Objectives

- To make careful observations of substances.
- To observe certain physical and chemical properties.
- To distinguish between physical and chemical changes.

Text references

elements, atom, compounds, molecule, symbols, Periodic Table, formulas, states of matter, physical properties, physical changes, chemical changes, chemical reaction, reactant, product

Discussion

Matter is defined as anything that has mass and occupies space. The basic building blocks of all matter are the 100+ **elements** (pure substances that cannot be decomposed into simpler pure substances). The smallest piece or unit of an element is called an **atom**. **Compounds** are pure substances made up of specific combinations of atoms of differing elements. For some compounds, the smallest piece or unit of a compound is called a **molecule**.

Chemical **symbols** are used to represent elements; a quick glance at a Periodic Table shows *all* the element symbols. For example, the element hydrogen is has the symbol H while the symbol O represents the element oxygen. **Chemical formulas** are symbols that represent substances by indicating the specific combination of elements from which the substance is made. For example, the element hydrogen (symbol = H) and oxygen (symbol = O) combine together to form the compound water. The symbol, or chemical formula, for water is H_2O. Subscripts after element symbols indicate the number of atoms of each element present in the basic unit of the compound (where no subscript appears, the number 1 is presumed). So, in water, there are 2 hydrogen atoms and one oxygen atom in one molecule of water.

Each element and compound has a unique set of characteristics or properties. **Physical properties** are characteristics that are observable without changing the composition of the substance. For example, is the substance blue in color? Is it solid? Elements and compounds found on earth typically occur in three **physical states** or **phases**: solid, liquid and gas. Solids have definite shape and volume. Liquids have definite volume and indefinite shape. Gases have indefinite shape and volume. Physical states are examples of physical properties.

Matter undergoes two types of changes: physical and chemical. **Physical changes** do not cause a change in *composition* of matter. A change in a substance such as melting (going from a solid to liquid state) or evaporation (going from a liquid to gaseous state) is an example of physical change. The arrangements of the atoms that make up the smallest pieces of the substance are not rearranged in a physical change. **Chemical changes** result in new substances having new properties and composition as compared to the original substance(s). The arrangements of the atoms that make up the smallest pieces of the substance are rearranged in a chemical change. Chemists generally refer to chemical changes as *chemical reactions* or more simply *reactions*. The substances that exist before a chemical reaction are called *reactants*, or less commonly, *reagents*. The substances that result from a chemical reaction are called *products*.

Chemical changes (reactions) of substances may be evidenced by changes readily visible to human senses. Some observational evidence which may indicate, but do not guarantee, chemical changes are:

- occurrence of a **color change**: a color change indicates the formation of a substance with a color different from any of the original substances.
- formation of **precipitate (solid product)** from combinations of: liquids, gases, or liquids mixed with gases. A precipitate may give a "cloudy" appearance to a liquid mixture. If allowed to stand, the precipitate will settle out to the bottom of a vessel. A precipitate may be separated from the liquid by filtration. The solid product may take on many forms: gooey, chunky, silty, lumpy, flakey etc. The best evidence of solid product is a cloudy appearance to the liquid mixture.
- formation of a **gaseous product** from a liquid or mixture of liquids: occurrence of bubbles (**effervescence**).
- signs of **burning** or **combustion:** flame

Report Sheets: **Observations**

Name_____ Date_____ Lab Section_____

Procedure

I. Observing Physical Properties of Elements and Compounds

1. **Elements:** Observe samples of elements available in vials on the front and/or side counter. Record the element symbol, physical state, and color in the table below. You may choose two elements (in addition to the four listed in the table) and fill those into the two blank rows provided. ***Do not open any containers.***

Element	Formula or Symbol	Physical State	Color
Hydrogen	**H_2 or H**	**gas**	**colorless**
Carbon			
Copper			
Iron			
Your Choice #1: _____			
Your Choice #2: _____			

2. **Compounds:** Observe samples of compounds provided to you in vials. Record the formula, physical state, and color. ***Do not open any containers.***

Compound	Formula	Physical State	Color
Carbon dioxide			
Carbon disulfide			
copper(I) oxide			
Copper(II) oxide			
copper(II) chloride			
iron(III) oxide			
iron(III) chloride			

II. Observing Physical and Chemical Changes

A. Place a ring clamp on a ring stand. Obtain one piece of aluminum foil and place it on a wire gauze on the ring clamp. **Carry out the following steps in the order** and record your observations in the table below. Decide whether a physical and/or a chemical change took place. Allow the foil to cool before beginning the next procedure. Use an unused patch of the same aluminum foil for each substance. Recycle the aluminum.

1. a) Place one large drop of **water** on the foil. Bring a lit wood splint near (but not touching) the surface of the water drop. In doing this, you are checking how this sample interacts with fire, in other words, the flammability of the sample.

   b) Place one large drop of **water** on the foil. Heat the drop gently with the Bunsen burner from below. Now, you are checking how the sample responds to heat.

2. a) Place one large drop of **isopropyl alcohol** on the foil. Bring a lit splint near (but not touching) the surface of the drop.

   b) Place one large drop of **isopropyl alcohol** on the foil. Heat the drop gently with the Bunsen burner from below.

3. a) Place a few crystals of **sugar** on the foil. Bring a lit splint near (but not touching) the surface of the crystals.

   b) Place a few crystals of **sugar** on the foil. Heat the drop gently with the Bunsen burner from below.

4. Your instructor will lead a similar investigation into the flammability and response to heat of **ammonium chloride** in a **fume hood. When heated, ammonium chloride gives off harmful fumes.** Be sure to record your observations of this instructor-led demonstration.

5. Your instructor will also demonstrate how copper wire interacts with flame/heat. Observe the copper wire prior to the demonstration (and record your observations). Then, observe the copper wire after it has been exposed to flame (what is the color?). Record these observations as well.

Substance	Observations	Physical, Chemical, or No Change	Explain Your Evidence
water with wood splint			
water with burner			
alcohol with wood splint			
alcohol with burner			
sugar with wood splint			
sugar with burner			
ammonium chloride with splint			
ammonium chloride with burner			
copper wire heated in burner			

B. In this part of the experiment you will be mixing chemicals and observing the results to decide whether a chemical reaction has taken place. Record all observations in your lab book. Dispose of used chemicals as described by your laboratory instructor. **Be sure to ask your instructor on the best technique for mixing chemicals once they are in a test-tube.**

To avoid cross-contamination: Do not put the tip of the dropper inside of the test tube! Always put the dropper back into the proper container.

1. **Your instructor will demonstrate this mixing and you will conduct mixing in 2-5:**
   Place 7 drops of iron(III) chloride solution, $FeCl_3$, in a small test-tube.
   Add 3 drops of potassium thiocyanate solution, KSCN. Mix. Record your observation.

2. Place 7 drops of sodium chloride solution, NaCl, in a small test-tube.
   Add 3 drops of ammonium nitrate solution, NH_4NO_3 solution. Mix. Record your observation.

3. Place 7 drops of barium chloride solution, $BaCl_2$, in a small test-tube.
   Add 3 drops of potassium chromate solution, K_2CrO_4. Mix. Record your observation.

4. Place 7 drops of copper(II) sulfate solution, $CuSO_4$, in a small test tube.
   Add **1 drop** of 3*M* ammonia, NH_3. **(*The bottle may be labeled NH_4OH*)**.
   Mix. Record your observation.
   Add a **2nd drop** of 3*M* ammonia, NH_3. Mix. Record your observation.
   Add a **3rd drop** of 3*M* ammonia, NH_3. Mix. Record your observation.
   Add a **4th drop** of 3*M* ammonia, NH_3. Mix. Record your observation.

5. Place a small amount of dry sodium hydrogen carbonate, $NaHCO_3$, in a small test-tube.
   Add 3 drops of dilute acetic acid, $HC_2H_3O_2$. Mix. Record your observation.

	Chemicals	Reaction? Circle yes or no	Evidence
1	**iron(III) chloride + potassium thiocyanate**	yes no	
2	**sodium chloride + ammonium nitrate**	yes no	
3	**barium chloride + potassium chromate**	yes no	
4	**copper(II) sulfate + ammonia**	Drop 1 yes no	
		Drop 2 yes no	
		Drop 3 yes no	
		Drop 4 yes no	
5	**sodium hydrogen carbonate + acetic acid**	yes no	

Waste Disposal

Do not put any chemical from today down the drain. Waste from each test tube in Part IIB should be discarded into the properly labeled waste container. Rinse each test tube with water and dispose of the rinse into the waste container as well. Your instructor will provide further details regarding this disposal procedure.

Answer the following questions in complete sentences and turn in with the Observations Report sheets.

1. **(a)** A work study student cleaning the lab comes across two containers whose labels have fallen off. She can see the substances through the glass of the container, but does not know what they are. When she looks at the labels, she sees that the symbols for the two substances are: "**C**" and "**Fe**". Referring to your notes from lab, describe how she might tell the two substances apart from one another.

(b) What *physical properties* (list at least two) can be used to distinguish one substance from one another, based on their appearance?

(c) In that same messy lab (which is **not** MCTC's lab), the student finds two more unlabeled bottles that are either CO_2 or H_2. Based on their appearance, how can she determine which substance is which?

(d) Is it always possible to distinguish two substances from one another based on their appearance? Explain your answer using specific examples.

2. a) List the colors of elemental copper and all the compounds containing copper. Does the elemental copper have the same color as its compounds?

b) Based on your answers in question 2(a), which copper compound was formed after your instructor heated the copper wire in Part II A5?

3. One of the indicators of a chemical change, *formation of bubbles*, can also be associated with physical changes under certain contexts. Describe and provide specific examples of situations in which bubble formation takes place during i) physical change and ii) chemical changes.

i) a physical change

ii) a chemical change

1. List the three physical states in which matter commonly occurs.

2. List some specific examples of physical properties.

3. Explain how a chemical change is different from a physical change.

4. List 4 observational evidences that a chemical change or reaction has occurred. You will be looking for such changes in lab this week.

5. Classify each of the following as a physical or a chemical change or neither.

(a) water boiling _____

(b) paper burning _____

(c) making ice cubes _____

(d) milk souring _____

(e) soda pop fizzing _____

(f) iron melting _____

(g) sugar dissolving in water _____

(h) glass shattering _____

6. Do you or your instructor perform any part of this week's experiment in a fume hood? What will be done in the fume hood? Why would one use the fume hood for this chemical?

7. How will you avoid cross-contamination of chemicals during this lab?