

Calculating $[\text{H}_3\text{O}^+]$ and $[\text{OH}^-]$ from pH

You have now learned to calculate the pH of a solution, given its $[\text{H}_3\text{O}^+]$. Suppose that you are given the pH of a solution instead. How can you determine its hydronium ion concentration?

You already know the following equation.

$$\text{pH} = -\log [\text{H}_3\text{O}^+]$$

Remember that the base of common logarithms is 10. Therefore, the antilog of a common logarithm is 10 raised to that number.

$$\begin{aligned}\log [\text{H}_3\text{O}^+] &= -\text{pH} \\ [\text{H}_3\text{O}^+] &= \text{antilog} (-\text{pH}) \\ [\text{H}_3\text{O}^+] &= 10^{-\text{pH}}\end{aligned}$$

The simplest cases are those in which pH values are integers. The exponent of 10 that gives the $[\text{H}_3\text{O}^+]$ is the negative of the pH. For an aqueous solution that has a pH of 2, for example, the $[\text{H}_3\text{O}^+]$ is equal to 10^{-2} M. Likewise, when the pH is 0, the $[\text{H}_3\text{O}^+]$ is 1 M because $10^0 = 1$. Sample Problem D shows how to convert a pH value that is a positive integer. Sample Problem E shows how to use a calculator to convert a pH that is not an integral number.

SAMPLE PROBLEM D

For more help, go to the *Math Tutor* at the end of this chapter.

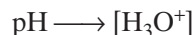
Determine the hydronium ion concentration of an aqueous solution that has a pH of 4.0.

SOLUTION

1 ANALYZE

Given: pH = 4.0
Unknown: $[\text{H}_3\text{O}^+]$

2 PLAN



This problem requires that you rearrange the pH equation and solve for the $[\text{H}_3\text{O}^+]$. Because 4.0 has one digit to the right of the decimal, the answer must have one significant figure.

$$\begin{aligned}\text{pH} &= -\log [\text{H}_3\text{O}^+] \\ \log [\text{H}_3\text{O}^+] &= -\text{pH} \\ [\text{H}_3\text{O}^+] &= \text{antilog} (-\text{pH}) \\ [\text{H}_3\text{O}^+] &= 1 \times 10^{-\text{pH}}\end{aligned}$$

3 COMPUTE

$$\begin{aligned}[\text{H}_3\text{O}^+] &= 1 \times 10^{-\text{pH}} \\ [\text{H}_3\text{O}^+] &= 1 \times 10^{-4} \text{ M}\end{aligned}$$

4 EVALUATE

A solution with a pH of 4.0 is acidic. The answer, 1×10^{-4} M, is greater than 1.0×10^{-7} M, which is correct for an acidic solution.