Laboratory Investigation: Flame Tests

Introduction
According to the quantum theory, electrons can occupy only specific (quantized) energy levels. When an atom absorbs energy, an electron can “jump” to a higher energy level. Electrons are less stable in higher energy levels so if a lower energy level is available, the electron will “fall” back, giving off energy in the process. This energy is emitted in the form of a photon of electromagnetic radiation, which is light. The color of the light depends on the specific energy change that is taking place.

White light is a continuous spectrum in which all wavelengths of visible light are present. However, an excited atom produces one or more specific lines in its spectrum corresponding to the specific changes in energy levels of its electrons. Because each element has a unique electron configuration, each element has a unique line spectrum.

Flame tests are an easy method of producing the characteristic colors of metal ions. The loosely-held electrons of a metal are easily excited to higher energy levels in the flame of a lab burner. The emission of energy in the visible portion of the spectrum as those electrons return to lower energy levels produces a colored flame. The color is a combination of the energy of each transition and may be used to determine the identity of the metal ion.

In this investigation you will perform flame tests on several metal ions, then use your results to determine the identity of an unknown solution.

Materials
Chemical splash goggles, Beaker with water for used q-tips, Lab burner, 8 q-tips, Solutions of the following chloride salts: Lithium (Li), Sodium (Na), Potassium (K), Calcium (Ca), Copper (Cu)

Safety
THE BIGGEST RISK IN THIS ACTIVITY IS FIRE – NOT CHEMICAL EXPOSURE.

When you work near the burner flame, tie back loose hair and secure loose or bulky clothing. Wear your goggles at all times during the investigation. Handle all solutions with care. Several of the salt solutions are toxic or may be irritating to your skin. If any of the solutions get on your skin, wash the affected area of skin with large amounts of water.

Procedure
1. Read the entire laboratory investigation before beginning.
2. Put on your goggles. Obtain a set of 6 test tubes. They are labeled on both the lids and sides of the tubes with the type of chloride salt, or with a number. The numbered tube is your unknown.
3. Light the burner and adjust the flame to low. Adjust the air intake at the bottom of the burner for a steady, light-blue flame. Caution: Tie back loose hair and keep loose or bulky clothing away from the flame.
4. Label 5 of your q-tips (by writing on the cardboard shaft) with the metal ions K, Ca, Cu, Na, and Li. Open the test tube labeled Li and dip one end of the q-tip in the solution. Close the tube and hold the soaked cotton to the edge of the flame near the bottom. Remove the q-tip before
it begins to burn. Record the color produced by lithium in the data table. Be descriptive with the words you choose because the difference in color between several of the metals is subtle. Repeat this step for each of your solutions, including your unknown. You may find that it becomes more difficult to obtain a good color if the q-tip has been soaking for too long in the solution. If you need to repeat a test, use the other side of the q-tip. If you need more, ask your teacher. Sometimes it takes a bit of practice. Waste is bad, practice is good. Only you know the difference.

5. Turn off the burner. Throw away your used q-tips, clean up your work area and wash your hands.

<table>
<thead>
<tr>
<th>Salt Solution</th>
<th>Color</th>
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<tbody>
<tr>
<td>Lithium (Li)</td>
<td></td>
</tr>
<tr>
<td>Sodium (Na)</td>
<td></td>
</tr>
<tr>
<td>Potassium (K)</td>
<td></td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td></td>
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<tr>
<td>Copper (Cu)</td>
<td></td>
</tr>
<tr>
<td>Unknown (number: ________)</td>
<td></td>
</tr>
</tbody>
</table>

Analysis and Conclusions
1. What is the identity of your unknown? What evidence supports this conclusion?

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2. What causes metal atoms to emit light when they are heated?

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3. When a glass rod is heated, a yellow-orange flame is observed around the heated point. What does this tell you about the chemical composition of glass?

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Waste is bad, practice is good.