Name _____ Date _____ Class _____

15 WATER AND AQUEOUS SYSTEMS

SECTION 15.1 WATER AND ITS PROPERTIES (pages 445–449)

This section describes the properties of water in the liquid and solid states and explains how hydrogen bonding affects the surface tension and vapor pressure of water.

▶ Water in the Liquid State (pages 445–447)

1. What unique substance is essential to all life on Earth?

water

2. Approximately what fraction of Earth's surface is covered in water? 3/4

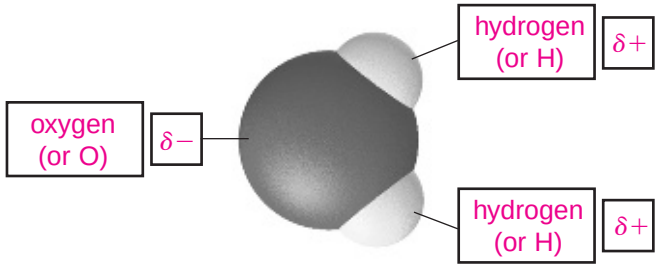
3. Circle the letter next to each sentence that is true concerning water molecules.

a. Each O — H covalent bond in a water molecule is nonpolar.

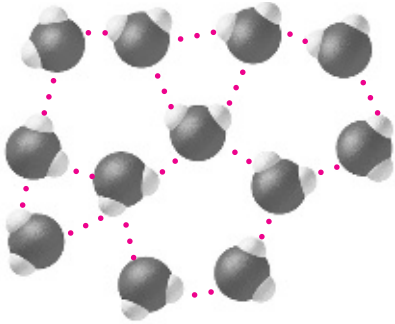
b. In a water molecule, the less electronegative hydrogen atoms acquire a partial positive charge and the oxygen atom acquires a partial negative charge.

c. Because the water molecule has an H — O — H bond angle of 105°, the molecule as a whole is polar.

4. The diagram below depicts a water molecule. Complete the labels showing the locations of the hydrogen atoms, the oxygen atom, and the regions of positive and negative charge.



5. The diagram below depicts a collection of water molecules. Draw dotted lines showing where hydrogen bonding occurs.



6. Circle the letter next to each sentence that describes a result of the surface tension of water.

a. In a full glass of water, the water surface seems to bulge over the rim of the glass.

b. Water beads up into small, nearly spherical drops on a paper towel.

c. Water forms nearly spherical drops at the end of an eyedropper.

d. An insect called a water strider is able to "walk" on water.

7. Using Figure 15.4 on page 447, explain why a water drop has surface tension.

Because water molecules at the surface cannot form hydrogen bonds with air molecules, molecules on the surface are drawn into the body of liquid. The inward pull on the molecules is surface tension.

8. Do liquids that have higher surface tension produce drops that are flatter or more nearly spherical than liquids with lower surface tension?

Liquids with higher surface tension produce drops that are more nearly spherical.

9. What is the name for an agent, such as a detergent, that has the ability to reduce surface tension? surfactant

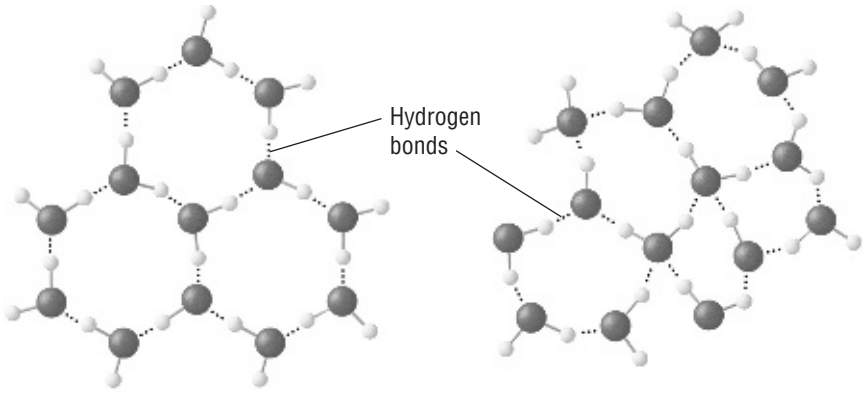
▶ Water in the Solid State (pages 448–449)

10. What happens to the density of most substances as they cool and solidify?

Density usually increases as a substance cools.

Name _____ Date _____ Class _____

11. The diagrams below show hydrogen bonding between water molecules.



(i) (ii)

a. Which diagram depicts ice? (i)

b. Which diagram depicts liquid water? (ii)

c. Why is ice less dense than liquid water? Refer to the diagrams to help you explain. Ice molecules are arranged in an open rigid framework as shown in diagram (i). When ice melts, the framework collapses, as shown in diagram (ii), and the molecules pack closer together.

12. Look at Table 15.1 on page 448. To four significant figures, list the density of

a. liquid water at 4°C 1.000 g/cm^3

b. liquid water at 0°C 0.9998 g/cm^3

c. ice at 0°C 0.9168 g/cm^3

13. What is unusual about the data in Question 12? Will ice float on liquid water?
The density of liquid water decreases from 4°C to 0°C, and ice at 0°C is less dense than liquid water at 0°C. Yes, ice will float on liquid water.

SECTION 15.2 HOMOGENOUS AQUEOUS SYSTEMS (pages 450–457)

This section describes the process of solvation; distinguishes among strong electrolytes, weak electrolytes, and nonelectrolytes; and explains water of hydration.

▶ Solvents and Solutes (page 450)

1. Water samples containing dissolved substances are called aqueous solutions.

CHAPTER 15, Water and Aqueous Systems *(continued)*

Match each term to its description by writing its letter on the line next to the description.

c	**2.** dissolving medium	**a.** solution
b	**3.** dissolved particles	**b.** solute
a	**4.** homogeneous mixture of particles in a dissolving medium	**c.** solvent

5. Is the following sentence true or false? After sodium chloride dissolves in a container of water, the sodium chloride will eventually settle to the bottom of the container if the solution remains undisturbed at a constant temperature.

false

6. Circle the letter next to each sentence that is true about aqueous solutions.

a. Solute particles can be either ionic or molecular, and their average diameters are usually less than 1 nanometer.

b. When a solution is filtered, both solute and solvent will pass through the filter paper.

c. Ionic compounds and substances containing polar covalent molecules readily dissolve in water.

d. Nonpolar covalent molecules, such as those found in oil, grease, and gasoline, readily dissolve in water.

▶ The Solution Process (page 451)

7. What happens when a solid crystal of sodium chloride is placed in water?

Water molecules collide with the crystal and attract its Na^+ and Cl^- ions.

8. What process occurs when solute ions become surrounded by solvent molecules? solvation

9. Look at the model of solvation in Figure 15.7 on page 451. If enough solvent is present, what will eventually happen to the ionic solid depicted at the bottom of the diagram?

All of the ions will become surrounded by solvent molecules and the ionic solid will disappear into the solution.

10. When a compound cannot be solvated to any significant extent, it is called insoluble .

Name _____ Date _____ Class _____

11. Circle the letter next to the one sentence that best explains why the ionic compounds barium sulfate ($BaSO_4$) and calcium carbonate ($CaCO_3$) are nearly insoluble in water.

a. The attractions between the ions in the crystals of these ionic compounds are weaker than the attractions between the ions and water molecules.

b. The attractions between the ions in the crystals of these ionic compounds are stronger than the attractions between the ions and water molecules.

c. There is no difference in the strength of the attractions between the ions in the crystals and the attractions between the ions and water molecules.

d. These ionic compounds are easily dissolved in water.

12. What saying sums up the observation that, as a rule, polar solvents dissolve ionic compounds and polar molecules, but nonpolar solvents dissolve nonpolar compounds? "like dissolves like"

▶ Electrolytes and Nonelectrolytes (pages 452–453)

13. What types of compounds can carry an electric current in the molten state or in aqueous solution? electrolytes

14. Is the following sentence true or false? All ionic compounds are electrolytes. true

15. Compounds that do not conduct an electric current in either aqueous solution or the molten state are called nonelectrolytes .

Look at the light bulbs in Figure 15.9 on page 453 to answer Questions 17, 18, and 19.

c **16.** Which bulb, *a, b,* or *c,* indicates that the solution is nonconductive?

b **17.** Which bulb, *a, b,* or *c,* indicates that the solution is weakly conductive?

a **18.** Which bulb, *a, b,* or *c,* indicates that the solution is highly conductive?

▶ Hydrates (pages 454–457)

19. Water in a crystal that is an integral part of the crystal structure is called water of hydration .

20. A compound that contains water as an integral part of its crystal structure is called a hydrate .

21. What does "•$5H_2O$" mean when included in a chemical formula?
The compound contains five water molecules per formula unit.

CHAPTER 15, Water and Aqueous Systems *(continued)*

22. Circle the letter next to each sentence that is true about hydrated compounds. Use Figures 15.10 on page 454 to help you.

a. Crystals of copper sulfate pentahydrate always contain five molecules of water for each copper and sulfate ion pair.

b. Heating blue crystals of copper sulfate pentahydrate above 100°C drives off the water of hydration, leaving a white anhydrous powder.

c. It is possible to regenerate copper sulfate pentahydrate by treating anhydrous copper sulfate with water.

d. Anhydrous cobalt(II) chloride is a good indicator for the presence of water because it changes from pink to blue when exposed to moisture.

23. If a hydrate has a vapor pressure greater than that of the water in the surrounding air, the hydrate will lose water to the air, or effloresce .

24. Hygroscopic substances that remove water from the air are used as drying agents called desiccants .

25. Look at Figure 15.13 on page 457. What happens to dry sodium hydroxide pellets that are exposed to normally moist air? What kind of compound exhibits this behavior?

The sodium hydroxide pellets remove enough water from the air to dissolve completely and form a solution. Sodium hydroxide is an example of a deliquescent compound.

Reading Skill Practice

By looking carefully at photographs and drawings in your textbook, you can better understand what you have read. Look carefully at Figure 15.8 on page 451. What important idea does this photograph communicate? Do your work on a separate sheet of paper.

Students should recognize that oil spills cause environmental problems because the insoluble oil spreads out across the water. As it spreads, it can come into contact with plants and animals. Oil clogs pores and does other damage to the life cycle of living organisms.

Name _____ Date _____ Class _____

SECTION 15.3 HETEROGENEOUS AQUEOUS SOLUTIONS (pages 459–462)

This section describes how colloids and suspensions differ from solutions and from one another. It also explains the Tyndall effect.

▶ Suspensions (page 459)

1. Is the following sentence true or false? Heterogeneous mixtures are not true solutions. _____true_____

2. Heterogeneous mixtures in which particles settle out upon standing are called _____suspensions_____ .

3. Is the following sentence true or false? When a suspension of clay particles in water is filtered, both clay and water will pass through the filter paper.

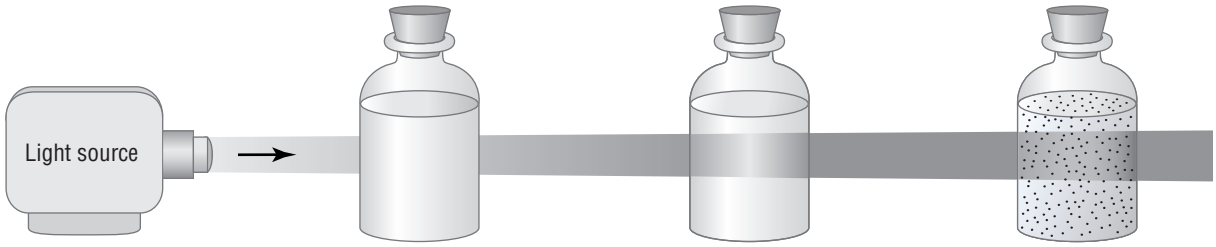
_____false_____

▶ Colloids (pages 460–462)

4. Heterogeneous mixtures in which particles are of intermediate size between those of true solutions and suspensions are called _____colloids_____ .

5. The scattering of light in all directions by colloidal particles is known as the _____Tyndall effect_____ .

6. Identify each type of system shown in the figure below.



Solution _____ Colloid _____ Suspension _____

Name _____ Date _____ Class _____

GUIDED PRACTICE PROBLEM

GUIDED PRACTICE PROBLEM 6 (page 456)

6. What is the percent by mass of water in $CuSO_4 \cdot 5H_2O$?

Analyze

a. What formula do you use to find percent by mass of water in a hydrate?

$$\text{percent } H_2O = \frac{\text{mass of water}}{\text{mass of hydrate}} \times 100\%$$

b. From the periodic table, what is the average atomic mass of each of the following elements?

Cu = 63.5 g O = 16.0 g

S = 32.1 g H = 1.0 g

Calculate

c. Determine the mass of water in the hydrate.

mass of $5H_2O$ = 5 × [(2 × 1.0 g) + 16.0 g] = 5 × 18.0 g = 90.0 g

d. Determine the mass of the hydrate.

mass of $CuSO_4 \cdot 5H_2O$ = 63.5 g + 32.1 g + (4 × 16.0 g) + 90.0 g = 249.6 g

e. Calculate the percent by mass of water.

$$\text{percent } H_2O = \frac{90.0 \text{ g}}{249.6 \text{ g}} \times 100\% = 36.1\ \%$$

Evaluate

f. How do you know that your answer is correct?

Because the mass of water accounts for about a third of the total mass of the hydrate, the percentage should be about 33%, which it is.

EXTRA PRACTICE (similar to Practice Problem 6, page 456)

6. What is the percent by mass of water in $CaCl_2 \cdot 2H_2O$?

mass of water = 2 × [(2 × 1.0) + 16.0] = 36.0 g

mass of hydrate = 40.1 + (2 × 35.5) + 36.0 = 147.1 g

$$\text{percent water} = \frac{36.0 \text{ g}}{147.1 \text{ g}} \times 100\% = 24.5\%$$