MR. STONE
CHEM. I

Experiment 3

SUBSTANCES, MIXTURES, AND REACTIONS

Learning Objectives

By the end of this experiment the student should have learned:

1. To distinguish elements from compounds.
2. To distinguish heterogeneous mixtures from homogeneous mixtures.
3. To observe and record properties of substances.
4. To filter mixtures.
5. To determine the concentration of a solution by weighing, evaporating to dryness and reweighing.

Discussion

The two kinds of pure substances that exist are known as elements and compounds. They may occur as solids, liquids, or gases. Compounds are composed of elements chemically combined in definite ratios. A mixture results when two or more pure substances are physically combined. The components of a mixture are not chemically combined and therefore can exist in any ratio. Water (H_2O) is physically and chemically different from a mixture of 67% by volume elemental hydrogen (H_2) and 33% by volume elemental oxygen (O_2) despite the fact that the hydrogen and oxygen are present in the same proportions in each. If the oxygen in the air we breathe were combined with carbon in the form of CO_2 rather than being in its elemental form, O_2, it would not support human life, as CO_2 is a totally different chemical species than O_2.

The determination of physical and chemical properties of substances yields information that is needed and utilized for many applications. Physical properties are those that are measured without a chemical change such as melting points, boiling point, color, density, and magnetic characteristics. Chemical properties are those that are determined by reactivity with other reagents under various conditions. All properties are useful for identification purposes and determination of applicability for a particular use.

If sugar is dissolved in water, a homogeneous mixture or solution is produced. (You should be aware that most solutions you deal with are predominantly water.) In contrast to a sugar-water solution orange juice contains discernible particles. Anytime it can be demonstrated that a mixture is not the same throughout, it is said to be a heterogeneous mixture. If particles in the mixture become visable under a microscope or light is scattered as it passes through a liquid mixture, the mixture is proven to be heterogeneous. A mixture of salt and sand may appear to be the same throughout but it is heterogeneous.

One of the most important tasks in chemistry is the separation of mixtures into their pure components. Most naturally occurring materials are mixtures and most synthetic processes produce mixtures. In order to isolate a desired substance, certain processes must be employed. In today's experiment you will perform two techniques commonly used to isolate substances, evaporation and filtration.

You will use evaporation to isolate sodium chloride from its aqueous solution. Knowing the mass of the solution before evaporation and the mass of the residue you will be able to calculate the concentration of the saturated sodium chloride solution.

$$\frac{\text{grams of sodium chloride residue}}{\text{grams of solution}} \times 100 = \text{mass \% NaCl}$$

You will use gravity filtration to isolate the synthetic product of the reaction between a solution of sodium carbonate and a solution of calcium chloride. The product, calcium carbonate ($CaCO_3$), is an ingredient in a number of commercial products such as paint and antacids. When a synthesis has been completed, it is important to verify the identity of the product. One technique used to characterize carbonates is to add acid. Many kinds of compounds do effervesce or fizz when acid is added, but if no effervescence occurs it is proof that the compound is not a carbonate. The test you will perform will illustrate one of several key types of observations that should alert you to the presence of a chemical reaction.

In part E of this experiment you will be looking for evidence of the occurrence of a chemical reaction. Formation of a precipitate and effervescence, as seen above, both indicate that a chemical reaction is occurring. In addition to these, be alert for a change of temperature or a change of color as evidence of a reaction. Based on your observations and some clues provided, you should be able to assign identities to four unknown solutions.

Procedure

ELEMENTS AND COMPOUNDS

A. Observe the color, appearance, and, using a magnet, the magnetic properties of the following substances:

   Iron metal, Fe
   Sulfur, S
   Iron(II) sulfide, FeS
   Ferrosoferric oxide, Fe_3O_4
   Iron(III) oxide, Fe_2O_3

B. Solutions (Note: M is a concentration term that stands for $\frac{\text{moles}}{\text{liter}}$. The concept will be dealt with later in the course.)

The following mixtures will be available:

1. 0.1 M NaCl (sodium chloride)
2. 0.1 M $CuSO_4$ (copper(II) sulfate)
3. saturated NaCl
4. 1.0 M $CuSO_4$
5. a starch suspension in water

Briefly describe and compare the five mixtures using the terms in the discussion section.

C. Evaporation

Solubility of sodium chloride in a saturated solution: The amount of sodium chloride dissolved in a saturated solution can be determined by evaporating a weighed amount of a saturated solution to dryness. Dryness is confirmed by repeated heating and weighing cycles until a constant mass is achieved (usually only two cycles are necessary).

Weigh a clean, dry evaporating dish to the nearest 0.01 gram. Carefully pour about 6 mL of a saturated sodium chloride solution into a graduated cylinder. Do not stir the solution before pouring. Leave the solid NaCl as undisturbed as possible in the bottom of its bottle. Transfer the 6 mL of NaCl solution to the evaporating dish and weigh the contents.

Put a 400 mL beaker about half full of water on a wire gauze above a Bunsen burner. Boil

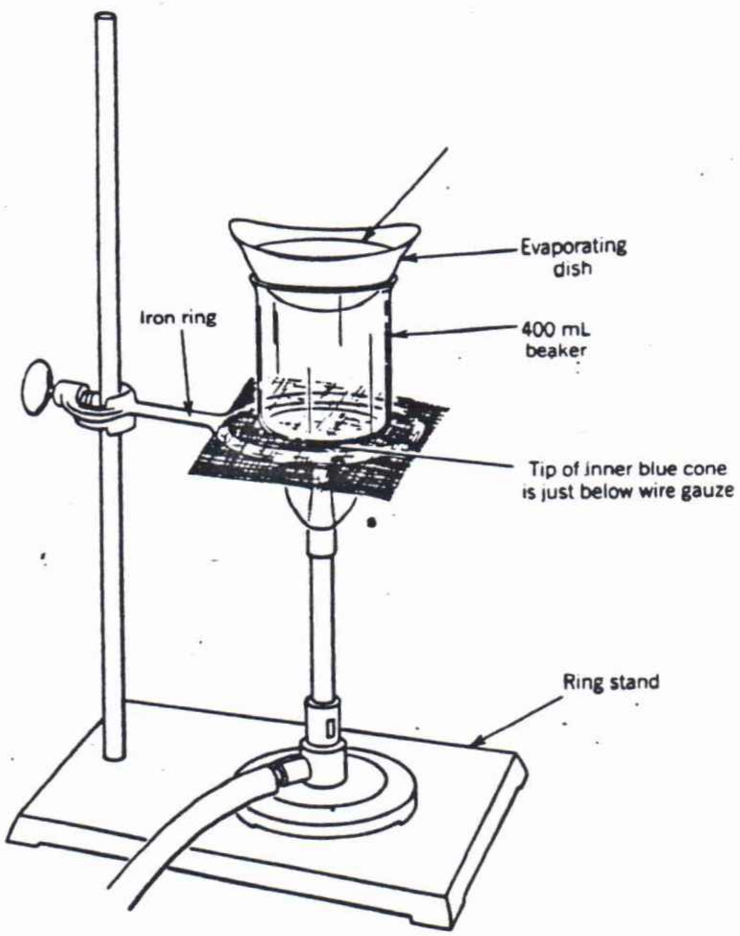

Figure 3-1

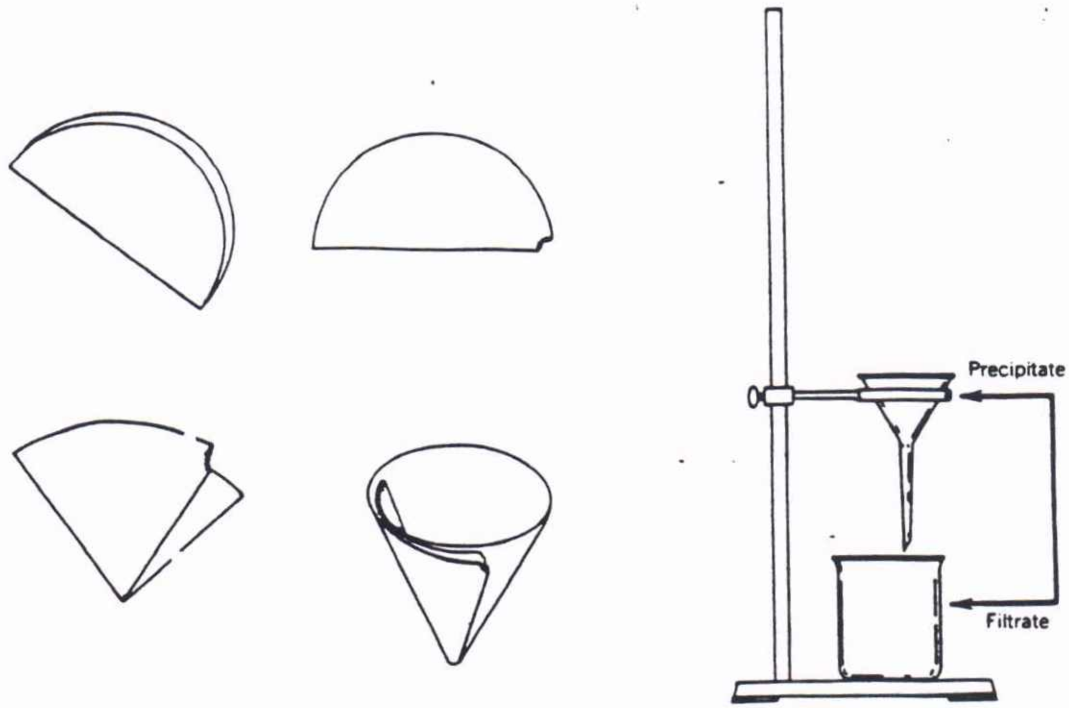

Figure 3-2

the water and suspend the evaporating dish in the 400 mL beaker. Boil the water (adding water as needed to the *beaker* to maintain a reasonable level) until the evaporating dish attains apparent dryness (about 20 minutes). Using beaker tongs, remove the beaker and evaporating dish from the flame. Holding it with crucible tongs, place the evaporating dish on a wire gauze and gently flame it for about 3 minutes and allow it to cool. Weigh to the nearest 0.01 gram. Again flame the evaporating dish gently (about 3 minutes), cool, and weigh. Repeat the process until successive weighing differences are less than 0.1 gram. Calculate the mass percent of NaCl in the saturated solution.

D. **Filtration**

Fold a piece of filter paper in half. Tear off about a half centimeter piece from one corner then fold it into quarters.

Open up one pocket of the filter paper so that it forms the shape of a cone. Put it into your funnel and wet it thoroughly with deionized water from your wash bottle so that it adheres uniformly to the inside wall of the funnel.

Put 10 mL of 0.1 M sodium carbonate into your 150 mL beaker. Add 10 mL of 0.1 M calcium chloride.

Record your observation.

Swirl the resulting mixture for a few seconds and filter it. When all the aqueous phase has drained, open up the filter paper and scrape the precipitate onto a watch glass, with a stirring rod. Using a medicine dropper, rapidly add about 10 drops of 6 M HCl to the precipitate. Describe your observations.

E. Unknown Solutions

Any one of the following occurrences indicates the presence of a chemical reaction:

1. Formation of a precipitate
2. A color change
3. Evolution of a gas
4. A change in temperature

There are four solutions labeled A, B, C, and D containing the chemicals for this experiment. One of them, phenolphthalein solution, is an acid-base indicator that is colorless in acid and pink in base. One of them, 1.0 M sodium carbonate, is basic. One of them, 6 M hydrochloric acid, reacts with carbonates to produce carbon dioxide gas. The other solution is 0.1 M calcium chloride. Using the above clues, the reactions you performed earlier and the reactions between the solutions, you should be able to identify which solution corresponds to each letter.

Write ppt. (precipitate), gas, or pink in the appropriate boxes.

	D	C	B
A			
B			
C			

Figure 3-3

In each of three test tubes, add about 2 mL of solution A. (You don't need to measure these quantities.) To the first tube add 2 mL of B, to the second, 2 mL of C, and to the third, 2 mL of D. Record your observations in the reactivity matrix. Then perform the operations necessary to fill in the remaining empty blanks in the matrix and record your observations.