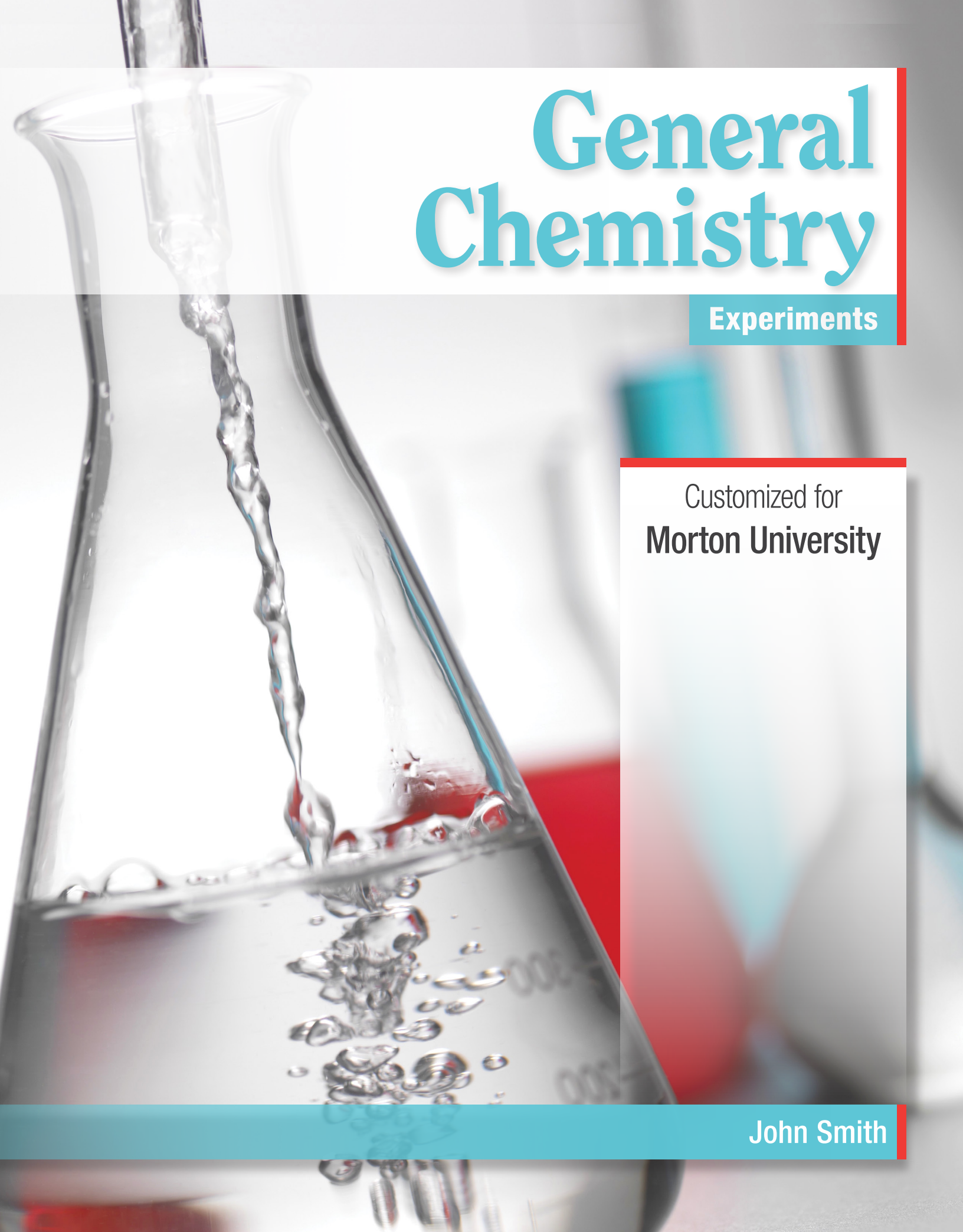


General Chemistry

Experiments

Customized for

Morton University

John Smith

LAB 4
Elements

Objectives

Students should be able to:

- Describe the periodic law.
- Apply the periodic law to identify elements that share similar properties based on their locations on the periodic table.
- Properly perform flame tests.
- Use chemical changes to identify elements that share similar properties.
- Use chemical changes to distinguish between different elements.
- Apply data obtained in this experiment to identify metal and halogen ion components of a mystery sample.

The **periodic law** states that the physical and chemical properties of the elements recur in a repeating pattern when they are ordered by increasing atomic number. On the **periodic table** (inside front cover), elements are arranged by increasing atomic number into horizontal rows and vertical columns. The rows are called **periods**, and the columns are called **groups**. This arrangement yields an important pattern: elements with similar properties are located within the same group. The pattern is a direct result of the fact that elements within a group possess the same number of **valence electrons**, those found in the outermost energy level of the atom. It is the valence electrons that are primarily responsible for an element's reactivity. For that reason, a group on the periodic table can be thought of as a "family" of elements that share many chemical properties. Some of the groups on the periodic table provided with this text are labeled with the family name for elements found within that group.

Because they share similar chemical properties, we often can identify which elements belong to the same family (i.e., group) by examining some of their chemical reactions. In this experiment, you will examine the reactivity of elements in three families: alkali metals, alkaline earth metals, and halogens. Like brothers and sisters, elements within a family still have individual characteristics that make them unique. In addition to identifying "family traits," you will use your experiments to identify distinguishing characteristics of the individual elements within a group.

It is important to note that you will *not* use pure samples of elements during this lab. Pure alkali metals, for example, can explode when they come into contact with water in the air! During the lab, you will use aqueous ("water-based") solutions that contain **ions**, which are charged forms of the elements.

For example, you will use a "sodium ion solution" rather than elemental sodium. The periodic law applies to these ions in the same way that it applies to the parent atoms because elements within a group form ions that bear identical charges.

In Part A, you will perform a flame test on six solutions, each containing a single alkali or alkaline earth metal ion. A flame test involves placing a small amount of solution on a metal loop and holding the loop in the tip of a flame. As the substance is heated, the color of the flame is observed (Fig. 4.1). Each metal ion produces a different color, providing information that should help you distinguish between the six metal ions you examine.

In Part B, you will examine the behavior of the six metal ions in three different chemical reactions. For example, you will observe the separate reactions of a barium ion solution with solutions of ammonium carbonate, ammonium hydrogen phosphate, and ammonium sulfate. You may observe no reaction for the barium ions with these substances, or you may observe the formation of a white solid. A solid formed when two solutions undergo a chemical reaction is called a **precipitate**. The formation of a precipitate generally causes the solution to turn cloudy because the grains of solid are very tiny and remain suspended in the liquid (Fig. 4.2). Large crystals are rarely observed during a precipitation reaction.

You will be able to use your results from Part B to classify the six metal ions into two families based on similar patterns of reactivity. For example, if barium and potassium ions both form white solids when mixed with the same substances, then they belong in the same chemical family. If they display different reactivities, then they belong in different families.

In Part C, you will examine the distinct behavior of three halogen ions under identical reaction conditions. When mixed with bleach (sodium hypochlorite), the halogen ions undergo a similar reaction but each exhibits a different color. Thus, observing the color produced by this reaction should allow you to distinguish between the three halogen ions.

In Part D, you will apply the testing procedures and data you gather from Parts A through C to a mystery solution in order to identify a metal ion and a halogen ion present.

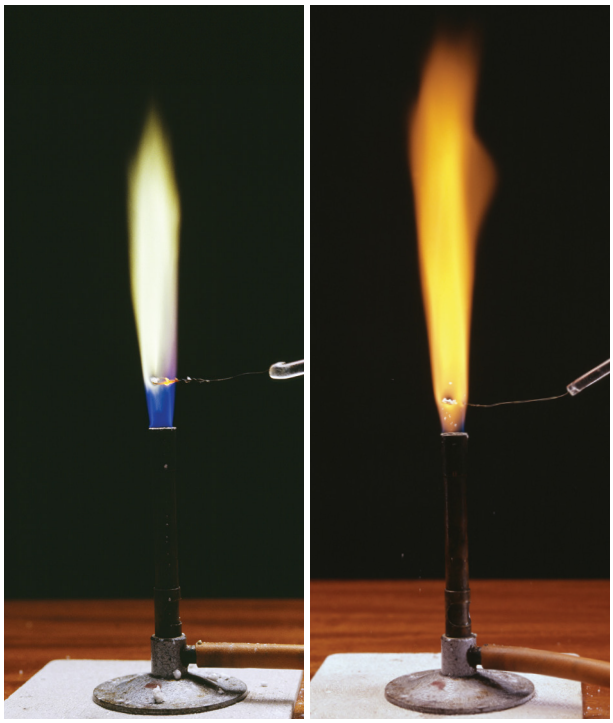


FIGURE **4.1** Flame tests involve holding a sample in a flame and observing the color produced.

Technique Tip

Flame tests can be difficult to read, so you may wish to repeat your flame tests several times in order to verify your observations. In addition, sodium often is present as an impurity in solutions of various alkali and alkaline earth metal ions. Sodium produces an orange-yellow flame test (Fig. 4.1). When present as an impurity, the sodium should produce only a weak orange-yellow color, and the color of the primary component of the solution should dominate. A true sample of sodium should produce an intense orange-yellow color during a flame test.

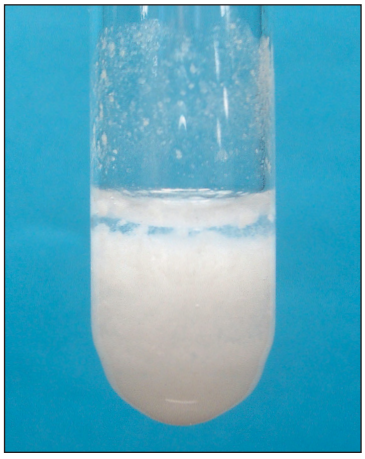


FIGURE **4.2** When a precipitate forms, the solution changes appearance from clear to cloudy.

Part A: Flame Tests for Metal Ions

Materials

- ❑ Test tubes
- ❑ Flame test wire
- ❑ Bunsen burner
- ❑ Hot plate
- ❑ 250 mL beaker
- ❑ Striker
- ❑ Test tube holder

⚠ SAFETY NOTE

Hydrochloric acid (HCl) is a strong acid. Handle with caution! Certain metal ions are toxic. Use caution and follow all instructor safety precautions when handling these chemicals!

1. Label six test tubes 1 through 6.
2. To each test tube, add 10 drops of the appropriate metal ion solution as indicated below:
   - Test Tube 1: barium ion solution
   - Test Tube 2: calcium ion solution
   - Test Tube 3: lithium ion solution
   - Test Tube 4: sodium ion solution
   - Test Tube 5: potassium ion solution
   - Test Tube 6: strontium ion solution
3. Clean a flame test wire by dipping it into a small amount of 6 M HCl and holding it in the flame of a Bunsen burner. Repeat this step two times.
4. Dip the test wire into test tube 1. Hold the wire loop into the tip of the burner flame. On the data sheet, page 55, record the color of the flame you observe.
5. Repeat steps 3 and 4 on the samples in test tubes 2 through 6. On the data sheet, record the color of the flame produced as each sample is heated.

NOTE: DO NOT discard the solutions in the test tubes. You will use them in Part B.

Part B: Reactions of Metal Ions

1. Prepare a boiling-water bath on a hot plate using a half-filled 250 mL beaker. Retain the water bath for Parts B and D.
2. To each of the test tubes used for the flame tests in Part A, add 5 drops of aqueous ammonium carbonate [$(NH_4)_2CO_3$]. If a solid forms, record *ppt* (precipitate) in the table on the data sheet, page 55. If no solid forms, record *NR* (no reaction) in the table.
3. Dispose of the test tube contents as directed by your instructor.
4. Refill each test tube with 10 drops of the appropriate metal ion solution listed in Part A, step 2.
5. To each test tube, add 5 drops of aqueous ammonium hydrogen phosphate [$(NH_4)_2HPO_4$]. Record your observations as *ppt* or *NR* on the data sheet table.
6. Dispose of the test tube contents as directed by your instructor.
7. Again, refill each test tube with 10 drops of the appropriate metal ion solution.
8. To each test tube, add 5 drops of ammonium sulfate [$(NH_4)_2SO_4$]. For any test tube in which you observe no precipitate formation, warm the solution by placing the test tube in the boiling-water bath for up to 5 minutes. Record your observations as *ppt* or *NR* on the data sheet table, including whether additional heat was necessary (+ *heat*).
9. Dispose of the test tube contents as directed by your instructor.

Part C: Halogen Ion Reactions

1. Label three test tubes 1 through 3.
2. To each test tube, add 10 drops of the appropriate halogen ion sample as indicated below:

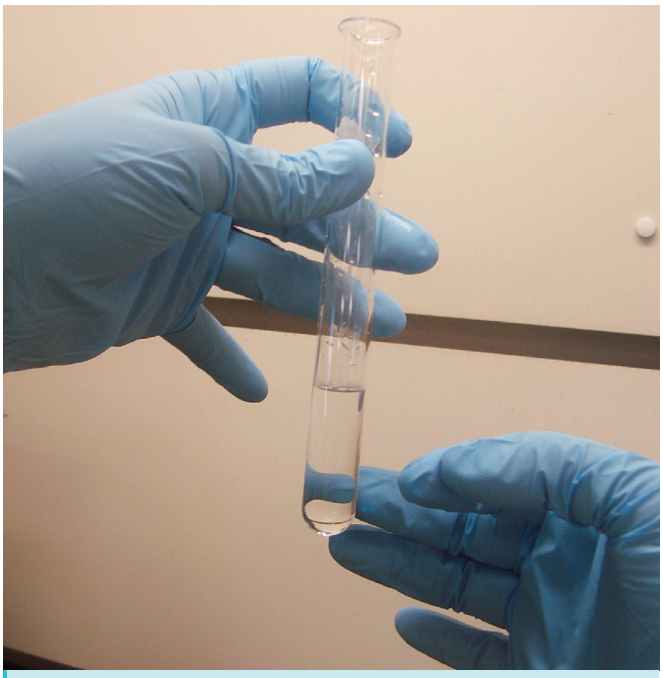
   Test Tube 1: chlorine ion

   Test Tube 2: bromine ion

   Test Tube 3: iodine ion
3. To each test tube, add 10 drops of hexane, 1 drop of 6 M nitric acid (HNO_3), and 5 drops of bleach (sodium hypochlorite).
4. Gently shake each test tube, and read the halogen test result by observing the color of the upper hexane layer (Fig. 4.3). Record the color of the hexane layer on the data sheet, page 56.
5. Dispose of the solution as directed by your instructor.

⚠ SAFETY NOTE

Nitric acid is a strong acid. Handle with caution! Hexanes and the elemental halogens produced during this test are flammable and inhalation hazards. Perform this test in a fume hood or appropriately ventilated area! Do not perform this test in the presence of open flames!



Technique Tip

To safely agitate a test tube, hold it between your thumb and split first two fingers. Flick the test tube using a finger from the opposite hand.

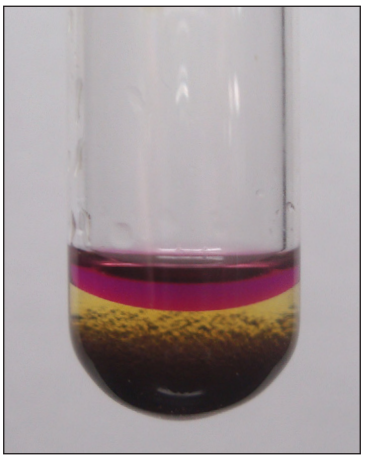


FIGURE **4.3** To read the halogen test result, observe the color of the upper hexane layer.

Name _____

Lab Partner _____

Lab Section _____ Date _____

Lab 4 DATA SHEET

1 Provide a term that matches each description below.

a Horizontal row on the periodic table _____

b Test that involves holding a sample in a flame _____

c Insoluble solid formed during a reaction in solution _____

d Charged form of an atom _____

e Column on the periodic table _____

f States that the properties of elements repeat in a recurring pattern when ordered by increasing atomic number

_____

2 The ions of six metals are investigated in this experiment. Name the six metals.

_____ _____

_____ _____

_____ _____

3 When performing a flame test, which element is often present as an impurity? How can the presence of this element as an impurity be distinguished from its presence as a primary component of a solution?

_____

_____

_____

_____

4 The ions of three halogens are investigated in this experiment. Name the three halogens.

_____

_____

_____