MiraCosta College
Introductory Chemistry Laboratory
Experiment 3

Substances and Mixtures:Separating a Mixture into Its Components

EXPERIMENTAL TASK

To separate a mixture of calcium carbonate, iron and sodium chloride into its component substances using physical means only, and determine the quantitative composition (in percent by mass) of the mixture.

Objectives

After completing this experiment, the student will be able to:

1. carry out an experimental method for separating a mixture into its component substances, using physical means only.
2. correctly and safely use a number of laboratory techniques as part of this separation.
3. make accurate and precise measurements, and record those measurements using standard units and the rules of significant figures.

Additional Reading

- General, Organic and Biological Chemistry, by Timberlake, section 2.1.
- Laboratory Handbook for General Chemistry, 2nd edition, by Griswold, et al, sections I, II, III, V, VI and VII.

Background

Classification of Matter: Matter is anything that occupies space and has mass. A sample of matter may be classified according to whether it contains just one fundamental type or many, and whether the various components of the sample are chemically joined or just mixed together. *Elements* are those samples of matter that contain just one fundamental type of matter (only one kind of atom). *Compounds* are samples of matter that contain more than one element, have specific chemical and physical properties, and in which the elements are chemically bonded in specific ratios. Neither elements nor compounds can be broken down or separated by physical means, so they are classed together as *substances*. A sample of matter that contains more than one substance, where the substances each retain their properties, is called a *mixture*. Mixtures can either be *homogeneous* (having just one identifiable phase) or *heterogeneous* (having more than one identifiable phase).

Chemical and Physical Changes: When a mixture is separated into its component substances, as in this experiment, it is important the substances are not allowed to undergo chemical change. How are chemical changes different from physical changes? A *chemical change* (also known as a *chemical reaction*), is a process in which the initial substances (*reactants*) are changed into one or more new chemical substances, and a *physical change* is a process in which the substances involved do not change into other substances. Each substance has distinct properties, so it should be possible to determine if the substances in the mixture are changing into new substances by examining the properties of the sample of matter before and after the process. *It is therefore very important to record the properties of whatever chemicals, or substances, are used in an experiment before they are mixed, heated, etc., as well as during and after the operation*.

What kinds of properties are used for this? Not all properties of matter can be used to identify a substance, but any property that is *characteristic* of the substance may be used: color, odor, density, melting point, boiling point, reactivity toward water (or oxygen or acid or base, etc.). These characteristics which can be used to identify substances might be called, "identifying properties," and are generally *intensive properties* (properties which do not depend on the amount of matter present--*extensive properties* are those which do depend on the amount of matter present, and include mass, volume, heat, etc.). Some of these identifying properties can be directly observed using one of more of the five senses, and some require measuring instruments or other indirect methods of observation. Properties of matter that cannot be used by themselves to identify substances include mass, temperature, volume, etc.

Copyright 2004 by Mark A. Yeager

When the reactants' observed or measured properties are compared with the products' properties, it is generally possible to determine whether or not any new substances have formed, and therefore whether a chemical change has taken place. This is not always easy to do, but one good rule of thumb that often decides the case is: it is generally true that if a color change takes place, a chemical reaction has taken place.

Experiment Design

The experimental task is that of separating a mixture of calcium carbonate, iron and sodium chloride. The mass of each component will then be measured, and these data will be used to calculate the percent composition of the mixture.

$$\text{\% of Component A} = \frac{\text{mass of A}}{\text{total mass of mixture}} \times 100\%$$

In designing the procedure it is important to first look at what is known about the system (the mixture and its components): what physical properties do the components have which can be used to separate the mixture? Another important consideration is that of what laboratory techniques are available to use, especially those described in The Laboratory Handbook for General Chemistry. A major part of this task is determining the mass of each component of the mixture, which means that each separation will have to be carried out carefully in order to both completely separate the components and to keep sample loss to a minimum, and that the measurements of the mass of each substance and of the mixture as a whole be performed accurately and precisely.

The final results of this experiment will be the percent composition by mass of each component in the mixture.

 Copyright 2004 by Mark A. Yeager

<u>Pre-lab Questions</u>

1. Identify each of these processes as generally being either a *physical change* or a *chemical change*:
    A. Rubbing alcohol evaporating from your skin.
    B. A candle burning.
    C. Salt dissolving in water.
    D. Crushing a solid into powder.

2. A sample of a mixture of salt and sugar has a total mass of 0.8920 g. If the sample contains 0.0982 g of salt, what percent of the sample is sugar?

3. In this procedure you are asked to obtain and measure about 5 g of the mixture. Describe in <u>detail</u>, including all safety precautions and standard lab practices, how you will do this.

 Copyright 2004 by Mark A. Yeager

BEFORE STARTING THE EXPERIMENT

Safety

The single most important aspect of working in the laboratory is SAFETY. Each section of the "Procedure" begins with safety points for that section, but you must always keep in mind the rules presented in both the "MCC Laboratory Safety Rules" and the Laboratory Handbook for General Chemistry. It is your responsibility to make sure that you follow all safety rules at all times, and to graciously help everybody else in the laboratory (including the instructor) to do the same. Remember to notify the instructor of any accident or spill, large or small. Do not pick up broken glass yourself. Label all containers before you put chemicals in them, even if the chemical is just water or the chemical will be in the container for only a few minutes. Use "Hot Hands" or crucible tongs, as appropriate, to handle hot glassware and other equipment.

Labeling containers: Make sure all watch glasses, beakers, evaporating dishes, etc., are clean and dry before using them, and that they are free of cracks or chips. *Always label a container BEFORE putting any chemical in it, even if it is just water.* Standard procedure for labeling containers of any kind is to obtain a piece of label tape from the instructor’s desk, apply it to the container and then write the label on the tape using a permanent lab marker. However, when the container will be heated in the drying oven it is important that label tape NOT be used. Instead, use the lab marker to write the label directly on the outside of the container (on the bottom of it , if necessary, as with a watch glass). The label can then be removed using a small amount of an organic solvent, such as ethanol or acetone (be careful—these are FLAMMABLE).

Hazardous Materials

You should consider all chemicals to be hazardous with regard to tasting and touching. Sections I and V of the Laboratory Handbook for General Chemistry describe the standard procedures and safety rules for handling chemicals. **Make sure you understand these sections before proceeding further in this experiment.**

The three substances in the mixture, **calcium carbonate**, **iron** and **sodium chloride**, are generally non-hazardous, but you should always treat any chemical as being an **irritant**--if you spill it on your skin or in your eyes, use water to rinse it off. Also, you should be very careful not to inhale the silicon carbide granules. ALL WASTES MUST BE DISCARDED IN THE APPROPRIATE WASTE CONTAINERS, AS DIRECTED BY THE INSTRUCTOR.

 Copyright 2004 by Mark A. Yeager

EXPERIMENT PROCEDURE

Label the bottom of a watch glass "calcium carbonate/iron/sodium chloride mixture." Determine the mass of the labeled watch glass, and record it in your notebook (you will need this mass later on). Label a 50-mL beaker with the same label. Use this labeled beaker to obtain about 10 mL of the mixture from the reagent cart. Take the watch glass and the beaker containing the mixture to the top-loading balance, place the watch glass on the balance pan (don't forget to re-zero the balance!), and transfer about 5 g of the mixture from the beaker to the watch glass. Determine and record the precise mass of the mixture in the watch glass.

Label a 50-mL beaker, "iron". Measure and record the mass of this empty, labeled beaker. Obtain a magnet and a piece of plastic wrap. Wrap the magnet in the plastic wrap so the magnet is completely covered. Use the wrapped magnet to remove all of the iron filings from the mixture and transfer them to the beaker. Try to keep from transferring any of the other components of the mixture. Measure and record the mass of the beaker + iron.

Label an evaporating dish with the names of the people in your group and the label, "sodium chloride." Determine and record its mass. Label a small beaker, "calcium carbonate & sodium chloride," and carefully transfer the remaining sand and salt from the watch glass to the beaker. Add about 15 mL of DI water (**not** tap water!) to the calcium carbonate & sodium chloride mixture in the beaker, and use a glass stir rod to stir the mixture until the sodium chloride has all dissolved (this will be difficult to observe directly—how will you know when it has happened?). Rinse the stir rod by holding it over the beaker and squirting a little DI water onto it, allowing the water to drop into the beaker.

Set up a gravity filtration apparatus, as described in the Laboratory Handbook for General Chemistry, but determine the mass of the dry filter paper first. Place the empty "sodium chloride" evaporating dish under the funnel, wet the filter paper with a little DI water, and then pour the mixture of calcium carbonate, sodium chloride and water from the beaker into the filter funnel (be careful not to fill it past the top of the filter paper!). Allow the liquid to pass through the filter paper, and then rinse all the remaining sodium chloride from the beaker into the funnel with as **little** DI water as possible. After all the liquid has passed through the filter paper, rinse the filter paper one more time by squirting a **little** DI water into the funnel, then allow this water to pass through the filter paper. Place the evaporating dish containing the sodium chloride/water mixture in the drying oven. You will come back to it later.

Copyright 2004 by Mark A. Yeager

Remove the original label from the watch glass with a Kimwipe that has a little ethanol or acetone on it, clean the watch glass, and then re-label it "calcium carbonate + filter paper". Add the names of the people in your group to the label. Measure and record the mass of the labeled watch glass, and then carefully transfer the filter paper containing the wet calcium carbonate from the funnel to the watch glass. Put the watch glass in the drying oven.

Check on the evaporating dish in the drying oven (remember to use a “hot hand”). Once all of the water has evaporated, and the sodium chloride appears dry, put the dish back in the oven for 5 more minutes to ensure complete dryness. Then take the dish to the lab bench, allow it to cool completely, and measure and record the mass of the dish + sodium chloride. Dispose of the waste solid in the proper waste container.

Check on the watch glass in the drying oven. Once the calcium carbonate appears dry, put the watch glass back in the oven for another 5 minutes to ensure complete dryness. Then take the watch glass to the lab bench, allow it to cool completely, and measure and record the mass of the watch glass + calcium carbonate + filter paper. Dispose of the waste solid in the proper waste container.

Clean-up: Always dispose of all wastes in the appropriate waste containers (liquids in ‘liquid waste,’ solids and paper in ‘dry waste,’ etc.). Wash all containers and utensils with soap and water, rinse with tap water and then with DI water, and then dry with paper towel.

Copyright 2004 by Mark A. Yeager

RESULTS

Calculations

Follow the instructor's directions concerning where and in what form to record data and calculations—most instructors require that all measurements and results of calculations be recorded in table form in the notebook in a separate "Results" section of the experiment, and that the work needed to perform the calculations be explicitly shown.

In order to calculate the percent composition of the mixture, both the mass of the original sample of the mixture and the final (dry) masses of the components of the mixture must be determined. The mass of the original sample of the mixture was measured directly, but the masses of the components must be calculated from other data. For instance, the mass of the mass of calcium carbonate ("CC") is:

CC mass = mass of (watch glass + CC + filter paper) – mass of watch glass – mass of filter paper

while the iron in the sample is:

Iron mass = mass of (beaker + iron) – mass of beaker

and the mass of the sodium chloride is:

Sodium chloride mass = mass of (evaporating dish + sodium chloride) – mass of evaporating dish

Use the equation given in the "Experiment Design" section (page 2) to calculate the percent composition of each component substance in the mixture.

The final results table for this experiment might look like this:

	Mixture	Calcium Carbonate	Iron	Sodium Chloride
Mass of sample (g)				
Percent of total (%)	(100)			

DISCUSSION

Important questions that should be answered in this section of the report are:

- What evidence was there that each separation involved only physical changes?
- Were the substances completely separated from each other? What observations show this?
- Was a portion of any component lost during the separations? What observations show this?

 Copyright 2004 by Mark A. Yeager