Learning Guide Module

Subject Code: Chemistry 1 **General Inorganic Chemistry**
Module Code: 1.0 **Introduction and Review**
Lesson Code: 1.2 **Properties and Classification of Matter**
Time Frame: **30 minutes**

Components	Task	TA[1] (min)	TA[2] (min)
Target 	After completing this module, you are expected to: **1.** classify the properties in samples of matter. **2.** classify the changes occurring in nature. **3.** distinguish the different classification of matter given samples of matter.	0.5	
Hook 	**"Guess the Mystery Substance"** The substance has the following properties! Physical state: *liquid* (at room temperature) Density: *0.79 g/cm^3* Color: *colorless* Flammability: *flammable* Volatility: *volatile* Boiling point: *64.7^{0}C* Solubility: *soluble in water*  Figure 1. Unknown substance (en.wikipedia.org) This substance can be added to gasoline that is occasionally used to fuel internal combustion engines. It is a promising energy carrier because, as a liquid, it is easier to store than hydrogen and natural gas. (en.wikipedia.org) ***What is the identity of this substance?*** 	2.5	
Ignite 	**The Properties of Matter** Matter is the "stuff" of the universe: rocks, water, planets, trees - *anything that occupies space (volume) and has mass*. Chemists distinguish several subcategories of matter based on composition and properties. Properties are the characteristics that give each sample of matter its unique identity.Suppose you are given a metal sample.	15	

Figure 2. A metal sample (homesciencetools.com)

What are the properties that can be identified to help established the identity of metal sample?

To aid in identifying a substance, we observe two types of properties, *physical* and *chemical*, which are closely related to two *types of change* that matter undergoes. Some of these concepts were discussed in you Integrated Science 2 subject but we will study them in detail here in this module.

Physical properties are characteristics displayed by a sample of matter without undergoing any change in its *composition*(relative amounts of elements.)
For example, the properties of the metal in Figure 2 include:

mass = 96.53 g
volume = 4.50 cm^3
density = 21.5 g/cm^3

An important physical property of a substance is its **physical state**, also called its **state of matter**(Jones & Atkins,2000, p 25). The three *most* common states of matter are *solid*, *liquid*, and *gas*. The sample in figure 2 is solid.

A **physical change** occurs when a substance alters its physical properties, *not* its composition(involves a process).
For example, if the metal sample in Figure 2 melts, that's physical change. Grinding solid sample, tearing of paper, cutting of grasses are other examples of physical changes.

Chemical properties are characteristics displayed by a sample of matter as it undergoes a change in composition. The chemical properties in Figure 2 are nonflammable and nonreactive.

A **chemical change**(or *chemical reaction*) occurs when a substance is converted into different substance. When a new substance is formed, we usually observed one of the following: a permanent *color change*, an *odor* or *bubbles* from the release of a gas, or light or heat from the release of energy.
The rusting of iron is an example of chemical change.

All measurable properties of matter fall into two categories: **extensive properties** and **intensive properties** (Chang & Cruickshank,2005, p 15).

Extensive property: The measured value of an extensive property depends on how much matter is being considered(Chang & Cruickshank,2005, p 15). The mass(96.53 g) and volume(4.50 cm^3)in Figure 2 are extensive properties. If we cut the metal sample and melt the other half, the mass and volume of the solid sample left decreases. Less matter means less mass and volume.

Intensive property: The measured value of an intensive property does not depend on the amount of matter being considered(Chang & Cruickshank,2005, p 15). The density (21.5 g/cm^3) in Figure 2 do not change even if you melt some amount of it. Other examples of intensive properties are melting point and boiling point.

Classification of Matter

The chemical **elements** are the basic building blocks of matter and in various combinations make up all the matter on Earth. The smallest particle of an element that can exist is called an **atom**. **Composition** refers to the types of atoms and the relative proportions of the different atoms in a sample of matter.

An **element** is the simplest type of matter with unique physical and chemical properties. *It consists* of *only one kind of atom* and, therefore, cannot be broken down into a simpler type of matter by any physical or chemical methods. Each element has a name, such as silicon, oxygen, or copper. *The periodic table of elements lists all the elements that we know*. All the elements –other than hydrogen and most of the helium – from which everything were formed inside a star (Jones & Atkins,2000, p 14). Even our flesh is a stardust (Jones & Atkins,2000, p 14).
Examples of elements are hydrogen, calcium, silicon and oxygen.

Figure 3. Silicon sample
(en.wikipedia.org)

A sample of silicon contains only silicon atoms. The macroscopic properties of a piece of silicon, such as color, density, and combustibility, are different from those of a piece of copper because the submicroscopic properties of silicon atoms are different from those of copper atoms; that is, *each element is unique because the properties of its atoms are unique.*

Several elements occur in molecular form: a **molecule** is an independent structure and *electrically neutral* group of two or more atoms bonded together(Silberberg, 2013,p 33). Oxygen, for example, occurs in air as *diatomic*(two-atom) molecules(Silberberg, 2013,p 33). A molecule of oxygen can be represented by the illustration below.

Figure 4. an oxygen molecule

A **compound** consists of two or more different elements that are bonded chemically. Many compounds, such as ammonia(1 nitrogen, 3 hydrogens), water(1 oxygen, 2 hydrogens), carbon monoxide(1

carbon, 1 oxygen) and carbon dioxide(1 carbon, 2 oxygens), consists of molecules. Hence, they are called *molecular compounds*. A water molecule, containing 2 hydrogen and 1 oxygen, can be represented by:

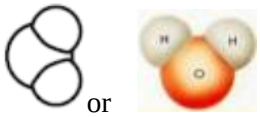


Figure 5. A water molecule

Sodium chloride, an *ionic compound* does not consist of molecules. We classify a compound as *ionic* if it consists of ions. An **ion** is a positively or negatively charged atom or bonded group of atoms. A positively charged ion is called a *cation* (pronounced *cat-eye-on)*; a negatively charged ion is called an *anion* (pronounced *an-eye-on*).

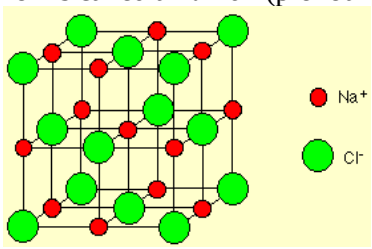


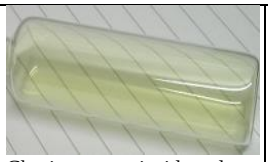
Figure 6. Crystal structure of sodium chloride
(chemguide.co.uk)

Sodium chloride does not have independent group of atoms but the ratio is for every 1 sodium, there is 1 chlorine.

Compounds may either be molecular or ionic. No matter what the compound, however, one defining feature is that the elements are presents in fixed parts by mass.Another defining feature of a compound is that *its properties are different from the properties of its component elements*.

For example, sodium metal is silvery and chlorine gas is yellow-green and poisonous. When the two elements react and form sodium chloride, the properties changes. Sodium chloride is a white, crystalline, nonpoisonous compound. In fact, we use sodium chloride in many of our food products.

Sodium: silvery white metal
(en.wikipedia.org/wiki/Sodium)



Chorine gas inside glass container. It is yellow-green in color.
(en.wikipedia.org/wiki/Chlorine)

Sodium chloride: white, crystalline, nonpoisonous
(indiamart.com)

Figure 7. Sodium metal, chlorine gas, and sodium chloride

Unlike element, a compound *can* be broken down into simpler substances – its component elements. For example, an electric current converts liquid water into oxygen gases and hydrogen gases. By definition, this breakdown is a chemical change, not a physical one. Table 1 shows the connections among properties, changes and classification of matter.

Table 1. Connections among properties, changes and classification of matter

Water $\xrightarrow{\text{electricity}}$ hydrogen gas + oxygen gas			
Classification of matter	compound	element	element
Physical property, boiling point	100^0C	-253^0C	-183^0C
Physical property density	1.0 g / mL	9.0×10^{-5} g/mL	1.4×10^{-3} g/mL
Chemical property, flammability	nonflammable	flammable	nonflammable
Chemical change	The conversion of water into hydrogen and oxygen.		
Note	In this example, when chemical change occurred, the compound is converted into elements; and the physical and chemical properties of the substances also change.		

Types of Mixtures

Each element and compound is a **substance**(or *pure substance*). The unknown substance in the "hook" section is *methanol*(a molecular compound). However, most materials are neither single elements nor single compounds. Instead, they are **mixtures** of substances. Wood, gasoline, wine, soil, and air are all mixtures. An important role of chemistry is the *analysis* of mixtures, the identification of substances they contain. The main characteristic of a mixture is that it has *variable composition*.

We can identify the different components of some mixtures with the unaided eye or an optical microscope. Such a patchwork of different substances is called a **heterogeneous mixture**. Many of the rocks that form the landscape are heterogeneous mixtures. Salad dressing, a slab of concrete, and the leaf of a plant are all heterogeneous.

Figure 7. Marble (sandatlas.org)

Figure 8. A leaf sample (calacademy.org)

In some mixtures, we cannot make out distinct components, even with a very powerful microscope: the molecules or ions of the components are so well mixed that the composition is the same throughout, no matter how large or small the sample. Such a mixture is called a **homogeneous mixture(solution)**. For example, syrup is a homogeneous mixture of sugar and water. The molecules of sugar are separated and mixed so thoroughly with the water that no distinctive regions or separate particles can be seen with a microscope.Seawater is a solution of salt and many other substances in water. Brass is a solid solution(alloy) of copper in zinc.

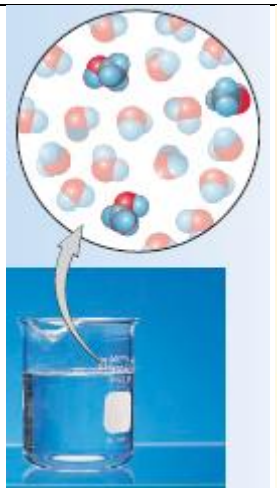


Figure 9. Molecular view of methanol solutionFigure 10. Brass Antique Microscope (Ebbing & Gammon, **year**)(pinterest.com)

Chemistry in Action: **HYDROGEN: Fuel for the future !**

Hydrogen, the simplest element, has long been described as fuel for the future. What are the properties of hydrogen that makes it fuel for the future?

Navigate

PART I. NONGRADED ASSESSMENT 10

1. Do these statements describe chemical or physical properties?
(a) A sapphire is blue.
(b) Lead is denser than aluminum.
(c) Oxygen gas supports combustion.
(d) The boiling point of ethanol is 78^0C.
(e) An iron nail is attracted to a magnet.
(f) Objects made of silver become tarnished.

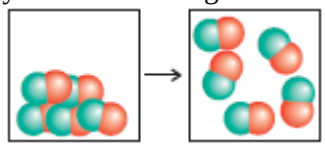
2. Identify all the physical properties and changes in the following statement: "Copper is a brown element obtained from copper sulfide ores by heating them in air, which forms copper oxide. Heating the copper oxide with carbon produces impure copper, which is purified by electrolysis."

3. Which of these properties are intensive and which are extensive?
(a) Color
(b) Area
(c) The cost of gasoline
(d) Heat of Combustion
(e) The price of platinum

4. Does each of these describe physical change or chemical change?
(a) chopping a log
(b) boiling canned soup

(c) toasting a slice of bread
(d) A spoonful of table salt dissolves in a bowl of soup.
(e) A flashlight beam slowly gets dimmer and finally goes out.
(f) The helium gas inside a balloon tends to leak out after a few hours.
(g) The iron in discarded automobiles slowly forms reddish brown, crumbly rust.
(h) The growth of plants depends on the sun's energy in a process called photosynthesis.

(i) Passing an electric current through molten magnesium chloride yields molten magnesium and gaseous chlorine.

(j) 

5. Indicate whether each sample of matter listed is a substance or a mixture; if it is a substance, indicate whether it is an element or compound; if it is a mixture, indicate whether it is homogeneous or heterogeneous.

		Substance or mixture	If a substance, classify as either element or compound If a mixture, classify as either homogeneous mixture or heterogeneous mixture
(a)	ice		
(b)	a silver-plated spoon		
(c)	clean fresh air		
(d)	platinum		
(e)	limestone		

PART II GRADED ASSESSMENT (Must be done outside the 30 minute time limit of the module)

1. Do these statements describe chemical or physical properties?

(a) The red color of rubies is due to the presence of chromium ions.
(b) Water boils below 100^0C on top of a mountain.
(c) Uranium is a radioactive element.
(d) Fertilizers help to increase agricultural production.

(e) A piece of paper spontaneously ignites when its temperature reaches 451 ^{0}F.

2. Identify all the physical properties and changes in the following statement: "The camp nurse measured the temperatureof the injured camper and ignited a propane burner, when the water began to boil some of the water vaporcondensed on the cold windows."

3. Which of these properties are intensive and which are extensive?

(a) The hardness of iron nail.
(b) The humidity of the atmosphere.
(c) The heat of vaporization of water.
(d) The temperature of water is 25^0 C.
(e) The energy produced when gasoline burns.

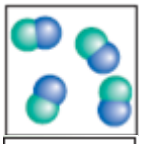
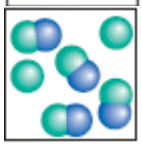
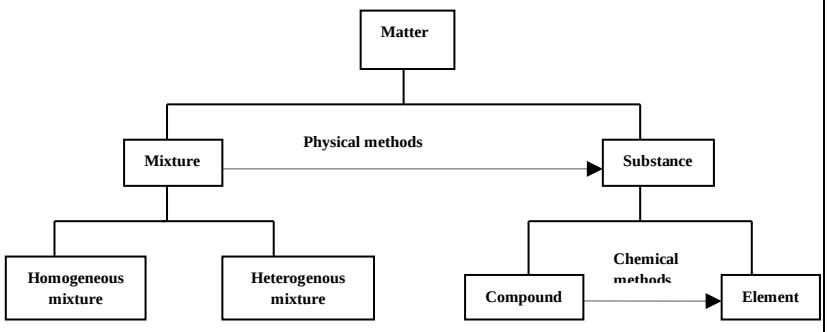
4. Does each of these describe physical change or chemical change?

(a) A piece of sliced apple turns brown.
(b) Frozen orange juice is reconstituted by adding water to it.
(c) A clay pot fired in a kiln becomes hard and covered by a glaze.
(d) A magnet separates a mixture of blank iron shavings and white sand.
(e) Yellow-green chlorine gas attacks silvery sodium metal to form white crystals of sodium chloride.

5. Indicate whether each sample of matter listed is a substance or a mixture; if it is a substance, indicate whether it is an element or compound; if it is a mixture, indicate whether it is homogeneous or heterogeneous.

		Substance or mixture	If a substance, classify as either element or compound If a mixture, classify as either homogeneous mixture or heterogeneous mixture
(a)	gold		
(b)	wood		
(c)	ethanol		
(d)	underground water		
(e)	steel		

6. Classifythe following as pure substance or mixture? Explain. If pure substance, classify whether element or compound. If mixture, classify whether homogeneous mixture or heterogeneous mixture.

	(a) Sulfur consists of sulfur atoms combined into octatomic molecules. (b) Baking powder, a leaving agent, contains 26% to 30% sodium hydrogen carbonate and 30% to 35% calcium dihydrogen phosphate by mass. (c) Cytosine, a component of DNA, consists of H,C,N, and O toms bonded in a specific arrangement. (d)  (e)  7. Additional assessment (a) Draw the model of solid, liquid, and gas at the atomic/molecular level.		
Knot 	Summary: • Properties are the qualities or attributes that distinguish one sample of matter from another. • Chemical changes or reactions are changes in composition. • Physical changes are changes in state or physical form and do not affect composition. • All matter exits as elements, compounds, or mixtures. • Every element or compound is a substance, matter with a fixed composition. • An element consists of one type of atom and occurs as collections of individual atoms or molecules. • A compound contains two or more elements chemically combined. Only chemical change can break down a compound into its elements. • A mixture consists of two or more substances mixed together, not chemically combined. It can be separated by physical changes.  Figure 11. Classification of matter	2	

[1]Time allocation suggested by the teacher

[2]Actual time spent by the student(for information purposes only

References

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Chang, R. And Cruickshank, B. (2005). *Chemistry*, 8th Ed. New York; McGraw-Hill

Prepared by: RODOLFO S. DEL ROSARIO	Reviewed by: PRINCESS ANN B. DIGNENENG
Position: Special Science Teacher IV	Position: Special Science Teacher II
Campus: CLC	Campus: CLC