Activities for chapter 13: States of matter

- What do I already know about states of matter? (index card) and Vocabulary table
- Chapter 13 reading guide (feb break assignment) and Powerpoints
- POGIL activities: (1) Kinetic Molecular Theory; (2) Phase Changes; (3) Intermolecular forces of attraction (Group Work in class week of feb 14 and finish for HW)
- Video animations on (1) molecular motion and (2) phase changes
- Heating curves and cooling curves
- Lab – cooling for lauric acid
- Practice problems for conversions involving pressure units and conversions for temperature between Celcius and kelvin scales (Using information from regents reference tables)

Kinetic Theory and a Model for Gases

The word *kinetic* refers to motion. The energy an object has because of its motion is called **kinetic energy.**

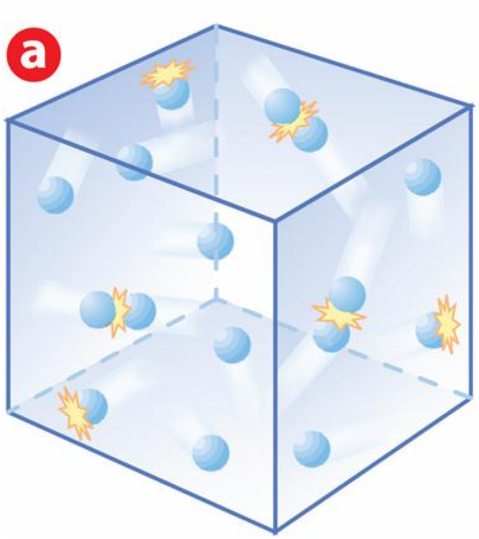
According to the **kinetic theory,** all matter consists of tiny particles that are in constant motion.

What are the three assumptions of the kinetic theory (kinetic molecular theory) as it applies to gases?

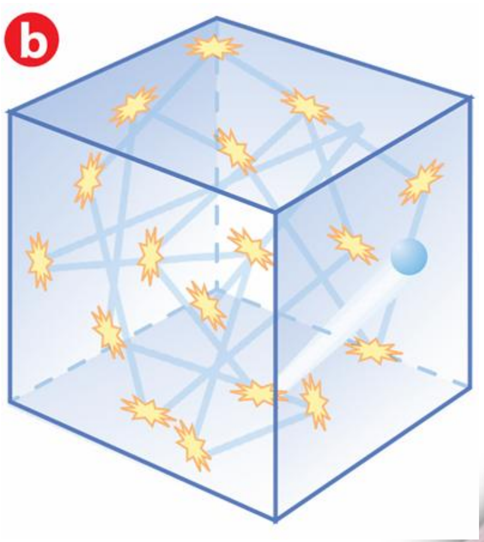
According to kinetic theory:

- The particles in a gas are considered to be small, hard spheres with an insignificant volume.
- The motion of the particles in a gas is rapid, constant, and random.
- All collisions between particles in a gas are perfectly elastic.

Particles in a gas are in rapid, constant motion.



Gas particles travel in straight-line paths.



Gas Pressure

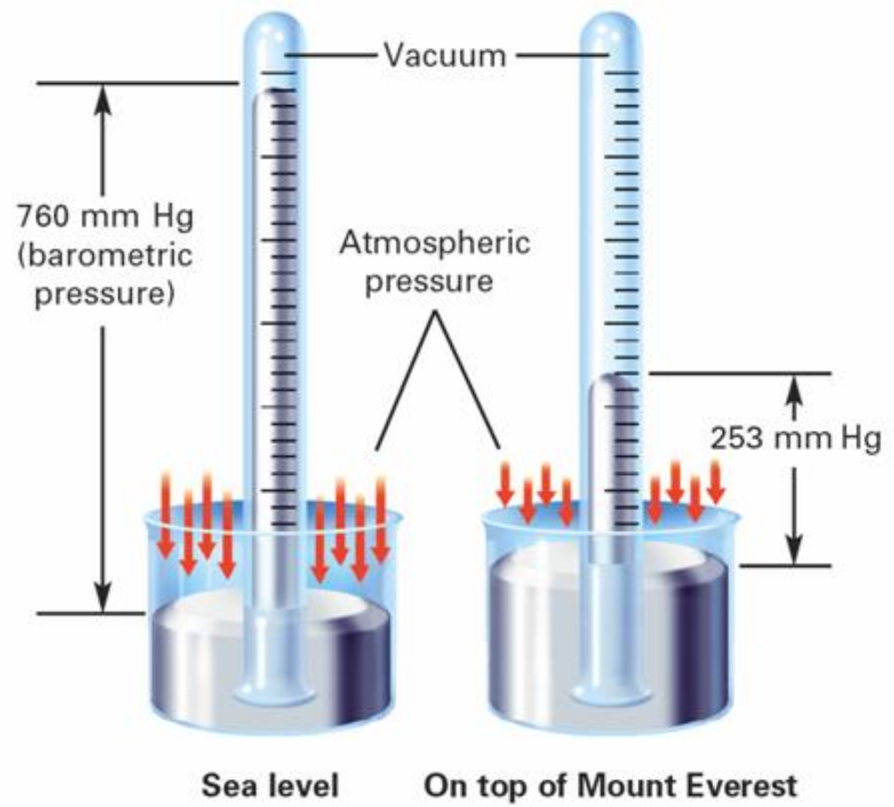
How does kinetic theory explain gas pressure?

Gas pressure results from the force exerted by a gas per unit surface area of an object.

- An empty space with no particles and no pressure is called a **vacuum**.
- **Atmospheric pressure** results from the collisions of atoms and molecules in air with objects.

Gas pressure is the result of simultaneous collisions of billions of rapidly moving particles in a gas with an object.

A **barometer** is a device that is used to measure atmospheric pressure.



- The SI unit of pressure is the **pascal (Pa).**
- One **standard atmosphere (atm)** is the pressure required to support 760 mm of mercury in a mercury barometer at 25° C.

$$1 \text{ atm} = 760 \text{ mm Hg} = 101.3 \text{ kPa}$$

SAMPLE PROBLEM 13.1

Converting Between Units of Pressure

A pressure gauge records a pressure of 450 kPa. What is this measurement expressed in atmospheres and millimeters of mercury?

Analyze ***List the knowns and the unknowns.***

Knowns

- pressure = 450 kPa
- 1 atm = 101.3 kPa
- 1 atm = 760 mm Hg

Unknowns

- pressure = ? atm
- pressure = ? mm Hg

For converting kPa ⟶ atm, the appropriate conversion factor is

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

For converting kPa ⟶ mm Hg, the appropriate conversion factor is

$$\frac{760 \text{ mm Hg}}{101.3 \text{ kPa}}$$

Calculate ***Solve for the unknowns.***

$$450 \text{ kPa} \times \frac{1 \text{ atm}}{101.3 \text{ kPa}} = 4.4 \text{ atm}$$

$$450 \text{ kPa} \times \frac{760 \text{ mm Hg}}{101.3 \text{ kPa}} = 3400 \text{ mm Hg} = 3.4 \times 10^3 \text{ mm Hg}$$

Evaluate ***Do the results make sense?***

Because the first conversion factor is much less than 1 and the second much greater than 1, it makes sense that the values expressed in atm and mm Hg are respectively smaller and larger than the value expressed in kPa.

1. What pressure, in kilopascals and in atmospheres, does a gas exert at 385 mm Hg?

Kinetic Energy and Temperature

What is the relationship between the temperature in kelvins and the average kinetic energy of particles?

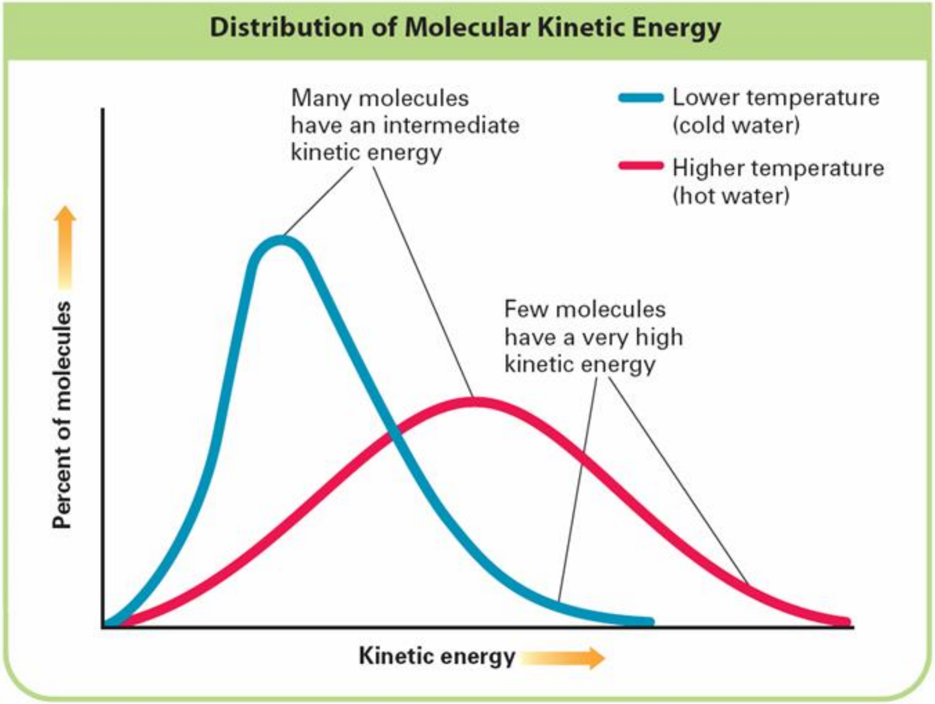
The Kelvin temperature of a substance is directly proportional to the average kinetic energy of the particles of the substance.

See Animation of molecular motion at:
http://www.wwnorton.com/college/chemistry/gilbert2/contents/ch10/studyplan.asp

See website for heating and cooling curves and KMT:
http://www.kentchemistry.com/links/Matter/HeatingCurve.htm

Average Kinetic Energy

The particles in any collection of atoms or molecules at a given temperature have a wide range of kinetic energies. Most of the particles have kinetic energies somewhere in the middle of this range.



Absolute zero

(0 K, or –273.15° C) is the temperature at which the motion of particles theoretically ceases.

- Particles would have no kinetic energy at absolute zero.
- Absolute zero has never been produced in the laboratory.

In this vacuum chamber, scientists cooled sodium vapor to nearly absolute zero.

13.1 Section Quiz.

Assess students' understanding of the concepts in Section 13.1.

Continue to:

-or-

Launch:

Section Quiz

ExamView® QuickTake

13.1 Section Quiz.

1. According to the kinetic theory, the particles in a gas

   a. are attracted to each other.

   b. are in constant random motion.

   c. have the same kinetic energy.

   d. have a significant volume.

2. The pressure a gas exerts on another object is caused by

   a. the physical size of the gas particles.

   b. collisions between gas particles and the object.

   c. collisions between gas particles.

   d. the chemical composition of the gas.

13.1 Section Quiz.

3. The average kinetic energy of the particles in a substance is directly proportional to the

a. Fahrenheit temperature.

b. Kelvin temperature.

c. molar mass of the substance.

d. Celsius temperature.

Hot lava oozes and flows, scorching everything in its path, and occasionally overrunning nearby houses. When the lava cools, it solidifies into rock. The **properties of liquids are related to intermolecular interactions**. You will learn about some of the properties of liquids.

End Show

A Model for Liquids

What factors determine the physical properties of a liquid?

a. Substances that can flow are referred to as fluids. Both liquids and gases are fluids.

Evaporation

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

When such a conversion occurs at the surface of a liquid that is not boiling, the process is called **evaporation**.

During evaporation, only those molecules with a certain minimum kinetic energy can escape from the surface of the liquid.

Evaporation

In an open container, molecules that evaporate can escape from the container.

In a closed container, the molecules cannot escape. They collect as a vapor above the liquid. Some molecules condense back into a liquid.

a Open container

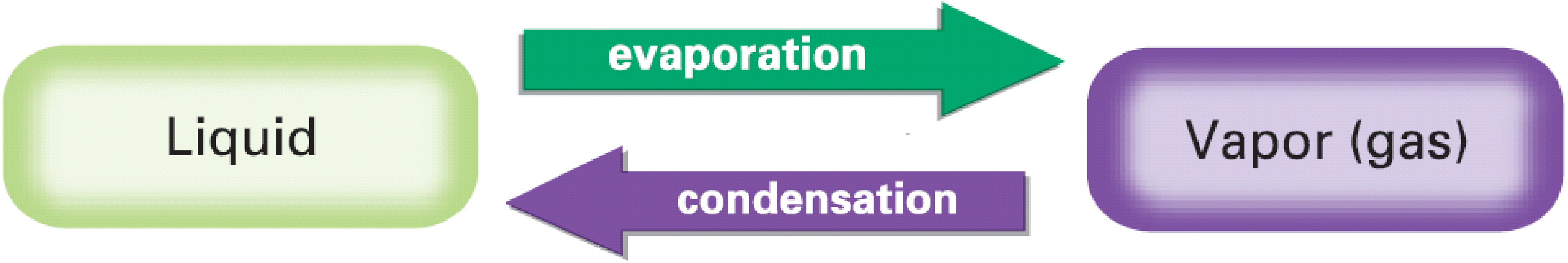
b Closed container

Vapor Pressure

When can a dynamic equilibrium exist between a liquid and its vapor?

Vapor Pressure

a. **Vapor pressure** is a measure of the force exerted by a gas above a liquid.



Vapor Pressure

In a system at constant vapor pressure, a dynamic equilibrium exists between the vapor and the liquid. The system is in equilibrium because the rate of evaporation of liquid equals the rate of condensation of vapor.

Vapor Pressure and Temperature Change

An increase in the temperature of a contained liquid increases the vapor pressure.

The particles in the warmed liquid have increased kinetic energy. As a result, more of the particles will have the minimum kinetic energy necessary to escape the surface of the liquid.

Vapor Pressure

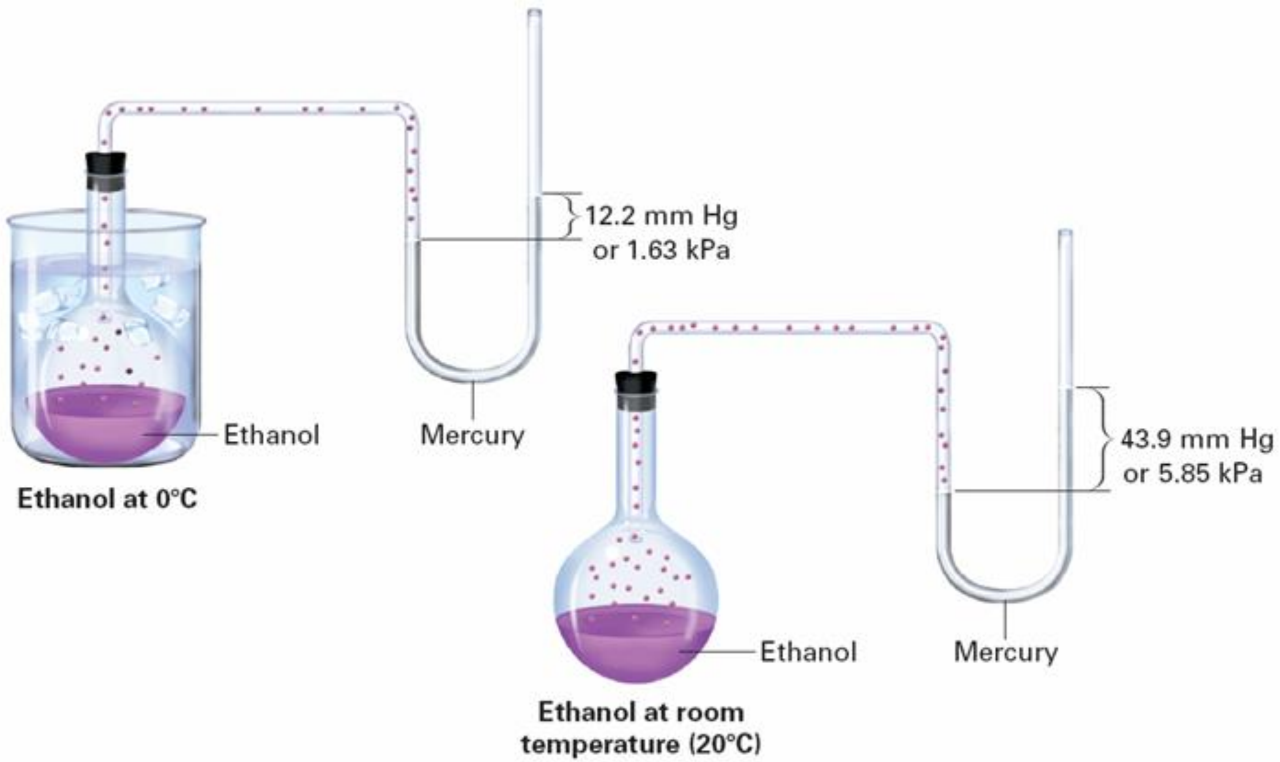
Table 13.1

Vapor Pressure (in kPa) of Three Substances at Different Temperatures

	0°C	20°C	40°C	60°C	80°C	100°C
Water	0.61	2.33	7.37	19.92	47.34	101.33
Ethanol	1.63	5.85	18.04	47.02	108.34	225.75
Diethyl ether	24.70	58.96	122.80	230.65	399.11	647.87

Vapor Pressure Measurements

The vapor pressure of a liquid can be determined with a device called a **manometer**.



Boiling Point

Under what conditions does boiling occur?

Boiling Point: Under what conditions does boiling occur?

When a liquid is heated to a temperature at which particles throughout the liquid have enough kinetic energy to vaporize, the liquid begins to boil.

The temperature at which the vapor pressure of the liquid is just equal to the external pressure on the liquid is the **boiling point (bp).**

Because a liquid boils when its vapor pressure is equal to the external pressure, liquids don't always boil at the same temperature.

Because a liquid can have various boiling points depending on pressure, the **normal boiling point** is defined as the boiling point of a liquid at a pressure of 101.3 kPa.

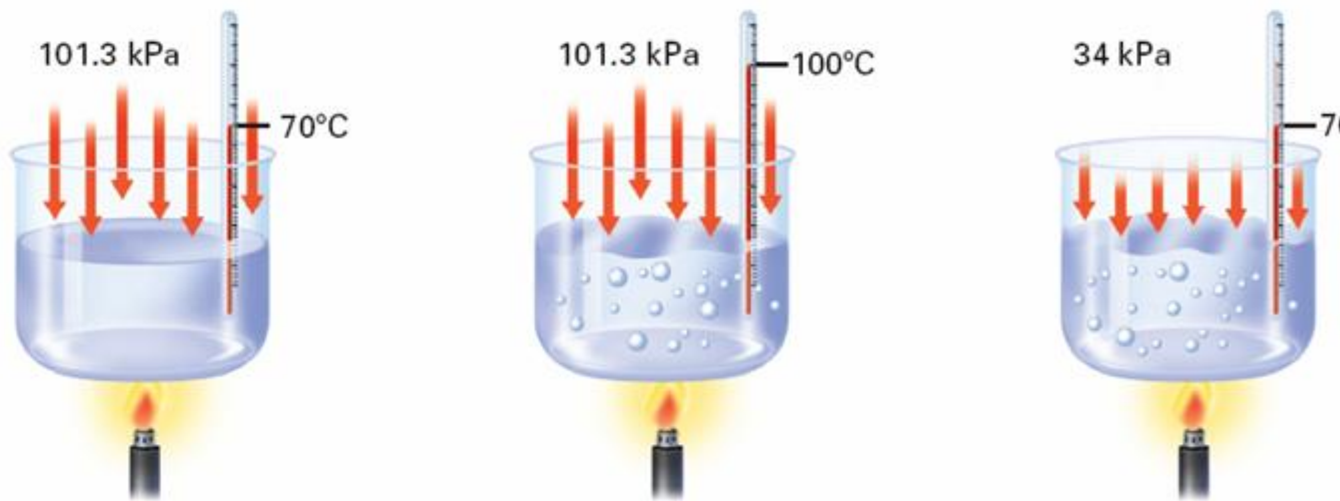
Boiling Point

a. Altitude and Boiling Point

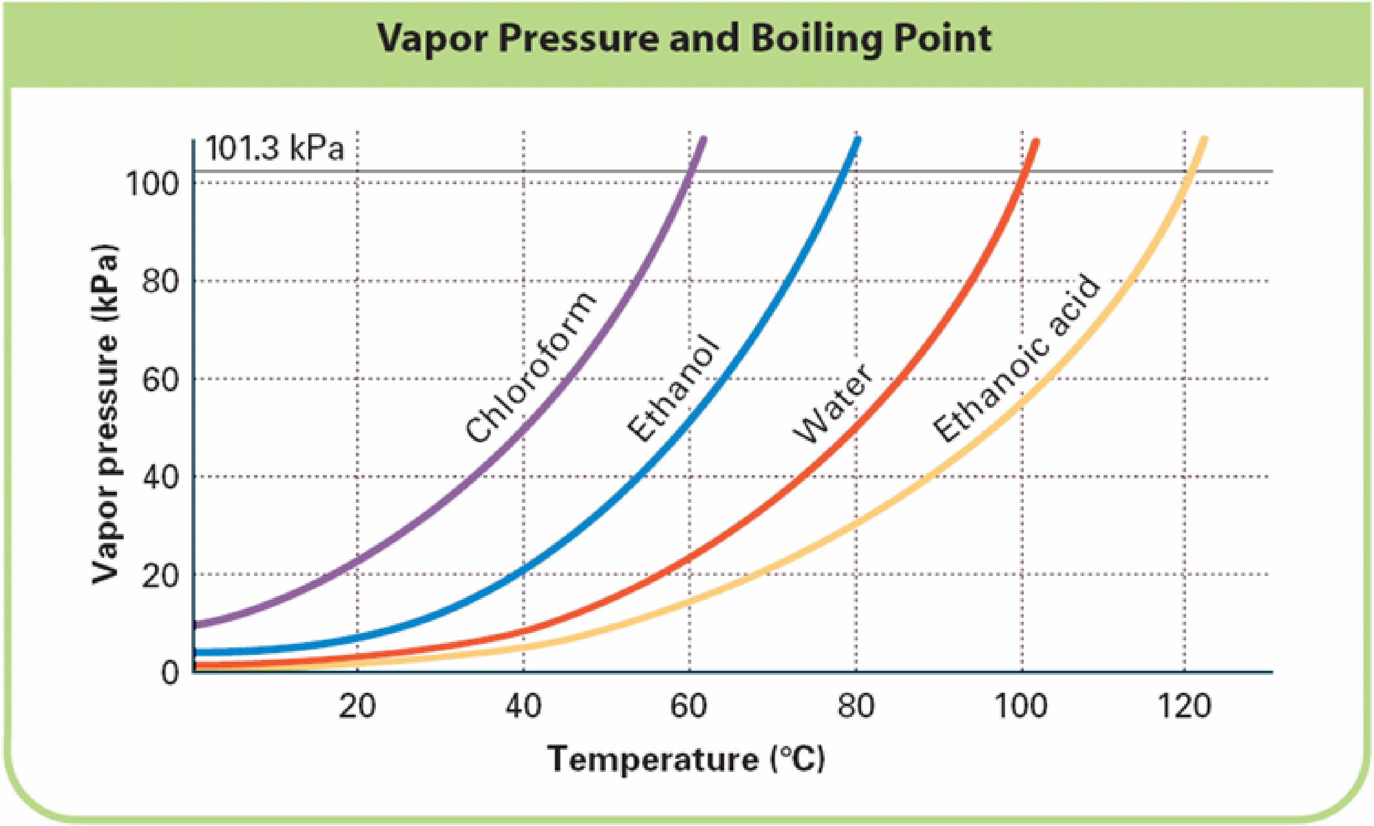
Sea Level Atmospheric pressure at the surface of water at 70°C is greater than its vapor pressure. Bubbles of vapor cannot form in the water, and it does not boil.

Sea Level At the boiling point, the vapor pressure is equal to atmospheric pressure. Bubbles of vapor form in the water, and it boils.

Atop Mount Everest At higher altitudes, the atmospheric pressure is lower than it is at sea level. Thus the water boils at a lower temperature.



Boiling Point



- See regents reference tables & POGIL on vapor pressure; see animation relating intermolecular forces to boiling point and vapor pressure

1. In liquids, the attractive forces are

a. very weak compared with the kinetic energies of the particles.

b. strong enough to keep the particles confined to fixed locations in the liquid.

c. strong enough to keep the particles from evaporating.

d. strong enough to keep particles relatively close together.

2. Which one of the following is a process that absorbs energy?

   a. freezing

   b. condensation

   c. evaporation

   d. solidifying

3. In a sealed gas-liquid system at constant temperature eventually

   a. there will be no more evaporation.

   b. the rate of condensation decreases to zero.

   c. the rate of condensation exceeds the rate of evaporation.

   d. the rate of evaporation equals the rate of condensation.

4. Where must particles have enough kinetic energy to vaporize for boiling to occur?

   a. at the surface of the liquid

   b. at the bottom of the container

   c. along the sides of the container

   d. throughout the liquid

5. The boiling point of a liquid

a. increases at higher altitudes.

b. decreases at higher altitudes.

c. is the same at all altitudes.

d. decreases as the pressure increases.