SAMPLE PROBLEM A

A 1.0×10^{-4} M solution of HNO_3 has been prepared for a laboratory experiment.
a. Calculate the $[H_3O^+]$ of this solution. b. Calculate the $[OH^-]$.

SOLUTION

1 ANALYZE

Given: Concentration of the solution = 1.0×10^{-4} M HNO_3
Unknown: **a.** $[H_3O^+]$ **b.** $[OH^-]$

2 PLAN

HNO_3 is a strong acid, which means that it is essentially 100% ionized in dilute solutions. One molecule of acid produces one hydronium ion. The concentration of the hydronium ions thus equals the concentration of the acid. Because the ion product, $[H_3O^+]\,[OH^-]$, is a constant, $[OH^-]$ can easily be determined by using the value for $[H_3O^+]$.

a.
$$\underset{1\text{ mol}}{HNO_3(l)} + \underset{1\text{ mol}}{H_2O(l)} \longrightarrow \underset{1\text{ mol}}{H_3O^+(aq)} + \underset{1\text{ mol}}{NO_3^-(aq)} \qquad \text{(assuming 100\% ionization)}$$

$$\text{molarity of } HNO_3 = \frac{\text{mol } HNO_3}{1\text{ L solution}}$$

$$\frac{\cancel{\text{mol } HNO_3}}{\text{L solution}} \times \frac{1\text{ mol } H_3O^+}{1\ \cancel{\text{mol } HNO_3}} = \frac{\text{mol } H_3O^+}{\text{L solution}} = \text{molarity of } H_3O^+$$

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

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

3 COMPUTE

a.
$$\frac{1.0 \times 10^{-4}\ \cancel{\text{mol } HNO_3}}{1\text{ L solution}} \times \frac{1\text{ mol } H_3O^+}{1\ \cancel{\text{mol } HNO_3}} = \frac{1.0 \times 10^{-4}\text{ mol } H_3O^+}{1\text{ L solution}} = 1.0 \times 10^{-4}\text{ M } H_3O^+$$

b.
$$[OH^-] = \frac{1.0 \times 10^{-14}}{[H_3O^+]} = \frac{1.0 \times 10^{-14}}{1.0 \times 10^{-4}} = 1.0 \times 10^{-10}\text{ M}$$

4 EVALUATE

Because the $[H_3O^+]$, 1.0×10^{-4}, is greater than 1.0×10^{-7}, the $[OH^-]$ must be less than 1.0×10^{-7}. The answers are correctly expressed to two significant digits.

PRACTICE

Answers in Appendix E

1. Determine the hydronium and hydroxide ion concentrations in a solution that is 1×10^{-4} M HCl.
2. Determine the hydronium and hydroxide ion concentrations in a solution that is 1.0×10^{-3} M HNO_3.
3. Determine the hydronium and hydroxide ion concentrations in a solution that is 3.0×10^{-2} M NaOH.
4. Determine the hydronium and hydroxide ion concentrations in a solution that is 1.0×10^{-4} M $Ca(OH)_2$.

extension

Go to **go.hrw.com** for more practice problems that ask you to calculate concentration of hydronium and hydroxide ions.

Keyword: HC6ABTX