Grade 10 NTI Day #6 Biology

Assignment: Please read the excerpt below as an independent reading assignment. Then read and answer the questions below the excerpt.

Properties of Water

LESSON 2.2

KEY QUESTIONS

- *How does the structure of water contribute to its unique properties?*
- *How does water's polarity influence its properties as a solvent?*
- *Why is it important for cells to buffer solutions against rapid changes in pH?*

HS-ESS2-5: Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

VOCABULARY

hydrogen bond • cohesion adhesion • mixture solution • solute • solvent suspension • pH scale acid • base • buffer

READING TOOL

As you read the section of the lesson under The Water Molecule, use the table in your **Biology Foundations Workbook** to list the causes and effects of the properties of water.

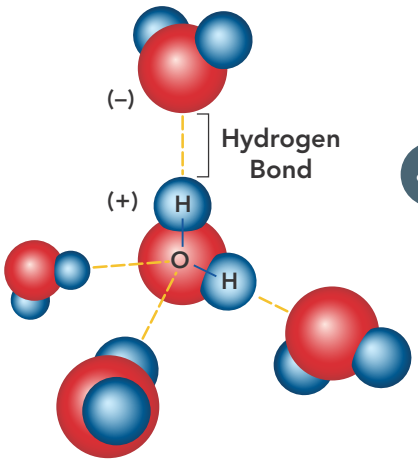
Looking back at our planet, an astronaut in space once said that if other beings have seen the Earth, they must surely call it "the blue planet." He referred, of course, to the oceans of water that cover nearly three fourths of Earth's surface. The very presence of liquid water tells a scientist that life may be present on such a planet. Why should life itself be connected so strongly to something so ordinary that we often take it for granted? The answer is that there is something very special about water and the role it plays in living things.

The Water Molecule

Water is one of the few compounds found in a liquid state over most of Earth's surface. Water (H_2O) looks like an ordinary molecule. However, there is more to the story.

Polarity With 8 protons, water's oxygen nucleus attracts electrons more strongly than the single protons of water's two hydrogen nuclei. As a result, water's shared electrons are more likely to be found near the oxygen nucleus. So, water has a partial negative charge on one end and a partial positive charge on the other. A molecule in which the charges are unevenly distributed is said to be polar, because the molecule is a bit like a magnet with two poles.

Because of their partial charges, polar molecules such as water can attract each other. The attraction between a hydrogen atom with a partial positive charge and another atom with a partial negative charge is known as a **hydrogen bond**, which is shown in **Figure 2-8**.



INTERACTIVITY

Figure 2-8
Hydrogen Bonding

Each molecule of water can form multiple hydrogen bonds with other water molecules.

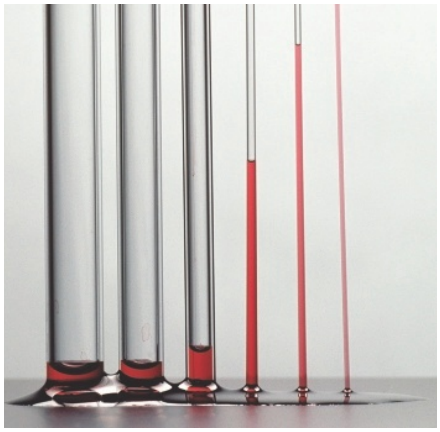
INTERACTIVITY

Explore the properties of water that make it so important to life on Earth.

Special Properties of Water

Hydrogen bonds are not as strong as covalent or ionic bonds, but they give one of life's most important molecules many of its unique characteristics. ***Because water is a polar molecule, it is able to form multiple hydrogen bonds, which account for many of water's special properties.*** These include the fact that water expands slightly upon freezing, making ice less dense than liquid water. Hydrogen bonding also explains water's ability to dissolve so many other substances, a property essential in living cells.

Cohesion The attraction between molecules of the same substance is called **cohesion**. Because a single water molecule may be involved in as many as four hydrogen bonds at the same time, water is extremely cohesive. Cohesion causes water molecules to be drawn together, which is why drops of water form beads on a smooth surface. Cohesion also produces surface tension, explaining why some insects and spiders can walk on a pond's surface.



Adhesion The attraction between molecules of different substances is called **adhesion**. Have you ever been asked to read the volume in a graduated cylinder at eye level? If so, you may have noticed that the surface of the water in the graduated cylinder dips slightly in the center. This is because the adhesion between water molecules and glass molecules is stronger than the cohesion between water molecules. Adhesion between water and glass also causes water to rise in a narrow tube against the force of gravity. This effect is called capillary action. Capillary action is one of the forces that draws water out of the roots of a plant and up into its stems and leaves. Cohesion holds the column of water together as it rises.

Heat Capacity Because of hydrogen bonding, water's heat capacity is relatively high. A substance's heat capacity is the amount of energy needed to raise its temperature by making its molecules move faster. This allows bodies of water, such as oceans and lakes, to absorb large amounts of heat with only small changes in temperature. The organisms living in the water are thus protected from drastic changes in temperature.

Water in Living Things Living things are composed mostly of water. Water accounts for approximately 60 percent of the mass of the human body. As a result, the chemical reactions that take place within living things do so in a water environment. Nearly everything that cells do—from growth and development to movement—takes place by means of chemical reactions in a water environment. That's why all living things, even those found in the driest places on Earth, depend upon a source of water.

READING CHECK Compare and Contrast How are cohesion and adhesion similar? How are they different?

Solutions and Suspensions

Water is often found as part of a mixture. A **mixture** is a material composed of two or more elements or compounds that are physically mixed together but not chemically combined. Earth's atmosphere is a mixture of nitrogen, oxygen, carbon dioxide, and other gases. Living things are in part composed of mixtures involving water. Two types of mixtures that can be made with water are solutions and suspensions.

READING TOOL

Complete a T-chart to compare and contrast solutions and suspensions. Be sure to include examples of each type of mixture.

Solutions

If a crystal of table salt is placed in a glass of warm water, sodium and chloride ions on the surface of the crystal are attracted to the polar water molecules. Ions break away from the crystal and are surrounded by water molecules, as illustrated in **Figure 2-9**. The ions gradually become dispersed in the water, forming a type of mixture called a **solution**. All the components of a solution are evenly distributed throughout the solution. In a saltwater solution, table salt is the **solute**—the substance that is dissolved. Water is the **solvent**—the substance in which the solute dissolves.

Water's polarity gives it the ability to dissolve both ionic compounds and other polar molecules. Water easily dissolves salts, sugars, minerals, gases, and even other solvents such as alcohol. Without exaggeration, water is life's most important solvent. But even water has limits. When a given amount of water has dissolved all of the solute it can, the solution is said to be saturated.

Suspensions

Some materials do not dissolve when placed in water but separate into pieces so small that they do not settle out. The movement of water molecules keeps the small particles suspended. Such mixtures of water and nondissolved material are known as **suspensions**. Some of the most important biological fluids are both solutions and suspensions. The blood that circulates through your body is mostly water. The water in the blood contains many dissolved compounds. However, blood also contains cells and other undissolved particles that remain in suspension as the blood moves through the body.

READING CHECK **Classify** In a cup of tea, what is the solvent? What is the solute?

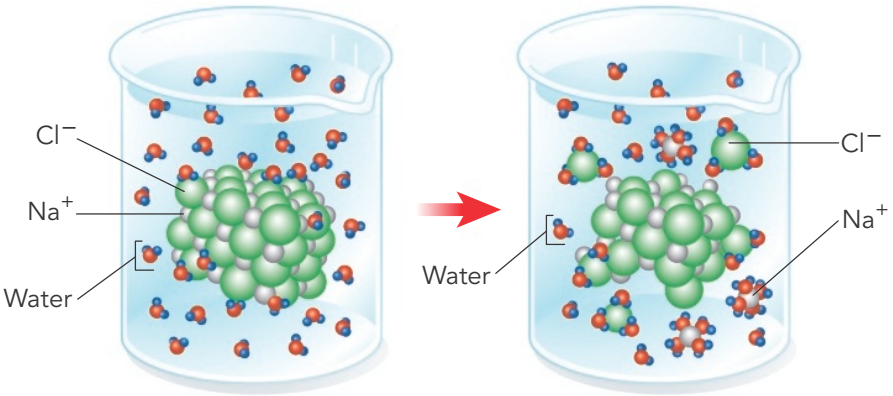


Figure 2-9

A Salt Solution

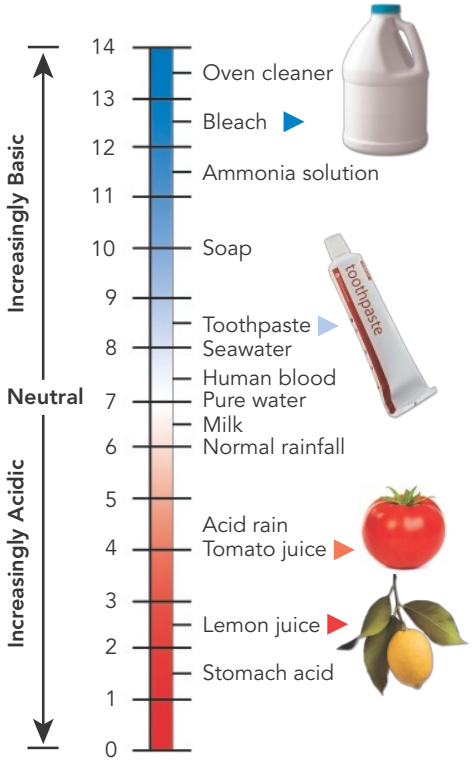
When an ionic compound such as sodium chloride is placed in water, water molecules surround and separate the positive and negative ions.

Interpret Diagrams What happens to the sodium ions and chloride ions in the solution?

Figure 2-10

The pH Scale

The concentration of H^+ ions determines whether solutions are acidic or basic. The most basic material on this scale is oven cleaner. The most acidic material on this pH scale is stomach acid.



Acids, Bases, and pH

Water molecules sometimes split apart to form ions. This reaction can be summarized by a chemical equation in which double arrows are used to show that the reaction can occur in either direction.

$$\underset{\textbf{water}}{H_2O} \rightleftharpoons \underset{\textbf{hydrogen ion}}{H^+} + \underset{\textbf{hydroxide ion}}{OH^-}$$

How often does this happen? In pure water, about 1 water molecule in 550 million splits to form ions in this way. Because the number of positive hydrogen ions produced is equal to the number of negative hydroxide ions produced, pure water is electrically neutral.

The pH Scale Chemists have devised a measurement system called the **pH scale** to indicate the concentration of H^+ ions in solution. As **Figure 2-10** shows, the pH scale ranges from 0 to 14. At a pH of 7, the concentration of H^+ ions and OH^- ions is equal. Pure water has a pH of 7. Solutions with a pH below 7 are called acidic because they have more H^+ ions than OH^- ions. The lower the pH, the greater the acidity. Solutions with a pH above 7 are called basic because they have more OH^- ions than H^+ ions. The higher the pH, the more basic the solution. Each step on the pH scale represents a factor of 10. For example, a liter of a solution with a pH of 4 has 10 times as many H^+ ions as a liter of a solution with a pH of 5.

Quick Lab Guided Inquiry

Acidic and Basic Foods

1. Construct a data table. Include spaces for food samples to be tested, predicted pH, and actual pH.
2. Predict whether the food samples provided are acidic or basic.
3. Tear off a 2-inch piece of pH paper for each sample you will test.
4. Test each food sample and record your observations in your data table. Touch the cut surface of each sample to a square of pH paper. Use a dropper pipette to place a drop of any liquid sample on a square of pH paper. Record the pH of each sample in your data table.

ANALYZE AND CONCLUDE

1. **Analyze Data** Use the pH measurements to classify the foods as acidic and basic. Was your prediction correct?
2. **Construct an Explanation** Based on your observations, are you able to classify the foods according to pH? For example, what pH group would you generalize most fruits to to be in? Explain your response using the data you collected.

Acids Where do all those extra H^+ ions in a low-pH solution come from? They come from acids. An **acid** is any compound that releases H^+ ions into solution. Acidic solutions contain higher concentrations of H^+ ions than pure water and have pH values below 7. The hydrochloric acid (HCl) produced by the stomach to help digest food is a strong acid with a pH of 1.5 to 3.0.

Bases A **base** is a compound that produces hydroxide (OH^-) ions in solution. Basic, or alkaline, solutions contain lower concentrations of H^+ ions than pure water and have pH values above 7. Strong bases, such as the lye (commonly NaOH) used in soapmaking, tend to have pH values ranging from 11 to 14.

Buffers The internal pH of most cells in the human body must generally be kept between 6.5 and 7.5. If the pH is lower or higher, it will affect the chemical reactions that take place within the cells. Thus, controlling pH is important for maintaining homeostasis. One of the ways that organisms control pH is through dissolved compounds called buffers. **Buffers** are weak acids or bases that can react with strong acids or bases to prevent sharp, sudden changes in pH. You can see one example of how buffers work in **Figure 2-11**. Blood, for example, has a normal pH of 7.4. Sudden changes in blood pH are usually prevented by a number of chemical buffers, such as bicarbonate and phosphate ions. ***Buffers dissolved in life's fluids play an important role in maintaining homeostasis.***

INTERACTIVITY

Explore how buffers help stabilize the pH of the blood during exercise.

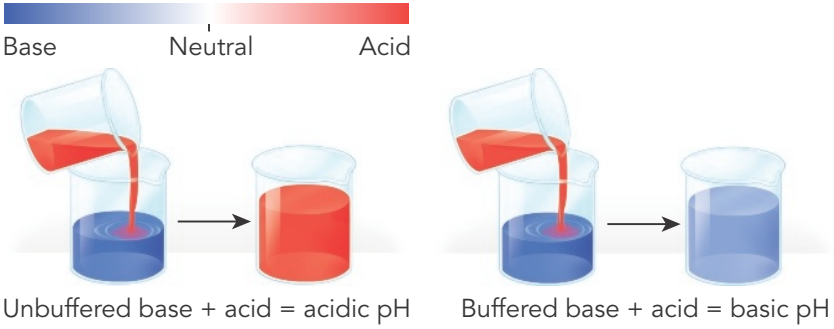


Figure 2-11

Buffers

Buffers help prevent drastic changes in pH. Adding acid to an unbuffered solution causes the pH of the unbuffered solution to decrease. If the solution contains a buffer, however, adding the acid will cause only a slight change in pH.

Name _____ Class _____ Date _____

Lesson Quiz

2.2 Properties of Water

Directions

For multiple choice questions, write the letter that best answers the question or completes the statement on the line provided. For other question types, follow the directions provided.

For question 1, complete the paragraph with words from the word bank. Write the correct word or phrase on each line. Not all words will be used.

1. Write a word from the word bank to complete each sentence.

acid	adhesion	base	cohesion	covalent	hydrogen	neutral	solute	solvent	vinegar	water

Amanda and Pol were in science lab, trying to identify a colorless liquid. Their observations are listed below. Complete each sentence by writing a word from the word bank.

a. When Amanda poured some of the liquid in a test tube, she noticed that the edges of the water curved upward, which is an example of _____.

b. When Pol filled another test tube to the top, the liquid formed a low dome, which is evidence of _____.

c. When Amanda added table salt to the first test tube and shook it, she noted that the liquid had dissolved the _____.

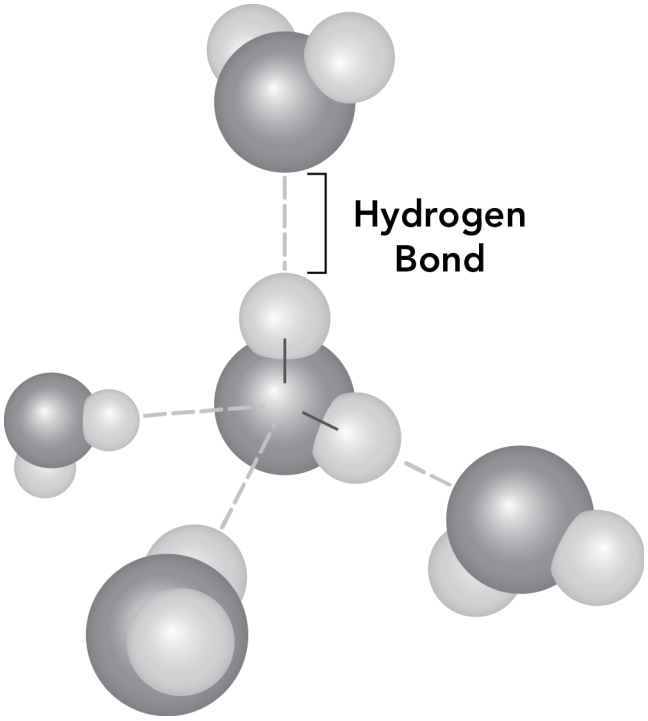
d. All of these indicated the presence of _____ bonds.

e. Pol measured the pH of the sample to be 7, which is a _____ value.

f. Based on all of the evidence Amanda and Pol gathered, the unknown liquid is _____.

Name _____ Class _____ Date _____

_____ **2.** The diagram shows hydrogen bonds between water molecules.



What describes each hydrogen bond?

a. an attraction between positive ends of two molecules
b. an attraction between negative ends of two molecules
c. an attraction between the positive end of one molecule and the negative end of another molecule
d. an attraction between neutral ends of two molecules

_____ **3.** Which of the following observations BEST demonstrates water's special property of cohesion?

a. a spoon held near a stream of water from a tap deflects the water towards itself
b. a drop of water behaves like glue to stick a slip of paper to a window
c. water can dissolve other substances, such as sugar and salt
d. water forms droplets of dew on a spider web in the morning

Name _____ Class _____ Date _____

_____ **4.** Blood is a mixture of a variety of materials. Some of the materials are dissolved in the fluid portion of blood. Other materials, such as blood cells, do not dissolve but move along with the blood.

For these reasons, blood is an example of which type of mixture?

a. a solvent
b. a solution
c. a suspension
d. a buffer

5. Circle the words or phrases that correctly complete the sentence.

Buffers are **(strong acids or weak bases / strong acids and weak bases / strong bases and weak acids / weak acids or weak bases)** that can react with strong acids and bases to **(prevent sudden changes in pH / keep solutions neutral / increase the effect of the base / increase the effect of the acid)**.

_____ **6.** Carrie is conducting an experiment on a solution. The solution's initial pH is 3.2. Then, as Carrie gradually adds Compound X into the solution, the pH increases to 9.8.

Which is the most likely identity of Compound X?

a. a strong acid, such as hydrochloric acid (HCl)
b. a strong base, such as sodium hydroxide (NaOH)
c. a salt, such as sodium chloride (NaCl)
d. a solvent, such as water (H_2O)