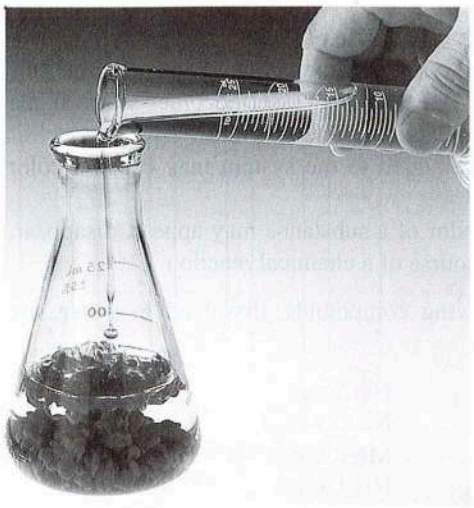

Experiment 2

Identification of a Compound: Chemical Properties

A potassium chromate solution added to a silver nitrate solution results in the formation of insoluble silver chromate.

OBJECTIVES

- To identify a compound on the basis of its **chemical properties**
- To design a systematic procedure for determining the presence of a particular compound in aqueous solution

Chemical property: characteristic of a substance that is dependent on its chemical environment

TECHNIQUES

The following techniques are used in the Experimental Procedure:

INTRODUCTION

Chemists, and scientists in general, develop and design experiments in an attempt to understand, explain, and predict various chemical phenomena. Carefully controlled (laboratory) conditions are needed to minimize the many parameters that affect the observations. Chemists organize and categorize their data and then systematically analyze the data to reach some conclusion; often, the conclusion may be to carefully plan more experiments!

It is presumptuous to believe that a chemist must know the result of an experiment before it is ever attempted; most often, an experiment is designed to determine the presence or absence of a **substance** or to determine or measure a parameter. A goal of the environmental or synthesis research chemist is, for example, to separate the substances of a reaction mixture (one generated in the laboratory or one found in nature) and then identify each substance through a systematic, or sometimes **trial-and-error,** study of their chemical and physical properties. As you will experience later, *Experiments 37–39* are designed to identify a specific ion (by taking advantage of its unique chemical properties) in a mixture of ions through a systematic sequence of analyses.

Substance: a pure element or compound having a unique set of chemical and physical properties

Trial-and-error study: a method that is often used to seek a pattern in the accumulated data

In this experiment, you will observe chemical reactions that are characteristic of various compounds under controlled conditions. After collecting and organizing your data, you will be given an unknown compound, one that you have previously investigated. The interpretations of the collected data will assist you in identifying your compound.

What observations will you be looking for? Chemical changes are generally accompanied by one or more of the following:

- A *gas* is evolved. This evolution may be quite rapid, or it may be a "fizzing" sound (Figure 2.1, page 54).

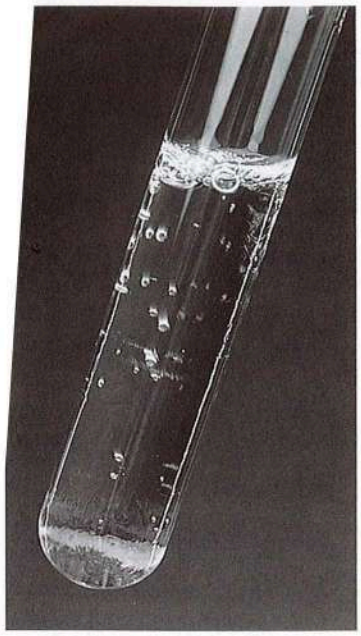

Figure 2.1 A reaction mixture of $NaHCO_3(aq)$ and $HCl(aq)$ produces CO_2 gas

Reagent: a solid chemical or a solution having a known concentration of solute

- A *precipitate* appears (or disappears). The nature of the precipitate is important. It may be crystalline, it may have color or it may merely cloud the solution.
- *Heat* may be evolved or absorbed. The reaction vessel becomes warm if the reaction is exothermic or cools if the reaction is endothermic.
- A *color change* occurs. A substance added to the system may cause a color change.
- A *change in odor* is detected. The odor of a substance may appear, disappear, or become more intense during the course of a chemical reaction.

The chemical properties of the following compounds, dissolved in water, are investigated in Part A of this experiment:

Sodium chloride	$NaCl(aq)$
Sodium carbonate	$Na_2CO_3(aq)$
Magnesium sulfate	$MgSO_4(aq)$
Ammonium chloride	$NH_4Cl(aq)$
Water	$H_2O(l)$

The following test **reagents** are used to identify and characterize these compounds:

Silver nitrate	$AgNO_3(aq)$
Sodium hydroxide	$NaOH(aq)$
Hydrochloric acid	$HCl(aq)$

In Part B of this experiment, the chemical properties of five compounds in aqueous solutions, labeled 1 through 5, are investigated with three reagents labeled A, B, and C. Chemical tests will be performed with these eight solutions. An unknown will then be issued and matched with one of the solutions, labeled 1 through 5.

EXPERIMENTAL PROCEDURE

A mix of $AgNO_3$ and NaCl solutions produce a white AgCl precipitate.

Procedure Overview: In Part A, a series of tests for the chemical properties of known compounds in aqueous solutions are conducted. A similar series of tests are conducted on an unknown set of compounds in Part B. In each case, an unknown compound is identified on the basis of the chemical properties observed.

You should discuss and interpret your observations on the known chemical tests with a partner, but each of you should analyze your own unknown compound. At each circled superscript (1–7) in the procedure, *stop* and record your observation on the ***Report Sheet***.

To organize your work, you will conduct a test on each known compound in the five aqueous solutions and the unknown compound with a single test reagent. The ***Report Sheet*** provides a "reaction matrix" for you to describe your observations. Because the space is limited, you may want to devise codes such as the following:

- pc—precipitate + color
- cc—cloudy + color
- nr—no reaction
- g—gas, no odor
- go—gas, odor

A. Chemical Properties of Known Compounds

1. Observations with silver nitrate test reagent

a. Use a permanent marker to label five small, clean test tubes (Figure 2.2a) or set up a clean 24-well plate (Figure 2.2b). Ask your instructor which setup you should use. Place 5–10 drops of each of the five "known" solutions into the labeled test tubes (or wells A1–A5).

b. Use a dropper pipet (or a dropper bottle) to deliver the silver nitrate solution. (**Caution:** *$AgNO_3$ forms black stains on the skin. The stain, caused by silver metal, causes no harm.*) If after adding several drops you observe a chemical change, then add 5–10 drops to see if there are additional changes. Record your observations in the matrix on the ***Report Sheet***.(1) Save your test solutions for

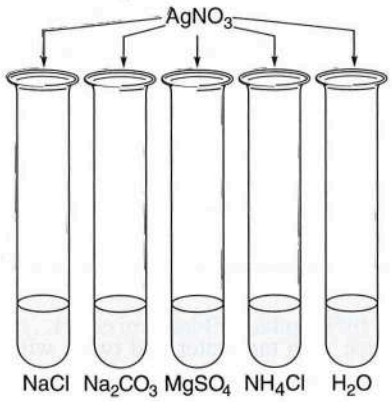

Figure 2.2a Arrangement of test tubes for testing with the silver nitrate reagent

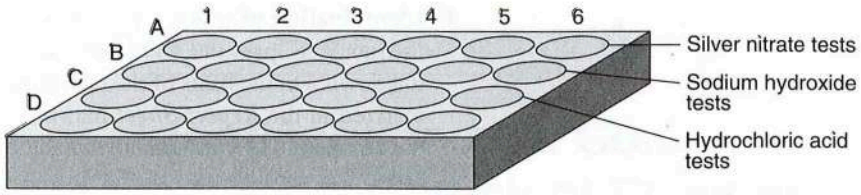

Figure 2.2b Arrangement of test solutions in the 24-well plate for testing salts

Part A.4. Write the formula for each precipitate that forms. Ask your lab instructor for assistance. For example, a mixture of NaCl(*aq*) and $AgNO_3$(*aq*) produces AgCl(*s*) as a precipitate. The insolubility of AgCl is noted in Appendix G.

Appendix G

2. **Observations with sodium hydroxide test reagent**

   a. Use a permanent marker to label five additional small, clean test tubes (Figure 2.3). Place 5–10 drops of each of the five "known" solutions into this second set of labeled test tubes (or wells B1–B5, Figure 2.2b).

   b. To each of these solutions, slowly add 5–10 drops of the sodium hydroxide solution; make observations as you add the solution. Check to see if a gas evolves in any of the tests. Check for odor. What is the nature of any precipitates that form? Observe *closely*.② Save your test solutions for reference in Part A.4. Write the formula for each of the precipitates that formed.

Appendix G

3. **Observations with hydrochloric acid test reagent**

   a. Use a permanent marker to label five additional small, clean test tubes (Figure 2.4). Place 5–10 drops of each of the five "known" solutions into this third set of labeled test tubes (or wells C1–C5, Figure 2.2b).

   b. Slowly add 5–10 drops of the hydrochloric test reagent to the solutions and record your observations. Check to see if any gas is evolved. Check for odor. Observe closely.③ Save your test solutions for reference in Part A.4. Write the formula for any compound that forms.

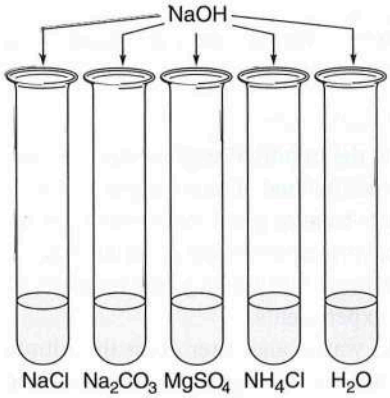

Figure 2.3 Arrangement of test tubes for testing with the sodium hydroxide reagent

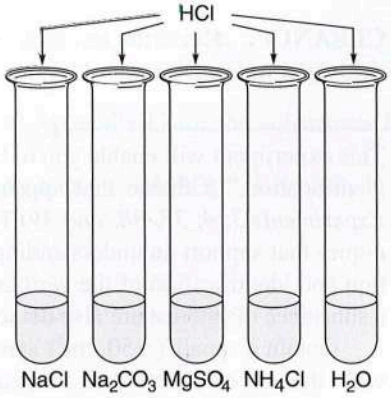

Figure 2.4 Arrangement of test tubes for testing with the hydrochloric acid reagent

Acids / Bases & Salts

4. **Identification of unknown.** Obtain an unknown for Part A from your laboratory instructor. Repeat the three tests with the reagents in Parts A.1, 2, and 3 on your unknown. On the basis of the data from the "known" solutions (collected and summarized in the ***Report Sheet*** matrix) and that of your unknown solution, identify the compound in your unknown solution.④

Disposal: Discard the test solutions in the Waste Salts container.

CLEANUP: Rinse the test tubes or well plate twice with tap water and twice with deionized water. Discard each rinse in the Waste Salts container.

B. Chemical Properties of Unknown Compounds

The design of the experiment in Part B is similar to that of Part A. Therefore, 15 clean test tubes or a clean 24-well plate is necessary.

A dropper pipet. 20 drops is ~1 mL of solution.

1. **Preparation of solutions.** On the reagent shelf are five solutions labeled 1 through 5, each containing a different compound. Use small clean test tubes or the well plate as your testing laboratory. About 1 mL of each test solution is necessary for analysis.
2. **Preparation of reagents.** Also on the reagent shelf are three reagents labeled A, B, and C. Use a dropper pipet (or dropper bottle) or a Beral pipet to deliver reagents A through C to the solutions.
3. **Testing the solutions**
   - **a.** Test each of the five solutions with drops (and then excess drops) of reagent A. If, after adding several drops, you observe a chemical change, add 5–10 drops more to see if there are additional changes. Observe closely and describe any evidence of chemical change; record your observations.⑤
   - **b.** With a fresh set of solutions 1–5 in clean test tubes (or wells), test each with reagent B.⑥ Repeat with reagent C.⑦
4. **Identification of unknown.** An unknown solution will be issued that is one of the five solutions from Part B.1. On the basis of the data in your reaction matrix and the data you have collected, identify your unknown as one of the five solutions.

Disposal: Discard the test solutions in the Waste Salts container.

CLEANUP: Rinse the test tubes or well plate twice with tap water and twice with deionized water. Discard each rinse in the Waste Salts container.

The Next Step

This experiment will enable you to better understand the importance of "separation and identification," a theme that appears throughout this manual. For example, refer to *Experiments 3, 4, 37, 38, and 39*. These experiments require good experimental techniques that support an understanding of the chemical principles involved in the separation and identification of the various compounds or ions. Additionally, the amounts of a substance of interest are also determined in other experiments.

Obtain a small (~50 cm^3) sample of soil, add water, and filter. Test the filtrate with the silver nitrate test reagent. Test a second soil sample *directly* with the hydrochloric acid test reagent. What are your conclusions?

Experiment 2 *Report Sheet*

Identification of a Compound: Chemical Properties

Date _____ Lab Sec. _____ Name _____ Desk No. _____

A. Chemical Properties of Known Compounds

Test	NaCl(*aq*)	Na_2CO_3(*aq*)	$MgSO_4$(*aq*)	NH_4Cl(*aq*)	H_2O(*l*)	Unknown
①$AgNO_3$(*aq*)						
②NaOH(*aq*)						
③HCl(*aq*)						

Write formulas for the precipitates that formed in Part A. (See Appendix G)

Part A.1						
Part A.2						
Part A.3						

Sample no. of unknown for Part A.4 _____

④Compound in unknown solution _____

B. Chemical Properties of Unknown Compounds

Solution No.	1	2	3	4	5	Unknown
⑤Reagent A						
⑥Reagent B						
⑦Reagent C						

Sample no. of unknown for Part B.4 _____

Compound of unknown is the same as Solution No. _____