Lab: The Case of the Contaminated Well

FOR THE TEACHER

Summary
In this lab, students will observe the colors produced when different metal salt solutions are heated in a flame. Students will take on the role of a forensic investigator and use their results to help them determine if collected evidence was contaminated.

Grade Level
High School

Objectives
By the end of this lab, students should be able to
- Use flame tests to identify a metal or metallic salt by the color that it produces when it is put into a flame.
- Identify an unknown metal by the color it emits when passed through a flame.

Chemistry Topics
This lab supports students' understanding of
- Energy
- Electromagnetic Spectrum
- Atomic structure
- Atomic spectra
- Electrons
- Visible light spectrum
- Identifying an Unknown

Time
Teacher Preparation: 30 minutes (longer if solution preparation is necessary)
Lesson: 45 minutes

Materials
- Metallic Salt Solutions:
  - 50 mL of 1.0M Barium Chloride (BaCl₂) – Note: Barium chloride is highly toxic. Do not ingest the salt or solution.
  - 50 mL of 1.0M Calcium Chloride (CaCl₂)
  - 50 mL of 1.0M Copper Chloride (CuCl₂)
  - 50 mL of 1.0M Lithium Chloride (LiCl)
  - 50 mL of 1.0M Potassium Chloride (KCl)
  - 50 mL of 1.0M Sodium Chloride (NaCl)
  - 50 mL of 1.0M Strontium Chloride (SrCl₂)
  - Evidence Sample from Well (see Teacher Notes)
  - Evidence Sample from Garage (see Teacher Notes)
- Deionized water
- 9, 100 mL beakers for Salt Solutions
- 9, 250mL beakers of water (for extinguishing flame)
- 9 Bunsen burners
- Wooden splints
- Striker

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Safety

- **Barium chloride** is highly toxic. Do not ingest the salt or solution.
- Wear proper personal protective equipment when preparing and working with solutions.
- Wash hands after handling materials used to prepare for or perform this experiment.
- Students should always wear safety goggles when handling chemicals in the lab.
- Students should wash their hands thoroughly before leaving the lab.
- When students complete the lab, instruct them how to clean up their materials and dispose of any chemicals.
- Always use caution around open flames. Keep flames away from flammable substances.
- Always be aware of an open flame. Open flames can cause burns. Do not reach over it, tie back hair, and secure loose clothing.

Teacher Notes

- This lab is designed to be set up as lab stations. Each station should include one 100ml beaker of the metal salt solutions with a number of soaking wooden splints, a Bunsen burner, and a 250ml of water for extinguishing the wooden splint.
- Students should spend 4-5 minutes at each station as the complete the procedure and collect data.
- There are many ways that a teacher can plan for conducting the forensic scenario in this lab. I include two additional stations, one labeled “well” and another “garage,” which are used to decide the outcome of the case. Using distilled water for the “well” sample and a sodium solution for the “garage” would suggest that the misguided youth had nothing to do with the well because they do not match in color. But sometimes I use a sodium salt solution for both the “well” sample and the “garage” sample, suggesting that the students are the sort who like to get into mischief, and did contaminate the well. The situation could be switched up from the morning to afternoon, so that students from different classes can’t share results. Likewise, alternative contaminates could be used in different classes.

Solution Preparation:

- If you need to make $\approx 1.0$M solutions of the metallic salts follow these instructions:
- Label each of the 100 mL beakers with the name of the salt that it will hold.
- Add the solid metallic salts to the beakers:
  - 12.2 grams of Barium Chloride ($\text{BaCl}_2\cdot 2\text{H}_2\text{O}$) – Note: **Barium chloride** is highly toxic. Do not ingest the salt or solution.
  - 5.5 grams of Calcium Chloride ($\text{CaCl}_2$)
  - 8.5 grams of Copper Chloride ($\text{CuCl}_2\cdot 2\text{H}_2\text{O}$)
  - 2.1 grams of Lithium Chloride ($\text{LiCl}$)
  - 3.7 grams of Potassium Chloride ($\text{KCl}$)
  - 2.9 grams of Sodium Chloride ($\text{NaCl}$)
  - 7.9 grams of Strontium Chloride ($\text{SrCl}_2$)
- Add deionized water up to the 50 mL mark.
- Note: If you do not have 100 mL beakers, substitute another piece of glassware and use a 50 mL graduated cylinder to add the deionized water.
- Use a separate wooden splint to stir each of the solutions.
- Distribute the remaining wooden splints between the solutions.
- Allow the splints to sit in the solutions overnight.
- One at a time, slowly pass the wooden splints through the burner flame. Repeat with additional splints until students have identified color. The flame will color as follows:
  - Barium Chloride: light green
  - Calcium Chloride: orange red
  - Copper Chloride: blue/green
FOR THE STUDENT

Lesson

The Case of the Contaminated Well

Scenario

Local commissioners decided it was time for the county to have its own Crime Investigative Service. Since you are a highly decorated chemistry student in high school, you have been hired to start this new crime fighting division. On your first day on the job, you get a call from an elderly woman with a complaint against the “lousy, good-for-nothin’ teenagers who lived next door.” She reports that these kids contaminated her well with some type of liquid. “I saw them do it! They put something in there and now I am afraid to drink my water!” You decide to take a sample of her well water for analysis. While interviewing the accused, you notice an unmarked container of water sitting on the workbench of the garage. Possibly, this contained the liquid that was added to the well. To be sure, you collect a sample to compare to the well sample. Fortunately, you remember a procedure that you conducted in chemistry class, called a flame test. It is a way to identify certain metal ions in a solution. You create a series of known solutions with possible contaminants and test them against both the garage sample and the neighbor’s well.

Materials

- Metallic Salt Solutions in labelled 100mL beakers:
  - 1.0M Barium Chloride (BaCl₂)
  - 1.0M Calcium Chloride (CaCl₂)
  - 1.0M Copper Chloride (CuCl₂)
  - 1.0M Lithium Chloride (LiCl)
  - 1.0M Potassium Chloride (KCl)
  - 1.0M Sodium Chloride (NaCl)
  - 1.0M Strontium Chloride (SrCl₂)
  - Evidence Sample from Well
  - Evidence Sample from Garage
- 250mL beakers of water (for extinguishing flame)
- Bunsen burners
- Wooden splints

Safety

- **Barium chloride** is highly toxic. Do not ingest the salt or solution.
- Always wear safety goggles when handling chemicals in the lab.
- Wash your hands thoroughly before leaving the lab.
- Follow the teacher’s instructions for cleanup of materials and disposal of chemicals.
- Always use caution around open flames. Keep flames away from flammable substances.
- Always be aware of an open flame. Open flames can cause burns. Do not reach over it, tie back hair, and secure loose clothing.
Procedure
1. You will spend 4-5 minutes at each lab station.
2. At each station you will find a labelled beaker containing a metal salt solution. There will be several wooden splints soaking in the solution.
3. Place a wooden splint soaked with the solution into a flame and observe the color. Record your observations in the data table provided.
4. When finished, extinguish the splint in the provided beaker of water. **Note:** *after the water solution has vaporized from the splint, the wooden splint gives off a yellow/orange flame. This is not to be confused with the actual color of the solution.*
5. Move through all of the stations and repeat steps 3 and 4 with each known sample.
6. After you have collected data from each station, repeat steps 3 and 4 for both the evidence sample from the well and the evidence sample from the garage. Record your observations in the data table provided.

Data

<table>
<thead>
<tr>
<th>Known Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Station</strong></td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
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<td>3</td>
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<td>6</td>
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<td>7</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Forensic Evidence Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Evidence type</strong></td>
</tr>
<tr>
<td>Well Sample</td>
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<tr>
<td>Garage Sample</td>
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</tbody>
</table>
Forensic Analysis
The leading detective of the case is wondering if he should press charges against the neighboring teenager. Write a report explaining your test and how he should proceed with the case.