Honors Chemistry Chapter 10 States (Sections 1-4, omit section 5).

Section 1 The Kinetic Molecular Theory of Matter pgs. 329-332.

Objectives:
1. State the kinetic-molecular theory of matter, and describe how it explains certain properties of matter.
2. List five assumptions of the kinetic-molecular theory of gases. Define the terms ideal gas and real gas.
3. Describe each of the following characteristic properties of gases: expansion, density, fluidity, compressibility, diffusion, and effusion.
4. Describe the conditions under which a real gas deviates from "ideal" behavior.

Vocabulary: Define the following.
1. kinetic-molecular theory--

2. ideal gas--

3. elastic collision

4. diffusion--

5. effusion--

6. real gas--

As you may recall from earlier discussions the major difference between the solid, liquid, and gas state of a substance is the distance between particles and the speed at which they move. Both of these factors are determined primarily by the heat present in the system.
The kinetic-molecular theory in essence states that all matter is in constant random motion.

Gases

A model that describes how gases behave is called the ideal gas model. The model is similar to but not identical to how real gases actually behave.

An ideal gas model is hypothetical. In this ideal gas model there are 5 basic assumptions. The assumptions are:

1. Gases consist of large numbers of tiny particles that are far apart relative to their size. Simply put this means that compared to the solid and liquid phase of this gas there are very few gas particles occupying a very large volume.

2. Collisions between gas particles and their container are perfectly elastic. (No energy lost in the collisions).

3. Gases are in continuous rapid motion.

4. There are no forces of attraction between gas particles.

5. The temperature of a gas depends on the average kinetic energy of the particles of the gas. This means that the speed at which the particles move depends on temperature. The higher the temperature the faster they move. It also means that lighter gases move faster than heavier gases. Kinetic energy is the energy of motion and is determined by the formula:

$$KE = \frac{1}{2}mv^2$$

What is the kinetic energy of a paper clip with a mass of 2.5 grams moving at a velocity of 145 km per hour?

<u>Answer</u>:

What is potential energy?

<u>Answer</u>:

Real gases act much the same as the ideal gases unless they are exposed to very low temperatures and high pressure.

1. **<u>Expansion</u>**
   Gases will expand to fill their container.
2. **<u>Fluidity</u>**
   Gases like liquids slide pass each other or flow.
3. **<u>Low Density</u>**
   There are very few gas particles occupying a volume at atmospheric pressure.
4. **<u>Compressibility</u>**
   Gas particles are far apart and therefore can be pushed together to occupy a smaller volume (compressed)
5. **<u>Diffusion and Effusion</u>**
   In diffusion substances move from areas of high concentration to low concentration until an equal distribution of particles is attained. This is due to the random motion of particles constantly colliding.
   Effusion is the process by which particles of gas pass through a tiny opening. Lighter particles effuse faster than heavier ones.

For each of the 6 properties of a gas listed above, list the assumption(s) of the kinetic-molecular theory that corresponds to the characteristic here.

Property	**Assumption(s)**
1. Expansion	
2. Fluidity	
3. Low Density	
4. Compressibility	
5. Diffusion	
6. Effusion	

A real gas unlike an ideal gas does occupy space and does exert attractive forces on other particles and as such does not conform entirely to the kinetic-molecular theory assumptions.

In general, nonpolar monatomic and diatomic gases display properties more similar to the ideal gas law than polar gases. The more polar the gas is the greater the deviation from the ideal gas laws.

What are 2 monatomic nonpolar gases?

Answer: 1. 2.

What are 2 diatomic nonpolar gases?

Answer: 1. 2.

What are 2 polar gases?

Answer: 1. 2.

Answer the following to test your knowledge of this section.

1. **Under what conditions would a real gas act like an ideal gas?**
2. **What causes gas in a closed container to produce pressure?**
3. **How does temperature affect the pressure a gas exerts in a closed container?**
4. **What happens to the distance between particles of a gas in compression?**

5. **What determines the rate of effusion?**

6. **How can any gas be turned into a liquid?**

7. **Why are gases considered fluid?**

8. **Which of the following would act like and ideal gas?**
   HCl, H_2O, Ne, NH_3, Cl_2

9. **A hurricane's wind speed increases from 80 miles an hour to 90 miles per hour just before landfall. If an object is picked up by these winds and thrown about, by what factor is the kinetic energy of that object increased if it strikes a car?**

Section 2 Liquids pgs. 333-336.
Objectives:

1. **Describe the motion of particles of liquids and the properties of liquids according to the kinetic-molecular theory.**
2. **Discuss the process by which liquids can change into a gas. Define vaporization.**
3. **Discuss the process by which liquids can change into a solid. Define freezing.**

Vocabulary: Define the following.

1. **fluid--**

2. **surface tension--**

3. **capillary action--**

4. **vaporization--**

5. **evaporation--**

6. **freezing--**

<u>Properties of Liquids and the Kinetic-Molecular Theory</u>
Liquids can only exist in a narrow temperature range and as such are not as common as gases and solids.
Liquids have a definite volume but take the shape of their container. Liquids are more ordered than gases because of stronger intermolecular forces which will be studied in a future chapter. The particles of liquids are in constant motion which explains their fluidity or the ability to flow and take the shape of their container.
<u>Properties</u>

1. **<u>Relatively High Density</u>**
   Liquids are hundreds of times denser than gases but only 10% less dense than solids.
2. **<u>Relative Incompressibility</u>**
   Liquids can transmit pressure equally in all directions.
   How might an air bubble in the brake fluid of an automobile affect braking ability?
   <u>Answer</u>:

3. **<u>Ability to Diffuse</u>**
   Food coloring is added to a beaker of cold water and a beaker of hot water. Describe what you think will happen and why! (Two part answer).
   <u>Answer</u>:

4. **<u>Surface Tension</u>**
   Surface tension tends to pull adjacent particles at the surface of a liquid together decreasing surface area to the smallest possible size.
   Why do liquid droplets form spheres?
   <u>Answer</u>:

5. **<u>Capillary Action</u>**
   Liquids will rise up in small diameter tubes. This is due to cohesion between adjacent particles and adhesion to the walls of the solid tube.
6. **<u>Evaporation and Boiling</u>**
   The change from a liquid to a gas is called vaporization.
   Evaporation occurs when particles escape from the surface of a nonboiling liquid.

Boiling occurs throughout the liquid and occurs at a certain temperature at sea level. What is this temperature called?
Answer:

7. **Formation of Solids**
   If a liquid is cooled enough it will turn into a solid.
   What is this temperature called?
   Answer:

What is the difference between the freezing point and the melting point of a substance.
Answer:

Answer the following questions.

1. **A sample of water has a fixed volume and shape. What state is it in?**
2. **What property of a liquid enables you to pour a liquid into a cup until the top of the liquid is slightly higher than the top of the cup?**
3. **During what process does a liquid change to a solid?**
4. **What is the main difference between boiling and evaporation?**
5. **Explain how evaporation and perspiration affect a person's body temperature.**
6. **What 2 ways can a liquid change to a gas?**
7. **What is the boiling point of water?**

Section 3 Solids pgs. 337-341

Objectives:

1. **Describe the motion of particles in solids and the properties of solids according to the kinetic-molecular theory.**
2. **Distinguish between the two types of solids.**
3. **Describe the different types of crystal symmetry. Define crystal structure and unit cell.**

Vocabulary: Define the following.

1. **crystalline solids--**
2. **crystal--**
3. **amorphous solids--**
4. **melting--**
5. **melting point--**
6. **supercooled liquids--**
7. **crystal structure--**
8. **unit cell--**

Properties of Solids

The particles that comprise a solid are held in a rigid fixed position due to their closeness to one another and the strong attraction between the particles. This fixed position limits the movement of the particles to vibrations around some fixed position.

There are two types of solids, crystalline and amorphous.

Crystalline solids are composed of crystals, which consist of regular repeating patterns, whereas amorphous solids have a random arrangement of particles.

1. **Definite Shape and Volume**
   The shape and volume change only slightly with changes in temperature and pressure because the particles are so tightly packed together. For instance most solids will expand or contract slightly with extremes in temperature. Highway roads especially going over bridges have expansion joints for this reason.

2. **Definite Melting Point**
   Crystalline solids have a definite melting point. Amorphous solids have no definite melting point and can flow over a wide range of temperatures. For this reason amorphous solids are often classified as supercooled liquids.

3. **High Density and Incompressibility**

4. **Low Rate of Diffusion**

Crystalline Solids

The three dimensional arrangement of particles is called the crystal structure with a geometric arrangement called a lattice. The smallest unit of this lattice is called the unit cell.

Crystal Classification

1. **Ionic Crystals**
   These types of crystals are found in ionic compounds, (metal/nonmetal).
   These consist of a regular arrangement of charged particles, melt at high temperature, are brittle, and are good insulators.
   Example: NaCl.
2. **Covalent Network**
   These have a large number of atoms covalently bonded to one another, melt at a high temperature, and are nonconductors or semiconductors.
   Example: Diamond
3. **Metallic**
   Metal cations surround by unbonded valence electrons that are free to move about allowing them to conduct an electric charge easily.
   Example: Copper
4. **Covalent Molecular Crystals**
   Consist of covalently bonded molecules held together by intermolecular forces, have low melting points, and are good insulators.
   Examples: NH_3, H_2O

<u>Amorphous Solids</u>
Glass and plastics.

<u>Answer the following questions</u>.

1. **How do solids differ from**
   a. **liquids**

   b. **gases**

2. **What is the difference between a crystalline and amorphous solid?**

3. **Why do ionic crystals melt at a higher temperature than covalent crystals?**

4. **What is the purpose of the lines cut every few feet into the cement of a sidewalk?**

<u>Section 4 Changes of State pgs. 342-348</u>
<u>Objectives</u>:

1. **Explain the relationship between equilibrium and changes of state.**
2. **Interpret phase diagrams.**
3. **Explain what is meant by equilibrium vapor pressure.**
4. **Describe the processes of boiling, freezing, melting, and sublimation.**

<u>Vocabulary</u>: Define the following.

1. **phase--**

2. **condensation--**

3. **equilibrium--**

4. **equilibrium vapor pressure--**

5. **volatile liquids--**

6. boiling--

7. boiling point--

8. molar enthalpy of vaporization--

9. freezing point--

10. molar enthalpy of fusion--

11. sublimation--

12. deposition--

13. phase diagram--

14. triple point--

15. critical point--

16. critical temperature--

17. critical pressure--

Changes of State and Equilibrium

The term phase is used to describe any part of a system that has a uniform composition such as the liquid phase or gas phase in a sealed bottle of water.

Where would the gas phase be in a bottle of water purchased at a store?
Answer:

Equilibrium occurs when two opposite changes occur at the same rate in a closed system such as the case of the bottled water mentioned above. The number of water molecules leaving the liquid water to become water vapor is equal to the number of water vapor molecules turning back into liquid water.

To gain a better understanding of the different changes between states of matter and the names associated with each change copy Table 2 Possible Changes of State here in your notes.

Table 2 Possible Changes of State

1.

2.

3.

4.

5.

6.

Equilibrium Vapor Pressure of a Liquid

The gas molecules in a closed system of gas and liquid exert a pressure due to collisions on both the liquid and the surrounding walls of the container. This is the equilibrium vapor pressure and increases with temperature. Increased evaporation increases vapor pressure.
Volatile liquids have weak attractive forces between them and evaporate easily and have high equilibrium pressure as contrasted with nonvolatile liquids.
The equilibrium vapor pressure explains boiling point as it relates to atmospheric pressure. The lower the atmospheric pressure the lower the temperature at which the substance boils. This is why the boiling point of a liquid is described in terms of pressure. The boiling point is the temperature at which the equilibrium vapor pressure equals the atmospheric pressure.
A vacuum evaporator causes boiling at lower than normal temperatures.
A pressure cooker increases pressure and increases the temperature at which a substance boils.
Some bacteria can actually survive the normal boiling point of water.

Which of the above devices would best be used to sterilize medical equipment?
<u>Answer</u>:

The actual name of the above instrument is an autoclave.

Once the boiling point of a liquid is reached additional heat does not change the temperature. This additional energy is not seen as a temperature change but is instead causes the liquid particles to move farther apart turning the liquid to a gas. This energy is stored in the gas as potential energy.
When water vapor near the top of a hurricane changes to liquid this potential energy is changed into heat. It is the heat generated by this change that keeps the hurricane's heat engine functioning. If upper altitude winds shear off the tops of the clouds the heat energy is dissipated and the hurricane weakens or dies off.

<u>Molar Enthalpy of Vaporization</u>
The amount of heat needed to vaporize one mole of liquid at the liquid's boiling point at constant pressure is the molar enthalpy of vaporization, ΔH_v.
The greater the attraction between particles, the higher the molar enthalpy of vaporization. Enthalpy is the amount of heat gained or lost from a system during a change at constant pressure. This is a unique characteristic of all liquids. Each has its own molar heat of vaporization.
Why does the evaporation of water from the skin cause cooling?
<u>Answer</u>:

<u>Freezing and Melting</u>
The normal freezing point of a crystalline substance is the temperature at which the solid and liquid are at equilibrium at 1 atmosphere of pressure (sea level).
Melting is the opposite of freezing and both processes occur at the same temperature. If heat is added to a system containing the solid and liquid phase, the temperature of the mixture will not increase until all the solid has melted. At this point the temperature will begin to rise.

<u>Molar Enthalpy of Fusion</u>
The molar Enthalpy of Fusion is the amount of heat needed to melt one mole of a solid at the solid's melting point, ΔH_f.
This also depends on the force of attraction between particles. The greater the attraction the larger the molar enthalpy of fusion.

<u>Sublimation and Deposition</u>

The change of state in which a substance passes from a solid to a gas without passing through the liquid phase is sublimation and the opposite change is called deposition.

Name two substances that undergo sublimation.

<u>Answer</u>:

<u>Phase Diagrams</u>

A phase diagram is a graph of pressure versus temperature that shows the conditions under which the phases of a substance exist.

The triple point of a substance is the temperature and pressure in which all three states of matter can exist.

The <u>critical point</u>, (C), indicates: 1. the critical temperature (t_c), the temperature above which the substance cannot exist as a liquid and, 2. the critical pressure (P_c) the lowest pressure at which the substance can exist as a liquid at the critical temperature.

Answer the following question.

1. What happens when a liquid-vapor system at equilibrium experiences an increase in temperature?

2. What happens when a liquid-vapor system at equilibrium experiences a decrease in temperature?

3. In what two ways can a substance vaporize?

4. List the opposite process for each of the following.

	<u>opposite process</u>
a. boiling	________________
b. freezing	________________
c. condensation	________________
d. deposition	________________

5. How does pressure affect the boiling point of a substance?

6. What is the triple of a substance?

7. What two points are found at the critical point?

8. Does food cook faster on a mountain or in a valley below sea level?

Explain your answer.

9. What is dynamic equilibrium?

10. How does an increase in evaporation affect vapor pressure?

11. A student fills a jar half way with water, adds a few ice cubes, and then seals the jar with a lid. How many phases are present in this system?

12. What is the name of the pressure cooker used in medical facilities to sterilize intruments?

13. Which type of liquid exerts a lower vapor pressure, a volatile or nonvolatile liquid?