

Separation of a Mixture

Percent Composition

Introduction

Most of the substances that we come in contact with every day—from the air we breathe to the water we drink and the foods we eat—are mixtures. How can the components of a mixture be separated and analyzed?

Concepts

- Mixture vs. pure substance
- Physical changes
- Physical properties
- Mass percent composition
- Percent yield

Background

A *mixture* is a combination of two or more *pure substances* that retain their separate chemical identities and properties. Since the amounts of each substance making up a mixture can be changed, the physical properties of a mixture depend on its composition. In contrast, the composition of a pure substance is constant, and thus pure substances have characteristic physical properties that do not change. Examples of *physical properties* that can be used to describe pure substances include solubility, conductivity, magnetism, density, boiling point and melting point.

By taking advantage of the unique physical properties of individual components within a mixture, it should be possible to separate a mixture into its components. For example, if one component in a mixture of two solids dissolves in water, while a second component does not, the components can be separated by adding water to the mixture and then filtering the residue. Subjecting the mixture to a physical change in this way would change the ratio of components in the mixture. This leads to one of the definitions of a mixture—a substance whose composition can be altered by a physical change. *Physical changes* that can be used to separate the components of a mixture include filtration, evaporation, crystallization, and distillation.

Mass percent composition is a convenient way to express the actual composition of a mixture in terms of the amount of each component. The mass percentage of each component in a mixture is calculated as follows:

$$\text{mass \% of component} = (\text{mass of component} / \text{total mass of mixture}) \times 100\%$$

In order to determine the percent composition of a mixture, it is necessary to separate the components quantitatively—without loss of material—and then measure the mass of each recovered component. The sum of the mass percentage of all components in a mixture equals 100%.

A flow chart is often used to illustrate the steps involved in the separation of a mixture. In a flow chart, the substances in the mixture are listed inside boxes and are connected by arrows. The actual physical steps that must be carried out to separate the components are

listed next to the arrows. Imagine a sample of seawater that has been collected at the beach. There is a liquid layer, consisting of dissolved salt in water, and solid sand particles suspended in the liquid. How can these components be separated? The flow chart in Figure 1 shows one possible method for the separation and recovery of the components in our hypothetical seawater sample.

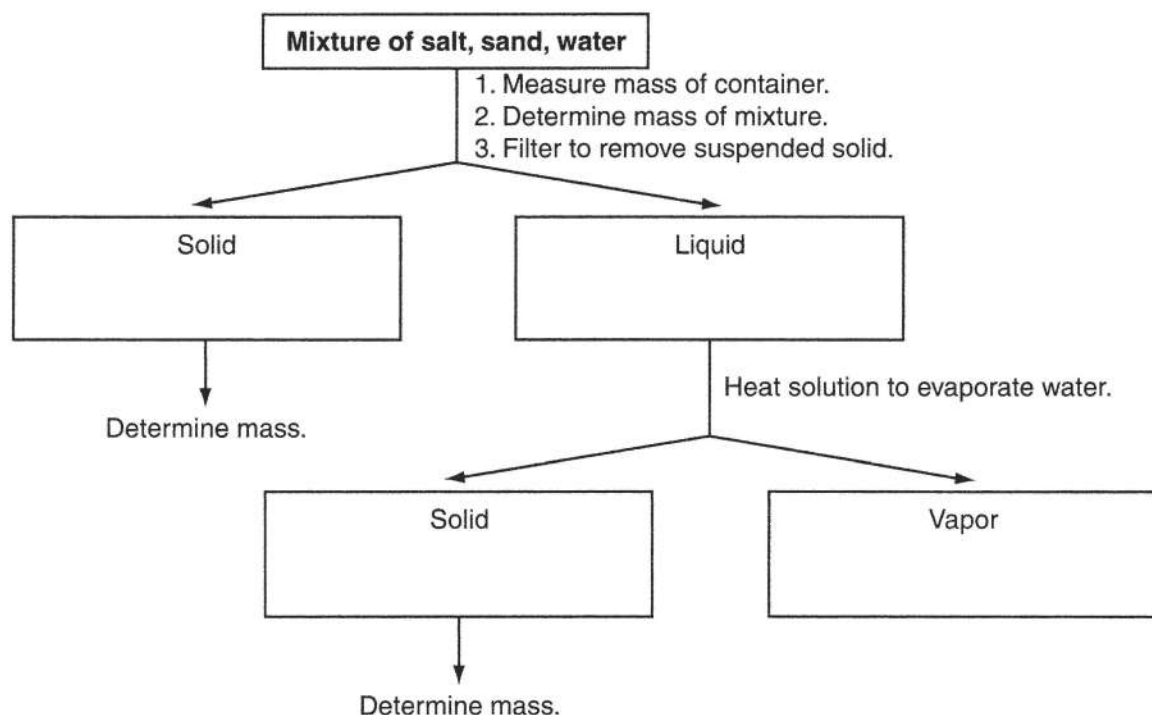


Figure 1.

Experiment Overview

The purpose of this experiment is to study the physical properties of salt, sand, and iron and use this information to design and carry out a procedure to separate a mixture of these substances. The mass percent composition of the mixture can be calculated from the masses of the recovered components.

Pre-Lab Questions

1. Think about the separation process outlined in Figure 1 and complete the flow chart to reveal the identities of the solid, liquid, and vapor components.
2. The Department of Transportation uses a mixture of sand and salt to de-ice roadways in the winter. The mixture contains 8.35 tons of salt and 6.28 tons of sand. What is the mass percent of each component in the mixture.
3. A bakery needs a mixture of flour and sugar to make cookies. The mixture should contain 62.5% flour and 37.5% sugar. You are in charge of ordering the components to make 275 pounds of the mixture. How many pounds of flour and sugar should be ordered?

Materials

| | |
|---------------------------------------|--------------------------------|
| Iron filings, Fe, 5 g | Filter funnel and filter paper |
| Salt (sodium chloride), NaCl, 5 g | Magnet |
| Sand, SiO ₂ , 5 g | Plastic bag |
| Mixture of salt, sand, iron, 2–3 g | Ring stand and ring |
| Balance, centigram (0.01 g precision) | Spatula or teaspoon scoop |
| Beakers, 50-mL, 2 | Stirring rod |
| Distilled water and wash bottle | Test tubes, small, 3 |
| Hot plate | Weighing dishes, 3 |

Safety Precautions

The materials in this lab activity are considered relatively nonhazardous. Observe all normal laboratory safety procedures. Wear chemical splash goggles whenever chemicals, glassware, or heat are used in the chemistry laboratory.

Procedure

Part A. Physical Properties of Substances

1. Using a spatula, transfer teaspoon-sized amounts of salt, sand, and iron filings to three plastic weighing dishes for observation.
2. Observe the physical appearance of each substance. Record all observations in Data Table A.
3. Insert a magnet into a plastic bag so that no surface of the magnet is exposed. Move the wrapped magnet through each substance in the dishes. If a substance is magnetic, it will stick to the bag that covers the magnet. *Note:* Do not place the bare magnet directly into the materials—it will be difficult to remove the magnetic material from the surface of the magnet. Record all observations in Data Table A.
4. To remove the magnetic material, carefully open the bag and remove the magnet. The magnetic material will fall off the bag (back into the weighing dish) when the magnet is removed.
5. Determine whether each substance is soluble in water by adding a small amount to separate test tubes containing about 2 mL of water. Gently swirl or shake the test tubes and record your observations in Data Table A.
6. Combine the remaining dry samples of sand and salt. Mix together and observe the combination. Describe its physical appearance in Data Table A.
7. Transfer this combined sample to a small beaker and add 10 mL of water. Stir the sample with a stirring rod and record any changes that occur.
8. Clamp a ring to a ring stand to support a filter funnel. Position the funnel above a beaker. Fold a piece of filter paper into quarters and place the paper in the funnel with three quarters placed to one side so that the paper forms a cone.

9. Wet the filter paper slightly with distilled water from a wash bottle and then slowly pour the mixture from step 7 into the funnel, using a stirring rod to guide the flow of liquid.
10. Using a wash bottle, rinse all of the solid remaining in the sample beaker into the funnel. Use a minimum amount of water (no more than 25 mL).
11. After all the liquid has passed through the funnel, gently remove the wet filter paper, open it half-way, and place it on a hot plate (low setting) to dry.

Part B. Separation of a Mixture

Design and carry out a procedure to separate a mixture of sand, salt, and iron filings and to determine the mass percentage of each component in the mixture.

12. Design a flow chart to indicate how the mixture can be separated and the exact steps that need to be taken to obtain the data you need.
13. Record the *code number* for your unknown mixture in Data Table B. Transfer about 2 g of the mixture to a preweighed beaker or weighing dish and measure the total mass of the mixture and the container. Determine the mass of the mixture. Record all data in Data Table B.
14. Separate the components of the mixture using your procedure.
15. Determine the mass of salt, sand, and iron in the sample mixture. Remember to record all data.