Chapter 2.2-2.1 Notes Name: _____
Classifying Matter 2.2

| Material | Operational Definition | Conceptual Definition | Example |
|---|---|---|---|
| **Pure Substance** | • Has the same proportions of components<br>• Has one set of properties | • Atoms are chemically combined in a fixed ratio<br>• Solid phase has only one pattern and/or grouping of atoms | • Any element or compound<br>• Salt: NaCl (one atom of Na to one Cl) |
| **Mixture** | • Has more than one set of properties<br>• Components that retain their own properties and can be separated<br>• Proportions can vary | • Composed of more than one substance | • Seawater (many dissolved substances that can be separated) |
| **Element** | • Cannot be decomposed | • A pure substance composed of only one type of atom | • Found on periodic table (Carbon, hydrogen etc.) |
| **Compound** | • Pure substance that can be decomposed | • A pure substance composed of more than one type of atom | • $CO_2$ can be decomposed to Carbon and Oxygen |

<u>Pure Substances:</u>

Elements:

- An *element* is composed of a single kind of atom. An atom is the smallest particle of an element that still has all the properties of the element.
- Here's an example: Gold is an element. If you slice and slice a chunk of gold until only one tiny particle is left that can't be chopped any more without losing the properties that make gold *gold*, then you've got an atom.
- Elements can be classified as metals, non-metals and metalloids. As you move to the left on the periodic table the elements have more metallic character.

Metals:

- Properties: good conductors of heat and electricity, malleable, ductile and lustrous, most pure metals are not hard.
- Alloys are hard, they are not pure substances, but mixtures that contain metals (steel).
- Metal oxides react with water to from bases
- Example: _____

Non-Metals:

- Poor conductors of heat and electric.
- Many are gas at room temperature and their solid phases shatter easily.
- Non-metal oxides react with water to form acids
- Example: _____

Metalloids:

- Have some metallic properties and some non-metallic properties

Allotropy:

- The property of some elements to exist in more than one form
- The atoms arrange themselves in different ways
- Allotropes of carbon
    - Carbon has many allotropes
    - Two allotropes are shown here, diamonds and graphite (in your pencil)

<u>Pure Substances: Compounds:</u>

- A *compound* is composed of two or more elements in a specific ratio. For example, water is a compound made up of two elements, hydrogen (H) and oxygen (O). These elements

are combined in a very specific way — in a ratio of two hydrogen atoms to one oxygen atom, known as: $H_20$

- Many compounds contain hydrogen and oxygen, but only one has that special 2 to 1 ratio we call water. The compound water has physical and chemical properties different from both hydrogen and oxygen — water's properties are a unique combination of the two elements.
- Chemists can't easily separate the components of a compound: They have to resort to some type of **chemical reaction**

Organic vs. Inorganic Compounds:

- Organic compounds have carbon and hydrogen atoms (might have more atoms but needs to have C and H)
- Inorganic compounds are all other compounds

Binary vs. Non-Binary Compounds:

- Binary (bi = 2) compound is composed of only 2 elements
- Non-binary have more or less than 2 elements

Ionic vs. Molecular Compounds:

- Ionic compounds consist of positively or negatively charged ions held together by the opposite electric charge (ionic bonds which transfers electrons).
    - Between a metal and a non-metal
- Molecular compounds are held together by shared valence electrons (covalent bonds)
    - Between non-metals (except ammonium $NH_4^+$ ion which is ionic)

Acids, Bases and Salts

- Acids can be recognised by hydrogen ions ( $H^+$ ) bonded to an anion (- ion)
    - dissociate in water to release $H^+$
    - have a pH under 7
    - HCL- Hydrochloric acid or $H_2SO_4$ Sulphuric acid (battery acid)
- Bases have a pH over 7 and can be recognized by hydroxide ions ($HO^-$)
    - Dissociate in water to release $HO^-$
    - NaOH
- Salts is any ionic compound other than a hydroxide
    - $CaCl_2$

What's the big deal?

- Acids and bases react to form salts (and water)
- Neutralization reaction – the acid and bases are neutralized
    - Example: _____

<u>Mixtures:</u>

- *Mixtures* are physical combinations of pure substances that have no definite or constant composition — the composition of a mixture varies according to who prepares the mixture.
- Mixture can be easily separated by **physical means**, such as filtration.
- For example, if you have a mixture of salt and sand, and you want to purify the sand by removing the salt. You can do this by adding water, dissolving the salt, and then filtering the mixture. You then end up with pure sand.
- Mixtures can be either homogeneous or heterogeneous.

Mixtures: Homogenous

- Are relatively uniform in composition; appears the same throughout.
- For example, if you dissolve sugar in water and mix it really well, your mixture is basically the same no matter where you sample it.
- It's hard to distinguish between a homogenous mixture and a compound. The important difference is the lack of chemical bonding and thus fixed proportions in homogenous mixtures

Homogenous Mixtures: Solutions

- Solutions are homogenous mixtures where the chemical species (components) form very small particles (less than 1nm or $10^{-9}$)
- A solute is dissolved in a solvent
    - salt dissolved in water: salt-solute
    - the salt is in aqueous solution (dissolved in water)
    - NaCl (aq)
- Concentration [ ] is a measure of solute in a solution

Special Mixtures: Colloids

- Colloid- A mixture of two phases of matter
- Appear homogenous to the naked eye but are actually made up dispersed particles between 1nm and 1μm, distributed in a solid, liquid or gas.
- Unlike in a solution the colloid particles can be in a different phase than what they are suspended in.
- Remain suspended indefinitely (don't settle out).

Tyndall Effect:

- The scattering of light by colloidal particles. Example headlights in fog.

Mixtures: Heterogeneous

- A mixture whose composition varies from position to position within the sample and one or more components is visible to the naked eye.
- For example, if you put some sugar in a jar, add some sand, and then give the jar a couple of shakes, your mixture doesn't have the same composition throughout the jar. Because the sand is heavier, there's probably more sand at the bottom of the jar and more sugar at the top.

Heterogeneous Mixtures: Suspensions

- Particles are larger than in solutions or colloids
- Particles are visible
- Because of their greater size they will settle out (form sediment) if left standing
    - Often solids in liquids or gasses: silt in water or dust in air

<u>Separating the Substances of a Mixture: Chapter 2.3</u>

Physical Separations: We will be studying physical separations of mixtures which can be classified as mechanical or non- mechanical separations

Mechanical Separations: Density Separation

- Density Separation- particles with higher density than the medium will sink (sediment). Methods:
    - Decanting- pouring off liquid leaving sediment
    - Filtration- pouring through a filter (filter is the filtrate, sediment is the residue).

Mechanical Separation: Centrifugation

- Centrifugation- rapid spinning that increases sinking of particles.

Non-Mechanical Separation: Chromatography

- Mixtures are separated according to the different solubilities of the components in liquids, or their adsorptions on solids
- A flowing liquid or gas (referred to as the mobile phase or the carrier) carries substances in a solution at different rates through a stationary phase
- Different substances travel through the stationary phase at a different rate thus can be separated and analyzed

Paper Chromatography

- We will do a lab on this
- In the stationary phase of paper chromatograph, the sample to be analyzed is spotted onto a piece of filter paper. The sample is carried along this stationary phase by a solvent which acts as the moving carrier

- The components of the sample are carried different distances along the paper, depending on their individual solubilities. after a length of time, therefore, the original spot is spread out into a series of bands. These bands are then analyzed, to determine their identities.

Non-Mechanical Separation: Distillation

- Separates a mixture because of the different vapour pressures of boiling points of the substances
- Best used for separating liquid and a dissolved solid

Non-Mechanical Separation: Froth Flotation

- Commonly used to extract minerals from crushed ore
- The crushed ore is mixed with water and a small amount of oil is added. The oil adheres only to the mineral grains making them hydrophobic.
- When air is bubbled through the mixture the mineral grains attach to the bubbles and float to the surface where they can be collected.

Which method should you choose?

- Look at the property of each substance and use those properties to separate substances
  - Hand separation/filtration → particle size
  - Evaporation/distillation → boiling point
  - Solvent extraction/recrystallization → differing solubilities
  - Gravity separation → density
  - Chromatography → differing solubilities

Chemical Nomenclature: Chapter 2.4

- writing formulas for ionic compounds requires a set of rules that must be followed so that there is consistency when reading formulas

Rules for Writing Chemical Formulas:

1. The symbol that is more metallic is written first. Metal (+) and non-metal (-).
2. Write the combining capacities (charge) for each element as a superscript. e.g. $Mg^{2+}$ and $Br^{-}$
3. Balance the combining capacities so that when they are written, the sum of the combining capacities is zero. The total charge on Mg is +2 and the total charge on Br is −1. Two bromide ions are required to balance the charge on magnesium.
4. Use subscripts to indicate the number of atoms of each element in the compound. e.g. When magnesium and bromine combine, there are two bromide ions for every one ion of magnesium ∴the formula is $MgBr_2$

Naming Ionic Compounds:

- When there are only two elements in an ionic compound, the less metallic element changes it's ending to '-ide"

| | |
|---|---|
| • chlorine → chloride<br>• fluorine → fluoride<br>• bromine → bromide<br>• oxygen → oxide<br>• sulphur → sulphide<br>• nitrogen → nitride<br>• phosphorus → phosphide<br>• carbon → carbide | • e.g. CaS is calcium sulphide<br>• NaBr is sodium bromide<br>• BeF2 is berylium fluoride |

Elements with more than one combining capacity:

- Some elements have more than one combining capacity. Lead has a combining capacity of +2 and +4 and can form both $PbBr_2$ and $PbBr_4$
- The name led bromide is not longer enough. We must be able to name the two compounds so that we can distinguish between $Pb^{2+}$ and $Pb^{4+}$
- We use Roman Numerals after the name of the metallic element to indicate the combining capacity. e.g. $PbBr_2$ is lead (II) bromide and PbBr4 is lead (IV) bromide.

Formulas for Polyatomic Ions:

- Polyatomic ions are groups of atoms that stay together and carry an overall charge.
- The charge on the polyatomic ion acts as the combining capacity and the group acts like a single ion. Parentheses are used to indicate that more than one polyatomic ion is present in a compound.
- e.g. The formula for magnesium nitrate is $Mg(NO_3)_2$. There are two nitrate ions present for every magnesium ion.

Writing Covalent Compounds:

- To write the formulas for covalent compounds, follow the same rules for ionic compounds.

Naming Covalent Compounds:

- Covalent compounds use prefixes to indicate the number of elements in the compound. CO and $CO_2$ both contain carbon and oxygen, but CO is named carbon monoxide and $CO_2$ is carbon dioxide.
- The prefixes before the name of the elements indicate the number of atoms in each compound. Here is a list of the first eight prefixes:

| | |
|---|---|
| Mon(o) - 1 | Pent(a) - 5 |
| Di - 2 | Hexa - 6 |
| Tri - 3 | Hepta - 7 |
| Tetr(a) - 4 | Octa - 8 |

- Examples:
  - $CBr_4$ is carbon _____bromide
  - $P_2O_3$ is ____phosphorus____trioxide
  - $PO_2$ is ____ phosphorus ____ioxide

## Chemistry Review Questions: 1

1. A mixture **(is/is not)** a chemical combining of substances.

2. In a compound the **(atoms/molecules)** are **(chemically/physically)** combined so that the elements that make up the compound **(retain/lose)** their identities and **(do/do not)** take on a new set of properties.

3. The smallest identifiable unit of a compound is a(n) _____, which is made up of _____ which are chemically bonded.

4. True or False: A mixture is always made up of a combination of elements.

5. In a mixture, the substances **(lose/retain)** their identities.

6. In a mixture the substances involved **(can/cannot)** be separated by a simple physical process. In a compound the elements involved **(can/cannot)** be separated by asimple physical process because the elements are **(physically combined/chemically bonded).**

7. True or False: An element can be broken down into a simpler substance.

8. The smallest identifiable unit of an element is a(n) _____.

9. Explain how to separate the sugar and water in a solution of sugar and water.

10. How would you separate a mixture of alcohol and water?

11. How would you separate sand and water?

12. Classify the following as pure substances or as mixtures:

| | | | | |
|---|---|---|---|---|
| a. | air | gasoline | grain | alcohol |
| b. | water | sugar | gold | mercury |

13. Classify the following as heterogeneous (E) or as homogeneous (O) mixtures:

| | | | |
|---|---|---|---|
| a. | sand & salt | hydrogen | iron |
| b. | salt water | unfiltered air | iron with rust |
| c. | pure water | an apple | nitric acid |
| d. | tossed salad | granite | wood |

14. Classify the following as an element, a compound, a solution, or a heterogeneous or homogenous mixture:

| | | | |
|---|---|---|---|
| a. | aluminum | raisin bread | gasoline |
| b. | carbon dioxide | tap water | grain alcohol |
| c. | sugar and water | sulfur | mercury |
| d. | sulfuric acid | Cola | nitrogen |
| e. | an orange | water & instant coffee | a dinner plate |
| f. | pencil led | carbon particles & sugar | glass ($siO_2$) |

15. Write the chemical formulas for the following:

a. sodium oxide
b. calcium hydroxide
c. potassium carbonate
d. zinc chloride
e. magnesium nitrate
f. aluminium carbonate

16. Write chemical formulas for the compounds in the table. The top row is the postiviely charged cations (metals) while the first column is the negatively charged anions (see pg 98-99 for polyatomic ions and their charges)

| | Zinc | Iron (II) | Iron (III) | Gallium | Silver | Lead (IV) |
|---|---|---|---|---|---|---|
| Chloride | | | | | | |
| Oxide | | | | | | |
| Nitrate | | | | | | |
| Sulphate | | | | | | |
| Perchlorate | | | | | | |
| Sulphite | | | | | | |