

Flame Test Lab

Objective

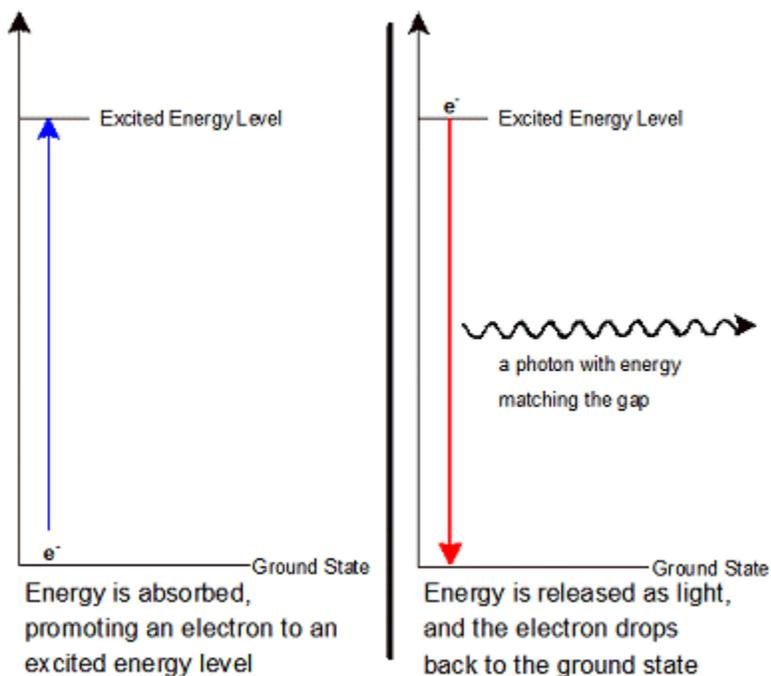
In this lab students will learn about atomic energy levels, emission spectroscopy, and flame tests for element identification.

Overview

Students will use small samples of 6 chloride salts of different metals. These they will place into a flame in order to observe the colors produced. These colors come from the excitation of electrons which then resume their ground states by emitting light of very specific colors.

Background

The electrons in an atom occupy different energy levels, as you know. When all of the electrons are at the lowest possible energy level they are said to be in the **ground state**. Electrons do not always stay in the ground state. Sometimes they can be promoted to a higher-energy electron shell. This can happen in two ways. First, the electron can absorb a photon of just the right amount of energy to move it from one quantum shell to another. Second, when atoms are heated or energized with electricity their electrons can gain energy. This promotes them to the higher-energy shell. When an electron is in a higher-energy shell it is said to be in an **excited state**.



Electrons in excited states do not usually stay in them for very long. When electrons lose their energy they do so by emitting a photon of light. Photons are particles with energy but no mass. Their energy is directly proportional to the frequency of the light (remember: $E = hf$). The photons emitted precisely match the quantum energy difference between the excited state and the ground state.

The light produced by very hot atoms in the gaseous state is a unique spectrum for each element. To observe the spectrum requires the use of a prism, diffraction grating, or spectroscope. Before complex instruments were invented to observe elemental spectra chemists sometimes identified metals in compounds by doing a flame test. Salts are a type of compound that include a metal and a non-metal. Sodium chloride (NaCl) is the most familiar example of a salt but others include calcium chloride (CaCl₂) and copper(II) chloride (CuCl₂). In flame tests salts that are dissolved in water are evaporated using a hot flame. In the flame the metal atoms become excited and produce their characteristic

spectrum of light. However, since the observer does not use a spectroscope only one color is observed. It turns out that many metals produce a unique single color under these conditions. Some metals do produce very similar colors but a practiced eye can often distinguish them. It is a traditional art of the chemistry laboratory to use these colors to identify specimens of compounds that contain unknown metals.

This ability of metal atoms to produce these colors is put to use by practitioners of the art of fireworks manufacture. By including different metal salts, or mixtures of metal salts, in the exploding shell of a firework, these artists can produce beautiful displays in nearly all the colors of the rainbow.

Materials

1. 1 small beaker filled with distilled water
2. 1 inoculation loop
3. 1 Bunsen burner
4. lighter
5. a series of metal solutions

Safety

- Wear goggles or risk sitting out the lab
- Treat all chemicals in this lab as toxic. Do not touch any of them with your bare hands.
- Wash well with water immediately if you touch chemicals accidentally
- Use caution with the burner
 - Do not leave burner unattended
 - Place burner near middle of lab bench
 - Tie back long hair
 - Do not wear baggy clothing in the lab
 - Hot objects look like cold objects: be cautious!
- Wash your hands with soap and water after you complete the day's lab work, even if you didn't touch any chemicals directly – some of these solutions are highly toxic

Procedure

1. You will share a set of metal salt solutions with the people in your class. Each partner group will need one beaker for the water rinse. Either 50-mL or 100-mL beakers will be fine.
2. Obtain an inoculation loop for your group.
3. Obtain 10 - 20 mL of water in your beaker.
4. Each group member must record information in a neat table with the following columns. Make this table before you even turn on the gas.

Color	Representative Wavelength (nm)	Wavelength Region (nm)
Violet	420	400 - 440
Blue	455	440 - 470
Blue-green	480	470 - 490
Green	525	490 - 560
Yellow-green	565	560 - 570
Yellow	580	570 - 585
Orange	620	585 - 630
Red	660	630 - 700

- a. **Name & Formula of Metal Chloride**
 - b. **Metal Ion**
 - c. **Color of Flame**
 - d. **Approx. Wavelength (nm)**
 - e. **Approx. Wavelength (m)**
5. Clean the inoculation loop by swirling it gently in the distilled water. Then, once you light the burner, heat the loop until it glows red hot. This step removes any ions clinging to the loop.
 6. Light and adjust your Bunsen burner. Be sure to clean your loop carefully. **Do not leave the loop in the flame too long as it can cause the loop to degrade and break.**
 7. To do a flame test with each metal salt dip your inoculation loop into your metal salt and get a film of the solution of a salt inside the loop (swirl the loop around in the solution) and bring it into the hottest part of the flame. If this produces poor color then try the edge of the burner flame. Repeat the dip into the salt solution as often as necessary to see the flame test color. Be sure not to over-heat the loop.
 8. Carefully note the color of each metal salt when it is put in the flame. Use the chart on the previous page to estimate the approximate wavelength of the color you see. Use the Representative Wavelength values. Record all data in the table you made earlier.
 9. Clean the inoculation loop using distilled water and heat each time you change from one metal salt to another. Failing to do so will result in mixed flame test colors. Again, do not over heat the loop.
 10. Clean out your beaker.

POST LAB QUESTIONS

1. Is the flame color a test for the metal or for the chloride in each compound? Explain your answer?
2. Why do different metals have different characteristic flame test colors?
3. Most salts contain a metal and a non-metal. Look at the compounds we tested and determine whether it is the metal or the non-metal that is responsible for the color produced in the flame test for that salt. How can you be sure your answer is correct?
4. Why do the chemicals have to be heated in the flame before the colored light is emitted?
5. Could flame tests be useful in determining identities of metals in a mixture of two or more salts? If so, what problems might arise? If not, why not? *Explain* your answer.