FLAME TESTS FOR METALS

PURPOSE

To observe and identify metallic ions, using flame tests.

BACKGROUND

Have you ever wondered why a candle flame is yellow? The characteristic yellow of a candle flame comes from the glow of burning carbon fragments. The carbon fragments are produced by the incomplete combustion reaction of the wick and candle wax. When elements, such as carbon, are heated to high temperatures, some of their electrons are excited to higher energy levels. When these excited electrons fall back to lower energy levels, they release excess energy in packages of light called photons, or light quanta. The color of the emitted light depends on its energy. Blue light is more energetic than red light, for example. When heated, each element emits a characteristic pattern of light energies, which is useful for identifying the element. The characteristic colors of light produced when substances are heated in the flame of a gas burner are the basis of flame tests for several elements.

In this experiment, you will perform the flame tests used to identify several metallic elements.

MATERIALS (PER PAIR)

- safety goggles
- 8 small test tubes
- test-tube rack
- paper towel
- scoopulas
- 50-mL beaker
- platinum wire or nichrome wire loop
- gas burner
- cobalt-blue glass
- potassium nitrate, KNO₃
- calcium nitrate, Ca(NO₃)₂
- strontium nitrate, Sr(NO₃)₂
- lithium nitrate, LiNO₃
- copper(II) nitrate, Cu(NO₃)₂
- sodium nitrate, NaNO₃
- barium nitrate, Ba(NO₃)₂
- 6M hydrochloric acid, HCl
- unknown salt

SAFETY FIRST!

In this lab, the solutions you will be using contain harmful materials. Avoid skin contact with these chemicals. Observe all precautions, especially the ones listed below. If you see a safety icon beside a step in the Procedure, refer to the list below for its meaning.

Caution: Wear your safety goggles. (All steps.)
Caution: Hydrochloric acid is corrosive and can cause severe burns. (Step 2.)

Caution: Do not taste any of the substances or touch them with your hands. (Step 1.)

Caution: Do not at any time touch the end of the wire loop used in the flame tests. This wire gets extremely hot and can cause severe burns. (Steps 2–5.)

Note: Return or dispose of all materials according to the instructions of your teacher. (Step 6.)

PROCEDURE
As you perform the experiment, record your observations in Data Table 1.

1. Place a test-tube rack on a paper towel. Write the chemical name for each of the seven metal salts next to a position in the rack where a test tube will be placed. Use scoopulas supplied with each salt to place peasized samples of each metal salt into a test tube. Place the tubes in the test-tube rack.

2. Pour about 15 mL of 6M HCl into a clean, labeled 50-mL beaker. Dip the wire loop into the 6M HCl and then heat it in the hot flame of a gas burner, as shown in Figure 6.1a. Continue this procedure until no color comes from the wire when it is put into the flame.

3. Dip the clean wire loop into a sample of metal salt and heat the sample in the burner flame, as shown in Figure 6.1b. Record the color of the flame in Data Table 1. Test the remaining samples, cleaning the wire loop as described in Step 2, before each new sample is tested. Record your observations.

4. View the flame colors produced by NaNO₃ and KNO₃ through cobalt-blue glass. Record your observations.

5. Perform a flame test on your unknown salt. Record your observations.

6. Dispose of the unused portions of your samples as directed by your teacher.

Figure 6.1a

Figure 6.1b
**OBSERVATIONS**

**DATA TABLE 1: FLAME TESTS**

<table>
<thead>
<tr>
<th>Ion</th>
<th>Flame Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>sodium, Na⁺</td>
<td></td>
</tr>
<tr>
<td>potassium, K⁺</td>
<td></td>
</tr>
<tr>
<td>calcium, Ca²⁺</td>
<td></td>
</tr>
<tr>
<td>barium, Ba²⁺</td>
<td></td>
</tr>
<tr>
<td>strontium, Sr²⁺</td>
<td></td>
</tr>
<tr>
<td>lithium, Li⁺</td>
<td></td>
</tr>
<tr>
<td>copper, Cu²⁺</td>
<td></td>
</tr>
<tr>
<td>sodium, Na⁺ (cobalt glass)</td>
<td></td>
</tr>
<tr>
<td>potassium, K⁺ (cobalt glass)</td>
<td></td>
</tr>
<tr>
<td>unknown</td>
<td></td>
</tr>
</tbody>
</table>

**ANALYSES AND CONCLUSIONS**

1. List the elements that produced the most easily identified colors.

2. Which elements are least easily identified? Explain.

3. Which element produces the most intense color?

4. Would flame tests be useful for detecting metal ions present in a mixture of metal ions? Explain.
5. The energy of colored light increases in the order red, yellow, green, blue, violet. List the metallic elements used in the flame tests in increasing order of the energy of the light emitted.

6. What is the purpose of using the cobalt glass in the identification of sodium and potassium?

GOING FURTHER

Do Research

In this lab, you observed that each element emits a unique color of light when heated in a flame. If these light emissions were examined through a prism, you would observe that the emitted light is actually composed of different wavelengths of light that may lie in the violet region, the green region, or the red region of the visible spectrum. Each element has a unique emission spectrum. Look up the emission spectra for the elements tested in this lab. Do research on how scientists apply these emission spectra to investigate the chemical composition of stars. For example, what is the emission spectrum of the sun, and what does this spectrum reveal about the types of elements in the sun?