ACTIVITY 1: INTRODUCTION

DIRECTIONS: Read the following introduction and define the words or groups of words in bold type.

CLASSIFICATION OF MATTER

Matter can be divided or classified into three general classes called elements, mixtures, and compounds as shown in Table 1 below. Elements are pure substances made up of only one type of matter. Compounds are pure substances made up of two or more elements combined chemically. Mixtures are made up of two or more substances combined physically. Mixtures may or may not have the same composition throughout.

THREE CLASSES OF MATTER		
Elements (symbols)	**Mixtures**	**Compounds** (formulas)
Oxygen (0)	Cement	Salt ($NaC\ell$)
Aluminum ($A\ell$)	Air	Baking Soda ($NaHC0_3$)
Hydrogen (H)	Ice Cream	Washing soda (Na_2C0_3)
Calcium (Ca)	Brass	Rust (Fe_20_3)
Copper (Cu)	Air	Lye (NaOH)
Nitrogen (N)	Paint	Muriatic acid ($HC\ell$)
Sodium (Na)	Pond water	Sand ($Si0_2$)
Iron (Fe)	Soil	Chalk ($CaC0_3$)
Carbon (C)	Mayonnaise	Sugar ($C_{12}H_{22}0_{11}$)
Zinc (Zn)	Salt water	Water (H_2O)

Table 1. Three classes of matter

PROPERTIES OF MATTER

All matter has certain properties or characteristics that distinguish it from other types of matter.
Properties of matter are the distinguishing characteristics of a substance which can be used to identify or 14
describe a substance. Two main types of properties are physical properties and chemical properties.

Physical properties are properties of a substance that can be observed without changing the chemical 18
composition of a substance. Physical properties include color, state of matter, density, boiling point, melting
point, and solubility. **Chemical properties** are properties which are dependent upon one substance reacting with 25
another substance. For example, a chemical property of zinc is that it reacts with hydrochloric acid.

CHANGES IN MATTER

Changes in matter occur often. Many changes occur spontaneously while others require some outside force such as heat or light. These changes in matter can be classified as either physical changes or chemical changes.

A **physical change** is a change in the size, shape, or form of a substance. It is a process that does not alter the 26
chemical composition of a substance. For example, changing ice to water vapor is a physical change. Tearing
paper into small pieces is another physical change. Physical changes are used to separate mixtures.

A **chemical change** is a process that changes the chemical composition of a substance. When a chemical 15
change takes place, a chemical reaction between two substances occurs. A **chemical reaction** is a reaction in 19
which a new substance or substances are formed. These new substances have different physical and
chemical properties than the original substances. For example, when sodium combines with chlorine to form
sodium chloride, a chemical change has taken place. Sodium chloride has different physical and chemical
properties than either sodium or chlorine.

ACTIVITY 1: (continued)

Evidences of a chemical reaction are a color change, the formation of a precipitate, fizzing or bubbling, a new odor produced, or heat or light given off. A **precipitate** is a new solid formed when two clear solutions 16 are combined. Chemical changes are used to combine elements and to separate the elements in a compound.

ELEMENTS

An **element** is a pure substance that cannot be broken down into simpler substances by ordinary 5 chemical means. Each element is characterized by a unique set of properties such as color, state of matter, density, boiling point, melting point, etc. These properties can be used to identify or describe an element. Distinguishing properties of some elements are listed in Table 2 below.

DISTINGUISHING PROPERTIES OF SOME ELEMENTS					
Element	Symbol	Properties	Element	Symbol	Properties
Calcium	Ca	silvery-white solid; metallic	Silver	Ag	silver solid; metallic; tarnishes
Iron	Fe	black solid; metallic; magnetic	Oxygen	O	colorless gas; odorless; supports combustion
Bromine	Br	dark red liquid; produces severe skin bums	Copper	Cu	reddish-orange solid; metallic; conducts electricity
Sulfur	S	yellow solid; insoluble in water; burns in air	Sodium	Na	silvery-white solid; reacts violently with water
Hydrogen	H	colorless gas; odorless; combustible	Zinc	Zn	silver solid; metallic; reacts with some acids
Carbon	C	black solid; reacts with oxygen	Chlorine	Cℓ	a yellow-green gas; poisonous; disagreeable odor
Gold	Au	yellow solid; metallic; soft	Iodine	I	bluish-black solid; crystalline; poisonous
Helium	He	colorless gas; does not react chemically	Mercury	Hg	silver liquid; high density

Table 2. Distinguishing properties of some elements

Elements are represented by chemical symbols. **Chemical symbols** are letters of the alphabet used to 3 represent elements, as shown in Table 3 below. Some elements are represented by one letter and some by two letters. When letters are used to represent elements, the first letter is always capitalized, while the second letter is never capitalized. For example, S represents the element sulfur and Si represents the element silicon. Hydrogen is represented by the letter H and helium is represented by the letters He. Some elements are represented by letters which come from their Latin or Greek name, as shown in Table 3 below.

SYMBOLS OF SOME COMMON ELEMENTS					
One Letter Symbols		Two Letter Symbols		Symbols Taken From Latin Names (in parentheses)	
Name	Symbol	Name	Symbol	Name	Symbol
Hydrogen	H	Calcium	Ca	Gold (aurum)	Au
Carbon	C	Helium	He	Iron (ferrum)	Fe
Sulfur	S	Silicon	Si	Sodium (natrium)	Na

Table 3. Letters are used to represent elements

All elements are made up of basic building blocks called atoms. An **atom** is the smallest part of an element that 4 has all of the properties of that element. All atoms of a given element contain the same type of atoms. Although there are over one hundred elements known at this time, some are more common to us than others. A list of the more common elements and their symbols is shown in Table 4 below.

ACTIVITY 1: (continued)

COMMON ELEMENTS AND THEIR SYMBOLS							
Element	Symbol	Element	Symbol	Element	Symbol	Element	Symbol
Aluminum	Aℓ	Cobalt	Co	Lithium	Li	Platinum	Pt
Barium	Ba	Copper	Cu	Magnesium	Mg	Potassium	K
Bismuth	Bi	Fluorine	F	Manganese	Mn	Silicon	Si
Boron	B	Gold	Au	Mercury	Hg	Silver	Ag
Bromine	Br	Helium	He	Neon	Ne	Sodium	Na
Calcium	Ca	Hydrogen	H	Nickel	Ni	Sulfur	S
Carbon	C	Iodine	I	Nitrogen	N	Tin	Sn
Chlorine	Cℓ	Iron	Fe	Oxygen	O	Tungsten	W
Chromium	Cr	Lead	Pb	Phosphorus	P	Zinc	Zn

Table 4. Common elements and their symbols

ATOMS

An atom has two major regions: the heavy, central area called the **nucleus** and the relatively empty 28
space around the nucleus. Atoms contain three small major sub-atomic particles called neutrons, electrons, and protons. Neutrons and protons are located in the central core or nucleus of the atom. Electrons travels rapidly around the nucleus at specific distances from the nucleus in energy levels, as shown in Fig. 5A below. **Energy** 29
levels are the regions occupied by electrons as they move around the nucleus. The first energy level is located closest to the nucleus and can hold two electrons. The second energy level can hold eight electrons, and the third energy level can hold up to 18 electrons. Energy levels farther from the nucleus can hold 32 or more electrons. Fig. 5B illustrates the energy levels present around an oxygen atom.

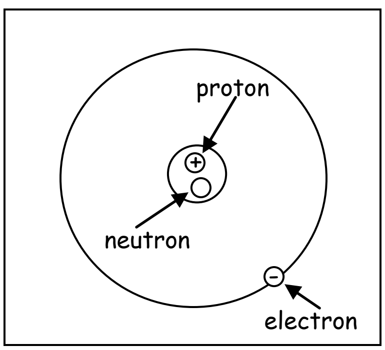
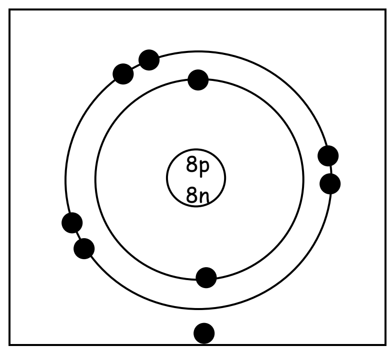


Fig 5A. General structure of an atom



5B. Structure of an oxygen atom

1
2 **Neutrons** are sub-atomic particles with no electric charge and an atomic mass unit of one. An **atomic mass unit** (amu) is 1/12 the mass of the carbon-12 atom. **Protons** are sub-atomic particles with a positive 20
electric charge and an atomic mass unit of one. **Electrons** are sub-atomic particles with a negative charge and, 13
because they are so small, are considered to have an atomic mass unit of zero. Table 5 below summarizes the characteristics of these three sub-atomic particles.

SUB-ATOMIC PARTICLES		
Sub-atomic Particle	Mass (amu)	Charge
Electron	1/1, 836 or 0	Negative (-)
Proton	1	Positive (+1)
Neutron	1, 837/1, 1836 or 1	None (0)

Table 5. Characteristics of three sub-atomic particles

ATOMIC NUMBER, ATOMIC MASS

All atoms of an element have the same number of protons. For example, each hydrogen atom has one proton in its nucleus, while each carbon atom has six protons in its nucleus. The number of protons in an atom is called the **atomic number**. The atomic number for some elements is listed in Table 6 below. In a neutral atom, 22
the atomic number can also be used to describe the number of electrons.

ATOMIC NUMBERS AND ATOMIC MASS NUMBERS					
Element	Atomic Number	Mass Number	Number of Protons	Number of Neutrons	Number of Electrons
Carbon	6	12	6	6	6
Boron	5	11	5	6	5
Oxygen	8	16	8	8	8
Neon	10	20	10	10	10

Table 6. Atomic numbers and atomic mass numbers for some elements

The **atomic mass number**, commonly referred to as the mass number, is the sum of the masses of the 6
protons and neutron in an atom. For example, oxygen has eight protons and eight neutrons, each with an atomic mass unit (amu) of one. Therefore, the atomic mass number for oxygen is 16 amu as shown in Table 6 above. Although all atoms of the same element have the same number of protons, they may differ in the number of neutrons they contain. **Isotopes** are atoms of the same element that differ in their number of neutrons. For 12
example, all carbon atoms have six protons, but may have six or eight neutrons.

Some elements exist in nature as two atoms chemically combined to form a molecule. Molecules composed of two atoms of the same element are called **diatomic molecules**. Elements that form diatomic 23
molecules are usually gases at normal room temperature. For example, at room temperature oxygen exists as two atoms joined together to form a molecule of oxygen gas with the formula, O_2. Other elements that form diatomic molecules are hydrogen, nitrogen, chlorine, fluorine, bromine, and iodine.

COMPOUNDS

A **compound** is a pure substance made up of different elements bonded together chemically. Compounds 21
can be broken down into simpler substances by ordinary chemical means. A compound is the result of the chemical combination of two or more elements or compounds. The smallest part of a compound that has all of the properties of that compound is a **molecule**. Because it is a pure substance, a compound is the same 7
throughout and has distinguishing properties that can be used to identify it. Table 7 below lists common compounds and some distinguishing properties of each compound.

DISTINGUISHING PROPERTIES OF SOME COMPOUNDS					
Compound	Formula	Properties	Compound	Formula	Properties
Sucrose	$C_{12}H_{22}H_{11}$	white solid; crystalline; sugary taste	Carbon dioxide	CO_2	colorless gas; does not support combustion
Hydrogen peroxide	H_2O_2	colorless liquid; decomposes in presence of light	Sodium bicarbonate	$NaHCO_3$	white solid; soluble in water
Manganese dioxide	MnO_2	black solid; used as a catalyst	Water	H_2O	colorless liquid; odorless
Copper carbonate	$CuCO_3$	blue-green solid; insoluble in water	Calcium carbonate	$CaCO_3$	white solid; insoluble in water
Sodium carbonate	Na_2CO_3	white solid; soluble in water	Copper sulfate	$CuSO_4$	blue solid; soluble in water
Calcium chloride	$CaC\ell_2$	white solid; soluble in water	Hydrochloric acid	$HC\ell$	colorless liquid: reacts with metals
Sodium sulfate	Na_2SO_4	white solid; crystalline; soluble in water	Carbon monoxide	CO	colorless gas; poisonous
Sulfuric acid	H_2SO_4	colorless liquid; acid; reacts with metals	Sodium chloride	$NaC\ell$	white solid; crystalline; salty taste

Table 7. Distinguishing properties of some compounds

ACTIVITY 1: (continued)

Compounds are represented by chemical formulas. **Chemical formulas** consist of letters and numbers 11
that show the elements in a compound and the number of atoms of each element present. Numbers used in chemical formulas are located to the right and slightly below the letter or letters that stand for the element. These numbers are called subscript numbers. **Subscripts** show the number of atoms of each element present in 8
a compound. For example, hydrogen peroxide has the chemical formula H_2O_2. It contains two atoms of hydrogen and two atoms of oxygen. Subscripts also show the ratio of elements combined in a compound, as shown in Table 8 below.

COMPOUNDS AND THEIR FORMULAS			
Name of Compound	Formula	Name of Compound	Formula
Sodium chloride	$NaC\ell$	Magnesium oxide	MgO
Hydrogen peroxide	H_2O_2	Sulfuric acid	H_2SO_4
Sodium carbonate	Na_2CO_3	Hydrochloric acid	$HC\ell$

Table 8. Compounds and their formulas

If no subscript numbers appear after the letter or letters for an element in a chemical formula, one atom of that element is present. The symbol for the element represents one atom of an element. The chemical formula for a compound represents one molecule of that compound. For example, water has the chemical formula H_2O. One molecule of water contains two atoms of hydrogen and one atom of oxygen.

Some compounds are familiar to us under a common name. For example, magnesium sulfate, $MgSO_4$, is known by the name Epsom salt. Epsom salt can be used to soak sprains. Hydrochloric acid, $HC\ell$, also known as muriatic acid, is commonly used to adjust the acidity of water in swimming pools. Sodium carbonate, Na_2CO_3, also known as washing soda, is commonly used as a water softener and as a cleaning agent. Some common compounds, their common names, and their chemical formulas are listed in Table 9 below.

COMMON COMPOUNDS					
Common Name	Chemical Name	Chemical Formula	Common Name	Chemical Name	Chemical Formula
Sand	Silicon dioxide	SiO_2	Soda Water	Carbonic acid	H_2CO_3
Ammonia	Ammonium hydroxide	NH_4OH	Washing soda	Sodium carbonate	Na_2CO_3
Rust	Iron oxide	Fe_2O_3	Chalk	Calcium carbonate	$CaCO_3$
Salt	Sodium chloride	$NaC\ell$	Epsom salt	Magnesium sulfate	$MgSO_4$
Water	Hydrogen oxide	H_2O	Lye	Sodium hydroxide	$NaOH$
Table sugar	Sucrose	$C_{12}H_{22}O_{11}$	Lemon Juice	Citric acid	$H_3C_6H_5O_7$
Muriatic acid	Hydrochloric acid	$HC\ell$	Wood alcohol	Methanol	CH_3OH
Baking soda	Sodium bicarbonate	$NaHCO_3$	Limestone	Calcium carbonate	$CaCO_3$
Vinegar	Acetic acid	HCH_3COO	Bleach	Sodium hypochlorite	$NaC\ell O$
Aspirin	Acetylsalicylic acid	$C_9H_8O_4$	Peroxide	Hydrogen peroxide	H_2O_2

Table 9. Common compounds

MIXTURES

A **mixture** is a substance which is made up of two or more substances mixed together physically but not 9
combined chemically. Mixtures may contain two or more different elements, two or more different compounds, or a combination of elements and compounds. Because the substances in a mixture are not chemically combined, the individual substances in a mixture retain their own properties. A mixture may or may not have the same composition throughout. A list of common mixtures and their components is shown in Table 10 below.

COMMON MIXTURES			
Mixture	Components of Mixture	Mixture	Components of Mixture
Cement	sand, water, mortar, gravel	Mayonnaise	eggs, oil, salt, water, vinegar, lemon juice
Iced tea	water, iced tea mix	Orange juice	orange juice mix, water
Salt water	salt, water	Fog	various gases, moisture
Air	oxygen, nitrogen, traces of other gases	Smog	various gases, dirt, smoke
Soil	dirt, sand, pebbles, small organisms	Seawater	water, salt
Chocolate sundae	ice cream, chocolate sauce, nuts	Cereal and milk	cereal, milk, sometimes sugar
Pond water	water, microscopic organisms	Paint	pigment, oil, water
Vegetable soup	tomato juice, meat, vegetables	Root beer float	root beer, ice cream
Ice Cream	cream, milk, gelatin, eggs, sometimes fruit	Sugar water	sugar, water
Brass	copper, zinc	Crystal Light™	crystal light™ mix, water

Table 10. Common mixtures and their components

SEPARATION OF MIXTURES

Mixtures can be separated by several physical methods. Physical methods used to separate mixtures include sifting, using a magnet, evaporation, solubility and filtration, chromatography, and distillation. Sifting can be used to separate mixtures which contain particles of different sizes. A magnet can be used to separate a mixture when one of the components of the mixture is attracted to a magnet.

Evaporation is a method of separating a liquid mixture by causing the liquid portion of the mixture to 24
become gas. When the liquid evaporates, the solid portion of the mixture is left. A mixture of salt water could be separated by letting the water evaporate over a period of days and the substance remaining would be salt.

Filtration is a method used to separate a mixture by filtering when there is a difference in the 10
solubility of the parts of a mixture. Solubility is the ability of a substance to dissolve in a liquid to form a solution. The mixture can be dissolved in water, and then filtered. The part of the mixture that was not soluble in water would be left on the filter paper. The part of the mixture that was in water would remain in the filtrate. The **filtrate** is the liquid that passes through the filter paper. Fig. 11A below illustrates the method of 30
separating mixtures using differences in solubility and filtering.

Chromatography is a method of separating a mixture by using chromatography paper and a solvent. 17
Chromatography paper is a special type of absorbent paper used for certain laboratory procedures. The components in the mixture will move up the chromatography paper to different heights depending on their properties. Individual substances in the mixture will be left as distinct bands or locations on the chromatography paper. The chromatography paper with its distinct bands or locations is now called a chromatogram. Chromatography is illustrated in Fig. 11B below.

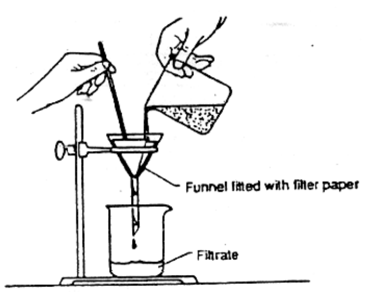
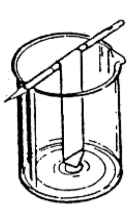
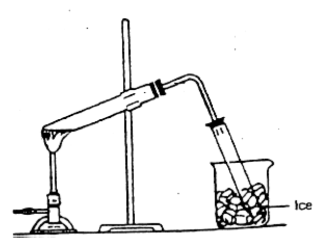


Fig. 11A Filtration


11B. Chromatography



11C. Distillation

Distillation is a method of separating a mixture by evaporating the liquid portion and then condensing 27
the vapor in a separate container. Dissolved solids that are not changed into a vapor remain in the original container. Fig. 11C above, illustrates distillation.