EXPERIMENT 1

Properties and Changes of Matter

Performance Goals

1–1 Determine experimentally the solubility of a pure substance in a given liquid, or, in the case of two liquids, determine their miscibility.

1–2 Determine experimentally which of two immiscible liquids is more dense.

1–3 Determine whether or not a chemical reaction occurs when you combine two solutions, and state the evidence for your decision.

CHEMICAL OVERVIEW

All material things that compose our universe are referred to as **matter.** Matter is commonly defined as that which has mass and occupies space. In this experiment you will examine some of the characteristics of matter and be introduced to some of the language of science in which these characteristics are described.

A **pure substance** is a sample of matter that has identical properties throughout, and a definite, fixed composition. **Physical properties** are those characteristics of a substance that can be observed without changing the composition of the substance. Common physical properties are taste, color, odor, melting and boiling points, solubility, and density. **Chemical properties** describe the behavior of a substance when it changes its composition by reacting with other substances or decomposing into two or more other pure substances. The ability to burn and the ability to react with water are chemical properties.

Matter can undergo two types of changes, physical and chemical. **Physical changes** do not cause a change in composition, only in appearance. For example, when copper is melted, only a change of state occurs; no new substance is formed. In a **chemical change,** substances are converted into new products having properties and compositions that are entirely different from those of the starting materials. Wood, for example, undergoes a chemical change when it burns by reacting with oxygen in the air, forming carbon dioxide and water vapor as the new products.

When two liquids are mixed, the mixture may be completely uniform in appearance. In this case the liquids are said to be **miscible.** Some liquids are miscible in all proportions, while others have a limited range of

miscibility. If the two liquids are not at all miscible, i.e., **immiscible,** two distinct layers will form when they are poured together. The liquid having the lower density will ''float'' on top of the other.

When a solid is added to and dissolves in a liquid, it is **soluble** in that liquid. The mixture formed is called a **solution.** A liquid solution is always clear; it may be colorless, or it may have a characteristic color. If the solid does not dissolve, it is said to be **insoluble.**

When two solutions are combined, a chemical change, or **reaction,** may occur in which new products form. If so, it will be evidenced by one of several visible changes. Among them are:

1. *Formation of a* **precipitate**, *or a solid product.* A precipitate is often very finely divided and distributed throughout the solution, giving a ''cloudy'' appearance. If allowed to stand, the precipitate will settle to the bottom of its container. The precipitate may be separated from the liquid by passing the mixture through a *filter* that collects the solid particles, but permits the solution to pass through.
2. *Formation of a gaseous product.* The gas produced bubbles out of the solution, a process called **effervescence.**
3. *Occurrence of a color change.* Usually a color change indicates the formation of a product with a color not originally present among the reactants. Sometimes the color will be the same as that of one of the reactants, but a darker or lighter shade.

In many cases no reaction occurs when two solutions are brought together.

SAFETY PRECAUTIONS AND DISPOSAL METHODS

Fumes from trichloroethane, xylene, and ammonia solutions are potentially harmful. Confine your use of these liquids to the fume hoods. Skin contact with these three liquids, or with hydrochloric acid, should be avoided. If it occurs, rinse the affected area thoroughly with water, and then wash with soap and water. Be sure to wear approved eye protection throughout the experiment.

Trichloroethane and xylene mixtures should be collected in stoppered bottles. **Do not pour them down the drain.** Solutions containing heavy metal precipitates should be collected in a separate container.

PROCEDURE

1. Mixing Liquids

A. Place about 20 drops of trichloroethane into a small-size test tube. Note this approximate quantity, because you will have several occasions in the experiment to estimate this volume in a test tube. Add about 10 drops of water and gently shake the test tube, or mix the contents with a stirring rod. Are the two liquids miscible? Record your observation on the work page.

If the two liquids are *not* miscible, identify the liquid, trichloroethane or water, that is on top. You may determine which liquid is on top by the relative quantities placed into the test tube: you added two

times as much trichloroethane as you did water. Record the name of the top liquid on your work page.

B. Discard the mixture from Part 1A and repeat the experiment, this time using about 20 drops of water first, followed by 10 drops of trichloroethane. If the liquids are not miscible, again record on the work page which liquid is on top.

C. Using a clean test tube, or the original one thoroughly rinsed with water, repeat the procedure with about 20 drops each of methanol (methyl alcohol) and water. It is not necessary this time or hereafter to reverse the order of liquids, as in Parts 1A and 1B. Again record your observations and conclusions.

D. Using a clean and thoroughly rinsed test tube, repeat the procedure again, this time with about 20 drops each of water and xylene. Record your observations and conclusions as before.

E. Using a clean *and dry* test tube (there must be no water present), perform the experiment once again, now using about 20 drops each of trichloroethane and xylene. Record your observations.

2. Dissolving a Solid in a Liquid

In this part of the experiment and the next, you will be preparing solutions. The procedure is to take about 4 mm—just over 1/8 inch—of the solid on the tip of a spatula and place it into about 10 mL of deionized (or distilled) water in a test tube. Shake the test tube gently, or stir the contents with a clean, dry stirring rod. If none of the solid appears to dissolve, the substance is insoluble. If *any* of it dissolves, but a small amount does not, add more water to get all of the solid into the solution.

A. Place a small quantity of barium chloride, $BaCl_2$, in water as described above. Does the solid dissolve in the water? Record your observations and save the solution for further use.

B. Add a small amount of sodium sulfate, Na_2SO_4, to about 10 mL of water in a second test tube. Does the solid dissolve? Record your observations and save the solution.

C. Combine the contents of the test tubes from Steps 2A and 2B in a large test tube. Record your observations. Set the test tube aside for 5 to 10 minutes and examine it again. Record what you see.

D. Add a small amount of barium sulfate, $BaSO_4$, to about 10 mL of water. Is this compound soluble? Record your observations.

3. Mixing Solutions

A. In a small test tube, dissolve a small amount of iron(III) chloride, $FeCl_3$, in about 2 mL of water. In another test tube, dissolve a small amount of potassium thiocyanate, KSCN, in about 2 mL of water. Mix the two solutions and record your observations.

B. In a small test tube, dissolve a small amount of sodium chloride, NaCl, in about 2 mL of water. In another test tube, dissolve a small amount of ammonium nitrate, NH_4NO_3, in about 2 mL of water. Mix the two solutions and record your observations.

C. In a small test tube, dissolve a small amount of sodium carbonate, Na_2CO_3, in about 2 mL of water. Add 2 to 3 drops of hydrochloric acid, HCl, watching carefully for any evidence of a chemical reaction. Then add some more HCl and watch for a reaction. Record your observations.

D. In a small test tube, dissolve a small amount of calcium chloride, $CaCl_2$, in about 2 mL of water. In another test tube, dissolve a small amount of sodium carbonate, Na_2CO_3, in about 2 mL of water. Mix the two solutions and record your observations.

E. In a small test tube, dissolve a small amount of copper(II) sulfate, $CuSO_4$, in about 2 mL of water. Add concentrated ammonia solution, $NH_3(aq)$, to it, a drop at a time. (Ammonia solutions are sometimes labeled ammonium hydroxide, NH_4OH.) Record your observations.

Name _____ *Date* _____ *Section* _____

Experiment 1

Advance Study Assignment

1. Distinguish between physical and chemical properties. Give an example of each.

2. Classify each of the following as a physical or chemical change:

a. Iron rusting _____

b. Boiling water _____

c. Burning a candle _____

d. Silver tarnishing (turning black) _____

3. Identify three forms of evidence that a chemical reaction has occurred:

a.

b.

c.

4. Define a precipitate.

Name _____ Date _____ Section _____

Experiment 1

Work Page

Part 1—Mixing Liquids

Step	*Mixture*	*Miscible or Immiscible*	*Liquid on Top*	*More Dense Liquid*
1A	Trichloroethane (20 drops) Water (10 drops)			
1B	Water (20 drops) Trichloroethane (10 drops)			
1C	Water Methanol			
1D	Water Xylene			
1E	Trichloroethane Xylene			

Questions

1. Is it possible from Parts 1A–1D to determine which of the liquids, xylene or trichloroethane, is more dense? If so, identify the liquid with the greater density and explain how you reached your conclusion; if not, explain why.

More dense liquid: _____

Explanation:

2. Is it possible from Part 1E alone to determine which of the liquids, xylene or trichloroethane, is more dense? If so, identify the liquid with the greater density and explain how you reached your conclusion; if not, explain why.

More dense liquid: _____

Explanation:

Part 2—Dissolving a Solid in a Liquid

2A. Barium chloride: Soluble (_____) or insoluble (_____)?

2B. Sodium sulfate: Soluble (_____) or insoluble (_____)?

2C. Mixture of contents of test tubes from 2A and 2B:
Immediate appearance:

Appearance 5–10 minutes later:

2D. Barium sulfate: Soluble (_____) or insoluble (_____)?

Optional. Based on your observations from Steps 2A, 2B, and 2D, suggest an explanation for your observation in Step 2C.

Part 3—Mixing Solutions

Step	*Solutions Combined*	*Reaction: Yes or No*	*Evidence*
3A	Iron(III) chloride Potassium thiocyanate		
3B	Sodium chloride Ammonium nitrate		
3C	Sodium carbonate Hydrochloric acid		
3D	Calcium chloride Sodium carbonate		
3E	Copper(II) sulfate Ammonia solution		

Name _____ Date _____ Section _____

Experiment 1

Report Sheet

Part 1—Mixing Liquids

Step	*Mixture*	*Miscible or Immiscible*	*Liquid on Top*	*More Dense Liquid*
1A	Trichloroethane (20 drops) Water (10 drops)			
1B	Water (20 drops) Trichloroethane (10 drops)			
1C	Water Methanol			
1D	Water Xylene			
1E	Trichloroethane Xylene			

Questions

1. Is it possible from Parts 1A–1D to determine which of the liquids, xylene or trichloroethane, is more dense? If so, identify the liquid with the greater density and explain how you reached your conclusion; if not, explain why.

More dense liquid: _____

Explanation:

2. Is it possible from Part 1E alone to determine which of the liquids, xylene or trichloroethane, is more dense? If so, identify the liquid with the greater density and explain how you reached your conclusion; if not, explain why.

More dense liquid: _____

Explanation:

Part 2—Dissolving a Solid in a Liquid

2A. Barium chloride: Soluble (_____) or insoluble (_____)?

2B. Sodium sulfate: Soluble (_____) or insoluble (_____)?

2C. Mixture of contents of test tubes from 2A and 2B:
Immediate appearance:

Appearance 5–10 minutes later:

2D. Barium sulfate: Soluble (_____) or insoluble (_____)?

Optional. Based on your observations from Steps 2A, 2B, and 2D, suggest an explanation for your observation in Step 2C.

Part 3—Mixing Solutions

Step	*Solutions Combined*	*Reaction: Yes or No*	*Evidence*
3A	Iron(III) chloride Potassium thiocyanate		
3B	Sodium chloride Ammonium nitrate		
3C	Sodium carbonate Hydrochloric acid		
3D	Calcium chloride Sodium carbonate		
3E	Copper(II) sulfate Ammonia solution		