Calculations Involving pH

If either the $[H_3O^+]$ or pH of a solution is known, the other can be calculated. Significant figures involving pH must be handled carefully. Because pH represents a logarithm, the number to the *left of the decimal* only locates the decimal point. It is not included when counting significant figures. So there must be as many significant figures to the *right of the decimal* as there are in the number whose logarithm was found. For example, a $[H_3O^+]$ value of 1×10^{-7} has *one* significant figure. Therefore, the pH, or –log, of this value must have one digit to the right of the decimal. Thus, pH = 7.0 has the correct number of significant figures.

Calculating pH from $[H_3O^+]$

You have already seen the simplest pH problems. In these problems, the $[H_3O^+]$ of the solution is an integral power of 10, such as 1 M or 0.01 M. The pH of this type of solution is the exponent of the hydronium ion concentration with the sign changed. For example, the pH of a solution in which $[H_3O^+]$ is 1×10^{-5} M is 5.0.

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

What is the pH of a 1.0×10^{-3} M NaOH solution?

SOLUTION

1 ANALYZE

Given: Identity and concentration of solution = 1.0×10^{-3} M NaOH
Unknown: pH of solution

2 PLAN

concentration of base $\longrightarrow$ concentration of OH^- $\longrightarrow$ concentration of H_3O^+ $\longrightarrow$ pH

NaOH is completely dissociated when it is dissolved in water. A 1.0×10^{-3} M NaOH solution therefore produces a $[OH^-]$ equal to 1.0×10^{-3} M. The ion product of $[H_3O^+]$ and $[OH^-]$ is a constant, 1.0×10^{-14}. By substitution, the $[H_3O^+]$ can be determined. The pH can then be calculated.

3 COMPUTE

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

$$[H_3O^+] = \frac{1.0 \times 10^{-14}}{[OH^-]} = \frac{1.0 \times 10^{-14}}{1.0 \times 10^{-3}} = 1.0 \times 10^{-11}\ \text{M}$$

$$\text{pH} = -\log\,[H_3O^+] = -\log\,(1.0 \times 10^{-11}) = 11.00$$

4 EVALUATE

The answer correctly indicates that NaOH forms a solution with pH > 7, which is basic.

PRACTICE *Answers in Appendix E*

1. Determine the pH of the following solutions:
   a. 1×10^{-3} M HCl
   b. 1.0×10^{-5} M HNO_3
   c. 1×10^{-4} M NaOH
   d. 1.0×10^{-2} M KOH

extension

Go to **go.hrw.com** for more practice problems that ask you to calculate pH.

Keyword: HC6ABTX