14.00, so pH + 2.34 = 14.00.
Therefore, the pH of 0.0046 M KOH solution = 14.00 − 2.34 = 11.66.

What is the hydronium ion concentration, $[H_3O^+]$, of a solution with a pH of 4.08? What is the pOH of the solution?

In this solution, $\log [H_3O^+] = -4.08$

$[H_3O^+] = \text{antilog}\,(-4.08) = 0.000\,083\ M = 8.3 \times 10^{-5}$ M

The pOH of the solution is 14.00 − pH = 14.00 − 4.08 = 9.92.

Practice

Answers in Appendix E

1. What is the pH of a 0.000 85 M solution of nitric acid, HNO_3, which is a strong acid?
2. What is the hydroxide ion concentration of an aqueous solution that has a pH of 9.95?