Name _____ Class _____ Date _____

Skills Practice Lab

DATASHEETS FOR IN-TEXT LAB

Flame Tests

Your company has been contacted by Julius and Annette Benetti. They are worried about some abandoned, rusted barrels of chemicals that their daughter found while playing in the vacant lot behind their home. The barrels have begun to leak a colored liquid that flows through their property before emptying into a local sewer. The Benettis want your company to identify the compound in the liquid. Earlier work indicates that it is a dissolved metal compound. Many metals, such as lead, have been determined to be hazardous to our health. Many compounds of these metals are often soluble in water and are therefore easily absorbed into the body.

Electrons in atoms jump from their ground state to excited states by absorbing energy. Eventually, these electrons fall back to their ground state, re-emitting the absorbed energy in the form of light. Because each atom has a unique structure and arrangement of electrons, each atom emits a unique spectrum of light. This characteristic light is the basis for the chemical test known as a flame test. In this test, the atoms are excited by being placed within a flame. As they re-emit the absorbed energy in the form of light, the color of the flame changes. For most metals, these changes are easily visible. However, even the presence of a tiny speck of another substance can interfere with the identification of the true color of a particular type of atom.

To determine what metal is contained in the barrels behind the Benettis' house, you must first perform flame tests with a variety of standard solutions of different metal compounds. Then you will perform a flame test with the unknown sample from the site to see if it matches any of the solutions you've used as standards. Be sure to keep your equipment very clean and perform multiple trials to check your work.

OBJECTIVES

Identify a set of flame-test color standards for selected metal ions.

Relate the colors of a flame test to the behavior of excited electrons in a metal ion.

Draw conclusions and identify an unknown metal ion by using a flame test.

Demonstrate proficiency in performing a flame test and in using a spectroscope.

Flame Tests *continued*

MATERIALS

- beaker, 250 mL
- Bunsen burner and related equipment
- $CaCl_2$ solution
- cobalt-glass plates
- crucible tongs
- distilled water
- flame-test wire
- glass test plate, or a microchemistry plate with wells
- HCl solution (1.0 M)
- K_2SO_4 solution
- Li_2SO_4 solution
- Na_2SO_4 solution
- NaCl crystals
- NaCl solution
- spectroscope
- $SrCl_2$ solution
- unknown solution

Always wear safety goggles, gloves, and a lab apron to protect your eyes and clothing. If you get a chemical in your eyes, immediately flush the chemical out at the eyewash station while calling to your teacher. Know the location of the emergency lab shower and eyewash station and the procedures for using them.

Do not touch any chemicals. If you get a chemical on your skin or clothing, wash the chemical off at the sink while calling to your teacher. Make sure you carefully read the labels and follow the precautions on all containers of chemicals that you use. If there are no precautions stated on the label, ask your teacher what precautions to follow. Do not taste any chemicals or items used in the laboratory. Never return leftovers to their original container; take only small amounts to avoid wasting supplies.

Call your teacher in the event of a spill. Spills should be cleaned up promptly, according to your teacher's directions.

Acids and bases are corrosive. If an acid or base spills onto your skin or clothing, wash the area immediately with running water. Call your teacher in the event of an acid spill. Acid or base spills should be cleaned up promptly.

Do not heat glassware that is broken, chipped, or cracked. Use tongs or a hot mitt to handle heated glassware and other equipment because hot glassware does not always look hot.

When using a Bunsen burner, confine long hair and loose clothing. If your clothing catches on fire, WALK to the emergency lab shower and use it to put out the fire.

Procedure

1. Put on safety goggles, gloves, and a lab apron.
2. Label a beaker "Waste." Thoroughly clean and dry a well strip. Fill the first well one-fourth full with 1.0 M HCl. Clean the test wire by first dipping it in the HCl and then holding it in the flame of the Bunsen burner. Repeat this procedure until the flame is not colored by the wire. When the wire is ready, rinse the well with distilled water, and collect the rinse water in the waste beaker.
3. Put 10 drops of each metal ion solution listed in the materials list except NaCl in a row in each well of the well strip. Put a row of 1.0 M HCl drops on a glass plate across from the metal ion solutions. Record the position of all of the chemicals placed in the wells. The wire will need to be cleaned thoroughly with HCl between each test solution to avoid contamination from the previous test.
4. Dip the wire into the $CaCl_2$ solution and then hold it in the flame of the Bunsen burner. Observe the color of the flame, and record it in the data table. Repeat the procedure again, but this time look through the spectroscope to view the results. Record the wavelengths you see from the flame. Perform each test three times. Clean the wire with the HCl as you did in step **2.**
5. Repeat step **4** with the K_2SO_4 and with each of the remaining solutions in the well strip. For each solution that you test, record the color of each flame and the wavelength observed with the spectroscope. After the solutions are tested, clean the wire thoroughly, rinse the well strip with distilled water, and collect the rinse water in the waste beaker.
6. Test another drop of Na_2SO_4, but this time view the flame through two pieces of cobalt glass. Clean the wire, and repeat the test using the K_2SO_4. View the flame through the cobalt glass. Record in your data table the colors and wavelengths of the flames. Clean the wire and the well strip, and rinse the well strip with distilled water. Pour the rinse water into the waste beaker.
7. Put a drop of K_2SO_4 in a clean well. Add a drop of Na_2SO_4. Flame-test the mixture. Observe the flame without the cobalt glass. Repeat the test, this time observing the flame through the cobalt glass. Record the colors and wavelengths of the flames in the data table. Clean the wire, and rinse the well strip with distilled water. Pour the rinse water into the waste beaker.
8. Test a drop of the NaCl solution in the flame, and then view it through the spectroscope. (Do not use the cobalt glass.) Record your observations. Clean the wire, and rinse the well strip with distilled water. Pour the rinse water into the waste beaker. Place a few crystals of NaCl in a clean well, dip the wire in the crystals, and do the flame test once more. Record the color of the flame test. Clean the wire, and rinse the well strip with distilled water. Pour the rinse water into the waste beaker.

9. Dip the wire into the unknown solution; then hold it in the Bunsen burner flame. Perform flame tests for the wire, both with and without the cobalt glass. Record your observations. Clean the wire, and rinse the well strip with distilled water. Pour the rinse water into the waste beaker.

10. Clean all apparatus and your lab station. Dispose of the contents of the waste beaker into the container designated by your teacher. Wash your hands thoroughly after cleaning up the lab area and equipment.

TABLE 1 FLAME TEST RESULTS

Metal Compound	Color of flame	Wavelengths (nm)
$CaCl_2$ solution		
K_2SO_4 solution		
Li_2SO_4 solution		
Na_2SO_4 solution		
$SrCl_2$ solution		
Na_2SO_4 (cobalt glass)		
K_2SO_4 (cobalt glass)		
Na_2SO_4 and K_2SO_4		
Na_2SO_4 and K_2SO_4 (cobalt glass)		
NaCl solution		
NaCl crystals		
Unknown solution		

Analysis

1. **Organizing data** Examine your data table, and create a summary of the flame test for each metal ion.

2. **Analyzing data** Account for any differences in the individual trials for the flame tests for the metal ions.

3. **Explaining events** Explain how viewing the flame through cobalt glass can make analyzing the ions being tested easier.

4. **Explaining events** Explain how the lines seen in the spectroscope relate to the position of electrons in the metal atom.

5. **Identifying patterns** For three of the metal ions tested, explain how the flame color you saw relates to the lines of color you saw when you looked through the spectroscope.

Conclusions

1. **Evaluating results** What metal ions are in the unknown solution from the barrels on the vacant lot?

2. **Evaluating methods** How would you characterize the flame test with respect to its sensitivity? What difficulties could occur when identifying ions by the flame test?

3. **Evaluating methods** Explain how you can use a spectroscope to identify the components of solutions containing several different metal ions.

4. **Applying ideas** Some stores sell jars of "fireplace crystals." When sprinkled on a log, these crystals make the flames blue, red, green, and violet. Explain how these crystals can change the flame's color. What ingredients would you expect the crystals to contain?

Extensions

1. **Designing experiments** A student performed flame tests on several unknown substances and observed that all of the flame colors were shades of red. What could the student do to correctly identify these substances? Explain your answer.

2. **Designing experiments** During a flood, the labels from three bottles of chemicals were lost. The three unlabeled bottles of white solids were known to contain the following substances: strontium nitrate, ammonium carbonate, and potassium sulfate. Explain how you could easily test the substances and relabel the three bottles. (Hint: Ammonium ions do not provide a distinctive flame color.)