Unit 2 Matter

The universe consists of *matter* and *energy*. Chemistry is the branch of science the studies *matter* as well as the *changes* it undergoes and the *energy changes* that accompany such transformations.

Matter defined: *anything with mass and volume*

A. Can be *macroscopic*: visible *without* a microscope

B. Can be *microscopic*: visible *with* a microscope

C. Can be *submicroscopic*: *not* visible – even with a light microscope

- *Scanning Tunneling Microscope* (STM), developed in 1981, image and manipulate individual atoms within elements
- The matter studied by chemistry is submicroscopic. To understand submicroscopic matter, chemists *study macroscopic behavior, composition, and structure and use models (three-dimensional representation containing essential structure of object/event in real world)*.

Volume defined: *measurement of the amount of space occupied by a sample of matter*

Mass defined: *measurement* reflecting the amount of *matter*. It can also be defined as *the amount of inertia (resistance to change) in an object*. The more mass in an object, the greater its *resistance to change in motion*. Mass is measured by an instrument called a *balance*, and the base unit is the *gram* (*g*).

Fill in the table to compare and contrast *mass* and *weight*.

Mass	Weight
Measures the amount of matter *Measured with balance in grams (g)*	*Measures gravitational pull on matter* *Measured with scale in newtons (N)*

Writing Activity: Answer in complete sentences.
The gravity on the Moon is 1/6 that on Earth. If a person weighs 120 pounds on earth, how much would she weigh on the Moon?
Her weight on the Moon would only be 20 pounds compared to her 120 pounds on Earth.

How would her mass on the Moon compare to her mass on Earth? *Her mass on the Moon would be the same as her mass on Earth.*

Classification of Matter

Matter can be classified based on its *state* or its *composition*.

State of Matter

A. *States of matter* are the physical forms by which matter is classified based upon the characteristics it exhibits.

1. Differences in state of matter are due to differences in the *kinetic energy* of the particles of matter.
2. There are *five* states or phases of matter:

   - *Bose-Einstein Condensate* (BEC): occurs close to *absolute zero* and is characterized by almost no motion, meaning *little to no kinetic energy*. All atoms merge into one *superatom*, with electrons moving to one energy level and all atoms becoming one entity.
   - *Solids*: have *low* kinetic energy and are held in position by *electrostatic attraction*. There are two types of solids: 1) *crystalline*, and 2) *amorphous*.
   - *Liquids*: have more kinetic energy than *solids* and are characterized by *indefinite* shape, *definite* volume, and viscosity (*resistance to flow*).
   - *Gases*: have more kinetic energy than *liquids*, allowing particles to flow and expand, giving them *indefinite* shape and volume
     - Vapor is defined as the gaseous state of matter from *a substance that is normally solid or liquid at room temperature. All vapors are gases, but all gases are not vapors*.
   - *Plasma*: most common form of matter, (*over 99% of the visible universe consists of plasma*). Kinetic energy of plasmas is so high that electrons are stripped from their atoms, creating *free-floating electrons* (negative charges) and *bare nuclei* (positive charges). As temperature decreases, the *electrons* return to their usual places. Ordinary solids, liquids, and gases are *electrically neutral and too cool or dense to be plasma*

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3. Chemistry typically studies only three states – *solids, liquids, gases* – because they tend to occur close to *close to room temperature and pressure* and are the three states generally *found on Earth*.

Increasing Energy 

	SOLID	LIQUID	GAS
Shape	*Definite shape*	*Indefinite shape*	*Indefinite shape*
Volume	*Definite volume*	*Definite volume*	*Indefinite volume*
Compressibility	*Incompressible*	*Virtually incompressible*	*Compressible*
Packing	*Tightly packed*	*Loosely packed*	*No packing*
Particle Movement	*Slight vibration; wiggling*	*Slide and flow; move past others*	*Moving freely; unrestricted*
Particle Order	*Highly ordered*	*Medium order; jumbled*	*No order*
Particle Energy	*Low energy*	*Medium energy*	*High energy*
***IMF**	*Strong IMF*	*Medium IMF*	*Weak/low IMF*

*IMF = *intramolecular forces - physical forces holding particles together*

4. Phase changes occur as particles *absorb* kinetic energy (*endothermic*) or *release* kinetic energy (*exothermic*).
   - Absorb energy: *fusion or melting (solid to liquid); vaporization or boiling (liquid to gas) - evaporation is vaporization only on the surface of a liquid; sublimation (solid to gas)*
   - Release energy: *condensation (gas to liquid); solidification or freezing (liquid to solid); deposition (gas to solid)*

Physical Properties

- *Characteristics observed through five senses or measured without changing composition or identity of matter*
- *Consistent and unchanging due to uniform and unchanging composition of pure substances*

Two Types

① Extensive properties *depend upon amount of substance present*

Examples: *mass, length, volume*

② Intensive properties *are independent of amount of substance present*

Examples: *state at room temperature, color, odor, taste, hardness, density, melting/boiling points, malleability, ductility, electrical/thermal conductivity*

Chemical Properties

- *The ability or inability of a substance to combine with or change into one or more other substances*
- *Evident when substances come in contact with each other or when energy is applied*

Examples

The ability to *rust, corrode, burn, explode, rot, change color, react*

or the *inability* to do these things

Substances have unique sets of physical and chemical properties that are helpful in identifying unknown substances.

Physical Changes

- *Changes which alter a substance without changing its composition or identity*

Examples

- *Cut, break, bend, grind, crumple, split, crush, dissolve, fold*
- *Include phase changes: melt, freeze, boil, vaporize, condense, evaporate*

The Law of Conservation of Mass

Mass is neither created nor destroyed in any physical or chemical process; it is conserved.

$$Mass_{reactants} = Mass_{products}$$

Chemical Changes

- *Processes involving one or more substances changing into new substances*
- *Also referred to as chemical reactions*
- *Starting substances [reactants] have different compositions and properties from new substances formed [products]*
- *Represented by chemical equations*

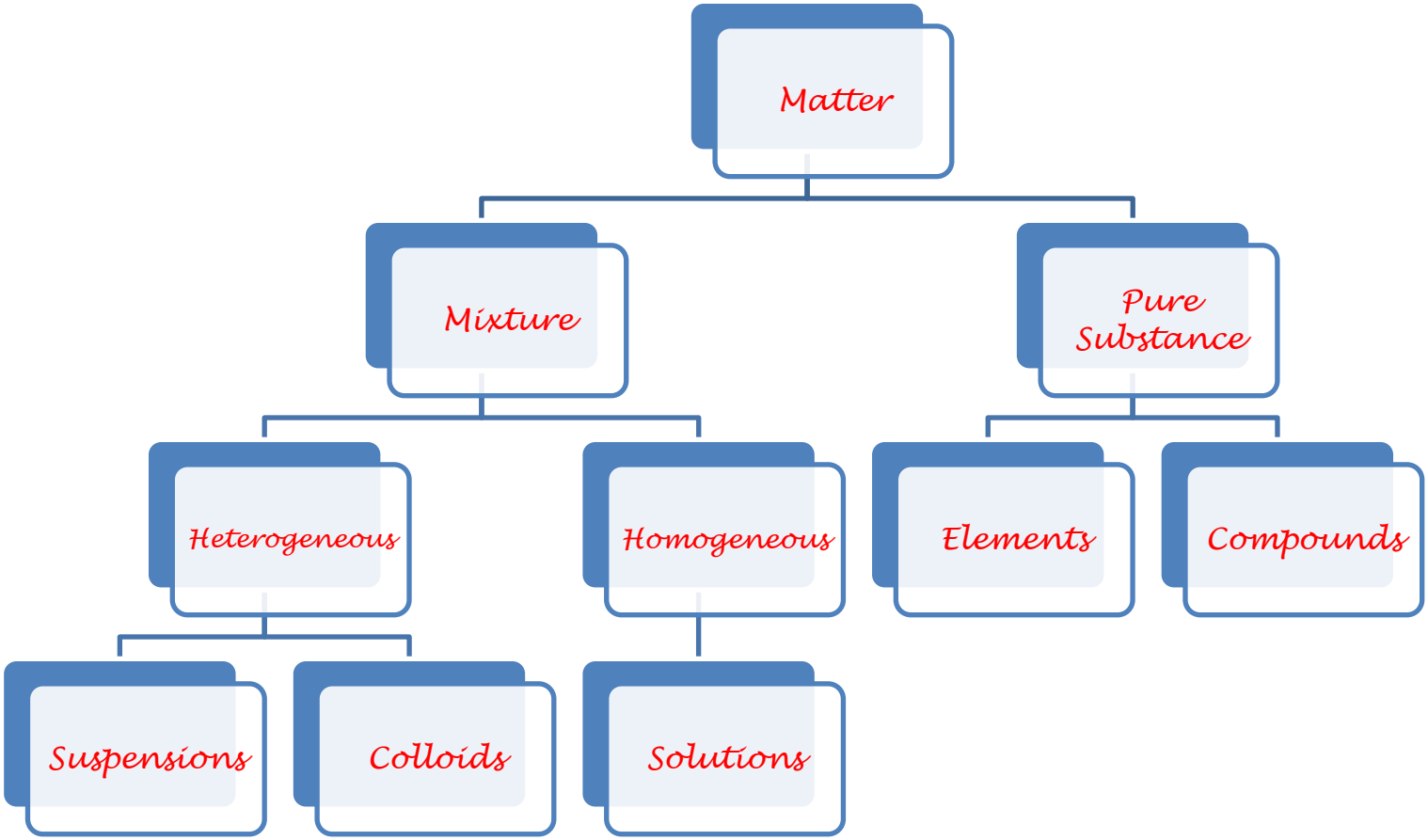
Examples

- *Explode, rust, oxidize, corrode, tarnish, ferment, burn, rot*

Indicators of Chemical Reaction

- *Formation of a gas*
- *Formation of a solid (precipitate)*
- *Change in temperature or energy*
- *Change in smell or production of odor*
- *Change in color*
- *Change in magnetism*

Classification of Matter Chart



Composition of Matter

A. Constant composition characterizes *pure substances*, whereas variable composition is characteristic of *mixtures*.

B. A pure substance is matter with *definite and uniform composition* with *distinct properties*. It is made of a single type of *atom* or *molecule*. Therefore, a *chemical formula* can be written.

C. A mixture is a *combination of two or more substances*, which *retain their distinct identities and characteristic properties*. The composition varies *from one sample to another* and *can vary within a single sample*. It is made of two or more types of *atoms* or *molecules* that are *physically combined* and consists of two parts: 1) *dispersed phase*: present in lesser amount, and 2) *dispersing medium*: present in greater amount.

D. Pure substances can be further subdivided into *elements* and *compounds*.

1. Elements are the *basic building blocks of matter* and cannot be broken down into simpler substances through *physical or chemical* means.
    - The *118* known elements are found on the *Periodic Table*, organized by *physical and chemical properties*. Elements numbered *1* through *92* occur naturally, while those numbered greater than *92* are *synthetic*.
    - Elements contain only one type of *atom*, they each have one *name*, and they are each represented by one *symbol*.
2. Compounds are composed of two or more substances *chemically combined* in *definite ratios*. The chemical combination results in *molecules* or *arrays of ions*.
    - Compounds can be broken down by *chemical* means, which require *energy*.
    - Properties of compounds are *distinctly different* from properties of *unbonded elements*.
        - Example: *hydrogen and oxygen are gases at room temperature and are combustible; these elements combine to form water, which is a liquid at room temperature and is not combustible*

E. Mixtures can be divided into two types of mixtures: *heterogeneous* and *homogeneous*.

1. Heterogeneous describes a *non-uniform* mixture of two or more substances, existing in *more than one phase*. Its components are *distinguishable* (distinct) and separate into *phases*. They tend to be *cloudy*, and the particles *settle into layers* over time. Heterogeneous mixtures are positive for the *Tyndall effect*.
    - The Tyndall effect is a phenomenon in which particles of mixture *scatter light*.
        - Positive: *beam of light can be seen when passed through heterogeneous mixtures*
        - Negative: *light is not visible when passed through homogeneous mixtures*
    - Heterogeneous mixtures with *large* particles are known as *suspensions*. The particles are usually visible and can be separated by *filtration or centrifuging*.
    - *Colloids* are heterogeneous mixtures with *intermediate* particles that are not completely *dissolved* and remain suspended, causing the mixture to appear *cloudy*. These particles cannot be *filtered out* and do not settle into *layers*.
        - Colloids are classified as *aerosols* or *foams* when one component is a gas, and *emulsions*, *sols*, or *gels* when only involving liquids and solids.
2. Homogeneous describes a *uniform* mixture of two or more substances, existing in a *single phase*. The composition is *variable* from one mixture to another but is *uniform* within an individual mixture.
    - Liquid homogeneous mixtures are *clear and transparent* but can be combinations of *solids, liquids, and gases*.
        - *Alloys* are solid in solid solutions (example: brass = copper + zinc). *Air* is a mixture of *gases* (nitrogen, oxygen, argon). Soft drinks are made of *solids, liquids, and gases*.
    - Also known as *solutions*.

- Consist of *solute* (substance that dissolves) and a *solvent* (dissolving agent present in greater amount). *Water* is the universal solvent, forming *aqueous* solutions.
- Homogeneous mixtures are made of multiple substances that appear *identical* because particles are so *small* and are mixed uniformly.
- Components are indistinguishable and do not separate into *layers*. Solutions cannot be separated by *filtration* or *centrifuging* due to small particle size.

Separation of Mixtures

A. Separation techniques are *physical methods to separate mixtures into their component substances*.

B. Separation Techniques

1. *Manual separation* basically means to separate "by hand." It involves using tools, such as tweezers or a magnet, to remove and separate components of a suspension.
2. *Filtration* uses a porous barrier to separate solids from liquids and is also used with suspensions. For example, *filter paper* can be used with a *funnel* to separate sand from water.
3. *Distillation* is based on the difference in boiling points of substances and is used to separate components of *solutions* and *colloids*. For example, when boiling salt water, the water will boil first, leaving the salt.
4. *Crystallization* results in the formation of pure solid particles of a solute from a solution. For example, when making *rock candy*, sugar forms solid crystals as liquid evaporates.
5. *Chromatography* separates components of solutions based on the tendency of components of a mixture to travel across the surface of another material, such as *ink dyes* moving across filter paper.
6. *Decantation* allows a liquid to be separated quickly from a heavier solid and is used with suspensions.
7. *Centrifuging* uses centripetal force to cause denser substances from a mixture to separate along the bottom while lighter substances move to the top.