AIM: Properties of and Changes in Matter Ideas

1. Matter is "stuff"; *everything* we can see and/or touch.

- An object (e.g., chair, pencil, book) is a particular piece of matter that has unique properties (features used to describe it).
- Some objects are composed of a single material; others are composed of more than one material.
- A material is a sample of matter having consistent, composition. For instance, a bicycle is an object that includes rubber, steal and plastic parts. These parts are formed from distinct materials.
- A substance is matter that can be found in many places and has the same properties wherever it is found. Water, for example is a substance that always melts from solid to liquid at 0^{o}C, no matter what its source.
- The word "substance" refers only to materials that are either an element or a compound.
  - Each substance is composed of one or more particular types of elements and has a constant composition.

2. Materials have properties (characteristics used to describe them, such as color, mass, size, etc.) that can be used to specifically identify them.

- Objects, materials, and substances can be identified and distinguished by their properties.
- Properties of a sample may be measured (quantitative properties, e.g., weight, size) or described using the five senses (qualitative properties, e.g., color, shape).
  - Mass is the property that defines the amount of matter and is usually measured with a balance.
  - Volume is the property of matter that tells us how much space the matter occupies.
  - Density is the amount of matter (mass) that occupies a given amount of space (volume).
  - Materials vary in the extent to which they absorb and reflect light and conduct heat (thermal energy) and electricity.
- Substances (elements and compounds) have distinct physical and chemical properties such as boiling point, density, color, and conductivity, which are independent of the amount of the sample.
  - Physical properties can be observed or measured without changing the identity/composition of a substance (e.g., boiling point, density).
  - Chemical properties are only observed by changing a substance into one or more different substances thereby changing its identity/composition. The changes produce different substances by rearranging the attachments (bonds) among the atoms of the original substances.
  - Chemical properties of substances are explained by the arrangement of atoms and molecules.
    - A molecule is a tiny particle of matter that is the smallest unit that makes up the unique properties of a particular compound. (e.g. Two hydrogen atoms combine with one oxygen atom to compose one molecule of the compound called water)

3. There are approximately 100 elements that represent the different "building blocks" that make up all matter.

- Elements are a class of substances composed of a single kind of atom.
  - An atom is a tiny particle of matter that is the smallest unit that makes up the unique properties of a particular elemental substance. All the atoms of a particular elemental substance are the same.
  - The atoms of different elements are different from one another. In particular, they have different masses.
- Elements are substances that cannot be changed (broken down) by heat or an electric current (chemical means) into other substances.

- Elements can be classified and identified by their properties. The periodic table organizes the elements into families of elements with similar properties.
  - An element's chemical properties – its reactivity and, particularly, its combining characteristics with oxygen (oxides), hydrogen (hydrides), and chlorine (chlorides), allow it to be grouped with other similarly-behaving elements.
  - When the elements are listed in order of increasing atomic number (or mass, with a few exceptions), elements with very similar properties (e.g., densities, chemical reactivities) occur at intervals in the list. The Periodic Table of the Elements was created by converting such a list into a table with elements in increasing atomic number arranged across the rows and elements sharing similar properties arranged in columns.
  - Elements can be classified, based on their respective physical and chemical properties, as metals, nonmetals, and metalloids (semi-metals).
    - The class of elements called metals exhibits characteristic physical properties such as conductivity and characteristic chemical properties such as reacting with nonmetals to produce salts.

4. Compounds are a class of substances composed of two or more different elements firmly attached (bonded) to one another.

- Compounds are substances that can be broken down by heat or an electric current (chemical means) into two or more different elemental substances.
  - It takes a great deal of energy (heating or electrical) to break compounds apart into separate elements.
- Each compound is made up of a fixed proportion of elements and possesses a definite number of each.
  - The arrangement of the atoms in a compound is an orderly three-dimensional structure that is determined by the properties of its atoms.
- Fundamental properties of a compound, including size, arrangement, and mass, are independent of quantity and temperature.

5. Acids and bases are classes of materials that exhibit particular chemical properties

- Chemical properties common to acids include: a sour taste, characteristic color changes with litmus and other acid/base indicators, and the tendency to react with bases to produce a salt and water.
- Chemical properties common to bases include: bitter taste, characteristic color changes with litmus or other acid/base indicators, and the tendency to react with acids to produce salt and water.
- Water solutions can be classified as acidic, basic, or neutral, given their characteristic behavior with acid-base indicators such as litmus, or via their chemical behavior.
- Acids can be either strong or weak; acetic acid (vinegar) and citric acid are examples of weak acids; sulfuric acid and hydrochloric acid are typical strong acids.
  - The "strength" of an acid is not the same as its concentration (the amount of the material in a given volume).

6. Chemical changes occur when one or more substances react to produce one or more different substances.

- A reaction is the change that occurs when atomic attachments (bonds) are rearranged.
- The three-dimensional arrangement of atoms attached together in a molecule determines the kinds of (chemical) changes that can occur.

- Evidence for occurrence of a chemical reaction is provided by noticeable and permanent change in the properties and appearance of the substances present. Characteristic observations that help identify chemical changes in a reacting mixture include changes in color, production of a solid or a gas, and changes in temperature.

7. Materials exist in several different states; the most commonly described states are solid, liquid, and gas. Each state of matter has characteristic properties.

- Samples of materials can be classified as solids, liquids, and gases according to their behaviors.
  - Solids have a definite shape and volume that does not depend on a container.
  - Liquids flow to take the shape of their container and have a definite volume that cannot be easily changed.
  - Gases expand to fill any shape and volume container and can easily be compressed into a smaller volume container.
- Properties of solids, liquids, and gases are explained by a model in which matter is composed of tiny particles in motion.
  - Particle motion in a solid is limited to vibration in fixed positions, while particles in liquids and gases can move randomly.

8. Matter can undergo changes of state (physical changes), which require a transfer of energy.

- Changes of state are physical, rather than chemical, changes.
- Melting and freezing are terms for opposite changes of state; melting is a change from solid to liquid; freezing is a change from liquid to solid.
- The melting point is the temperature at which a solid substance melts to form the liquid state of the substance. The freezing point of a liquid substance is the temperature at which the liquid freezes to form the solid state of the substance.
- For any particular substance (material), melting and freezing points are the same.
- Vaporizing and condensing are opposite changes in state; vaporizing is a change from liquid to gas and condensing is a change from gas to liquid.
- Sublimation and deposition are terms for opposite changes in state; sublimation is a change from solid to gas, deposition is a change from gas to solid.
- One way to change matter from one state to another and back again is by heating and cooling.
- Adding energy to a substance raises the temperature of the substance, causing its molecules to move faster. Removing energy from a substance lowers the temperature of the substance, causing its molecules to move slower.
  - During a change of state, continued heating or cooling of a substance does not equate to a change in temperature. Thermal energy that is added or removed during the change of state affects the bonds between the molecules rather than affecting the temperature of the substance.
- When substances undergo changes of state, neither atoms nor molecules themselves are changed in structure.

9. Mass is conserved when substances undergo chemical change or changes of state in a closed system.

- A closed system is any environment in which no matter can enter or leave.
- In a closed system, the same particles are present before and after a change of state.
- Chemical change involves the rearrangement of atoms involved, not the transformation, creation, or destruction of any of those atoms.
  - When substances undergo chemical change, the quantities and kinds of atoms do not change. The total number of molecules, however, may change.