Atoms and Molecules

- Molecules are made of smaller entities (atoms) which are bonded together. Therefore molecules are divisible.
- Misconception: Element and atom are synonyms. Proper conception: Elements are atoms with the same number of protons in the nucleus; atoms with different numbers of protons are different elements.
- Misconception: Molecules are basic, simple, indivisible entities. Proper conception: Molecules are made of smaller entities (atoms) which are bonded together. Therefore molecules are divisible.
- Elements are the simplest substances in nature that contain smallest particles called atoms, and all atoms of the same element have identical chemical properties. When atoms of different elements are joined together in groups, they form molecules.

Pure substances and mixtures

- Matter is anything that has mass and takes up space, and is always either a pure substance (i.e., an element or compound) or a mixture of substances.
- Compounds are made of two or more kinds of atoms held together chemically (bonded).
- Mixtures are formed when elements and/or compounds are combined physically.
- Compounds possess their own set of properties and these properties are different from the properties of the elements that form them.
- We get energy from the compounds that make up our food.
- Misconception: Air is a substance. Proper Conception: Air is a mixture of substances, mostly nitrogen and oxygen, but also small amounts of water, carbon dioxide, and other gases.
- Classifying matter is important because we are able to predict behavior and properties based on the material’s characteristics. For example, we know that we can separate sugar from water in a sugar solution because it is a mixture of two compounds. We cannot, however, separate the hydrogen from the oxygen in water without breaking strong chemical bonds within the water molecule.
- Misconception: Particles possess the same properties as the compounds they form. Proper conception: Compounds possess their own set of properties and these properties are different from the properties of the elements that form them.
- Matter is classified as pure substances and mixtures. A Pure substance is a single element or compound, and a mixture is formed as a result of combining different compounds and/or elements.
Movement of Particles in Solids, Liquids, Gases, and Plasmas states

- Molecules themselves do not expand. A heated substance may appear to expand because heat causes molecules to move faster (and further apart).
- Misconception: Gases have no mass. Proper Conception: Gases contain matter whose particles are relatively far apart from each other, so their density is lower than most liquids and solids.
- Misconception: Molecules expand when heated. Proper conception: Molecules themselves do not expand. A heated substance may appear to expand because heat causes molecules to move faster (and further apart).
- Misconception: At absolute zero motion of every part of an object stops. Proper Conception: Temperature is a quantity that measures how fast the atoms and molecules which make up the object move or oscillate. As an object is cooled the oscillations of its atoms and/or molecules slow down up to a point in which this oscillations are the slowest they can possible be. The temperature which corresponds to this point is called absolute zero.
Physical and Chemical Properties of Matter

- Matter can be described by its physical and chemical properties.
- Misconception: Mass and volume, which both describe an "amount of matter", are the same property. Proper Conception: Mass is a measure of the amount of matter. Volume is the amount of space that matter occupies.
- Misconception: Weight and mass is the same thing. Proper Conception: Mass is a measure of the amount of matter that forms (or composes) an object. Weight is the result of the force of gravity on the mass of an object.
- Characteristics of matter, called properties, are used to help us understand how and why matter undergoes the changes that it does, or to predict how matter will behave under conditions not yet observed or studied. Properties can be classified as physical or chemical, depending on whether or not the property can be observed without another (different) substance present.
- Chemical elements possess their own characteristic properties, (density, boiling point, melting point, solubility, etc.) and these properties are used to distinguish one element from another.
- The properties of a substance are those characteristics that are used to identify or describe it. A substance has characteristic properties which are independent of the amount of the sample.
- Physical properties are readily observable and will retain the same composition (nothing new is created).
  - Color, size, odor, luster, hardness, melting point, boiling points, conductivity, density (mass divided by volume)
  - Changes in state of matter (melting, boiling, freezing, condensing) do not create a new substance and retain their original composition and is therefore a physical property.
- Chemical properties are only observable during a chemical reaction and allows for change (something new is created). The property is the ability to change whereas the change is the action itself.
  - Reactivity (describes how easily something reacts with something else), combustibility (a substance or material that is able or likely to catch fire and burn)
- Physical properties of substances are those properties that can be observed, and measured, without changing the composition of the substance as compared to chemical properties as those that can be observed and measured when the substance is undergoing change.
Changes in Matter as Physical or Chemical

- Changes of state are physical changes. Molecule shape, size and mass do not change as a material changes from one state to another. Even though a material’s appearance varies depending on its state, the molecules of that material have not changed. The difference in state (and appearance) is the result of changes in the forces (and average distance) between them.

- Changes in matter can also be classified as chemical or physical, depending on whether a new substance is formed from the starting materials.

- During phase changes, the particles that make up the material move apart or closer together, depending on whether energy is being added or taken away.

- Whether the change is physical or chemical, the total amount of matter always stays the same, even though the materials may appear much different after the change as compared to before.

- When matter undergoes change, it always involves energy moving into or out of the system, often in the form of heat. When energy is absorbed by the system, the atoms gain kinetic energy, potential energy, or both. When energy leaves the system, the atoms lose kinetic energy, potential energy, or both. Every spontaneous process occurs in the direction of decreasing (lowering) the energy of the system.

- After a chemical change, the products may be changed back into the original reactants only through another chemical change. After a physical change, the components may be separated or united by other physical changes.

- Energy is involved in chemical and physical changes.

- As the energy of particles changes, their movement changes and the phase in which matter is present might change.

- As particles are exposed to increasing levels of energy, their speed of movement increases and they will experience a change of phase.

- Physical change- any change in size, shape, or form, or state where the identity of the matter stays the same
  - Ex. Melting, freezing, condensing, evaporating, breaking, cutting, bending

- Chemical changes are associated with the formation of a precipitate (the calcium carbonate precipitated from egg shell), evolution of a gas (baking soda and vinegar, hydrogen peroxide and liver or potato), color change (apple, food coloring), and energy change (sugar)

- Chemical change- occurs when one type of matter changes into a different type of matter with different properties
  - Substances before a chemical change are “reactants.” After a chemical change, the new substances are formed, they are termed “products.” After a chemical change, the product cannot go back to its original reactants.
  - Many reactions involve heat. Some produce a gas- bubbling. Formation of precipitate (to cause a solid to separate out from a solution) and changes in color are also observable evidence.
  - Ex. Burning, digestion, respiration, photosynthesis, decomposition, rusting, fermenting
  - Classic evidences for chemical changes include the formation of a gas, solid; color change; change in temperature; or emission of light. Unfortunately, many physical changes are also accompanied by these characteristics.

- The main difference between physical and chemical changes is what types of bonds you are breaking or forming during the process. Bonds WITHIN a substance requires chemical
changes, because new substances are formed. Bonds BETWEEN substances are formed and broken during physical changes; no new substances are formed in these processes.

- Misconception: Physical changes are reversible; chemical changes are not. Proper Conception: Physical changes are those in which one or more physical properties change but no new substances are formed; Chemical changes involve the formation of a new substance that exhibits chemical properties different from the starting materials. Most common physical and chemical changes are reversible, but some are more “difficult” (require more energy) to accomplish.

- Misconception: Materials change temperature during phase changes. Proper Conception: During phase changes, energy is either absorbed to overcome attractive forces between particles, or lost when particles “stick” together. Since the temperature does not change in these transformations, the average velocity of particles in both phases is the same during these processes.

- Misconception: Phase changes always involve energy going into the system. Proper conception: Phase changes from more ordered to less ordered states involves an absorption of energy (e.g. solids to liquids); energy is evolved in the reverse process (e.g. liquids to solids).

- Misconception: Phase changes are chemical changes. Proper conception: Although this is less “cut and dried” than some sources would suggest, during a phase change no new substances are formed so it is classified as a physical change.

- Misconception: The signs of a chemical change (gas evolution, color change, precipitate formation, heat produced) are definitive evidence to be used to classify a process. Proper conception: The signs of chemical change are not definitive and if applied as such, can lead to gross mislabeling of processes. For example, if a cup of yellow dye is mixed with a cup of blue dye, the green color that results is not definitive evidence of a chemical change. These “markers” should be applied with caution and with other observations before a conclusion is drawn about the nature of a particular process.

- Misconception: Heat and temperature are synonyms Proper conception: Heat is a form of energy that moves from a hotter object towards a colder one. Temperature is a measure of the average relative motion of the particles that compose a material. Heat is an extensive property [a property which depends on the size of the sample observed such as mass/volume] while temperature is an intensive [property independent of the size of sample such as melting point, boiling point, color] one.

- Misconception: All chemical and physical changes are exothermic. Proper conception: Energy is released when bonds form. Energy is absorbed when bonds are broken. In exothermic reactions the products possess less energy than the reactants. Energy is released when the bonds form, and energy is required for a bond to be broken.

- Misconceptions: Molecules of solids are hard; molecules of gases are soft; Molecules of solids are cubes; molecules of gases are round; Molecules of solids are biggest; molecules of gases are smallest. Proper Conception: Changes of state are physical changes. Molecule shape, size and mass do not change as a material changes from one state to another. Even though a material’s appearance varies depending on its state, the molecules of that material have not changed. The difference in state (and appearance) is the result of changes in the forces (and average distance) between them.

- Misconception: Physical change means you can get the substance back; after a chemical change can’t. Proper Conception: After a chemical change, the products may be changed back into the original reactants only through another chemical change. After a physical change, the components may be separated or united by other physical changes.
Periodic Table

- The Periodic Table of Elements represents our understanding of the structure and usefulness of the atoms that have been identified in our environment.
- There is a finite number (about 100) of different kinds of “building blocks” (elements) that constitute the entirety of matter in the universe, from distant stars to the paper and ink that make up this document.
- The modern periodic table contains over 100 squares for the elements. They are arranged by increasing atomic number (left to right, up to down). The square has the atomic number, atomic mass, element name, and element’s chemical symbol.
- Properties of an element can be predicted from its location in the periodic table. Each horizontal row of the table is called a period (7 periods) where each row represents the number of energy levels present in an atom of the element. The columns are called groups (18 groups). Elements in each group have similar characteristics.
- Metals are located on the left, Nonmetals on the right, metalloids are in a zigzag line between metals and nonmetals.
- Elements located on the left of the Periodic Table are most reactive metals, least reactive in the middle, nonmetals on the right.

Law of Conservation of Matter

- Matter can neither be created nor destroyed but can be changed from one form to another.
- Atoms are not created or destroyed in chemical reactions. Therefore, the number and kind of atoms do not change. Mass and the number of atoms are conserved.
- The Law of Conservation of Matter, also known as the Law of Conservation of Mass, states that the total mass of the products of a reaction is equal to the total mass of the reactants. In other words, Matter is not created or destroyed, but only changes its form.
- No matter how substances within a closed system interact with one another, or how they combine or break apart, the total mass of the system remains the same.
- When atoms rearrange themselves to make new substances, energy is often released or absorbed. However, the total amount of energy before and after the change is always the same.
- Misconception: Mass is conserved, but not the number or species of atoms. Proper Conception: Atoms are not created or destroyed in chemical reactions. Therefore, the number and kind of atoms do not change. Mass and the number of atoms are conserved.