See below for calculating pOH

Sample Problem

Calculating the pH of a Solution

Problem

Calculate the pH of a solution with $[H_3O^+] = 3.8 \times 10^{-3}$ mol/L.

What Is Required?

You need to calculate the pH, given $[H_3O^+]$.

What Is Given?

You know that $[H_3O^+]$ is 3.8×10^{-3} mol/L.

Plan Your Strategy

Use the equation $pH = -\log [H_3O^+]$ to solve for the unknown.

Act on Your Strategy

$$pH = -\log (3.8 \times 10^{-3}) = 2.42$$

Check Your Solution

$[H_3O^+]$ is greater than 1.0×10^{-7} mol/L. Therefore, the pH should be less than 7.00. The solution is acidic, as you would expect.

PROBLEM TIP

Appendix D, "Math and Chemistry", explains how you can do these calculations with a calculator.

Practice Problems

16. Calculate the pH of each solution, given the hydronium ion concentration.

(a) $[H_3O^+] = 0.0027$ mol/L

(b) $[H_3O^+] = 7.28 \times 10^{-8}$ mol/L

(c) $[H_3O^+] = 9.7 \times 10^{-5}$ mol/L

(d) $[H_3O^+] = 8.27 \times 10^{-12}$

17. $[H_3O^+]$ in a cola drink is about 5.0×10^{-3} mol/L. Calculate the pH of the drink. State whether the drink is acidic or basic.

18. A glass of orange juice has $[H_3O^+]$ of 2.9×10^{-4} mol/L. Calculate the pH of the juice. State whether the result is acidic or basic.

19. (a) $[H_3O^+]$ in a dilute solution of nitric acid, HNO_3, is 6.3×10^{-3} mol/L. Calculate the pH of the solution.

(b) $[H_3O^+]$ of a solution of sodium hydroxide is 6.59×10^{-10} mol/L. Calculate the pH of the solution.

Web LINK

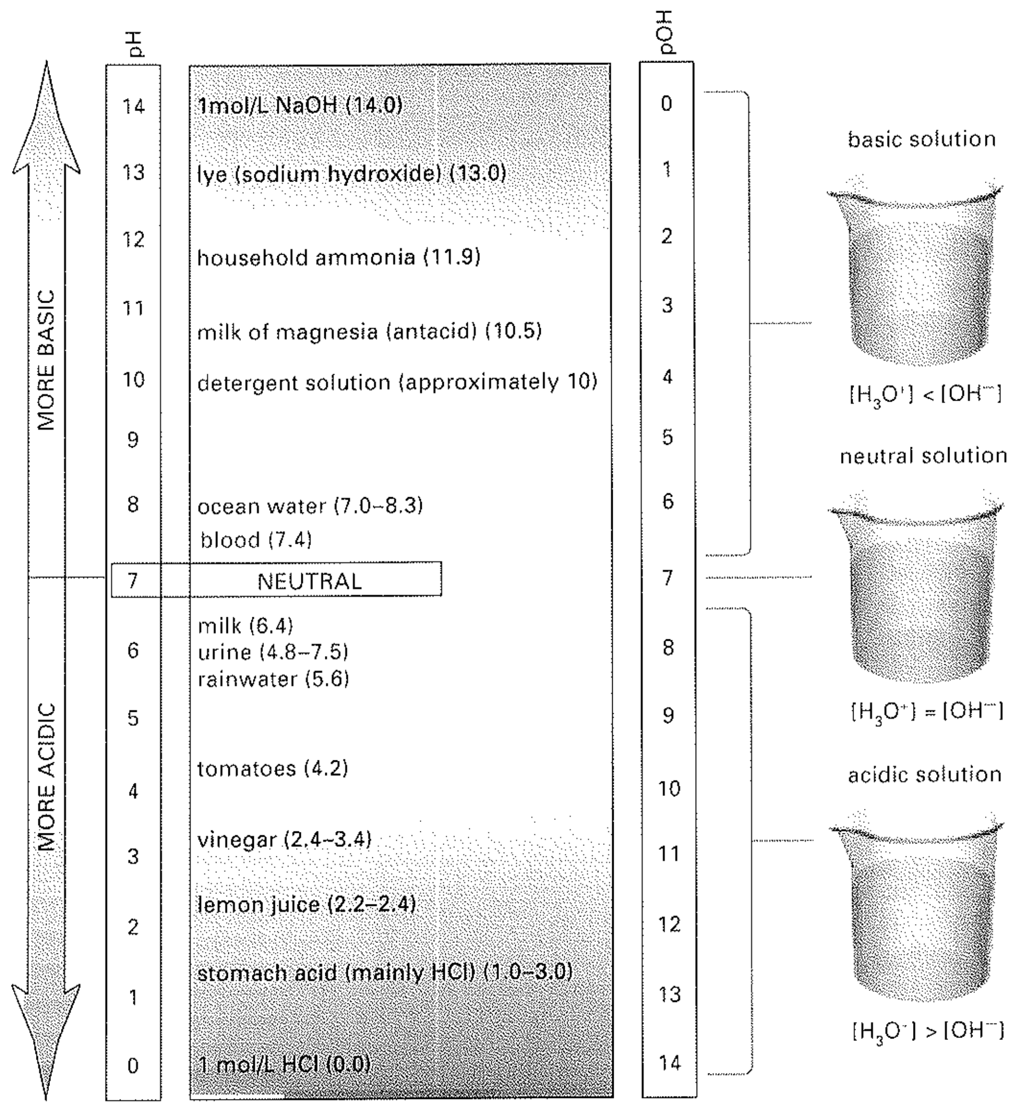
www.mcgrawhill.ca/links/atlchemistry

Many people, for both personal and professional reasons, rely on pH meters to provide quick, reliable pH measurements. Use the Internet to find out how a pH meter works, and what jobs or tasks it is used for. To start your research, go to the web site above and click on **Web Links**. Prepare a brief report, a web page, or a brochure to present your findings.

Just as pH refers to the exponential power of the hydronium ion concentration in a solution, **pOH** refers to the power of hydroxide ion concentration. You can calculate the **pOH** of a solution from the $[OH^-]$. Notice the relationship between pH and pOH shown below, and in the Concept Organizer.

$$pOH = -\log[OH^-]$$
$$K_w = [H_3O^+][OH^-] = 1.0 \times 10^{-14} \text{ at } 25^\circ C$$
$$\therefore pH + pOH = 14$$

Concept Organizer pH, pOH, $[H_3O^+]$, $[OH^-]$, and Acid-Base Strength



Math LINK

Prove the relationship $pH + pOH = 14$ as follows. Record the ion product equation and its value at 25°C. Take the logarithm of both sides. Then reverse the sign of each term. What is your result?

Sample Problem
Calculating pH and pOH

Problem

A liquid shampoo has a hydroxide ion concentration of 6.8×10^{-5} mol/L at 25°C.

(a) Is the shampoo acidic, basic, or neutral?

(b) Calculate the hydronium ion concentration.

(c) What is the pH and the pOH of the shampoo?

Solution

(a) Compare $[OH^-]$ in the shampoo with $[OH^-]$ in neutral water at 25°C.

$[OH^-] = 6.8 \times 10^{-5}$ mol/L, which is greater than 1×10^{-7} mol/L. Therefore, the shampoo is basic.

(b) Use the equation $[H_3O^+] = \frac{1.0 \times 10^{-14}}{[OH^-]}$ to find the hydronium ion concentration.

$$[H_3O^+] = \frac{1.0 \times 10^{-14}}{6.8 \times 10^{-5}}$$
$$= 1.5 \times 10^{-10} \text{ mol/L}$$

(c) Substitute known values into the equations $pH = -\log[H_3O^+]$ and $pOH = -\log[OH^-]$.

$$pH = -\log(1.5 \times 10^{-10})$$
$$= 9.83$$

$$pOH = -\log(6.8 \times 10^{-5})$$
$$= 4.17$$

Check Your Solution

$pH + pOH = 14$

PROBLEM TIP

When you work with logarithms, *the number of significant digits in a number must equal the number of digits after the decimal in the number's logarithm.* Here **1.5** $\times 10^{-10}$ has two significant digits. Therefore, the calculated pH, 9.**83**, must have two significant digits after the decimal.

Another Way to Find $[H_3O^+]$ and $[OH^-]$

You can calculate $[H_3O^+]$ or $[OH^-]$ by finding the *antilog* of the pH or pOH.

$$[H_3O^+] = 10^{-pH}$$
$$[OH^-] = 10^{-pOH}$$

If you are using a calculator, you can use it to find the antilog of a number in one of two ways. If the logarithm is entered in the calculator, you can press the two keys [INV] and [LOG] in sequence. (Some calculators may have a [10^x] button instead.) Alternatively, since $[H_3O^+] = 10^{-pH}$ and $[OH^-] = 10^{-pOH}$, you can enter 10, press the [y^x] button, enter the negative value of pH (or pOH), and then press [=].

Sample Problem

Finding pOH, $[H_3O^+]$, and $[OH^-]$

Problem

If the pH of urine is outside the normal range of values, this can indicate medical problems. Suppose that the pH of a urine sample was measured to be 5.53 at 25°C. Calculate pOH, $[H_3O^+]$, and $[OH^-]$ for the sample.

Solution

You use the known value, pH = 5.53, to calculate the required values.

$$pOH = 14.00 - 5.53$$
$$= 8.47$$

$$[H_3O^+] = 10^{-5.53}$$
$$= 3.0 \times 10^{-6} \text{ mol/L}$$

$$[OH^-] = 10^{-8.47}$$
$$= 3.4 \times 10^{-9} \text{ mol/L}$$

Continued

Continued...

Check Your Solution

In this problem, the ion product constant is a useful check:

$$[H_3O^+][OH^-] = (3.0 \times 10^{-6}) \times (3.4 \times 10^{-9})$$
$$= 1.0 \times 10^{-14}$$

This value equals the expected value for K_w at 25°C.

Practice Problems

20. $[H_3O^+]$ of a sample of milk is found to be 3.98×10^{-7} mol/L. Is the milk acidic, neutral, or basic? Calculate the pH and $[OH^-]$ of the sample.
21. A sample of household ammonia has a pH of 11.9. What is the pOH and $[OH^-]$ of the sample?
22. Phenol, C_6H_5OH, is used as a disinfectant. An aqueous solution of phenol was found to have a pH of 4.72. Is phenol acidic, neutral, or basic? Calculate $[H_3O^+]$, $[OH^-]$, and pOH of the solution.
23. At normal body temperature, 37°C, the value of K_w for water is 2.5×10^{-14}. Calculate $[H_3O^+]$ and $[OH^-]$ at this temperature. Is pure water at 37°C acidic, neutral, or basic?
24. A sample of baking soda was dissolved in water and the pOH of the solution was found to be 5.81 at 25°C. Is the solution acidic, basic, or neutral? Calculate the pH, $[H_3O^+]$, and $[OH^-]$ of the solution.
25. A chemist dissolved some Aspirin™ in water. The chemist then measured the pH of the solution and found it to be 2.73 at 25°C. What are $[H_3O^+]$ and $[OH^-]$ of the solution?

Dilution Calculations involving Acids and Bases

When chemists go to use an acid in the lab, they commonly use a stock solution of known concentration and dilute it to the concentration they need. A chemist may want to dilute the stock solution either to a specific $[H_3O^+]$, a specific pH, or a specific $[OH^-]$ before use. Thus, calculations involving dilutions of acids and bases are very common in a practical lab setting. You have already studied the basis of these calculations in Unit 3. Where diluting acids and bases is concerned, the main idea is that *the number of moles of acid (or base) remains constant, and thus the number of moles* (n = CV) *before dilution equals the number of moles after dilution.*

This means that acid (or base) dilution problems may be summarized as shown in Figure 14.14. Note that the given or wanted parameters may be any of pH, pOH, $[H^+]$ or $[OH^-]$. This is possible because any given pH or pOH is directly related to the concentration of its respective hydronium or hydroxide ion.