17 WATER AND AQUEOUS SYSTEMS
PLANNING GUIDE

SECTION	STUDENT ACTIVITIES/FEATURES	TEACHER'S RESOURCE PACKAGE
17.1 Liquid Water and Its Properties **Objectives** ▸ Describe the hydrogen bonding that occurs in water ▸ Explain the high surface tension and low vapor pressure of water in terms of hydrogen bonding	**Discover It!** *Observing Surface Tension,* p. 474 **Link to Health** *Water and Exercise,* p. 478	**Review Module** (Chapters 17–20) ▸ Section Review 17.1 ▸ Practice Problems ▸ Quizzes
17.2 Water Vapor and Ice **Objectives** ▸ Account for the high heat of vaporization and the high boiling point of water in terms of hydrogen bonding ▸ Explain why ice floats in water		**Review Module** ▸ Section Review 17.2 ▸ Practice Problems ▸ Interpreting Graphics ▸ Quizzes
17.3 Aqueous Solutions **Objectives** ▸ Explain the significance of the statement "like dissolves like" ▸ Distinguish among strong electrolytes, weak electrolytes, and nonelectrolytes, giving examples of each	**Link to Sanitation** *Wastewater Treatment,* p. 485 **Sample Problem** 17-1 **Small-Scale Lab** *Electrolytes,* p. 489	**Review Module** ▸ Section Review 17.3 ▸ Practice Problems ▸ Quizzes **Laboratory Recordsheet** 17-1 **Laboratory Manual** ▸ Experiment 26: *The Solvent Properties of Water* ▸ Experiment 27: *Distillation* ▸ Experiment 28: *Water of Hydration* **Laboratory Practicals** 17-1 and 17-2 **Laboratory Manual,** Experiment 29: *Electrolytes and Nonelectrolytes* **Small-Scale Chemistry Lab Manual,** Experiment 22: *Electrolytes*
17.4 Heterogeneous Aqueous Systems **Objectives** ▸ Explain how colloids and suspensions differ from solutions ▸ Describe the Tyndall effect	**Mini Lab** *Surfactants,* p. 493 **Chemistry Serving . . . the Environment** *El Niño: Little Child, Big Problem,* p. 494 **Chemistry in Careers** *Oceanographer,* p. 494	**Review Module** ▸ Section 17.4 ▸ Practice Problems ▸ Vocabulary Review 17 ▸ Chapter 17 Tests and Quizzes **Laboratory Recordsheet** 17-2 **Solutions Manual for Chapter Reviews** **Graphing Calculator Problems**

TECHNOLOGY RESOURCES

Internet Connections
Within this chapter, you will see the chemSURF logo. If you and your students have access to the Internet, the following URL address will provide various Internet connections that are related to topics and features presented in this chapter.

http://www.chemsurf.com

You can also find relevant chapter material at
The Chemistry Place address:
http://www.chemplace.com

CD-ROMs

Chem ASAP! CD-ROM
- Chapter 17

ResourcePro CD-ROM
- Chapter 17

ActivChemistry CD-ROM
- Electrolytes

Assessment Resources CD-ROM

Overhead Transparencies
- #57: Bonding in Water
- #58: Solvation
- #59: Electrolytes and Nonelectrolytes

PLANNING FOR ACTIVITIES

STUDENT EDITION

Discover It! p. 474
- waxed paper
- rulers
- teaspoons
- cups
- tap water
- liquid dish detergent

Small-Scale Lab, p. 489
- pencils
- paper
- rulers
- reaction surfaces
- conductivity testers
- chemicals

Mini Lab p. 493
- shallow dishes or Petri dishes
- water
- paper clips
- rubber bands (2 in. long)
- vegetable oil
- liquid dish detergent

TEACHER'S EDITION

Activity, p. 480
- ice
- beaker
- room temperature water
- thermometer

Activity, p. 484
- zinc and copper strips
- lemon
- voltmeter *or* copper and zinc solutions
- salt
- light bulb

Teacher Demo, p. 485
- light bulb (in a porcelain socket)
- 9V or lantern battery
- two copper metal strips immersed in aqueous solution to be tested
- lamp cord
- alligator clips
- 0.1*M* solution of:
  glucose ($C_6H_{12}O_6$)
  alanine ($HC_3H_6O_2N$)
  glycerine ($HC_2H_4O_2N$)
  ascorbic acid ($HC_6H_2O_6$)
  malonic acid ($H_2C_3H_2O_4$)
  citric acid ($H_3C_6H_5O_7$)
  acetic acid ($HC_2H_3O_2$)
  hydrochloric acid (HCl)
- beakers for each solution

ASSESSMENT

Student Edition
- Section Reviews 17.1–17.4
- Chapter 17 Review, pp. 495–498
- Alternative Assessment, p. 499

Technology
Chem ASAP! CD-ROM
- Assessment 17.1–17.4

Assessment Resources CD-ROM
- Chapter 17 Tests

Teacher's Resource Package
Review Module (Chap. 17–20)
- Vocabulary Review
- Chapter 17 Test A and Test B
- Chapter 17 Quizzes

Name _____ Class _____ Date _____

17.1 LIQUID WATER AND ITS PROPERTIES
SECTION REVIEW

Objectives

- Describe the hydrogen bonding that occurs in water
- Explain the high surface tension and low vapor pressure of water in terms of hydrogen bonding

Key Terms

- surface tension
- surfactant

Part A Completion

Use this completion exercise to check your understanding of the concepts and terms that are introduced in this section. Each blank can be completed with a term, short phrase, or number.

Each O—H bond in a water molecule is highly __1__. Oxygen acquires a slightly __2__ charge, while hydrogen acquires a slightly __3__ charge. Since the H—O—H bond angle is 105 °, the water molecule as a whole is __4__.

Water molecules are attracted to each other as a result of intermolecular __5__ bonds. This bonding accounts for many properties of water, such as its __6__ vapor pressure and __7__ boiling point. Hydrogen bonding is also responsible for the high __8__ tension of water. Liquids tend to minimize their surface area and form __9__ droplets because of their surface tension. The surface tension of water can be reduced by adding a __10__.

Water has a high __11__ capacity, which helps to moderate the air __12__ around large bodies of water.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____

Part B True-False

Classify each of these statements as always true, AT; sometimes true, ST; or never true, NT.

_____ **13.** Hydrogen bonding is responsible for the polar nature of the water molecule.

_____ **14.** The water molecule is a straight molecule.

_____ **15.** Detergents lower the surface tension of water by interfering with the formation of hydrogen bonds.

_____ **16.** Polar molecules are attracted to one another by dipole interactions.

Part C Matching

Match each description in Column B to the correct term in Column A.

Column A	Column B
_____ **17.** surface tension	**a.** inward force that tends to minimize the surface area of a liquid
_____ **18.** surfactant	**b.** the amount of heat required to raise the temperature of 1 gram of a substance by 1 °C
_____ **19.** hydrogen bond	**c.** a wetting agent
_____ **20.** specific heat capacity	**d.** intermolecular attraction between a hydrogen atom and a highly electronegative atom such as oxygen, on an adjacent molecule

Part D Questions and Problems

Answer the following in the space provided.

21. State whether each of the following properties of water is higher or lower than compounds of similar size and molecular mass.

a. vapor pressure

_____

b. surface tension

_____

c. specific heat capacity

_____

d. boiling point

_____

e. heat of vaporization

_____

22. Calculate the amount of energy necessary to raise the temperature of 100.0 g of water by 2.0 °C.

23. Calculate the amount of energy necessary to raise the temperature of 100.0 g of iron by 20.0 °C.

Name _____ Class _____ Date _____

17.2 WATER VAPOR AND ICE
SECTION REVIEW

Objectives

- Account for the high heat of vaporization and the high boiling point of water in terms of hydrogen bonding
- Explain why ice floats in water

Part A Completion

Use this completion exercise to check your understanding of the concepts and terms that are introduced in this section. Each blank can be completed with a term, short phrase, or number.

Water absorbs a large amount of heat as it evaporates because of __1__. The heat of vaporization is the amount of __2__ needed to convert 1 g of a substance from a liquid to a gas at the boiling point. The large amount of heat is necessary to break the hydrogen bonds that hold the __3__ of liquid water together.

The reverse of vaporization is __4__. The heat of condensation of a substance is __5__ to its heat of vaporization.

Molecular compounds with molar masses similar to water are usually __6__ or low boiling liquids. Water is an important __7__. Its high boiling point is due to __8__.

__9__ floats in liquid water. This is because it is less __10__ than water. Ice has a rigid open structure, which is also due to __11__.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____

Part B True-False

Classify each of these statements as always true, AT; sometimes true, ST; or never true, NT.

_____ **12.** Ice is more dense than water.

_____ **13.** Molecular compounds of low molar mass are gases at normal atmospheric pressure.

_____ **14.** Hydrogen bonding accounts for water's high boiling point.

_____ **15.** Water becomes more dense as it is cooled.

Name _____ Class _____ Date _____

Part C Questions and Problems

Answer the following questions or problems in the space provided. Show your work.

16. How much energy is required to change 86.0 g of water at 100 °C to 86.0 g of steam at 100 °C? Express your answer in kilojoules.

17. Methane, CH_4, has a formula mass of 16 amu, a melting point of −183 °C, and a boiling point of −164 °C. Water, H_2O, has a formula mass of 18 amu, a melting point of 0 °C, and a boiling point of 100 °C. Explain why there is such a difference in the melting and boiling points when the formula masses of the two compounds are so close.

Name _____ Class _____ Date _____

17.3 AQUEOUS SOLUTIONS
SECTION REVIEW

Objectives

- Explain the significance of the statement "like dissolves like"
- Distinguish among strong electrolytes, weak electrolytes, and nonelectrolytes, giving examples of each

Key Terms

- aqueous solutions
- solvent
- solute
- solvation
- electrolytes
- nonelectrolytes
- weak electrolyte
- strong electrolyte
- water of hydration
- effloresce
- hygroscopic
- dessicants
- deliquescent

Key Equation

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

Part A Completion

Use this completion exercise to check your understanding of the concepts and terms that are introduced in this section. Each blank can be completed with a term, short phrase, or number.

Water is a polar liquid and an excellent __1__ for many substances. Aqueous solutions are __2__ mixtures of ions or molecules in water. The solubility of a solute depends on solute-solvent interactions. A good rule to remember is __3__.

Substances that dissolve as ions are known as __4__. A solute that is completely ionized in solution is a __5__ electrolyte. A weak electrolyte is only __6__ ionized. A solution of an electrolyte will __7__ an electric current, whereas a solution of a __8__ is nonconducting.

Many crystals are __9__; they contain water of hydration. In the process called __10__, the water of hydration is lost from a hydrate that is exposed to the air.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

Name _____ Class _____ Date _____

Part B True-False

Classify each of these statements as always true, AT; sometimes true, ST; or never true, NT.

_____ **11.** Carbon tetrafluoride is a nonelectrolyte.

_____ **12.** Hydrates are crystals that contain a fixed quantity of water within their structure.

_____ **13.** Covalent solutes are very soluble in water.

_____ **14.** Solutions are always homogeneous.

Part C Matching

Match each description in Column B to the correct term in Column A.

Column A	Column B
_____ **15.** aqueous solutions	**a.** the dissolved particles in a solution
_____ **16.** solute	**b.** compounds that conduct electric current in aqueous solution
_____ **17.** solvation	**c.** able to remove moisture from air
_____ **18.** electrolyte	**d.** water samples containing dissolved substances
_____ **19.** nonelectrolytes	**e.** drying agents
_____ **20.** water of hydration	**f.** compounds that do not conduct electric current in aqueous solution
_____ **21.** hygroscopic	**g.** water contained in the crystal structure of a compound
_____ **22.** dessicants	**h.** process that occurs when a solute dissolves

Part D Questions and Problems

Answer the following questions or problems in the space provided. Show your work.

23. Calculate the percent by mass of water in Glauber's salt ($Na_2SO_4 \cdot 10H_2O$).

24. Which of the following substances dissolve to a significant extent in water?

a. C_6H_6

b. NaCl

c. Na_2SO_4

d. N_2

Name _____ Class _____ Date _____

17.4 HETEROGENEOUS AQUEOUS SYSTEMS
SECTION REVIEW

Objectives

- Explain how colloids and suspensions differ from solutions
- Describe the Tyndall effect

Key Terms

- suspension
- colloids
- Tyndall effect
- Brownian motion
- emulsions

Part A Completion

Use this completion exercise to check your understanding of the concepts and terms that are introduced in this section. Each blank can be completed with a term, short phrase, or number.

The component particles of a suspension are much __1__ than those of a solution. Gravity or __2__ will separate the suspended particles from a suspension. The particles in a colloid generally do not settle under gravity, and they pass through ordinary filter paper unchanged. __3__ are good at scattering light, as are suspensions, as evidenced by the __4__. Colloidal dispersions also exhibit __5__ motion. The particles in solutions are small __6__ or __7__. They cannot be trapped by filter paper, nor do they exhibit the Tyndall effect.

__8__ are colloidal dispersions of liquids in liquids. Emulsifying agents maintain the __9__ of an emulsion and allow the formation of __10__ for liquids that do not ordinarily mix.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

Part B True-False

Classify each of these statements as always true, AT; sometimes true, ST; or never true, NT.

_____ **11.** The scattering of light by colloidal particles is called Brownian motion.

_____ **12.** Heterogeneous aqueous systems can be separated by filtration.

_____ **13.** Emulsifying agents are essential to forming and maintaining emulsions.

_____ **14.** Colloids are dispersions of liquids in liquids.

_____ **15.** The random motion of particles is known as the Tyndall effect.

Part C Matching

Match each description in Column B to the correct term in Column A.

Column A	Column B
_____ **16.** suspensions	**a.** chaotic movement of colloidal particles
_____ **17.** colloids	**b.** heterogeneous mixtures containing particles intermediate in size between those of suspensions and solutions
_____ **18.** Tyndall effect	**c.** substance necessary to the formation and stability of an emulsion
_____ **19.** Brownian motion	**d.** scattering of visible light by colloidal particles
_____ **20.** emulsions	**e.** mixtures from which particles settle on standing
_____ **21.** emulsifying agent	**f.** dispersions of liquids in liquids

Part D Questions and Problems

Answer the following questions in the space provided.

22. What is the typical particle size in a colloidal dispersion?

a. greater than 100 nm

b. 1 nm to 100 nm

c. less than 1 nm

d. There are no particles in a colloidal dispersion.

23. What is the typical particle size in a suspension?

a. greater than 100 nm

b. 1 nm to 100 nm

c. less than 1 nm

d. There are no particles in a suspension.

Name _____ Class _____ Date _____

17 WATER AND AQUEOUS SYSTEMS
PRACTICE PROBLEMS

In your notebook, answer the following questions and problems.

SECTION 17.1 LIQUID WATER AND ITS PROPERTIES

1. In your own words, explain what a hydrogen bond is.
2. Depict the hydrogen bonding between three water molecules.
3. How is hydrogen bonding responsible for the high boiling point of water?
4. Explain how large bodies of water are able to moderate air temperature.
5. How much heat is needed to raise the temperature of 10.0 g of liquid water from 20.0 °C to 30.0 °C? How much heat is needed to raise the temperature of the same mass of iron through the same range of temperature? What is the ratio of the amounts of energy needed to raise the temperature of 10.0 g of water and 10.0 g of iron by 10 °C respectively? (The specific heat capacities of $H_2O(l)$ and $Fe(s)$ are 4.18 J/(g × °C) and 0.447 J/(g × °C) respectively.)

SECTION 17.2 WATER VAPOR AND ICE

1. Explain why it gets warmer before it rains.
2. How much energy in kilojoules is released when 180.0 g of water vapor at 100 °C condenses to liquid water at the same temperature? (The molar heat of condensation for water is $\Delta H_{cond} = -40.7$ kJ/mol.)
3. How much energy in kilojoules is required to change 78.3 g of ice at 0 °C to liquid water at the same temperature? (The molar heat of fusion for water is $\Delta H_{fus} = 6.01$ kJ/mol.)
4. Explain why the density of ice at 0 °C is less than the density of liquid water at 0 °C.

SECTION 17.3 AQUEOUS SOLUTIONS

1. Identify the solute and solvent in a dilute aqueous solution of potassium chloride.
2. Write an equation showing how ammonia is ionized when it dissolves in water.
3. Give an example of a polar molecular compound that dissolves in water and that is a nonelectrolyte.
4. Explain the meaning of the term *hygroscopic*.
5. Which of the following compounds are soluble in water? Which are insoluble?
   a. $CaCl_2$
   b. N_2
   c. HBr
   d. $NH_4C_2H_3O_2$

Name _____ Class _____ Date _____

6. Write equations to show how the following compounds dissociate in water.
   a. NH_4NO_3
   b. KOH
7. Write the formulas for the following hydrates.
   a. Calcium sulfate dihydrate
   b. Cobalt(II) chloride hexahydrate
8. Find the percent by mass of water in $NiCl_2 \cdot 6H_2O$.

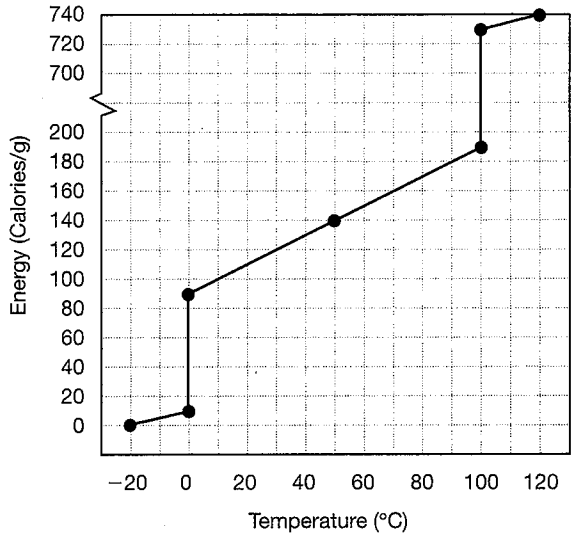
SECTION 17.4 HETEROGENEOUS AQUEOUS SYSTEMS

1. Distinguish colloids and suspensions from solutions by discussing their properties.
2. What is Brownian motion?
3. Classify each of the following mixtures as a colloid, suspension, or solution.
   a. fog
   b. milk
   c. sodium chloride dissolved in water
   d. cornstarch in water
   e. potting soil shaken with water
   f. soap suds
   g. a mixture of sucrose and water

Name _____ Class _____ Date _____

17 INTERPRETING GRAPHICS

USE WITH SECTION 17.2



The graph above plots energy vs. temperature as one gram of water is converted from ice at −20 °C to steam at 120 °C.

Use the graph above to answer the questions below.

1. What is the approximate specific heat capacity of ice?

2. What is the approximate specific heat capacity of steam?

3. How many calories of heat are needed to heat 1.00 gram of ice at −20 °C to steam at 120 °C?

Name _____ Class _____ Date _____

4. How many calories of heat are required to heat 1.00 gram of ice at 0 °C to water at 50 °C?

5. What is the heat of fusion of water?

6. How many calories of heat are required to heat 1.00 gram of water at 50 °C to steam at 100 °C?

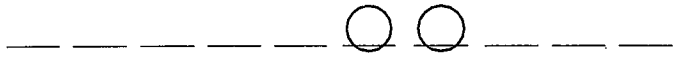
7. Explain why the heating curve becomes vertical at 0 °C and 100 °C.

Name _____ Class _____ Date _____

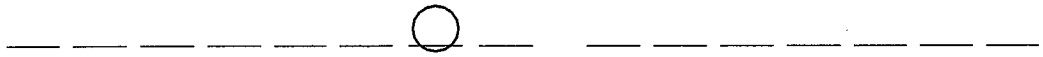
17 VOCABULARY REVIEW

Each clue describes a vocabulary term. Read the clues and write the letters of each term on the lines provided.

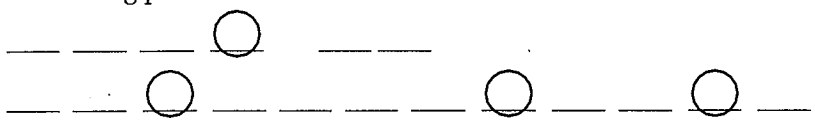
1. Clue: hygroscopic substances used as drying agents.



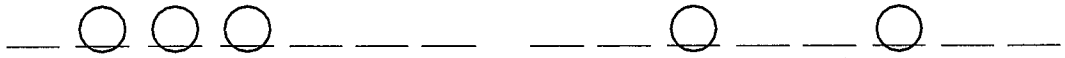
2. Clue: a relatively strong intermolecular force responsible for water's high surface tension.



3. Clue: the amount of energy needed to change 1 gram of a substance to a gas at the boiling point.

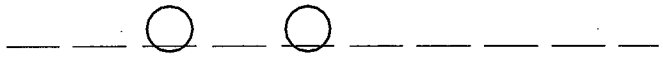


4. Clue: a solution in which the solvent is water.

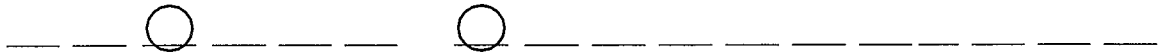


5. Clue: the dissolving medium in a solution.

6. Clue: a wetting agent that interferes with hydrogen bonding in water.

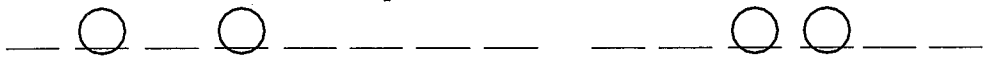


7. Clue: a substance that completely dissociates into its ions in solution.



8. Clue: the water loosely held in a crystal structure.

9. Clue: the chaotic movement of particles in a solution.



Write the letters found inside the circles on the lines below. Then unscramble them to find the three states of a substance essential for life on Earth.

SCRAMBLED LETTERS:

_____

_____

SOLUTION:

1. _____
2. _____
3. _____

Name _____ Class _____ Date _____

17 WATER AND AQUEOUS SYSTEMS

Quiz for CHAPTER 17

Some Properties of Water

Specific Heat	*4.18 J/(g × °C)*
Heat of vaporization	*2.26 kJ/g*
Heat of fusion	*334 J/g*

Write the letter of the best answer in the blank.

_____ **1.** The attractions between adjacent water molecules are called: *17.1*
a. hydrogen bonds. **c.** nonpolar covalent bonds.
b. ionic bonds. **d.** polar covalent bonds.

_____ **2.** Surface tension is: *17.1*
a. the inward force that tends to minimize the surface area of a liquid.
b. increased by detergents.
c. decreased by hydrogen bonding.
d. all of the above

_____ **3.** How many joules are needed to raise the temperature of 10.0 g of water from 15.0 °C to 35 °C? *17.1*
a. 41.8 J **c.** 836 J
b. 150 J **d.** 627 J

_____ **4.** Which of the following is an example of a strong electrolyte? *17.3*
a. acetic acid **c.** NaCl
b. sucrose **d.** H_2O

_____ **5.** Which of the following mixtures do *not* exhibit the Tyndall effect? *17.4*
a. colloids **c.** emulsions
b. solutions **d.** suspensions

Fill in the word(s) that will make each statement true.

6. In a solution, the dissolved particles are known as the _____. *17.3*

7. In a solution, the dissolving medium is called the _____. *17.3*

8. Water samples containing dissolved substances are called _____. *17.3*

9. The expression "_____" sums up the dissolving of polar or nonpolar solvents and solutes. *17.3*

Solve the following problem in the space provided. Show your work.

10. How much energy is released when 12 g of steam at 100 °C condense to 12 g of water at 100 °C? *17.2*

Name _____ Class _____ Date _____

17 WATER AND AQUEOUS SYSTEMS

CHAPTER TEST A

A. Completion

Fill in the word(s) that will make each statement true.

1. A compound that does not conduct an electric current in aqueous solution or when molten is called a(n) __1__. 1. _____
2. A substance is said to be __2__ when it is able to remove sufficient water from the air to dissolve completely and form a solution. 2. _____
3. A mixture from which some of the particles will settle slowly upon standing is a(n) __3__. 3. _____
4. The dissolving medium of a solution is called the __4__. 4. _____
5. A hydrate will __5__ if its vapor pressure is higher than the vapor pressure of the water vapor in the air. 5. _____
6. The chaotic movements of colloidal particles are known as __6__. 6. _____
7. __7__ are colloidal dispersions of liquids in liquids. 7. _____
8. A __8__ contains water molecules that form part of its crystal structure. 8. _____
9. The scattering of visible light in all directions by colloids or suspensions is called the __9__. 9. _____
10. __10__ is the inward force or pull that tends to minimize the surface area of a liquid. 10. _____

B. Multiple Choice

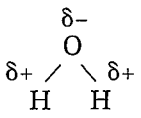
Write the letter of the best answer in the blank.

_____ **11.** The high surface tension of water is due to the:
- **a.** small size of water molecules.
- **b.** low mass of water molecules.
- **c.** hydrogen bonding between water molecules.
- **d.** covalent bonds in water molecules.

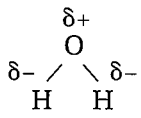
_____ **12.** Salts and other compounds that remove moisture from air are said to be:
- **a.** efflorescent.
- **b.** surfactant.
- **c.** colloidal.
- **d.** hygroscopic.

Name _____ Class _____ Date _____

_____ **13.** A water molecule is best represented by:

a.


b. H—O—H

c.


d. H—H—O

_____ **14.** Based *solely* upon its formula mass, one would expect water to:
a. have a high boiling point.
b. have a low boiling point.
c. be a solid at room temperature.
d. be a liquid at room temperature.

_____ **15.** The density of ice is less than the density of water because:
a. ice has a lower molecular mass than water.
b. the same mass occupies a smaller volume.
c. the molecules are more closely packed.
d. hydrogen bonding in ice produces an open framework.

_____ **16.** A solution is a mixture:
a. from which the solute cannot be filtered.
b. that is colloidal.
c. that is heterogeneous.
d. in which a solid solute is always dissolved in a liquid solvent.

_____ **17.** Which of the following is *not* an electrolyte?
a. cane sugar(*aq*)
b. HCl(*aq*)
c. KCl(*aq*)
d. $(NH_4)_2SO_4(aq)$

_____ **18.** An electric current is conducted by:
a. a solution of NaCl.
b. a sugar solution.
c. solid NaCl.
d. solid sugar.

_____ **19.** How many water molecules are in two formula units of barium hydroxide octahydrate, $Ba(OH)_2 \cdot 8H_2O$?
a. 2
b. 8
c. 16
d. 20

_____ **20.** Which of these would you expect to be soluble in the nonpolar solvent carbon disulfide, CS_2?
a. $MgCl_2$
b. $CaCO_3$
c. CBr_4
d. H_2O

_____ **21.** Gelatin would best be classed as:
a. a colloidal dispersion.
b. a suspension.
c. a heterogeneous mixture.
d. an aqueous solution.

_____ **22.** A typical kind of emulsion is:
a. muddy water.
b. mayonnaise.
c. sea water.
d. smoke.

_____ **23.** When sodium chloride is mixed with water, it forms:
a. a dispersion.
b. an emulsion.
c. a solution.
d. a suspension.

Name _____ Class _____ Date _____

C. True-False

Classify each of these statements as always true, AT; sometimes true, ST; or never true, NT.

_____ **24.** Ionic solutes are very soluble in water.

_____ **25.** The condensation of steam is an exothermic process.

_____ **26.** Liquids decrease in density as they cool.

_____ **27.** Hydrates are hygroscopic.

_____ **28.** Rubbing alcohol, C_3H_7OH, is an electrolyte.

D. Problems

Solve the following problems in the space provided. Show your work.

29. What is the percentage by mass of water in the hydrate $CoCl_2 \cdot 6H_2O$?

30. How many calories are liberated when 72 g of steam are condensed to liquid water at 100 °C?

31. How many kilojoules are required to heat 39.5 g of liquid water from 15.0 °C to 48.0 °C?

Name _____ Class _____ Date _____

E. Essay

Write a short essay for the following.

32. Describe the process of solvation of ionic solids in water.

Name _____ Class _____ Date _____

17 WATER AND AQUEOUS SYSTEMS

CHAPTER TEST B

A. Completion

Fill in the word(s) that will make each statement true.

1. Salts and other compounds that remove moisture from air are said to be _____.
2. When a solute dissolves, the process is referred to as _____.
3. When salt is dissolved in water, the salt particles are referred to as the _____.
4. In terms of their effect on the surface tension of water, wetting agents such as soaps and detergents are called _____.
5. Another name for drying agents is _____.
6. Mixtures containing particles that are intermediate in size between those of suspensions and true solutions are called _____.
7. Water samples containing dissolved substances are called _____ solutions.
8. Surface tension is explained by the ability of water to form _____ bonds.
9. Compounds that do not conduct an electric current in either aqueous solution or when molten are referred to as _____.
10. When a hydrate loses its water of hydration, it is said to _____.

B. Multiple Choice

Choose the best answer and write its letter in the blank.

_____ **11.** The hydrogen bonding that occurs in water accounts for water's:
- **a.** high vapor pressure.
- **b.** high specific heat capacity.
- **c.** low boiling point.
- **d.** all of the above

_____ **12.** A liquid that has strong intermolecular attractions has:
- **a.** a high surface tension.
- **b.** an intermediate surface tension.
- **c.** a low surface tension.
- **d.** no surface tension.

Name _____ Class _____ Date _____

_____ **13.** If the heat of vaporization of water is 2.26 kJ/g at 100 °C, how many kJ would be required to vaporize 9.00 g of water at 100 °C?
a. 1.13 kJ
b. 20.3 kJ
c. 22.6 kJ
d. 0.251 kJ

_____ **14.** Ice floats on liquid water because its density is:
a. lower than that of liquid water.
b. the same as that of liquid water.
c. higher than that of liquid water.
d. none of these

_____ **15.** If the heat of solidification of water is 334 J/g at 0 °C, how many kJ of heat are released when 15 g of water freeze at 0 °C?
a. 0.022 kJ
b. 5.0×10^3 kJ
c. 22 kJ
d. 5.0 kJ

_____ **16.** If salt is dissolved in water, water serves as the:
a. solute.
b. solvent.
c. dissolved medium.
d. none of these

_____ **17.** Which of the following would be expected to dissolve very readily in water?
a. CH_4
b. H_2
c. NaOH
d. CBr_4

_____ **18.** Which of the following would be expected to dissolve readily in the nonpolar solvent CCl_4?
a. table salt
b. KNO_3
c. grease
d. $Ca(OH)_2$

_____ **19.** The electrolyte among the following is:
a. KCl.
b. $Mg(NO_3)_2$.
c. NH_4OH.
d. all of these

_____ **20.** Mixtures from which some of the particles will settle slowly upon standing are referred to as:
a. homogeneous.
b. solutions.
c. suspensions.
d. colloids.

_____ **21.** The scattering of a beam of light as it passes through a colloid is referred to as:
a. efflorescence.
b. Brownian motion.
c. the Tyndall effect.
d. deliquescence.

_____ **22.** Smoke is an example of a(n):
a. solution.
b. suspension.
c. colloid.
d. emulsion.

_____ **23.** Which of the following is true about hygroscopic substances?
a. They have low vapor pressures.
b. They remove moisture from the air.
c. They can be used as drying agents.
d. all of these

Name _____ Class _____ Date _____

_____ **24.** What is the percent by mass of water in $MgSO_4 \cdot 7H_2O$?

a. 51.1%
b. 195%
c. 56.0%
d. 21.0%

C. True-False

Classify each of these statements as always true, AT; sometimes true, ST; or never true, NT.

_____ **25.** Detergents are used in washing clothes because they reduce the surface tension of water.

_____ **26.** Since the specific heat capacity of iron is less than that of water, more energy is required to raise the temperature of one gram of iron by one degree than for one gram of water by that same amount.

_____ **27.** The vaporization of water is an endothermic process.

_____ **28.** Solids can float in their own liquids.

_____ **29.** As a general rule, like dissolves like.

_____ **30.** All ionic compounds are electrolytes.

_____ **31.** The strength of an aqueous electrolyte is determined by the extent to which the solute particles ionize.

_____ **32.** In general, the particles in a colloid are larger than those in a suspension.

_____ **33.** Brownian motion is caused by the water molecules of the medium colliding with the small, dispersed colloidal particles dissolved in that medium.

_____ **34.** Soaps and detergents are good emulsifying agents.

D. Problems

Solve the following problems in the space provided. Show your work.

35. How many kilojoules would be required to vaporize 0.250 mol of water at 100 °C?

36. How much heat would be released (in J) if 12.0 g of steam condense to water at 100 °C?

Name _____ Class _____ Date _____

37. How much heat (in kJ) would be required to melt 3.5 mol of ice at 0 °C to water at 0 °C?

38. Determine the percent by mass of water in $Na_2SO_4 \cdot 10H_2O$.

E. Essay

Write a short essay for the following.

39. Using at least two of the concepts presented in this chapter, explain how soaps and detergents work in removing oil and grease from clothing.

17 WATER AND AQUEOUS SYSTEMS
PLANNING GUIDE

SECTION	STUDENT ACTIVITIES/FEATURES	TEACHER'S RESOURCE PACKAGE
17.1 Liquid Water and Its Properties **Objectives** ▸ Describe the hydrogen bonding that occurs in water ▸ Explain the high surface tension and low vapor pressure of water in terms of hydrogen bonding	**Discover It!** *Observing Surface Tension,* p. 474 **Link to Health** *Water and Exercise,* p. 478	**Review Module** (Chapters 17–20) ▸ Section Review 17.1 ▸ Practice Problems ▸ Quizzes
17.2 Water Vapor and Ice **Objectives** ▸ Account for the high heat of vaporization and the high boiling point of water in terms of hydrogen bonding ▸ Explain why ice floats in water		**Review Module** ▸ Section Review 17.2 ▸ Practice Problems ▸ Interpreting Graphics ▸ Quizzes
17.3 Aqueous Solutions **Objectives** ▸ Explain the significance of the statement "like dissolves like" ▸ Distinguish among strong electrolytes, weak electrolytes, and nonelectrolytes, giving examples of each	**Link to Sanitation** *Wastewater Treatment,* p. 485 **Sample Problem** 17-1 **Small-Scale Lab** *Electrolytes,* p. 489	**Review Module** ▸ Section Review 17.3 ▸ Practice Problems ▸ Quizzes **Laboratory Recordsheet** 17-1 **Laboratory Manual** ▸ Experiment 26: *The Solvent Properties of Water* ▸ Experiment 27: *Distillation* ▸ Experiment 28: *Water of Hydration* **Laboratory Practicals** 17-1 and 17-2 **Laboratory Manual,** Experiment 29: *Electrolytes and Nonelectrolytes* **Small-Scale Chemistry Lab Manual,** Experiment 22: *Electrolytes*
17.4 Heterogeneous Aqueous Systems **Objectives** ▸ Explain how colloids and suspensions differ from solutions ▸ Describe the Tyndall effect	**Mini Lab** *Surfactants,* p. 493 **Chemistry Serving . . . the Environment** *El Niño: Little Child, Big Problem,* p. 494 **Chemistry in Careers** *Oceanographer,* p. 494	**Review Module** ▸ Section 17.4 ▸ Practice Problems ▸ Vocabulary Review 17 ▸ Chapter 17 Tests and Quizzes **Laboratory Recordsheet** 17-2 **Solutions Manual for Chapter Reviews** **Graphing Calculator Problems**

TECHNOLOGY RESOURCES

Internet Connections
Within this chapter, you will see the chemSURF logo. If you and your students have access to the Internet, the following URL address will provide various Internet connections that are related to topics and features presented in this chapter.

http://www.chemsurf.com

You can also find relevant chapter material at
The Chemistry Place address:
http://www.chemplace.com

CD-ROMs

Chem ASAP! CD-ROM
- Chapter 17

ResourcePro CD-ROM
- Chapter 17

ActivChemistry CD-ROM
- Electrolytes

Assessment Resources CD-ROM

Overhead Transparencies
- #57: Bonding in Water
- #58: Solvation
- #59: Electrolytes and Nonelectrolytes

PLANNING FOR ACTIVITIES

STUDENT EDITION

Discover It! p. 474
- waxed paper
- rulers
- teaspoons
- cups
- tap water
- liquid dish detergent

Small-Scale Lab, p. 489
- pencils
- paper
- rulers
- reaction surfaces
- conductivity testers
- chemicals

Mini Lab p. 493
- shallow dishes or Petri dishes
- water
- paper clips
- rubber bands (2 in. long)
- vegetable oil
- liquid dish detergent

TEACHER'S EDITION

Activity, p. 480
- ice
- beaker
- room temperature water
- thermometer

Activity, p. 484
- zinc and copper strips
- lemon
- voltmeter *or* copper and zinc solutions
- salt
- light bulb

Teacher Demo, p. 485
- light bulb (in a porcelain socket)
- 9V or lantern battery
- two copper metal strips immersed in aqueous solution to be tested
- lamp cord
- alligator clips
- 0.1*M* solution of:
  glucose ($C_6H_{12}O_6$)
  alanine ($HC_3H_6O_2N$)
  glycerine ($HC_2H_4O_2N$)
  ascorbic acid ($HC_6H_2O_6$)
  malonic acid ($H_2C_3H_2O_4$)
  citric acid ($H_3C_6H_5O_7$)
  acetic acid ($HC_2H_3O_2$)
  hydrochloric acid (HCl)
- beakers for each solution

ASSESSMENT

Student Edition
- Section Reviews 17.1–17.4
- Chapter 17 Review, pp. 495–498
- Alternative Assessment, p. 499

Technology
Chem ASAP! CD-ROM
- Assessment 17.1–17.4

Assessment Resources CD-ROM
- Chapter 17 Tests

Teacher's Resource Package
Review Module (Chap. 17–20)
- Vocabulary Review
- Chapter 17 Test A and Test B
- Chapter 17 Quizzes

Name _____ Class _____ Date _____

17.1 LIQUID WATER AND ITS PROPERTIES
SECTION REVIEW

Objectives

- Describe the hydrogen bonding that occurs in water
- Explain the high surface tension and low vapor pressure of water in terms of hydrogen bonding

Key Terms

- surface tension
- surfactant

Part A Completion

Use this completion exercise to check your understanding of the concepts and terms that are introduced in this section. Each blank can be completed with a term, short phrase, or number.

Each O—H bond in a water molecule is highly __1__. Oxygen acquires a slightly __2__ charge, while hydrogen acquires a slightly __3__ charge. Since the H—O—H bond angle is 105 °, the water molecule as a whole is __4__.

Water molecules are attracted to each other as a result of intermolecular __5__ bonds. This bonding accounts for many properties of water, such as its __6__ vapor pressure and __7__ boiling point. Hydrogen bonding is also responsible for the high __8__ tension of water. Liquids tend to minimize their surface area and form __9__ droplets because of their surface tension. The surface tension of water can be reduced by adding a __10__.

Water has a high __11__ capacity, which helps to moderate the air __12__ around large bodies of water.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____

Part B True-False

Classify each of these statements as always true, AT; sometimes true, ST; or never true, NT.

_____ **13.** Hydrogen bonding is responsible for the polar nature of the water molecule.

_____ **14.** The water molecule is a straight molecule.

_____ **15.** Detergents lower the surface tension of water by interfering with the formation of hydrogen bonds.

_____ **16.** Polar molecules are attracted to one another by dipole interactions.

Part C Matching

Match each description in Column B to the correct term in Column A.

Column A	Column B
_____ **17.** surface tension	**a.** inward force that tends to minimize the surface area of a liquid
_____ **18.** surfactant	**b.** the amount of heat required to raise the temperature of 1 gram of a substance by 1 °C
_____ **19.** hydrogen bond	**c.** a wetting agent
_____ **20.** specific heat capacity	**d.** intermolecular attraction between a hydrogen atom and a highly electronegative atom such as oxygen, on an adjacent molecule

Part D Questions and Problems

Answer the following in the space provided.

21. State whether each of the following properties of water is higher or lower than compounds of similar size and molecular mass.

a. vapor pressure

_____

b. surface tension

_____

c. specific heat capacity

_____

d. boiling point

_____

e. heat of vaporization

_____

22. Calculate the amount of energy necessary to raise the temperature of 100.0 g of water by 2.0 °C.

23. Calculate the amount of energy necessary to raise the temperature of 100.0 g of iron by 20.0 °C.

Name _____ Class _____ Date _____

17.2 WATER VAPOR AND ICE
SECTION REVIEW

Objectives

- Account for the high heat of vaporization and the high boiling point of water in terms of hydrogen bonding
- Explain why ice floats in water

Part A Completion

Use this completion exercise to check your understanding of the concepts and terms that are introduced in this section. Each blank can be completed with a term, short phrase, or number.

Water absorbs a large amount of heat as it evaporates because of __1__. The heat of vaporization is the amount of __2__ needed to convert 1 g of a substance from a liquid to a gas at the boiling point. The large amount of heat is necessary to break the hydrogen bonds that hold the __3__ of liquid water together.

The reverse of vaporization is __4__. The heat of condensation of a substance is __5__ to its heat of vaporization.

Molecular compounds with molar masses similar to water are usually __6__ or low boiling liquids. Water is an important __7__. Its high boiling point is due to __8__.

__9__ floats in liquid water. This is because it is less __10__ than water. Ice has a rigid open structure, which is also due to __11__.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____

Part B True-False

Classify each of these statements as always true, AT; sometimes true, ST; or never true, NT.

_____ **12.** Ice is more dense than water.

_____ **13.** Molecular compounds of low molar mass are gases at normal atmospheric pressure.

_____ **14.** Hydrogen bonding accounts for water's high boiling point.

_____ **15.** Water becomes more dense as it is cooled.

Name _____ Class _____ Date _____

Part C Questions and Problems

Answer the following questions or problems in the space provided. Show your work.

16. How much energy is required to change 86.0 g of water at 100 °C to 86.0 g of steam at 100 °C? Express your answer in kilojoules.

17. Methane, CH_4, has a formula mass of 16 amu, a melting point of −183 °C, and a boiling point of −164 °C. Water, H_2O, has a formula mass of 18 amu, a melting point of 0 °C, and a boiling point of 100 °C. Explain why there is such a difference in the melting and boiling points when the formula masses of the two compounds are so close.

Name _____ Class _____ Date _____

17.3 AQUEOUS SOLUTIONS
SECTION REVIEW

Objectives

- Explain the significance of the statement "like dissolves like"
- Distinguish among strong electrolytes, weak electrolytes, and nonelectrolytes, giving examples of each

Key Terms

- aqueous solutions
- solvent
- solute
- solvation
- electrolytes
- nonelectrolytes
- weak electrolyte
- strong electrolyte
- water of hydration
- effloresce
- hygroscopic
- dessicants
- deliquescent

Key Equation

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

Part A Completion

Use this completion exercise to check your understanding of the concepts and terms that are introduced in this section. Each blank can be completed with a term, short phrase, or number.

Water is a polar liquid and an excellent ___1___ for many substances. Aqueous solutions are ___2___ mixtures of ions or molecules in water. The solubility of a solute depends on solute-solvent interactions. A good rule to remember is ___3___.

Substances that dissolve as ions are known as ___4___. A solute that is completely ionized in solution is a ___5___ electrolyte. A weak electrolyte is only ___6___ ionized. A solution of an electrolyte will ___7___ an electric current, whereas a solution of a ___8___ is nonconducting.

Many crystals are ___9___; they contain water of hydration. In the process called ___10___, the water of hydration is lost from a hydrate that is exposed to the air.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

Name _____ Class _____ Date _____

Part B True-False

Classify each of these statements as always true, AT; sometimes true, ST; or never true, NT.

_____ **11.** Carbon tetrafluoride is a nonelectrolyte.

_____ **12.** Hydrates are crystals that contain a fixed quantity of water within their structure.

_____ **13.** Covalent solutes are very soluble in water.

_____ **14.** Solutions are always homogeneous.

Part C Matching

Match each description in Column B to the correct term in Column A.

Column A	Column B
_____ **15.** aqueous solutions	**a.** the dissolved particles in a solution
_____ **16.** solute	**b.** compounds that conduct electric current in aqueous solution
_____ **17.** solvation	**c.** able to remove moisture from air
_____ **18.** electrolyte	**d.** water samples containing dissolved substances
_____ **19.** nonelectrolytes	**e.** drying agents
_____ **20.** water of hydration	**f.** compounds that do not conduct electric current in aqueous solution
_____ **21.** hygroscopic	**g.** water contained in the crystal structure of a compound
_____ **22.** dessicants	**h.** process that occurs when a solute dissolves

Part D Questions and Problems

Answer the following questions or problems in the space provided. Show your work.

23. Calculate the percent by mass of water in Glauber's salt ($Na_2SO_4 \cdot 10H_2O$).

24. Which of the following substances dissolve to a significant extent in water?

a. C_6H_6

b. NaCl

c. Na_2SO_4

d. N_2

Name _____ Class _____ Date _____

17.4 HETEROGENEOUS AQUEOUS SYSTEMS
SECTION REVIEW

Objectives

- Explain how colloids and suspensions differ from solutions
- Describe the Tyndall effect

Key Terms

- suspension
- colloids
- Tyndall effect
- Brownian motion
- emulsions

Part A Completion

Use this completion exercise to check your understanding of the concepts and terms that are introduced in this section. Each blank can be completed with a term, short phrase, or number.

The component particles of a suspension are much __1__ than those of a solution. Gravity or __2__ will separate the suspended particles from a suspension. The particles in a colloid generally do not settle under gravity, and they pass through ordinary filter paper unchanged. __3__ are good at scattering light, as are suspensions, as evidenced by the __4__. Colloidal dispersions also exhibit __5__ motion. The particles in solutions are small __6__ or __7__. They cannot be trapped by filter paper, nor do they exhibit the Tyndall effect.

__8__ are colloidal dispersions of liquids in liquids. Emulsifying agents maintain the __9__ of an emulsion and allow the formation of __10__ for liquids that do not ordinarily mix.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

Part B True-False

Classify each of these statements as always true, AT; sometimes true, ST; or never true, NT.

_____ **11.** The scattering of light by colloidal particles is called Brownian motion.

_____ **12.** Heterogeneous aqueous systems can be separated by filtration.

_____ **13.** Emulsifying agents are essential to forming and maintaining emulsions.

_____ **14.** Colloids are dispersions of liquids in liquids.

_____ **15.** The random motion of particles is known as the Tyndall effect.

Part C Matching

Match each description in Column B to the correct term in Column A.

Column A	Column B
_____ **16.** suspensions	**a.** chaotic movement of colloidal particles
_____ **17.** colloids	**b.** heterogeneous mixtures containing particles intermediate in size between those of suspensions and solutions
_____ **18.** Tyndall effect	**c.** substance necessary to the formation and stability of an emulsion
_____ **19.** Brownian motion	**d.** scattering of visible light by colloidal particles
_____ **20.** emulsions	**e.** mixtures from which particles settle on standing
_____ **21.** emulsifying agent	**f.** dispersions of liquids in liquids

Part D Questions and Problems

Answer the following questions in the space provided.

22. What is the typical particle size in a colloidal dispersion?

a. greater than 100 nm

b. 1 nm to 100 nm

c. less than 1 nm

d. There are no particles in a colloidal dispersion.

23. What is the typical particle size in a suspension?

a. greater than 100 nm

b. 1 nm to 100 nm

c. less than 1 nm

d. There are no particles in a suspension.

Name _____ Class _____ Date _____

17 WATER AND AQUEOUS SYSTEMS
PRACTICE PROBLEMS

In your notebook, answer the following questions and problems.

SECTION 17.1 LIQUID WATER AND ITS PROPERTIES

1. In your own words, explain what a hydrogen bond is.
2. Depict the hydrogen bonding between three water molecules.
3. How is hydrogen bonding responsible for the high boiling point of water?
4. Explain how large bodies of water are able to moderate air temperature.
5. How much heat is needed to raise the temperature of 10.0 g of liquid water from 20.0 °C to 30.0 °C? How much heat is needed to raise the temperature of the same mass of iron through the same range of temperature? What is the ratio of the amounts of energy needed to raise the temperature of 10.0 g of water and 10.0 g of iron by 10 °C respectively? (The specific heat capacities of $H_2O(l)$ and $Fe(s)$ are 4.18 J/(g × °C) and 0.447 J/(g × °C) respectively.)

SECTION 17.2 WATER VAPOR AND ICE

1. Explain why it gets warmer before it rains.
2. How much energy in kilojoules is released when 180.0 g of water vapor at 100 °C condenses to liquid water at the same temperature? (The molar heat of condensation for water is $\Delta H_{cond} = -40.7$ kJ/mol.)
3. How much energy in kilojoules is required to change 78.3 g of ice at 0 °C to liquid water at the same temperature? (The molar heat of fusion for water is $\Delta H_{fus} = 6.01$ kJ/mol.)
4. Explain why the density of ice at 0 °C is less than the density of liquid water at 0 °C.

SECTION 17.3 AQUEOUS SOLUTIONS

1. Identify the solute and solvent in a dilute aqueous solution of potassium chloride.
2. Write an equation showing how ammonia is ionized when it dissolves in water.
3. Give an example of a polar molecular compound that dissolves in water and that is a nonelectrolyte.
4. Explain the meaning of the term *hygroscopic*.
5. Which of the following compounds are soluble in water? Which are insoluble?
   a. $CaCl_2$
   b. N_2
   c. HBr
   d. $NH_4C_2H_3O_2$

6. Write equations to show how the following compounds dissociate in water.
   a. NH_4NO_3
   b. KOH
7. Write the formulas for the following hydrates.
   a. Calcium sulfate dihydrate
   b. Cobalt(II) chloride hexahydrate
8. Find the percent by mass of water in $NiCl_2 \cdot 6H_2O$.

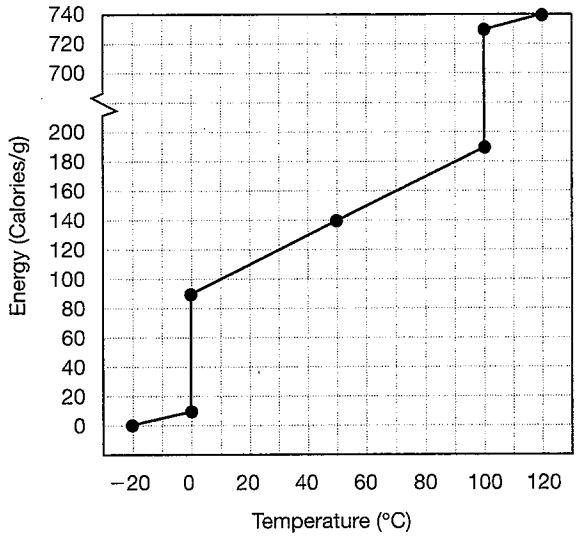
SECTION 17.4 HETEROGENEOUS AQUEOUS SYSTEMS

1. Distinguish colloids and suspensions from solutions by discussing their properties.
2. What is Brownian motion?
3. Classify each of the following mixtures as a colloid, suspension, or solution.
   a. fog
   b. milk
   c. sodium chloride dissolved in water
   d. cornstarch in water
   e. potting soil shaken with water
   f. soap suds
   g. a mixture of sucrose and water

Name _____ Class _____ Date _____

17 INTERPRETING GRAPHICS

USE WITH SECTION 17.2



The graph above plots energy vs. temperature as one gram of water is converted from ice at −20 °C to steam at 120 °C.

Use the graph above to answer the questions below.

1. What is the approximate specific heat capacity of ice?

2. What is the approximate specific heat capacity of steam?

3. How many calories of heat are needed to heat 1.00 gram of ice at −20 °C to steam at 120 °C?

Name _____ Class _____ Date _____

4. How many calories of heat are required to heat 1.00 gram of ice at 0 °C to water at 50 °C?

5. What is the heat of fusion of water?

6. How many calories of heat are required to heat 1.00 gram of water at 50 °C to steam at 100 °C?

7. Explain why the heating curve becomes vertical at 0 °C and 100 °C.

Name _____ Class _____ Date _____

17 VOCABULARY REVIEW

Each clue describes a vocabulary term. Read the clues and write the letters of each term on the lines provided.

1. Clue: hygroscopic substances used as drying agents.
   ___ ___ ___ ___ ___ ◯ ◯ ___ ___ ___

2. Clue: a relatively strong intermolecular force responsible for water's high surface tension.
   ___ ___ ___ ___ ___ ___ ◯ ___ ___ ___ ___ ___ ___ ___ ___

3. Clue: the amount of energy needed to change 1 gram of a substance to a gas at the boiling point.
   ___ ___ ___ ◯ ___ ___
   ___ ___ ◯ ___ ___ ___ ___ ◯ ___ ___ ◯ ___

4. Clue: a solution in which the solvent is water.
   ___ ◯ ◯ ◯ ___ ___ ___ ___ ___ ◯ ___ ___ ◯ ___ ___

5. Clue: the dissolving medium in a solution.
   ___ ___ ___ ◯ ___ ___ ___

6. Clue: a wetting agent that interferes with hydrogen bonding in water.
   ___ ___ ◯ ___ ◯ ___ ___ ___ ___ ___

7. Clue: a substance that completely dissociates into its ions in solution.
   ___ ___ ◯ ___ ___ ___ ◯ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___

8. Clue: the water loosely held in a crystal structure.
   ◯ ___ ___ ___ ___ ___ ___ ___ ___ ◯ ___ ___ ___ ◯ ___ ___

9. Clue: the chaotic movement of particles in a solution.
   ___ ◯ ___ ◯ ___ ___ ___ ___ ___ ___ ◯ ◯ ___ ___

Write the letters found inside the circles on the lines below. Then unscramble them to find the three states of a substance essential for life on Earth.

SCRAMBLED LETTERS:

___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___

___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___

SOLUTION:

1. ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___
2. ___ ___ ___
3. ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___

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17 WATER AND AQUEOUS SYSTEMS

Quiz for CHAPTER 17

Some Properties of Water

Specific Heat	*4.18 J/(g × °C)*
Heat of vaporization	*2.26 kJ/g*
Heat of fusion	*334 J/g*

Write the letter of the best answer in the blank.

_____ **1.** The attractions between adjacent water molecules are called: *17.1*
a. hydrogen bonds. **c.** nonpolar covalent bonds.
b. ionic bonds. **d.** polar covalent bonds.

_____ **2.** Surface tension is: *17.1*
a. the inward force that tends to minimize the surface area of a liquid.
b. increased by detergents.
c. decreased by hydrogen bonding.
d. all of the above

_____ **3.** How many joules are needed to raise the temperature of 10.0 g of water from 15.0 °C to 35 °C? *17.1*
a. 41.8 J **c.** 836 J
b. 150 J **d.** 627 J

_____ **4.** Which of the following is an example of a strong electrolyte? *17.3*
a. acetic acid **c.** NaCl
b. sucrose **d.** H_2O

_____ **5.** Which of the following mixtures do *not* exhibit the Tyndall effect? *17.4*
a. colloids **c.** emulsions
b. solutions **d.** suspensions

Fill in the word(s) that will make each statement true.

6. In a solution, the dissolved particles are known as the _____. *17.3*

7. In a solution, the dissolving medium is called the _____. *17.3*

8. Water samples containing dissolved substances are called _____. *17.3*

9. The expression "_____" sums up the dissolving of polar or nonpolar solvents and solutes. *17.3*

Solve the following problem in the space provided. Show your work.

10. How much energy is released when 12 g of steam at 100 °C condense to 12 g of water at 100 °C? *17.2*

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CHAPTER TEST A

A. Completion

Fill in the word(s) that will make each statement true.

1. A compound that does not conduct an electric current in aqueous solution or when molten is called a(n) ___1___. 1. _____

2. A substance is said to be ___2___ when it is able to remove sufficient water from the air to dissolve completely and form a solution. 2. _____

3. A mixture from which some of the particles will settle slowly upon standing is a(n) ___3___. 3. _____

4. The dissolving medium of a solution is called the ___4___. 4. _____

5. A hydrate will ___5___ if its vapor pressure is higher than the vapor pressure of the water vapor in the air. 5. _____

6. The chaotic movements of colloidal particles are known as ___6___. 6. _____

7. ___7___ are colloidal dispersions of liquids in liquids. 7. _____

8. A ___8___ contains water molecules that form part of its crystal structure. 8. _____

9. The scattering of visible light in all directions by colloids or suspensions is called the ___9___. 9. _____

10. ___10___ is the inward force or pull that tends to minimize the surface area of a liquid. 10. _____

B. Multiple Choice

Write the letter of the best answer in the blank.

_____ **11.** The high surface tension of water is due to the:
- **a.** small size of water molecules.
- **b.** low mass of water molecules.
- **c.** hydrogen bonding between water molecules.
- **d.** covalent bonds in water molecules.

_____ **12.** Salts and other compounds that remove moisture from air are said to be:
- **a.** efflorescent.
- **b.** surfactant.
- **c.** colloidal.
- **d.** hygroscopic.

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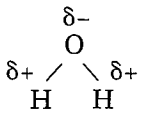
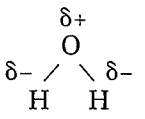
_____ **13.** A water molecule is best represented by:

a.


b. H—O—H

c.


d. H—H—O

_____ **14.** Based *solely* upon its formula mass, one would expect water to:
a. have a high boiling point.
b. have a low boiling point.
c. be a solid at room temperature.
d. be a liquid at room temperature.

_____ **15.** The density of ice is less than the density of water because:
a. ice has a lower molecular mass than water.
b. the same mass occupies a smaller volume.
c. the molecules are more closely packed.
d. hydrogen bonding in ice produces an open framework.

_____ **16.** A solution is a mixture:
a. from which the solute cannot be filtered.
b. that is colloidal.
c. that is heterogeneous.
d. in which a solid solute is always dissolved in a liquid solvent.

_____ **17.** Which of the following is *not* an electrolyte?
a. cane sugar(*aq*)
b. HCl(*aq*)
c. KCl(*aq*)
d. $(NH_4)_2SO_4(aq)$

_____ **18.** An electric current is conducted by:
a. a solution of NaCl.
b. a sugar solution.
c. solid NaCl.
d. solid sugar.

_____ **19.** How many water molecules are in two formula units of barium hydroxide octahydrate, $Ba(OH)_2 \cdot 8H_2O$?
a. 2
b. 8
c. 16
d. 20

_____ **20.** Which of these would you expect to be soluble in the nonpolar solvent carbon disulfide, CS_2?
a. $MgCl_2$
b. $CaCO_3$
c. CBr_4
d. H_2O

_____ **21.** Gelatin would best be classed as:
a. a colloidal dispersion.
b. a suspension.
c. a heterogeneous mixture.
d. an aqueous solution.

_____ **22.** A typical kind of emulsion is:
a. muddy water.
b. mayonnaise.
c. sea water.
d. smoke.

_____ **23.** When sodium chloride is mixed with water, it forms:
a. a dispersion.
b. an emulsion.
c. a solution.
d. a suspension.

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C. True-False

Classify each of these statements as always true, AT; sometimes true, ST; or never true, NT.

_____ **24.** Ionic solutes are very soluble in water.

_____ **25.** The condensation of steam is an exothermic process.

_____ **26.** Liquids decrease in density as they cool.

_____ **27.** Hydrates are hygroscopic.

_____ **28.** Rubbing alcohol, C_3H_7OH, is an electrolyte.

D. Problems

Solve the following problems in the space provided. Show your work.

29. What is the percentage by mass of water in the hydrate $CoCl_2 \cdot 6H_2O$?

30. How many calories are liberated when 72 g of steam are condensed to liquid water at 100 °C?

31. How many kilojoules are required to heat 39.5 g of liquid water from 15.0 °C to 48.0 °C?

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E. Essay

Write a short essay for the following.

32. Describe the process of solvation of ionic solids in water.

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CHAPTER TEST B

A. Completion

Fill in the word(s) that will make each statement true.

1. Salts and other compounds that remove moisture from air are said to be _____.
2. When a solute dissolves, the process is referred to as _____.
3. When salt is dissolved in water, the salt particles are referred to as the _____.
4. In terms of their effect on the surface tension of water, wetting agents such as soaps and detergents are called _____.
5. Another name for drying agents is _____.
6. Mixtures containing particles that are intermediate in size between those of suspensions and true solutions are called _____.
7. Water samples containing dissolved substances are called _____ solutions.
8. Surface tension is explained by the ability of water to form _____ bonds.
9. Compounds that do not conduct an electric current in either aqueous solution or when molten are referred to as _____.
10. When a hydrate loses its water of hydration, it is said to _____.

B. Multiple Choice

Choose the best answer and write its letter in the blank.

_____ **11.** The hydrogen bonding that occurs in water accounts for water's:
- **a.** high vapor pressure.
- **b.** high specific heat capacity.
- **c.** low boiling point.
- **d.** all of the above

_____ **12.** A liquid that has strong intermolecular attractions has:
- **a.** a high surface tension.
- **b.** an intermediate surface tension.
- **c.** a low surface tension.
- **d.** no surface tension.

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_____ **13.** If the heat of vaporization of water is 2.26 kJ/g at 100 °C, how many kJ would be required to vaporize 9.00 g of water at 100 °C?
a. 1.13 kJ **c.** 22.6 kJ
b. 20.3 kJ **d.** 0.251 kJ

_____ **14.** Ice floats on liquid water because its density is:
a. lower than that of liquid water.
b. the same as that of liquid water.
c. higher than that of liquid water.
d. none of these

_____ **15.** If the heat of solidification of water is 334 J/g at 0 °C, how many kJ of heat are released when 15 g of water freeze at 0 °C?
a. 0.022 kJ **c.** 22 kJ
b. 5.0×10^3 kJ **d.** 5.0 kJ

_____ **16.** If salt is dissolved in water, water serves as the:
a. solute. **c.** dissolved medium.
b. solvent. **d.** none of these

_____ **17.** Which of the following would be expected to dissolve very readily in water?
a. CH_4 **c.** NaOH
b. H_2 **d.** CBr_4

_____ **18.** Which of the following would be expected to dissolve readily in the nonpolar solvent CCl_4?
a. table salt **c.** grease
b. KNO_3 **d.** $Ca(OH)_2$

_____ **19.** The electrolyte among the following is:
a. KCl. **c.** NH_4OH.
b. $Mg(NO_3)_2$. **d.** all of these

_____ **20.** Mixtures from which some of the particles will settle slowly upon standing are referred to as:
a. homogeneous. **c.** suspensions.
b. solutions. **d.** colloids.

_____ **21.** The scattering of a beam of light as it passes through a colloid is referred to as:
a. efflorescence. **c.** the Tyndall effect.
b. Brownian motion. **d.** deliquescence.

_____ **22.** Smoke is an example of a(n):
a. solution. **c.** colloid.
b. suspension. **d.** emulsion.

_____ **23.** Which of the following is true about hygroscopic substances?
a. They have low vapor pressures.
b. They remove moisture from the air.
c. They can be used as drying agents.
d. all of these

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_____ **24.** What is the percent by mass of water in $MgSO_4 \cdot 7H_2O$?

a. 51.1%
b. 195%
c. 56.0%
d. 21.0%

C. True-False

Classify each of these statements as always true, AT; sometimes true, ST; or never true, NT.

_____ **25.** Detergents are used in washing clothes because they reduce the surface tension of water.

_____ **26.** Since the specific heat capacity of iron is less than that of water, more energy is required to raise the temperature of one gram of iron by one degree than for one gram of water by that same amount.

_____ **27.** The vaporization of water is an endothermic process.

_____ **28.** Solids can float in their own liquids.

_____ **29.** As a general rule, like dissolves like.

_____ **30.** All ionic compounds are electrolytes.

_____ **31.** The strength of an aqueous electrolyte is determined by the extent to which the solute particles ionize.

_____ **32.** In general, the particles in a colloid are larger than those in a suspension.

_____ **33.** Brownian motion is caused by the water molecules of the medium colliding with the small, dispersed colloidal particles dissolved in that medium.

_____ **34.** Soaps and detergents are good emulsifying agents.

D. Problems

Solve the following problems in the space provided. Show your work.

35. How many kilojoules would be required to vaporize 0.250 mol of water at 100 °C?

36. How much heat would be released (in J) if 12.0 g of steam condense to water at 100 °C?

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37. How much heat (in kJ) would be required to melt 3.5 mol of ice at 0 °C to water at 0 °C?

38. Determine the percent by mass of water in $Na_2SO_4 \cdot 10H_2O$.

E. Essay

Write a short essay for the following.

39. Using at least two of the concepts presented in this chapter, explain how soaps and detergents work in removing oil and grease from clothing.