Black Hills State University

Middle School Science Content Knowledge
Praxis Review Sheet:
Kinetic Theories and States of Matter

ELED 303 Earth and Physical Science
for Elementary Teachers

Kinetic Theory and States of Matter

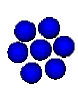
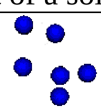
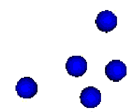
Kinetic Molecular Theory

Kinetic energy is energy that an object has because of its motion. The Kinetic Molecular Theory explains the forces between molecules and the energy that they possess. This theory is based on three theories about matter.

- Matter is composed of small particles (atoms, molecules, and ions).
- The space the molecules occupy (volume) depends on the space between the molecules and not the space the molecules occupy themselves.
- The molecules are in constant motion. This motion is different for each of the three states of matter. They are colliding with each other and the walls of their container. When the molecules collide with each other, or with the walls of a container, there is no significant loss of energy. Absolute zero is the temperature used to describe when all movement is as slow as it can possibly be.

Temperature is the term used to explain how hot or cold an object is. Temperature is the average kinetic energy of particles in the substance. Water molecules at 0º C. lave lower kinetic energy than water at 100º C.

States of Matter

Solid - Molecules are held close to each other by their attractions of charge. They will bend and/or vibrate, but will stay in close proximity. The molecules have an ordered arrangement.	**Liquid -** Molecules will flow or glide over one another, but stay toward the bottom of the container. Motion is a bit more random than that of a solid. They have enough kinetic energy to slip out of the ordered arrangement of a solid.	**Gas -** Molecules are in continual straight-line motion. The kinetic energy of the molecule is greater than the attractive force between them, thus they are much farther apart and move freely of each other.
		

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Mass, Volume, and Density

Mass is the measure of the heaviness of a substance, usually is weighed in grams. The characteristics of atoms in the material determine the mass. The more tightly packed they are, the greater the mass; and the larger the atomic number, or the atomic mass, the greater the mass of the substance. Hydrogen, number 2 on the periodic chart, has an atomic mass of 4, because it has 2 protons and 2 neutrons in its nucleus. Gold has an atomic mass of 197, so each atom is much heavier. Mass is often referred to as weight. To distinguish between mass and weight, think of a lump of gold both here and on the moon. It would have the same mass in both places, but would weigh less on the moon because its gravity is about 1/6 of Earth's.

The **volume** of a substance is the three-dimensional space it occupies. It is measured in cubic centimeters or millimeters. One cubic centimeter equals 1 millimeter. When scientists set up the metric system, they set those quantities up that way to make science easier.

Density is the ratio of mass to volume. To determine the density of a substance, divide its mass by its volume. Water has a density of about 1, and objects that sink in water, such as steel, have a higher density. In contrast, steel's density is about 8.

Phase Changes or Changes of State

The process of changing state requires that energy by absorbed or released. It is usually measured in calories. One calorie is the amount of heat required to raise the temperature of 1 gram of water 1 degree C.

Water

The range of temperatures found on Earth's surface and the physical properties of water allow water to occur commonly and in abundance in all three phases: solid, liquid, and gas. Phase changes usually refer to the changes of state of water on Earth.

Processes to Change the State of Water

- **Evaporation** is the process in which a liquid is changed to gas. Water can change from liquid to vapor only when energy is available. Evaporation requires energy, usually in the form of heat in the atmosphere. When you take energy from an object, it gets cooler. The heat energy went into the water molecules and caused them to speed up and evaporate. When water evaporates from a surface, the amount of water vapor in the air increases.
- **Condensation** occurs when water changes from gas to liquid by condensation. The water molecules release their stored heat energy and form fog or clouds.
- **Melting** occurs when a solid is changed to a liquid
- **Freezing** occurs when a liquid is changed to a solid
- **Sublimation** occurs when a solid is changed directly to a gas (e.g., ice cubes shrinking in a freezer)
- **Deposition** occurs when water vapor (gas) changed to a solid (e.g., frost in a freezer compartment)

Gas Laws

Gas molecules move so quickly and are so far apart that they overcome the attractive forces between them; therefore, they don't have a definite shape or volume. The simplest gas laws relate pressure, volume, and temperature in pairs. **Pressure** is force exerted per unit area. In a fluid, either a liquid or a gas, the pressure applied to a fluid is transmitted throughout the fluid. If you squeeze on one end of a balloon, the other end will bulge out. **Volume** is a measure of the space the gas occupies.

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Boyle's Law

Boyle's law (named after Robert Boyle and his work in 1662) states that the pressure and volume of a gas are inversely proportional to one another, or $PV = k$, where P is pressure, V is volume, and k is a constant of proportionality. In other words, if you squeeze gas into a smaller space, the pressure will increase, and the molecules will strike the surface of the container more often. If you increase the volume of the container, the pressure will decrease, and the molecules will strike the surface less often.

Charles's Law

Charles's law (published by Jacques Charles in 1787), states that the volume of an enclosed gas is directly proportional to its temperature, or $V = kT$. This expression is strictly true only if the temperature is measured on an absolute scale. The volume of a gas increases with increasing temperature, as long as the pressure doesn't change. The volume of a gas decreases with decreasing temperature, as long as the pressure doesn't change.

When the molecules in a gas are heated, they travel faster and separate as the temperature rises. This is called **thermal expansion**, which describes the increase in the size of a substance as the temperature increases.

The Pressure-Temperature Relationship

A third law states that the pressure is directly proportional to the absolute temperature, or $P = kT$.

The Ideal Gas Law

The three gas laws relating two variables can be combined into a single law relating pressure, temperature, and volume, which states that the product of pressure and volume is directly proportional to the absolute temperature, or $PV = kT$. This law describes the behavior of real gases only with a certain range of values for the variables. At temperatures or pressures near those at which the gas condenses to a liquid, the behavior departs from this equation. Nevertheless, it is useful to consider an ideal gas, or perfect gas, an imaginary substance that conforms to this equation for all values of the variables.

Characteristics of Crystals

Crystals are substances in which the atoms are arranged in an orderly, repetitive manner. They can be liquid or solid.

The silicate minerals, those containing oxygen and silicon atoms, form crystalline structures. All have a silicon-oxygen tetrahedron as a base, with four oxygen atoms attaching themselves to a much smaller silicon atom. The tetrahedrons can appear singly, in chains, in double chains, in sheets, and in three-dimensional networks.

Silicate Mineral Tetrahedron Base

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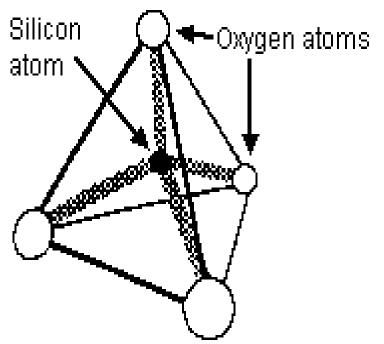
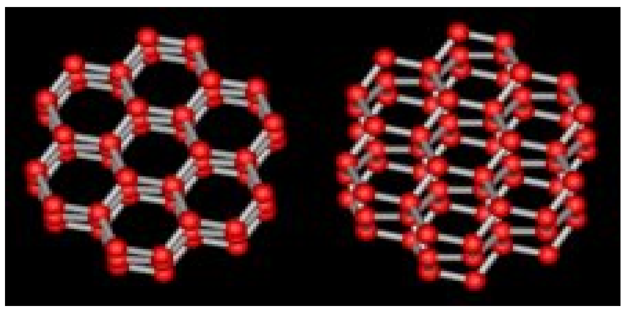


- Taken from http://www.union.edu/PUBLIC/GEODEPT/hollocher/pedagogy/K-12_labs/Labs/RF1/RF1.htm

When water freezes into ice, the water molecules stack together to form a regular crystalline lattice with six-fold symmetry. This hexagonal crystal symmetry determines the shape of snow crystals. Faces, or facets, appear on many growing crystals because some surfaces grow more slowly than others do.

Snow flake



Ice lattice

- Taken from http://www.its.caltech.edu/~atomic/snowcrystals/

Liquid crystals do not change states in the usual manner. Liquid crystals start to flow during the melting phase similar to a liquid, but don't lose their orderly arrangement. They retain the arrangement in specific directions. They are highly responsive to temperature changes and electric fields. Because of these properties, they are used in making liquid crystal displays in numerous electronic apparatus, such as clocks and computers.

Websites

http://www.school-for-champions.com/science/matterstates2.htm/ - changes of state of matter

Resources

Tarbuck, E. J. & Lutgens, F. K. (2006). *Earth Science.* Upper Saddle River, NJ: Pearson Prentice Hall. ISBN Number 0-13-149751-0.

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