**Chapter 3 – States of Matter (Sec 3.1 pages 68-74 & Sec 3.3 pages 84-96)**

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***Section 3.1 – Solids, Liquids, and Gases (pages 68-74)***

*Key Concepts:*

* *How can shape and volume be used to classify materials?*
* *How can kinetic theory and forces of attraction be used to explain the behavior of gases, liquids, and solids?*

*Vocabulary:*

* Solid
* Liquid
* Gas
* Kinetic Energy

*Describing the States of Matter*

* Materials can be classified as solids, liquids, or gases based on whether their shapes and volumes are definite or variable.
* **Solid**: ­­­­­­­­­­­­­\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + The term definite means that the shape and volume of an object won’t change depending upon which container it is placed in.
  + However, the term definite does not mean that the shape or volume can never change (pencil sharpened)
  + The atoms (particles) in a solid are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and are arranged in a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
    - Almost all solids have some type of orderly arrangement of particles at the atomic level.
* **Liquid:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + A liquid always has the same shape as its container and can be poured from one container to another.
  + The atoms in a liquid are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ but their arrangement is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_ than the arrangement of those in a solid.
* **Gas**: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + A gas takes the shape and volume of its container.
  + Gaseous atoms are in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ throughout their entire container.
  + Due to their random arrangement and ability to take the shape of their container, gases can be easily compressed into a smaller container.
* Other states of matter:
  + On earth, almost all of the matter exists in the form of solid, liquid, or gas.
    - Plasma
      * However, 99% of all the matter can be observed in the universe exists in a state that is not common on earth.
      * At extremely \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, such as those found on the sun or other stars, matter exists as plasma.
    - Bose-Einstein Condensate (BEC)
      * In the 1920s, Satyendra Bose, a physicist from India, wrote a paper on the behavior of light.
        + After Albert Einstein read the paper, he made a bold prediction.

Einstein predicted that a fifth state of matter would exist at extremely \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

At temperatures near -273 °C, groups of atoms would behave as though they were a single particle.

In 1995, scientists were able to produce this 5th state of matter, becoming known as the Bose-Einstein Condensate – it behaved just as Einstein had predicted.

*Kinetic Theory*

* **Kinetic Energy:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + The faster an object is moving, the greater its kinetic energy
  + The kinetic theory of matter says that all particles of matter are in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

*Explaining the Behavior of Gases*

* Motion in Gases
  + The particles in a gas are never \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + At room temperature, the average speed of the particles in a sample of gas is about 1600 kilometers per hour.
    - The use of the term “average” is a clue that not all particles are moving at the same speed.
    - Some are moving faster than the average speed and some are moving slower than the average speed.
  + The particles will move in a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ until they collide with another particle or the walls of the container.
    - During a collision, one atom may \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and slow down while another atom \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and speeds up.
    - No matter what, the total kinetic energy of the system \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
  + There are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ among the particles in all matter.
    - If the particles are apart and moving fast, as in a gas, the attractions are too weak to have an effect.
    - Under ordinary conditions, scientists ignore the forces of attractions in a gas.
* Kinetic Theory of Gases
  + The \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of particles in a gas allows a gas to fill a container of any shape or size.
  + Kinetic Theory, as applied to gases:
    - Particles in a gas are in constant, random motion.
    - The motion of one particle is unaffected by the motion of other particles unless the particles collide.
    - Forces of attraction among particles in a gas can be ignored under ordinary conditions.

*Explaining the Behavior of Liquids*

* The particles in a liquid also have kinetic energy.
* Particles in a liquid are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ than the particles in a gas.
  + Therefore, attractions between the particles in a liquid do affect the movement of particles.
* A liquid takes the shape if its container because particles in a liquid \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ to new locations.
  + The volume of a liquid is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ because \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ keep the particles close together.
  + Because forces of attraction limit the motion of particles in a liquid, the particles in a liquid cannot spread out and fill a container.
  + Example: students walking in a hallway.

*Explaining the Behavior of Solids*

* Solids have a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ because particles in a solid vibrate around in fixed locations.
* \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ between the particles restrict their motion and keep each atom in a fixed location relative to its neighbors.
* Examples: Audience in a movie theater

***Section 3.3 – Phase Changes (pages 84-91)***

*Key Concepts:*

* What are six common phase changes?
* What happens to a substance’s temperature and a system’s energy during a phase change?
* How does the arrangement of water molecules change during melting and freezing?
* How are evaporation and boiling different?

*Vocabulary:*

1. Phase change
2. Endothermic
3. Heat of fusion
4. Exothermic
5. Vaporization
6. Heat of vaporization
7. Evaporation
8. Vapor pressure
9. Condensation
10. Sublimation
11. Deposition

*Characteristics of Phase Changes*

* When at least two states of the same substance are present, scientists describe each different state as a phase.
  + **Phase change:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Melting, freezing, vaporization, condensation, sublimation, and deposition are six common phase changes.
* Temperature and Phase Changes
  + The temperature of a substance \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ during a phase change.
    - Until the phase change is complete, the temperature \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
    - Once the phase change is complete, the temperature will continue to increase/decrease depending upon the phase change.
* Energy and Phase Changes
  + During a phase change, energy is transferred between a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and its \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
    - The direction of the transfer depends on the type of phase change.
    - Energy is either \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ during the phase change.
  + **Endothermic:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
    - Examples: Melting, Vaporization, Sublimation
    - The amount of energy absorbed depends upon the substance.
      * **Heat of fusion:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + **Exothermic:** ­­­­­­­­­­­­­­­­­\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
    - Examples: Freezing, condensation, deposition
    - Farmers use this concept to protect their crops from damage.
      * When farmers expect temperatures to drop slightly below 0°C, they spray the crops with water.
      * As the water freezes, it \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
        + The flow of heat slows the drop of temperature and helps protect the crops from damage as the heat is flowing from the water (being frozen) into the crops.

*Melting and Freezing*

* The arrangement of molecules in a substance becomes less orderly as the substance melts and more orderly as the substance freezes.
* Melting: Ice Example
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + In ice, attractions between molecules keep the molecules in fixed positions.
  + When removed from a freezer and placed into an empty glass, heat flows from the air to the ice.
  + As the ice \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, the molecules \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
  + At the melting point, some molecules gain enough energy to overcome the attractions and move from their fixed positions.
    - Once all molecules have enough energy to move, melting is complete.
  + Any energy gained by the water after the phase change increases the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ of the molecules and the temperature rises.
* Freezing: Water to Ice Example
  + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + When liquid water is placed in a freezer, energy flows from the water to the air in the freezer, and the water cools down.
  + As the average kinetic energy of its molecules \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, they move more slowly.
  + At the freezing point of water, some molecules move slowly enough for the attractions between molecules to have an effect.
    - When all of the molecules have been drawn into an orderly arrangement, freezing is complete.
    - Any energy removed from the ice after the phase change decreases the average kinetic energy of the molecules, and the temperature of the ice drops.
* Melting and Freezing do not always mean hot and cold temperatures, respectively.
  + Substances that exist as a gas at room temperature have already not only melted, but have also already vaporized.
  + Substances such as silicon freezes at 1412 °C (2574 °F)

*Vaporization and Condensation*

* **Vaporization:**  \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Endothermic process
  + Substance must absorb energy in order to change from a liquid to a gas.
  + **Heat of vaporization:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
    - Varies from substance to substance
  + Two vaporization processes:
    - **Evaporation:** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
      * Molecules near the surface of the liquid are moving fast enough to escape the liquid and become a vapor
        + Vapor: the gaseous phase of a substance that is normally a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ at room temperature
      * The greater the surface area of the container, the faster the water evaporates
      * What happens in a closed container?
        + As the liquid evaporates, a vapor collects above the liquid.
        + \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is called **vapor pressure**.

Vapor pressure \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ as the temperature \_\_\_\_\_\_\_\_\_\_\_\_\_\_.

At higher temperatures, more water molecules have enough kinetic energy to overcome the attractions of other molecules in the liquid.

* + - **Boiling**
      * As you heat a pot of water, both the temperature and the vapor pressure increase.
        + When the vapor pressure \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ the atmospheric pressure, the water boils.

The temperature at which this happens is known as the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

* + - * Kinetic theory explains what happens when water boils.
        + As temperature increases, water molecules move faster and faster.
        + When the temperature reaches 100 °C, some molecules below the surface of the liquid have enough kinetic energy to overcome the attraction of neighboring molecules.

Because water vapor is less dense than liquid water, the bubbles quickly rise to the surface.

* + - * Boiling point of a liquid depends upon the atmospheric pressure.
        + At sea level, the normal boiling point of water is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
        + At higher elevations, the atmospheric pressure is lower.

Denver, Colorado: mile-high city

The vapor pressure of water will equal the atmospheric pressure at a lower temperature – can be as low as 95 °C

Takes food longer to cook due to lower temperature

* **Condensation** – \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Condensation is an exothermic process – energy is released
  + Examples: bathroom mirror, morning dew

*Sublimation and Deposition*

* **Sublimation:**  the phase change in which a substance changes from a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Endothermic
  + Example: solid carbon dioxide, also known as, dry ice
* **Deposition:** the phase change in which a substance changes from a \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
  + Exothermic
  + Example: Frost on a windshield