Name KEY Class _____ Date _____

13 States of Matter

Big Idea KINETIC THEORY

13.1 The Nature of Gases

Essential Understanding Temperature and pressure affect gases much more than they affect any other state of matter.

Kinetic Theory and a Model for Gases

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

2. **Summarize the 3 assumptions of the Kinetic Theory:**

1. Particles in a gas are considered to be small, hard spheres with an insignificant volume
2. The motion of particles in a gas is rapid, constant + random
3. All collisions between particles in a gas are perfectly elastic

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.

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

4. Gas pressure results from the force exerted by a gas per unit surface area.

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

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

The left column is at sea level and right is an altitude of 9000 m. Because atmospheric pressure decreases as altitude increases the colum on the right is lower

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 101.3kpa or 1atm

Kinetic Energy and Temperature

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

The temp of a substance increases

12. The temperature 0 K, or −273.15°C, is called absolute zero. Theoretically, particles of matter at this temperature would have no

kinetic energy/motion

Practice Problems:

1. What pressure, in kilopascals (kPa) AND in atmospheres (atm), does a gas exert at 385 mmHg? Show work using dimensional analysis.

$$385\ \text{mmHg} \left| \frac{101.3\ \text{kPa}}{760\ \text{mmHg}} \right. = 51.3\ \text{kPa}$$

$$385\ \text{mmHg} \left| \frac{1\ \text{atm}}{760\ \text{mmHg}} \right. = 0.507\ \text{atm}$$

Answers: 51.3 kPa and 0.507 atm

2. What pressure, in kilopascals (kPa) AND in mmHg, does a gas exert at 1.561 atm? Show work using dimensional analysis.

$$1.561\ \text{atm} \left| \frac{101.3\ \text{kPa}}{1\ \text{atm}} \right. = 158.1\ \text{kPa}$$

$$1.561\ \text{atm} \left| \frac{760\ \text{mmHg}}{1\ \text{atm}} \right. = 1186\ \text{mmHg}$$

Answers: 1186 mmHg and 158.1 kPa

3. The pressure at the top of mount Everest is 33.7 kPa. Is that pressure greater or less than 0.25 atm? Explain and show work.

greater

$$\frac{33.7\ \text{kPa}}{101.3\ \text{kPa}} \times 1\ \text{atm} = 0.33\ \text{atm} > 0.25\ \text{atm}$$

4. As the temperature of a gas increases, the average speed of its molecules _____.

A) decreases
(B) increases
C) remains constant
D) decreases, then increases
E) increases, then decreases

5. As the temperature of a substance **decreases**, the average kinetic energy of its particles _____.

(A) decreases
B) increases
C) remains constant
D) decreases, then increases
E) increases, then decreases

CH13 TEMPERATURE CONVERSIONS

The Formula to go from Celsius to Kelvin:	The Formula to go from Celsius to Fahrenheit:
°C + 273 = K	(°C × 1.8) + 32 = °F or 9/5

1. The recommended temperature of coffee is 82°C.
   82+273=
   (82×1.8)+32=
   Kelvin = 355K
   Fahrenheit = 179.6°F
2. The melting point of Aluminum is 660°C.
   660+273=
   (660×1.8)+32=
   Kelvin = 933K
   Fahrenheit = 1220°F
3. The coldest temperature recorded on Earth is -89°C.
   -89+273=
   (-89×1.8)+32=
   Kelvin = 184K
   Fahrenheit = -128.2°F
4. The hottest temperature recorded on Earth is 58°C.
   58+273=
   (58×1.8)+32=
   Kelvin = 331K
   Fahrenheit = 136.4°F
5. The average surface temperature of Saturn is -130°C.
   -130+273=
   (-130×1.8)+32=
   Kelvin = 143K
   Fahrenheit = -202°F
6. The temperature of camp fire is 897°C.
   897+273=
   (897×1.8)+32=
   Kelvin = 1170K
   Fahrenheit = 1646.6°F
7. The average surface temperature of Venus is 500°C.
   500+273=
   (500×1.8)+32=
   Kelvin = 773K
   Fahrenheit = 932°F
8. The average surface temperature of Jupiter is -121°C.
   -121+273=
   (-121×1.8)+32=
   Kelvin = 152K
   Fahrenheit = -185.8°F
9. The melting point of lead is 328°C.
   328+273=
   (328×1.8)+32=
   Kelvin = 601K
   Fahrenheit = 622.4°F
10. The average surface temperature of the Sun is 5507°C.
    5507+273=
    (5507×1.8)+32=
    Kelvin = 5780K
    Fahrenheit = 9944.6°F

13.2 The Nature of Liquids

Essential Understanding The properties and physical changes of liquids are the result of the particle motion and the attraction between particles in a liquid.

A Model for Liquids

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

14. 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.

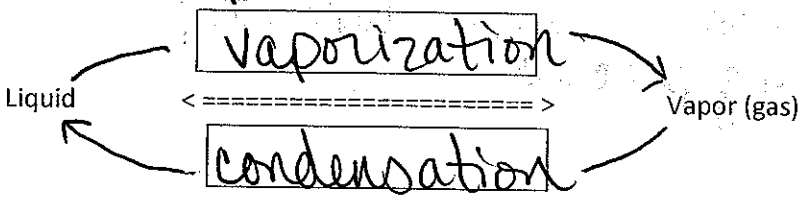
c. Increasing pressure on a liquid has almost no effect on its volume.

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

Evaporation

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

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

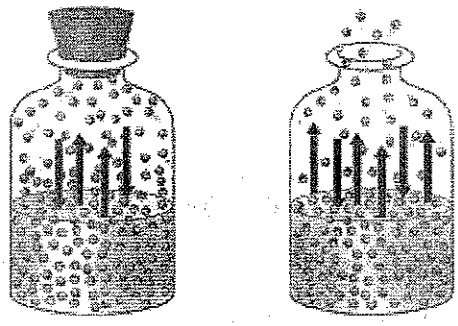


17. As a liquid evaporates, why do only some of the particles break away from the surface of the liquid? Why does the liquid evaporate faster if the temperature is increased?

Most of the molecules do not have enough kinetic energy to overcome the attractive forces. As the temperature ↑, the KE ↑ and more particles have enough KE to overcome the forces keeping them in the l state

18. 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 7–10 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)

19. From which of the containers are water molecules able to escape? B

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

21. In which container will the water level remain constant? A

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

23. 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

Vapor Pressure

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

(a.) Vapor pressure exists 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. Condensation on the inside of the terrarium indicates that there is no liquid-vapor equilibrium in the sealed terrarium.

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

Boiling Point

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

26. Look at Figure 13.8. Why does the boiling point decrease as altitude increases?

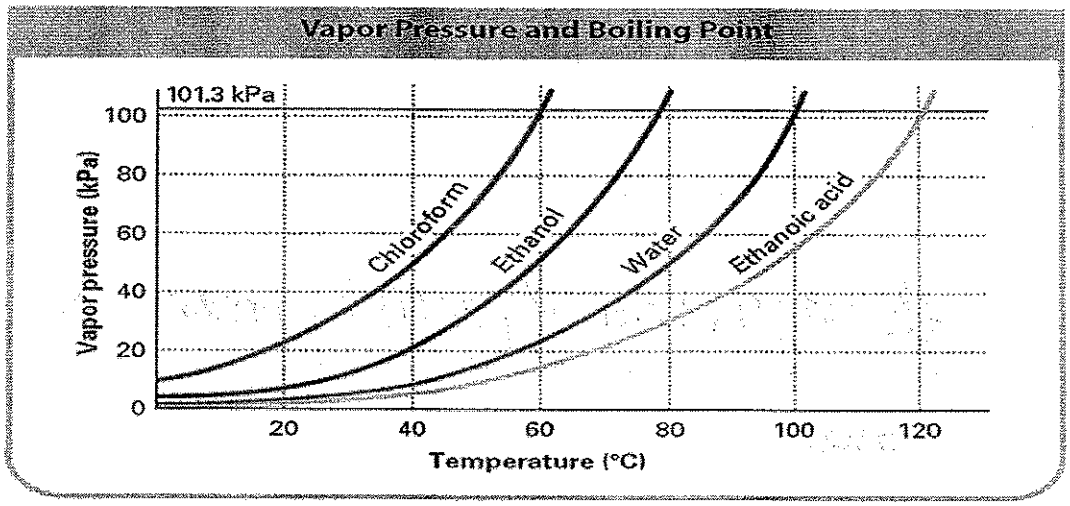
At higher altitudes atmospheric pressure is lower than at sea level. Because boiling occurs when vapor pressure = atmospheric pressure a liquid will boil at a lower temperature

27. Use Figure 13.9. 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

28. 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

Practice Problems:



1. What is the boiling point of chloroform at standard pressure (101.3 kPa)?

   60°C

2. What is the vapor pressure of ethanol at 40°C?

   20 kPa

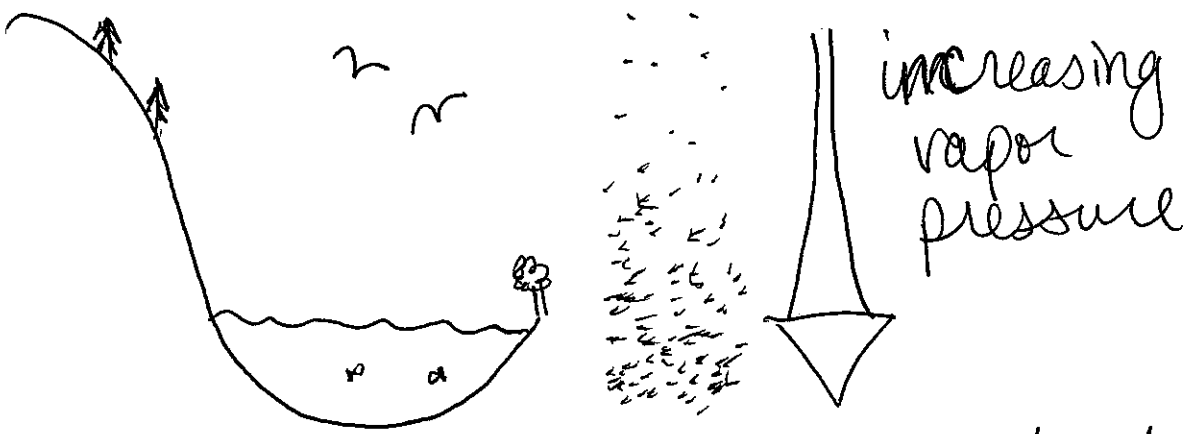
3. What would the atmospheric pressure need to be for ethanoic acid to boil at 80°C?

   25 kPa

4. What must the atmospheric pressure be in order get water to boil at 298K?

   ~5 kPa

5. Draw a diagram to show the relative amounts of atmospheric pressures at (1) below sea level, (2) at sea level, (3) above sea level. Then explain explain why pasta would take longer to cook on the top of Mount Everest than they would at sea level.
   Hint: use figure 13.8 in your text to help you



Pasta would take longer at a high altitude because the lower vapor pressure lowers the boiling pt which means it cooks at a lower temp. for longer.

13.3 The Nature of Solids

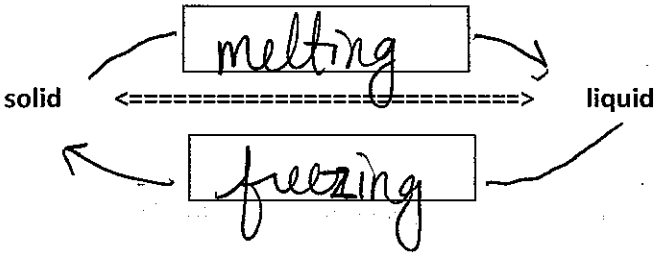
Essential Understanding The properties of solids are related to their structure.

A Model for Solids

29. 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

30. A solid melts when the organization of particles breaks down

31. 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



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13.3 THE NATURE OF SOLIDS

Section Review

Objectives

- Evaluate how the way particles are organized explains the properties of solids
- Identify the factors that determine the shape of a crystal
- Explain how allotropes of an element are different

Vocabulary

- melting point
- crystal
- unit cell
- allotropes
- amorphous solid
- glass

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.

Solids tend to be dense and difficult to __1__. They do not flow or take the shape of their containers, like liquids do, because the particles in solids vibrate around __2__ points. When a solid is heated until its particles vibrate so rapidly that they are no longer held in fixed positions, the solid __3__. The __4__ is the temperature at which a solid changes to a liquid. The melting and __5__ of a substance are at the same temperature. In general, ionic solids tend to have relatively __6__ melting points, while molecular solids tend to have relatively low melting points. Most solids are __7__. The particles are arranged in a pattern known as a crystal __8__. The smallest subunit of a crystal lattice is the __9__. Some solids lack an ordered internal structure and are called __10__ solids.

1. Compress
2. fixed
3. melts
4. melting pt
5. freezing pt
6. high
7. crystalline
8. lattice
9. unit cell
10. amphorous

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Part B True-False

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

AT 11. Glasses do not melt at a definite temperature, but soften gradually.

ST 12. Solid substances can exist in more than one form.

AT 13. Allotropes are two or more different elements that exist in the same state with the same crystal system.

ST 14. When the atoms in a solid have a random arrangement, the solid is a glass.

AT 15. The type of bonding that exists between the atoms in a crystal tends to determine the melting point of the solid.

Part C Matching

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

Column A	Column B
e 16. crystal	a. describes a solid in which the particles are randomly arranged
c 17. unit cell	b. transparent fusion products of inorganic substances that have cooled to a rigid state without crystallizing
f 18. rhombohedral	c. the smallest group of particles within a crystal that retains the geometric shape of the crystal
a 19. amorphous	d. the temperature at which a solid changes to a liquid
b 20. glasses	e. has a regular three-dimensional arrangement of particles
g 21. solid	f. one of the seven crystal systems.
d 22. melting point	g. dense state of matter that has a fixed shape and is not easily compressed

Part D Questions and Problems

Answer the following in the space provided.

24. Explain what happens at the particle level when a solid melts.

At this temperature, the vibration in the solid becomes too great and eventually overcomes the attractive forces between the molecules and they can then slide past one another.

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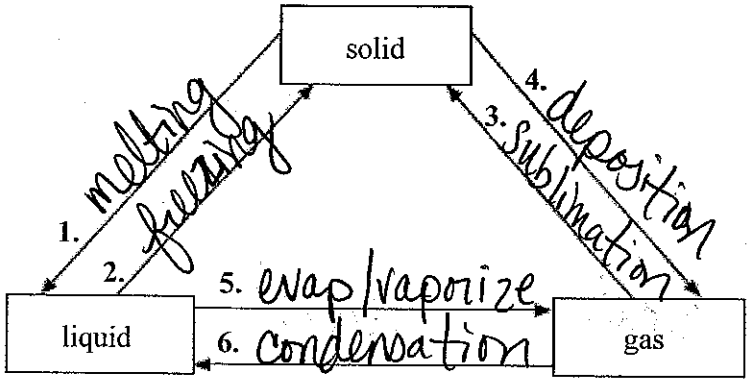
13.4 Changes of State

Essential Understanding Changes of state depend on changes in energy of the particles involved.

On each arrow, fill in the appropriate change of state.



Sublimation

32. The process of sublimation requires more energy than evaporation.

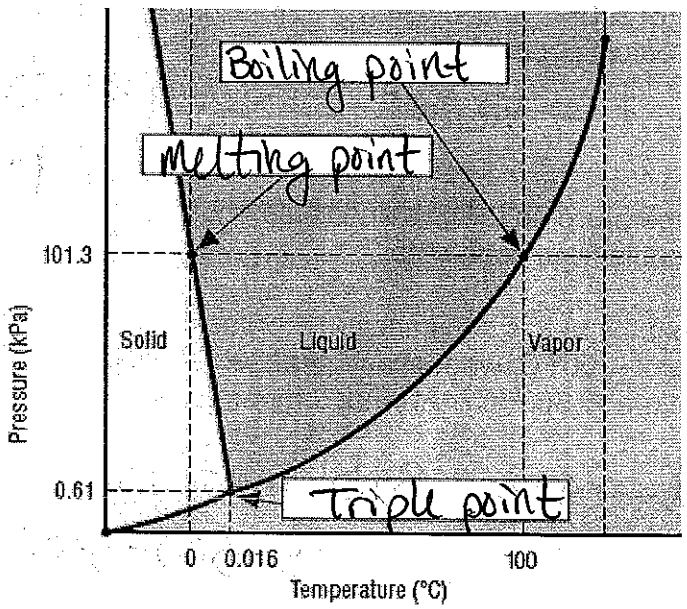
33. Is the following sentence true or false? Solids have vapor pressure because some particles near the surface of a solid substance have enough kinetic energy to escape directly into the vapor phase. true

Phase Diagrams

34. What does a phase diagram show?
The temperature & pressure conditions at which a substance exists in the solid, liquid & vapor phases

35. What is the triple point of a substance?
It represents the only conditions of temperature and pressure at which all 3 phases can exist in equilibrium

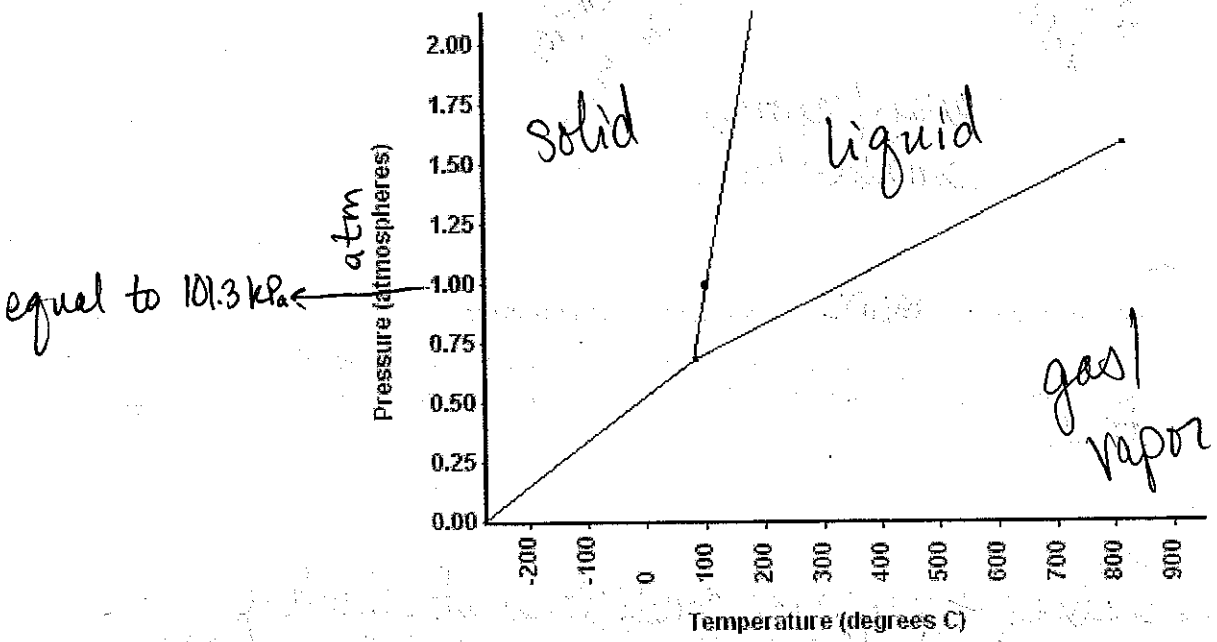
36. In the phase diagram for water shown below, label the melting point and boiling point at normal atmospheric pressure, and the triple point.



37. 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?

Because the pressure AND temperature conditions are not likely to occur in nature

Refer to the phase diagram below when answering the questions on this worksheet:



equal to 101.3 kPa

1) What is the normal freezing point of this substance? 100°C

2) What is the normal boiling point of this substance? 375°C

3) What is the normal melting point of this substance? 100°C

4) If I had a quantity of this substance at a pressure of 1.25 atm and a temperature of 300° C and lowered the pressure to 0.25 atm, what phase transition(s) would occur?

liquid → vapor evaporation/ vaporization

5) At what temperature do the gas and liquid phases become indistinguishable from each other? 825°C

6) If I had a quantity of this substance at a pressure of 0.75 atm and a temperature of -100° C, what phase change(s) would occur if I increased the temperature to 600° C? At what temperature(s) would they occur?

solid → gas sublimation @ 300-350° C

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