Name _____ Date _____ Class _____

13 STATES OF MATTER

SECTION 13.1 THE NATURE OF GASES (pages 385–389)

This section introduces the kinetic theory and describes how it applies to gases. It defines gas pressure and explains how temperature is related to the kinetic energy of the particles of a substance.

▶ Kinetic Theory and a Model for Gases (pages 385–386)

1. The energy an object has because of its motion is called _kinetic energy_.

2. Circle the letter of each sentence that is true about the assumptions of the kinetic theory concerning gases.

(a.) A gas is composed of particles with insignificant volume that are relatively far apart from each other.

b. Strong attractive forces exist between particles of a gas.

c. Gases tend to collect near the bottom of a container.

(d.) The paths of uninterrupted travel of particles in a gas are relatively short because the particles are constantly colliding with each other or with other objects.

3. Is the following statement true or false? According to the kinetic theory, collisions between particles in a gas are perfectly elastic because kinetic energy is transferred without loss from one particle to another, and the total kinetic energy remains constant. _true_

▶ Gas Pressure (pages 386–387)

4. Gas pressure results from the force exerted by a gas per _unit surface area of an object_.

5. Simultaneous collisions of billions of particles in a gas with an object result in _gas pressure_.

6. What force holds the particles of air in Earth's atmosphere? _gravity_

7. What kind of pressure is measured with a barometer?

atmospheric pressure

Name _____ Date _____ Class _____

8. Look at Figure 13.2 on page 386. What accounts for the difference in height of the two mercury columns shown in the figure?

The mercury column on the left is shown at sea level; the one on the right is shown at an altitude of 9000 m. Because atmospheric pressure decreases as altitude increases, the column on the right is lower than the one on the left.

9. Circle the letter next to every name of a unit of pressure.

a. mm Hg
b. standard
c. pascal
d. kPa
e. atm
f. degree

10. Standard temperature and pressure (STP) are defined as a temperature of 0°C and a pressure of 101.3 kPa or 1 atm

▶ Kinetic Energy and Temperature (pages 388–389)

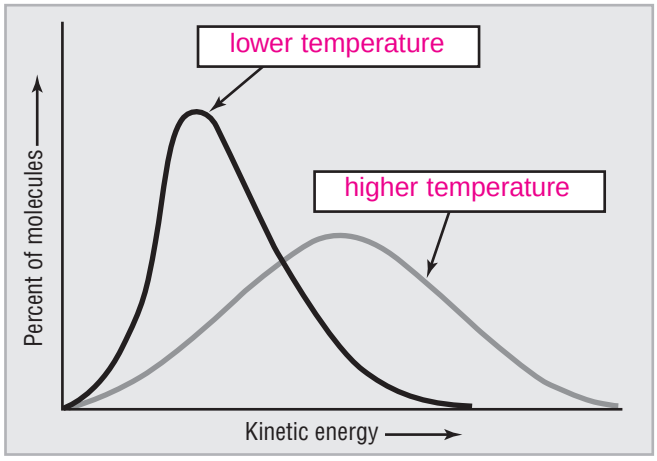
11. What happens to the temperature of a substance when the average kinetic energy of its particles increases?

The temperature of the substance increases.

12. Is the following statement true or false. All the particles in a substance at a given temperature have the same kinetic energy. false

13. The temperature 0K, or −273.15°C, is called kinetic energy zero. Theoretically, particles of matter at this temperature would have no kinetic energy/motion.

14. On the graph below, write the labels *lower temperature* and *higher temperature* to identify the curve that depicts the kinetic energy distribution of particles in a liquid at a lower temperature and at a higher temperature.



Name _____ Date _____ Class _____

15. Circle the letter of the temperature scale that correctly completes this sentence. Temperature on the _____ scale is directly proportional to the average kinetic energy of the particles of a substance.

a. Celsius

b. Kelvin

c. Fahrenheit

d. Centigrade

SECTION 13.2 THE NATURE OF LIQUIDS (pages 390–395)

This section describes a model for liquids in terms of kinetic energy and the attractive forces between the particles in a liquid. It also uses kinetic theory to distinguish evaporation from boiling.

▶ A Model for Liquids (page 390)

1. Is the following sentence true or false? The kinetic theory states that there are no attractions between the particles of a liquid.

false

2. Circle the letter next to each sentence that is true about the particles of a liquid.

a. Most of the particles in a liquid have enough kinetic energy to escape into a gaseous state.

b. Liquids are much denser than gases because intermolecular forces reduce the amount of space between the particles in a liquid.

c. Increasing pressure on a liquid has hardly any effect on its volume.

d. Liquid particles are free to slide past one another.

▶ Evaporation (page 391)

3. The conversion of a liquid to a gas or vapor is called vaporization .

4. When vaporization occurs at the surface of a liquid that is not boiling, the process is called evaporation .

5. As a liquid evaporates, why do only some of the particles break away from the surface of the liquid? Why does the liquid evaporate faster if the temperature is increased?

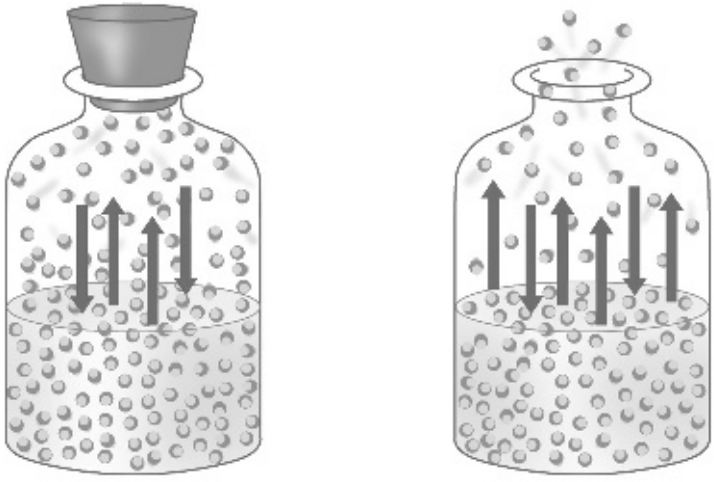
Most of the molecules do not have enough kinetic energy to overcome the attractive forces. As the temperature is increased, the average kinetic energy increases and more particles have enough kinetic energy to overcome the forces keeping them in the liquid state.

Name _____ Date _____ Class _____

CHAPTER 13, States of Matter *(continued)*

6. Is the following sentence true or false? Evaporation is a cooling process because the particles in a liquid with the highest kinetic energy tend to escape first, leaving the remaining particles with a lower average kinetic energy and, thus, a lower temperature. _____true_____

Questions 7, 8, 9, and 10 refer to either container A or container B below. Think of each container as a system involving both liquid water and water vapor.



(a) (b)

7. From which of the containers are water molecules able to escape? __b__

8. In which container can a dynamic equilibrium between water molecules in the liquid state and water molecules in the vapor state be established? __a__

9. In which container will the water level remain constant? __a__

10. From which container is it possible for all of the liquid water to disappear through evaporation? __b__

11. What causes the chill you may feel after stepping out of a swimming pool on a warm, windy day?

Wind causes water on the skin to evaporate, which is a cooling process.

Name _____ Date _____ Class _____

▶ Vapor Pressure (pages 392–393)

12. Circle the letter next to each sentence that is true about vapor pressure.

a. Vapor pressure arises when particles of a liquid in a closed, partly filled container vaporize and collide with the walls of the container.

b. After a time in a closed, partly filled container, a liquid will evaporate and its vapor will condense at equal rates.

c. Look at Figure 13.6b on page 391. Condensation on the inside of the terrarium indicates that there is not a liquid-vapor equilibrium in the sealed terrarium.

d. When the temperature of a contained liquid increases, its vapor pressure increases.

13. Look at Figure 13.7 on page 393. How does the vapor pressure of the ethanol in the manometer change when the temperature is increased from 0°C to 20°C? Circle the letter of the correct answer.

a. The vapor pressure decreases by more than 4 kPa.

b. The vapor pressure remains constant.

c. The vapor pressure increases by more than 4 kPa.

d. There is no way to detect a change in vapor pressure with a manometer.

▶ Boiling Point (pages 393–395)

14. The boiling point of a liquid is the temperature at which the vapor pressure of the liquid is just equal to the external pressure .

15. Look at Figure 13.8 on page 394. Why does the boiling point decrease as altitude increases?

At higher altitudes, atmospheric pressure is lower than it is at sea level. Because boiling occurs when vapor pressure is equal to atmospheric pressure, a liquid boils at a lower temperature.

16. Use Figure 13.9 on page 394. At approximately what temperature would ethanol boil atop Mount Everest, where the atmospheric pressure is 34 kPa? Circle the letter next to the best estimate.

a. 50°C **b.** 100°C **c.** 0°C **d.** 85°C

17. Is the following sentence true or false? After a liquid reaches its boiling point, its temperature continues to rise until all the liquid vaporizes. false

Reading Skill Practice

Writing a summary can help you remember what you have read. When you write a summary, include only the most important points. Write a summary of the discussion of boiling point on pages 393–395. Do your work on a separate sheet of paper.

Students' summaries should include a definition of boiling point and normal boiling point. They should also include the effects of pressure on the temperature of a boiling liquid.

SECTION 13.3 THE NATURE OF SOLIDS (pages 396–399)

This section describes the highly organized structures of solids, distinguishes between a crystal lattice and a unit cell, and explains how allotropes of an element differ.

▶ A Model for Solids (page 396)

1. Is the following sentence true or false? Although particles in solids have kinetic energy, the motion of particles in solids is restricted to vibrations about fixed points. _____true_____

2. A solid melts when _____the organization of its particles breaks down_____.

3. Is the following sentence true or false? The temperature at which the liquid and solid states of a substance are in equilibrium is the same as the melting point *and* the freezing point of the substance. _____true_____

▶ Crystal Structure and Unit Cells (pages 396–399)

4. How are particles arranged in a crystal?

They are arranged in an orderly, repeating, three-dimensional pattern.

5. What type of solid has a relatively low melting point?

A molecular solid has a relatively low melting point.

6. Do all solids melt when heated? Explain.

No; some solids, such as wood, decompose.

7. Circle the letter next to each sentence that is true about solids.

a. Most solid substances are not crystalline.

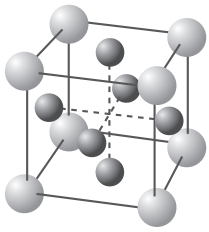
b. All crystals have sides, or faces, that intersect at angles that are characteristic for a given substance.

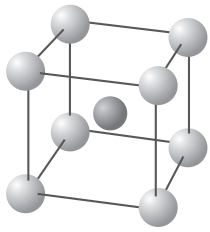
c. There are seven groups, or crystal systems, into which all crystals may be classified.

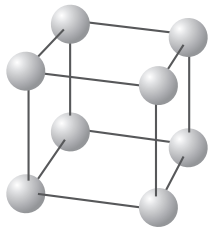
d. The orderly array of sodium ions and chloride ions gives crystals of table salt their regular shape.

Name _____ Date _____ Class _____

Identify the unit cell in each figure below as simple cubic, body-centered cubic, or face-centered cubic.







8. face-centered cubic **9.** body-centered cubic **10.** simple cubic

11. Is the following sentence true or false? Some solid substances can exist in more than one form. Give an example to support your answer.

True. The element carbon has at least three solid forms: graphite, diamond, and buckminsterfullerene.

12. Two or more different molecular forms of the same element in the same physical state are called allotropes .

13. What is an amorphous solid?

An amorphous solid lacks an ordered internal structure.

14. Circle the letter next to each solid that is an amorphous solid.

a. table salt **c.** plastic

b. rubber **d.** glass

15. How are glasses different from crystalline solids?

The internal structures of glasses are intermediate between free-flowing liquids and crystalline solids. Glasses do not have a definite melting point, but soften when heated. Glass breaks into irregular, jagged pieces when shattered.

SECTION 13.4 CHANGES OF STATE (pages 401–404)

This section describes the process of sublimation. It also explains phase changes between solid, liquid, and vapor states and how to interpret a phase diagram.

▶ Sublimation (page 401)

1. The process by which wet laundry dries on an outdoor clothesline in winter is called sublimation .

2. Is the following sentence true or false? Solids have vapor pressure because some particles near the surface of a solid substance have enough kinetic energy to escape directly into the vapor phase. true

▶ Phase Diagrams (pages 402–403)

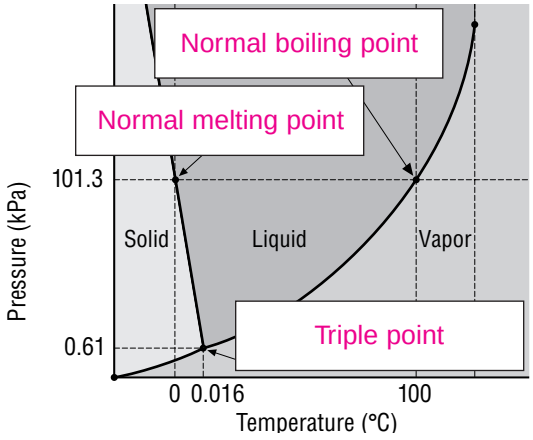
3. What does a phase diagram show?

A phase diagram shows the temperature and pressure conditions at which a substance exists in the solid, liquid, and vapor phases.

4. What is the triple point of a substance?

The triple point represents the only conditions of temperature and pressure at which three phases of a substance can exist in equilibrium.

5. In the phase diagram for water shown below, label the melting point and boiling point at normal atmospheric pressure, and the triple point.



6. Use the phase diagram above to answer the following question. Why is a laboratory required to produce the conditions necessary for observing water at the triple point?

From the diagram, the triple point of water is at a pressure of 0.61 kPa, far below atmospheric pressure. Laboratory equipment is necessary to achieve pressures this low.

Name _____ Date _____ Class _____

GUIDED PRACTICE PROBLEM

GUIDED PRACTICE PROBLEM 2 (page 387)

2. The pressure at the top of Mount Everest is 33.7 kPa. Is that pressure greater than or less than 0.25 atm?

Analyze

Step 1. To convert kPa to atm, what conversion factor do you need to use?

$\frac{1\ \text{atm}}{101.3\ \text{kPa}}$

Step 2. Why can you use an estimate to solve this problem?

Because "greater than or less than" questions don't require an exact answer. An estimate will probably be sufficient to produce the correct answer.

Calculate

Step 3. Write the expression needed to find the answer.

$33.7\ \cancel{\text{kPa}} \times \frac{1\ \text{atm}}{101.3\ \cancel{\text{kPa}}} = \frac{33.7}{101.3}\ \text{atm}$

Step 4. Which common fraction is this number close to?

$\frac{33.7}{101.3}$ atm is close to $\frac{33}{99}$ atm or $\frac{1}{3}$ atm.

Step 5. What is this fraction written as a decimal? Is this number greater than or less than 0.25?

0.333 is greater than 0.25.

Evaluate

Step 6. Are you confident your estimate gave a correct answer to this problem?

Because the estimate is more than 30% greater than 0.25, you can be confident that the difference isn't due to rounding.

EXTRA PRACTICE (similar to Practice Problem 1, page 387)

1. What pressure, in atmospheres, does a gas exert at 152 mm Hg?

$152\ \cancel{\text{mm Hg}} \times \frac{1\ \text{atm}}{760\ \cancel{\text{mm Hg}}} = 0.200\ \text{atm}$

What is this pressure in kilopascals?

$0.200\ \cancel{\text{atm}} \times \frac{101.3\ \text{kPa}}{\cancel{1\ \text{atm}}} = 20.3\ \text{kPa}$