P.O. Box 219 • Batavia, IL 60510
(800) 452-1261 • Fax (866) 452-1436
www.flinnsci.com • E-mail: flinn@flinnsci.com

FLINN SCIENTIFIC, INC
"Your Safer Source for Science Supplies"

Catalog No. AP5607

Publication No. 5607

Flame Test Kit

Student Laboratory Kit

Introduction

Just as a fingerprint is unique to each person, the color of light emitted by metals heated in a flame is unique to each metal. In this laboratory activity, the characteristic color of light emitted for calcium, copper, lithium, potassium, sodium, and strontium will be observed.

Chemical Concepts

- Flame Tests
- Absorption/Emission

Background

Absorption and Emission of Light in a Flame

When a substance is heated in a flame, the substance's electrons absorb energy from the flame. This absorbed energy allows the electrons to be promoted to excited energy levels. From these excited energy levels, the electrons naturally want to make a transition, or relax, back down to the ground state. When an electron makes a transition from a higher energy level to a lower energy level, a particle of light called a *photon* is emitted. A photon is commonly represented by a squiggly line (see Figure 1).

An electron may relax all the way back down to the ground state in a single step, emitting a photon in the process. Or, an electron may relax back down to the ground state in a series of smaller steps, emitting a photon with each step. In either case, the energy of each emitted photon is equal to the difference in energy between the excited state and the state to which the electron relaxes. The energy of the emitted photon determines the color of light observed in the flame. Because colors of light are commonly referred to in terms of their wavelength, equation 1 is used to convert the energy of the emitted photon to its wavelength.

$$\Delta E = \frac{hc}{\lambda} \qquad \text{Equation 1}$$

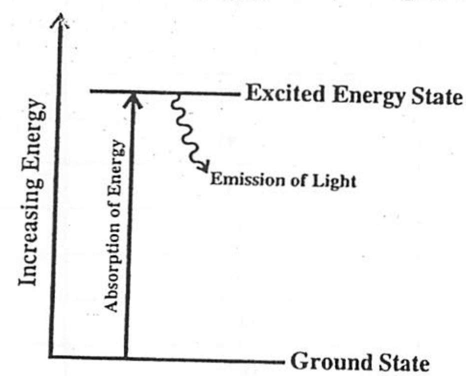

Figure 1. Absorption and Emission of Light.

In Equation 1,

ΔE is the difference in energy between the two energy levels in Joules,
h is Plank's constant ($h = 6.626 \times 10^{-34}$ J·sec),
c is the speed of light ($c = 2.998 \times 10^{8}$ m/sec), and
λ is the wavelength of light in meters.

Wavelengths are commonly listed in units of nanometers ($1 \text{ m} = 1 \times 10^{9}$ nm), so a conversion between meters and nanometers is generally made.

The color of light observed when a substance is heated in a flame varies from substance to substance. Because each element has a different electronic configuration, the electronic transitions for a given substance are unique. Therefore, the difference in energy between energy levels, the exact energy of the emitted photon, and its corresponding wavelength and color are unique to each substance. As a result, the color observed when a substance is heated in a flame can be used as a means of identification.

The Visible Portion of the Electromagnetic Spectrum

Visible light is a form of electromagnetic radiation. Other familiar forms of electromagnetic radiation include γ-rays such as those from radioactive materials and from space, X-rays which are used to detect bones and teeth, ultraviolet (UV) radiation from the sun, infrared (IR) radiation which is given off in the form of heat, the microwaves used in radar signals and microwave ovens, and radio waves used for radio and television communication. Together, all forms of electromagnetic radiation make up the electromagnetic spectrum (see Figure 2). The visible portion of the electromagnetic spectrum is the only portion that can be detected by the human eye—all other forms of electromagnetic radiation are invisible to the human eye.

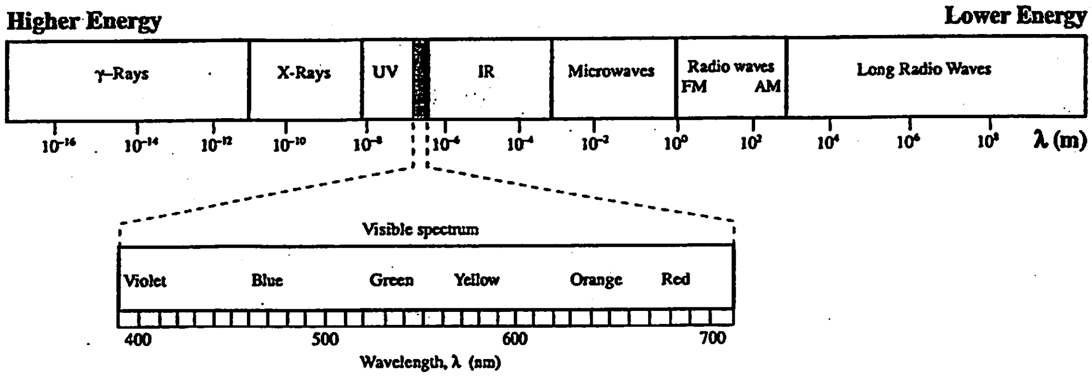

Figure 2. The Electromagnetic Spectrum.

The visible portion of the electromagnetic spectrum is only a small part of the entire spectrum. It spans the wavelength region from about 400 to 700 nm. Light of 400 nm is seen as violet and light of 700 nm is seen as red. According to equation 1, wavelength is inversely proportional to energy. Therefore, violet light (400 nm) is higher energy light than red light (700 nm). The color of light observed by the human eye varies from red to violet according to the familiar mnemonic ROY G BIV: red, orange, yellow, green, blue, indigo, and violet. As the color of light changes, so does the amount of energy it possesses.

Table 1 lists the wavelengths associated with each of the colors in the visible spectrum. The representative wavelengths are used as a benchmark for each color. For example, instead of referring to green as light in the wavelength range 500–560 nm, one may simply refer to green light as 520 nm light.

Representative Wavelength, nm	Wavelength Region, nm	Color
410	400–425	Violet
470	425–480	Blue
490	480–500	Blue-green
520	500–560	Green
565	560–580	Yellow-green
580	580–585	Yellow
600	585–650	Orange
650	650–700	Red

Table 1.

Materials

Chemicals

Calcium chloride, $CaCl_2 \cdot 2H_2O$, 1–1.5 g

Cupric chloride, $CuCl_2 \cdot 2H_2O$, 1–1.5 g

Lithium chloride, LiCl, 1–1.5 g

Potassium chloride, KCl, 1–1.5 g

Sodium chloride, NaCl, 1–1.5 g

Strontium chloride, $SrCl_2 \cdot 6H_2O$, 1–1.5 g

Water, distilled or deionized, 250 mL

Equipment

Beakers, 250-mL, 2

Laboratory burner

Watch glasses or weighing dishes, 6

Wooden splints soaked in water, 6

Safety Precautions

Cupric chloride is highly toxic by ingestion; avoid contact with eyes, skin, and mucous membranes. Lithium chloride is moderately toxic by ingestion and is a body tissue irritant. Fully extinguish the wooden splints by immersing them in a beaker of water before discarding them in the trash to avoid trashcan fires. Wear chemical splash goggles, chemical-resistant gloves, and a chemical-resistant apron. Wash hands thoroughly with soap and water before leaving the laboratory.

Procedure

1. Fill a 250-mL beaker about half-full with distilled or deionized water. Obtain six wooden splints that have been soaked in distilled or deionized water. Place them in this beaker of water to continue soaking at your lab station.
2. Fill a second 250-mL beaker about half-full with tap water. Label this beaker "rinse water".
3. Label six watchglasses (or weighing dishes) "$CaCl_2$", "$CuCl_2$", "LiCl", "NaCl", "KCl", "$SrCl_2$". Place a small scoopful (about 1–1.5 g) of each metallic solid in the corresponding watchglass (or weighing dish).
4. Light the laboratory burner.
5. Dip the soaked end of one of the wooden splints in one of the metallic salts, then place it in the flame. Observe the color of the flame. Allow the splint to burn until the color fades. Try not to allow any of the solid to fall into the barrel of the laboratory burner. If necessary, repeat the test with the same splint and salt.
6. Immerse the wooden splint in the "rinse water" to fully extinguish it, then discard it in the trash.
7. Record your observations for the flame color produced by the metallic salt in the Data Table.
8. Repeat Steps 5–7 for the other five metallic salts. Record your observations for the flame color produced by each metallic salt in the Data Table.

Name: ______________________________

Data Table 1

Metal	Color of Flame

Data Table 2

Metal/Color of Flame	λ (nm)	λ (m)	ΔE (J)

Post-Lab Questions

1. Use Table 1 in the *Background* section to record the approximate wavelength of light emitted for each metal in Data Table 2.
2. Convert each of the wavelengths in the Data Table from nanometers to meters. Record the wavelengths in meters in the Data Analysis Table. Show at least one sample calculation in the space below.
3. Use Equation 1 from the *Background* section to calculate the change in energy, ΔE, for each metal. Show all work. Record the values in Joules in Data Table 2.
4. Predict the color of the flame if the following materials were heated in the flame. Explain your predictions.
   a. Cupric nitrate, $Cu(NO_3)_2$
   b. Sodium sulfate, Na_2SO_4
   c. Potassium nitrate, KNO_3