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LABORATORY - WATER SOLUBILITY & PH

Purpose/Objectives

- Observe the solubility and insolubility of different chemicals in water.
- Identify characteristics of chemicals that make them soluble or insoluble in water.
- Predict solubility of biologically relevant molecules in water.
- Identify pH values for acid, neutral, and basic solutions.
- Use a pH indicator to analyze molecules that are soluble in water to determine if they form an acidic or basic solution.
- Observe how buffers can play a role in regulating pH in biological systems.

Background

On average, living organisms are 70% or more water. Water is life's essential chemical. Water is required for the basic chemical reactions of life. Some of water's properties make it ideal for maintaining biological organisms:

- Water is a liquid at room temperature due to hydrogen-bond attractions between molecules.
- Water is a good solvent. It is a polar molecule, which means it has partial positive and negative charges, which can interact with the positive or negative charges on hydrophilic (water loving) chemicals. The molecules that dissolve in water are called "solutes".
- Water takes a lot of energy to raise or lower its temperature helping living organisms maintain a more constant temperature.
- Water can fill vessels and spaces in living organisms and provides lubrication.

In this lab you will observe how water interacts with several chemicals. You will observe some chemicals that are soluble (are able to dissolve) in water and other chemicals that are insoluble (unable to dissolve) in water. Some chemicals may fall in-between or are "partially soluble". Water-soluble chemicals are also described as being **HYDROPHILIC** or water loving; chemicals that are insoluble in water are called **HYDROPHOBIC** or water fearing. Generally, chemicals that have full or partial charges are hydrophilic or **POLAR**; chemicals without any charges are hydrophobic or **NONPOLAR**.

Here is another way to express these ideas:

Polar molecules will mix with other polar molecules to form solutions.
Nonpolar molecules will mix with other nonpolar molecules to form solutions.
Polar molecules WILL NOT mix with nonpolar molecules.

Polar molecules that dissolve in water can form solutions that acidic, neutral, or basic. Acids are compounds that contain hydrogen and can dissolve in water to release more hydrogen ions (H^+) into solution. For example, hydrochloric acid (HCl) dissolves in water as follows:

$$HCl \text{ in } H_2O \rightarrow H^+ + Cl^-$$

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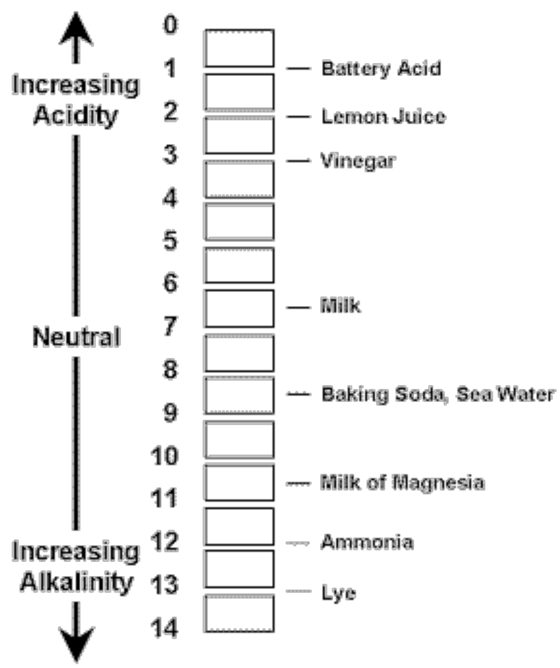
Bases are substances that dissolve in water to release more hydroxide ions (OH-) into solution. For example, a typical base according to the Arrhenius definition is sodium hydroxide (NaOH):

$$NaOH \text{ in } H_2O \rightarrow Na^+ + OH^-$$

Water itself sometimes dissociates into hydrogen ions and hydroxide ions. The number of water molecules that do this is very small and the number of H^+ ions always equals the number of OH^- ions. When $H^+ = OH^-$, the solution is neutral.

$$H_2O \rightarrow H^+ + OH^-$$

The amount of acid (H^+) ions in a solution is measured using the pH scale. The pH scale reads from 0 to 14. The value 7 is given to neutral solutions, which have equal amounts of acid (H^+) and base (OH^-). The values below 7 are acid (more and more H^+) and the values above 7 (less and less H^+) are basic. Both strong acids (i.e. pH 1) and strong bases (i.e. pH 14) can burn skin, but weaker acids and bases are used in foods and common chemicals.



Living organisms can only survive within very small ranges of pH values near neutral. To keep the pH levels within the living range, organisms regulate their pH by using buffers. Buffers are solutions that resist changes in pH. Therefore, a buffer can keep a constant pH while different acids or bases are added to it. In the human body, the blood has a buffer system to maintain pH levels in homeostasis near 7.4.

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Instructor Demonstration:

1. The instructor will demonstrate the process of adding substances to water and observing if they are soluble or not. Then she will assign each table a substance to test.

    Inorganic chemicals

    NaCl (table salt)
    Sodium bicarbonate (Baking soda, $NaHCO_3$)
    Ethanol (C_2H_5OH)

    Carbohydrates:

    Glucose (a monosaccharide)
    Sucrose (table sugar, a disaccharide)
    Corn starch (a polysaccharide)
    Metamucil (fiber)

    Proteins:

    Protein powder (a mix of many amino acids)

    Lipids:

    vegetable oil

Student Procedure:

Materials

Ceramic spotting plate
Toothpicks
10X bromothymol blue pH indicator in dropper bottle
plastic pipette bulb
250mL beaker filled about ½ way with tap water
test tubes with samples for testing

1. Gather materials. Fill 250mL beaker with water.
2. Place 5 drops of pH7 buffer (neutral solution) in one well of the ceramic spotting plate.
3. Add 3 drops of 10X bromothymol blue pH indicator to the same well, mix with a toothpick if needed. Record the color of the bromothymol blue in the table on the assignment sheet. This color represents neutral.
4. Clean the plastic pipette bulb by squeezing it a few times in the 250mL beaker full of water.
5. Using the same procedure (steps 2-3), repeat with the HCl (acidic solution) in a second well. The color of bromothymol in HCl represents acid. Clean the plastic pipette bulb.
6. Repeat again with the NaOH (basic solution) in a third well. The color of bromothymol blue represents base. Clean the plastic pipette bulb.
7. Now that you know the indicator colors that designate acid, neutral, or base, test the rest of substances and record the color on the table using the same procedure (don't forget to clean to plastic pipette bulb).
8. Rinse plates in sink and clean up all materials
9. Observe the instructor demonstration of buffers and pH regulation.
10. Answer questions on the assignment sheet.

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LAB ASSIGNMENT – WATER SOLUBILITY & pH

1. What is the molecular formula for water?

2. What does H stand for in the molecular formula for water?

3. What does O stand for in the molecular formula for water?

4. Draw 3 water molecules, label each atom appropriately, label at least two polar covalent bonds, indicate where the partial positive and partial negative charges are located, and draw and label a few hydrogen bonds.

5. Indicate the solubility of each of the chemicals tested. Options are: soluble, insoluble, partially soluble.

Chemical	Solubility & Observations
NaCl	
Baking soda	
Ethanol	
Glucose	
Sucrose	
Corn starch	
Metamucil	
Vegetable oil	
Protein powder	

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6. Were all the inorganic molecules water-soluble? Why or why not?

7. Were all the carbohydrates soluble in water? Why or why not?

8. What are the chemical properties of the carbohydrates that are not immediately or completely soluble in water?

9. Why are some proteins water-soluble and other proteins are not water-soluble?

10. Why aren't lipids such as vegetable oil soluble in water?

11. Would you expect small, polar molecules to be soluble in water? Why or why not?

12. Would you expect large, polar molecules to be soluble in water? Why or why not?

13. Would you expect small, nonpolar molecules to be soluble in water? Why or why not?

14. Would you expect large, nonpolar molecules to be soluble in water? Why or why not?

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15. Write the chemical equation representing how water can split into hydrogen ions and hydroxide ions.

16. What is the chemical definition of an acid?

17. What is the chemical definition of a base?

18. Why is water neutral?

19. Complete the chart:

Solution	Color	Acid/Neutral/Base

20. What are some other acid solutions that you may encounter in your daily lives?

21. What are some other basic solutions that you may encounter in your daily lives?

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22. What type of pH would a strong acid have?

23. What type of pH would a weak base have?

24. Why can't we measure the pH of pure vegetable oil?

25. What is the pH of human blood?

26. What happened in the instructor's demonstration of buffers? What was the difference between the water and the buffer solution?

27. Why are buffers important in biological systems?

28. If beer has a pH of 3 and baking soda has a pH of 9 which best completes the following statement? Beer ___________________ than baking soda.

    a. has a greater hydrogen ion concentration
    b. is less acidic
    c. has a lower hydrogen ion concentration
    d. is a stronger base