**Directions:** These are concepts you have been discussed during 1st semester in this course. They are organized by unit topic. If you have questions about a particular topic, refer back to your notes, watch a YouTube video, do some reading in your textbook or ask for an explanation in class.

**Concept - Nature of Science**

*Understand how to determine variables*:

Dependent variable (also called the responding variable) – this is the variable that is measured. You could also describe it as the results of the experiment or exploration.

Independent Variable (also called the manipulated variable) – the variable you have control over, what you can choose to manipulate or change. It is usually what you think will affect the dependent variable.

Control Variable – a condition that is not changed throughout an experiment.

**Concept – Atomic Theory**

*Matter is composed of discrete units called atoms. Atoms are composed of sub-atomic particles called protons, neutrons, and electrons*.

Recognize that atoms are the smallest unit of an element and are composed of sub-atomic particles (electrons surrounding a nucleus containing protons and neutrons)

*Describe the structure of atoms and differentiate among identification, description, location, mass, and electrical charge of subatomic particles:*

Atomic Structure – protons and neutrons are located in the nucleus and contain most of the atom’s mass. Electrons are located in a cloud around the nucleus and occupy the largest volume of the atom.

Charges of subatomic particles – protons are positively charged, neutrons are neutrally charged and electrons are negatively charged. Adding a neutron to a neutrally atom will result in a radioactive isotope of that element. Adding an electron to a neutrally charged atom will result in a negatively charged atom. Adding a proton to a neutrally charged atom will change the identity of the atom and if no other changes are made the atom will have a net positive charge.

**Concept – Periodicity**

*Elements are grouped in the periodic table according to similarities of their properties.*

Recognize that elements are grouped in the periodic table according to similarities. Elements that lie in the same column on the periodic table (called a "group") have identical valance electron configurations and behave in a similar fashion chemically. For instance, all the group 18 elements are inert, or noble gases.

*Relate properties of atoms and their position in the periodic table to the arrangement of their electrons*

The Periodic Table of the Elements arranges all of the known elements in an informative array. Elements are arranged in order of increasing atomic number. Order generally coincides with increasing atomic mass. Most mass in an atom is contained in the nucleus, this is identified on the table as the atomic mass. The atomic number tells you the number of protons in an atom; this is what identifies the element. For instance carbon always has 6 proton, and its atomic number is 6.

**Concept – Compounds and Mixtures**

*There are a finite number of elements and that their atoms combine in a multitude of ways to produce compounds that make up all of the living and nonliving things that we encounter.*

A molecule is formed when two or more atoms join together chemically. A compound is a molecule that contains at least two different elements. All compounds are molecules but not all molecules are compounds.

When organisms use compounds for energy the elements in the compound can be rearranged to make new molecules.

*Identify basic examples of and compare and classify the properties of compounds, including acids, bases, and salts.*

An acid is a substance that donates hydrogen ions. Because of this, when an acid is dissolved in water, the balance between hydrogen ions and hydroxide ions is shifted. Now there are more hydrogen ions than hydroxide ions in the solution. This kind of solution is acidic.

A base is a substance that accepts hydrogen ions. When a base is dissolved in water, the balance between hydrogen ions and hydroxide ions shifts the opposite way. Because the base "soaks up" hydrogen ions, the result is a solution with more hydroxide ions than hydrogen ions. This kind of solution is alkaline.

The pH scale is a measure of the degree of the acidity or the alkalinity of a solution this scale ranges from 0 to 14. Solutions that are acids fall in the range from 0.0 - 6.9; solutions that are bases fall in the range of 7.1 – 14.0. The midpoint of 7.0 on the pH scale represents a "neutral" solution which is neither acid nor alkaline.

*Distinguish among mixtures (including solutions) and pure substances.*

Mixtures - A mixture is a substance made by combining two or more different materials in such a way that no chemical reaction occurs. A mixture can usually be separated back into its original components. Some examples of mixtures are a tossed salad, salt water and a mixed bag of M&M's candy.

Solution - A solution is a homogeneous type of mixture of two or more substances. A solution has two parts: a solute and a solvent. The solute is the substance that dissolves, and the solvent is the majority of the solution

Heterogeneous Mixture - a mixture of physically distinct substances with different properties, for example trail mix, salads, etc.

Homogeneous Mixtures - A homogeneous mixture has the same uniform appearance and composition throughout. Many homogeneous mixtures are commonly referred to as solutions. For example chocolate milk, coffee, etc.

Describe simple laboratory techniques that can be used to separate homogeneous and heterogeneous mixtures (e.g. filtration, distillation, chromatography, evaporation, etc.).

*Differentiate between physical and chemical properties and physical and chemical changes of matter.*

Physical properties of matter are those that can be observed without changing the chemical identity of the substance. They are used to describe and observe matter. In general they are properties that can be measured and observed. For example, color, melting point, boiling point, density, mass, volume and length are all physical properties.

Chemical property is those that decide how a substance reacts or behaves when exposed to another substance. Good examples of chemical properties are: how iron reacts to moisture, oxidation (browning) of peeled apples or potatoes or how bread rises when baked.

There are several differences between a physical and chemical change in matter or substances. A physical change in a substance doesn't change what the substance is. In a chemical change where there is a chemical reaction, a new substance is formed and energy is either given off or absorbed.

**Concept – Properties of Matter**

*Explain why an object or a person has the same mass on Earth and on the Moon but different weights on Earth and on the Moon.*

The difference between mass and weight is that mass is the amount of matter in a material and weight is a measure of how the force of gravity acts upon that mass.

*Describe solids as the state in which intermolecular attractions keep the molecules in fixed spatial relationships.* *Describe liquids as the state in which intermolecular attractions keep molecules in proximity, but not fixed in relationships. Describe gases as the state in which molecules are comparatively separated and intermolecular attractions have relatively little effect on their respective motions.*

Solids - In a solid the particles (ions, atoms or molecules) are closely packed together. The forces between particles are strong so that the particles cannot move freely but can only vibrate. As a result, a solid has a stable, definite shape, and a definite volume. Solids can only change their shape by force, as when broken or cut. These are the slowest moving molecules.

Liquids - Liquids have a definite volume, but not a definite shape. Instead, they take the shape of their container to the extent they are indeed "contained" by something such as beaker or a cupped hand or even a puddle. The molecules are close, but not as close as a solid.

Gases - Gases have no definite volume and no definite shape. They expand to fill the size and shape of their container. The oxygen that we breathe and steam from a pot are both examples of gases. The molecules are very far apart in a gas, and there are minimal intermolecular forces. Each atom is free to move in any direction. These molecules are the fastest moving molecules.

*Distinguish the four states of matter, i.e., solid, liquid, gas, and plasma, for a substance.*

Changes of state are physical changes in matter. They are reversible changes that do not involve changes in matter’s chemical makeup or chemical properties. When energy is added, the particles move faster; when energy is removed, the particles of matter move more slowly. Common changes of state include:

Melting – changing from a solid to a liquid, energy is added

Freezing – changing from a liquid to a solid, energy is removed

Sublimation - changing from a solid to a gas, energy is added

Deposition – changing from a gas to a solid, energy is removed

Condensation – changing from a gas to a liquid, energy is removed

Vaporization - changing form a liquid to a gas, energy is added

*Describe density and/or calculate and compare the densities of various materials using the materials’ masses and volumes.*

Density is the ratio of mass to volume—or it can also be viewed as the amount of matter within a given area. To determine density, the mass and volume of a sample of material must be measured. Volume can be defined as the amount of three-dimensional space an object occupies and mass as the quantity of matter that an object contains.

Density is calculated by dividing the mass by the volume. When volume stays the same increasing mass will increase the density of the object. When the mass stays the same and volume increases the density of the object is less.

*Describe physical properties and/or compare the physical properties of various materials.*

Certain general physical properties are used to identify unknown substances. These are density, thermal or electrical conductivity, solubility, magnetic properties, and melting/boiling points. For example: the physical properties of metals include:

Luster (shininess)

Good conductors of heat and electricity.

High density (heavy for their size)

High melting point.

Ductile (most metals can be drawn out into thin wires)

Malleable (most metals can be hammered into thin sheets)

**Concept – Changes in Matter (8 questions)**

*Differentiate between physical and chemical changes of matter.*

A chemical reaction is a process that involves rearrangement of the molecular structure of a substance, as compared to a change in physical form.

Chemical change is any change that results in the formation of new chemical substances in a chemical reaction. At the molecular level, chemical change involves making or breaking of bonds between atoms. Evidence for chemical change can include observations of color change, formation of a gas (bubbles), formation of a precipitate, noticeable odor, and temperature change. These changes are chemical:

Iron rusting - iron oxide forms

Gasoline burning - water vapor and carbon dioxide form

Eggs cooking - fluid protein molecules uncoil and crosslink to form a network

Bread rising - yeast converts carbohydrates into carbon dioxide gas

Milk souring - sour-tasting lactic acid is produced

Sun tanning - vitamin D and melanin is produced

Physical change rearranges molecules but doesn't affect their internal structures. Some examples of physical change are:

Whipping egg whites - air is forced into the fluid, but no new substance is produced

Magnetizing a compass needle - there is realignment of groups of iron atoms, but no real change within the iron atoms themselves.

Paper tearing – while there may be more pieces available they still remain paper.

Boiling water - water molecules are forced away from each other when the liquid changes to vapor, but the molecules are still H2O.

Dissolving sugar in water - sugar molecules are dispersed within the water, but the individual sugar molecules are unchanged.

Dicing potatoes - cutting usually separates molecules without changing them.

*What evidence supports the Law of Conservation of Mass?*

During any chemical reaction no particles are created or destroyed: the atoms are simply rearranged from the reactants to the products. This means that mass is always conserved. In other words, the total mass of products at the end of the reaction is equal to the total mass of the reactants at the beginning.

When an object undergoes a physical change the law of conservation of mass applies because the mass of twill be identical to the mass of what you started with. For example, if you melt an ice cube, the mass of the water will be identical to the mass of the ice.

*Describe how temperature influences chemical changes*

When you raise the temperature of a system, the molecules bounce around a lot more. They have more energy. When they bounce around more, they are more likely to collide. That fact means they are also more likely to combine. When you lower the temperature, the molecules are slower and collide less. So increasing temperature will increase the reaction rate while decreasing the temperature will slow reaction rates.

**Concept – Cycling and Conservation of Mass in the Biosphere**

*Describe the process of photosynthesis, such as the role of light, carbon dioxide, water, chlorophyll, production of food, and release of oxygen.*

Photosynthesis is a process used by plants and other organisms to convert light energy from the Sun into chemical energy that can be later released to fuel the organisms' activities.

Three things required for photosynthesis to occur in plants are carbon dioxide, water, and sunlight. The formula for this reaction is:

Carbon Dioxide + Water + solar energy --🡪 Glucose + Oxygen

6 CO2 + 6 H2O + solar energy ------🡪 C6H12O6 + 6O2

An important thing to remember is that the light reactions of photosynthesis cannot occur without sunlight…which means that this does not occur during nighttime!

*Explain how the products of cellular respiration are used as reactants for photosynthesis and that photosynthesis stores energy and cellular respiration releases energy.*

Organisms mainly use two types of molecules for chemical energy: glucose and ATP.

Glucose is the end product of photosynthesis, and it is the nearly universal food for life.

ATP (adenosine triphosphate) is the energy-carrying molecule that cells use for energy.

Cellular respiration actually uses glucose for energy. However, it doesn’t produce light or intense heat as some other types of reactions do. This is because it releases the energy in glucose slowly, in many small steps. It uses the energy that is released to form molecules of ATP.

Cellular respiration involves many chemical reactions, which can be summed up with this chemical equation: C6H12O6 + 6O2 → 6CO2 + 6H2O + Chemical Energy (in ATP)

Cellular respiration occurs in plants and animals - whenever glucose is used to provide energy to the organism

ATP is the molecule needed to provide energy for animals when they need to perform a task such as running, lifting, swimming, etc.

*Demonstrate that carbon and energy are transferred and conserved within the Earth’s spheres.*

Carbon is the basis of life on Earth. Scientists consider 99.9% of all organisms on the planet to be carbon based life. Those organisms need carbon to survive. Whether the carbon is in the form of a sugar or carbon dioxide gas, we all need it. Unlike energy, carbon is continuously cycled and reused. The Earth only has a fixed amount of carbon.

There are four essential steps in the carbon cycle:

1. Carbon enters the atmosphere as carbon dioxide from respiration (breathing) and combustion (burning).

2. Carbon dioxide is absorbed by autotrophs (life forms that make their own food e.g. plants) to make glucose in photosynthesis. One of the end products of photpsynehesis is oxygen.

3. Heterotrophs (life forms that cannot make their own food e.g. animals) feed on the plants. Thus passing the carbon compounds along the food chain. Most of the carbon these animals consume is exhaled as carbon dioxide. This is through the process of cellular respiration. The animals and plants then eventually die.

4. The dead organisms (dead animals and plants) are eaten by decomposers, such as fungi and bacteria, in the ground. The carbon that was in their bodies is then returned to the soil or atmosphere. In some circumstances the process of decomposition is prevented. The decomposed plants and animals may then be available as fossil fuel in the future for combustion.