Lab: Flame Tests / Spectral Tubes

AP Chemistry

Chemist: _____ Date: _____

Introduction

Why do candles burn yellow? Dark suckers? Why does copper sometimes burn blue and other times green? Different elements will release flames of various colors when they are heated. Heating elements is a common way of identifying elements. This lab will explore the pattern of light energies emitted when heating various elements.

Concepts

- Energy levels
- Light Energy
- Frequency and Wavelength

Background

A flame test is an experiment in chemistry used to see what kind of ions are present. The color of the flame will depending on temperature. The test involves adding a sample of an element or compound to a non-luminous flame and observing the color that results.

Commonly, wooden splints are sometimes used, mostly because solutions can be dried onto them, and they are inexpensive. When using a splint, one must be careful to wave the splint through the flame rather than holding it in the flame for extended periods, to avoid setting the splint itself on fire. Sodium is a common component or contaminant in many compounds and its spectrum tends to dominate over others.

The flame test is fast and easy to perform, and does not require any equipment not usually found in a chemistry laboratory. However, the range of detected elements is small, and the test relies on the subjective experience of the experimenter rather than any objective measurements. The test has difficulty detecting small concentrations of some elements, while too strong a result may be produced for certain others, which tends to drown out weaker signals. Although the flame test only gives qualitative information, not quantitative data about the actual proportion of elements in the sample, quantitative data can be obtained by the related techniques of flame photometry or flame emission spectroscopy.

Now, you may be wondering how we will get different colors in the lab. It's actually pretty simple. The energy levels in atoms and ions are the key to the production and detection of light. The colors of dyes and other compounds results from electron jumps between levels. For example, the colors of fireworks result from jumps of electrons from one shell to another. The kinds of light that interact with atoms indicate the energy differences between shells and energy levels in the quantum theory model of the atom. Typically the valence electrons are the ones involved in these jumps.

Experiment Overview
The purpose of this experiment is to physically observe the releasing of energy from excited electrons dropping down different numbers of energy levels.

Safety Precautions
When using a Bunsen burner, check the rubber tubing for any signs of holes or possible leaks. Avoid contact of all chemicals with eyes and skin. Clean up all chemical spills immediately. Wear chemical splash goggles and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory. Please consult current Material Safety Data Sheets for additional safety, handling, and disposal information.

Materials
1 Bunsen burner
$CuCl_2$ (s)
NaCl (s)
LiCl (s).
$CaCl_2$ (s)
KCl (s)
$BaCl_2$ (s)
$SrCl_2$ (s)
7 Wooden Splints minimum
1 250 mL beaker filled with water
1 250 mL waste beaker
Small cups/beakers to hold compounds
Spectral tubes
Power source
Spectrometers / diffraction glasses

Procedure:
Flame Tests

1. Fill a beaker half full with water. Soak wood splints in water.
2. Dip the splint into the desired chemical compound to adhere several crystals.
3. Insert the splint into the flame, and observe the color produced.
4. Extinguish the wood splint in the waste beaker, which is full of water.

Atomic Spectra

1. Insert the hydrogen tube into the power source. Turn it on.
2. Using the diffraction grating, observe the line spectra that results. Sketch this as data for this spectral tube.
3. Turn off the power source.
4. Repeat for neon and krypton.

Data Table

Compound	Flame Color
NaCl	
$SrCl_2$	
LiCl	
KCl	
$CuCl_2$	
$CaCl_2$	
H_3BO_3	
$BaCl_2$	

Questions

1. What causes the color when you place the metallic salts into the flame? Be specific.

2. What salt releases the highest energy photon? How do you know?

3. Use some type of reference source and list the wavelength (in meters) of the colors that you see. Now use the wave equation to calculate the frequencies.

4. Using the info from #3. Use E=hv to calculate the energy of each photon for each different salt compound and its corresponding color.

5. Write the electron configuration for each metal. Try and explain why you see the different colors based on this information about each metal.

6. Answer the following questions regarding neon and krypton's atomic spectra.
   a. Why did neon and krypton produce a different set of spectral lines with different energy transitions?
   b. How can we use atomic spectra as a means of identifying stars in the galaxy?
   c. Complete the following:
      i. An orbital diagram for neon.
      ii. A ground-state electron configuration for xenon.