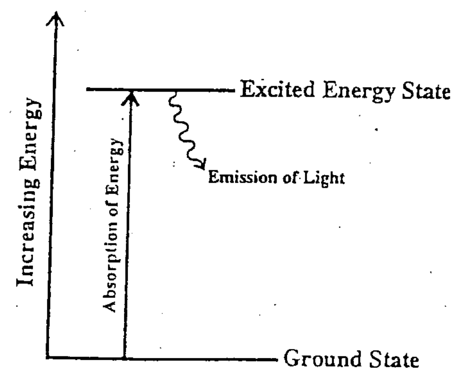
Chemistry Honors
Lab 3 Flame Test Lab

OBJECTIVES
1. To observe the unique colors emitted by known metals as they absorb and emit energy.
2. Compare colors emitted to wavelengths of the visible spectrum of light.
3. Calculate energy released by known metals.
4. Identify an unknown element based color, wavelength, and energy released.

BACKGROUND:

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 moved to an excited state where they occupy higher energy levels. From these excited energy levels, the electrons naturally want to move back down to the original ground state which is more stable. 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. Photons represent energy released as an electron returns to ground state and is in the form of visible light. A photon is commonly represented by a squiggly line (see Figure 1).

Figure 1. Absorption and Emission of Light.



Electrons may move back down to the ground state in a single step, emitting a single photon, or they may return through a series of smaller steps, emitting a photon with each step. The energy of the emitted photon determines the color of light observed in the flame.

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

Colors of light are commonly referred to in terms of their wavelength, so the following equation is used to calculate the energy, in Joules.

$$\Delta E = \frac{hc}{\lambda}$$

ΔE = the difference of energy between the two energy levels.
h = Plank's constant (h = 6.626×10^{-34} J · sec)
c = speed of light (2.998×10^{8} m/sec)
λ = the wavelength of light in meters
*wavelengths will need to be converted from nanometers to meters using the convertion: 1 meter = 1×10^{9} nm

The Visible Portion of the Electromagnetic Spectrum

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

The visible portion of the EM spectrum is only a small part of the entire spectrum. It spans a wavelength region from about 400 to 700 nanometers (nm). Light of 400 nm is seen as violet and light of 700 nm is seen as red. Violet light is higher energy light than red light because the wavelengths are closer together; 400 nm is shorter than 700 nm. As the color of light changes, so does the energy it has.

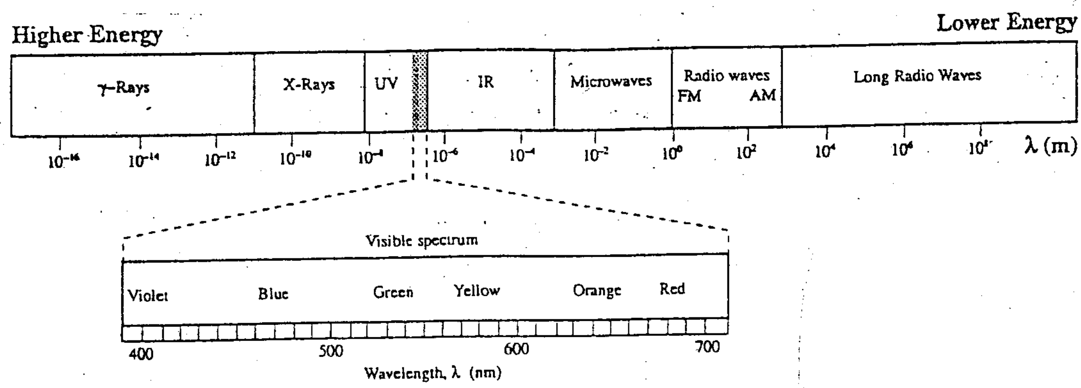


Figure 2. The Electromagnetic Spectrum.

Table 1 lists the wavelengths associated with each of the colors in the visible spectrum. The representative wavelengths are used as benchmarks for each color. A color of yellow-orange may be estimated at 585 depending on the degree of yellow or orange that is seen. When obtaining a wavelength for an observed color, estimate wavelength and express as a single value rather than as a range.

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.

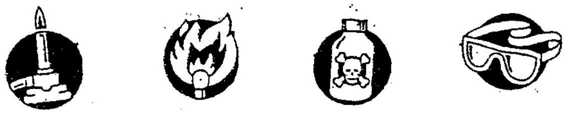
HYPOTHESIS:

MATERIALS:

bunsen burner
striker
test tube with Distilled water
test tube rack
beaker with tap water

Calcium chloride ($CaCl_2$)
Cupric chloride ($CuCl_2$)
Lithium chloride (LiCl)
Sodium chloride (NaCl)
Strontium chloride ($SrCl_2$)
Unknown metal salt

SAFETY PRECAUTIONS:



Cupric chloride is highly toxic by ingestion; avoid contact with eyes, skin, and mucous membranes. Fully extinguish the wooden sticks by immersing them in a beaker of water before discarding them in the trash to avoid fires. Goggle safety.

PROCEDURES:

1. Check materials at lab station. You should have one test tube with distilled water and 6 soaked wooden sticks, Bunsen burner, striker, 250 mL beaker, 5 cups labeled with known metals, and 1 cup of unknown.
2. Fill the 250 mL beaker about half full of tap water. This is to place the burned sticks into before throwing them away.
3. Light the Bunsen burner.
4. Dip one end of the soaked wooden stick in one of the metal salts, tap off any extra in the sink, then place it in the flame.
5. Observe and record the color of the flame in the data table. Allow the sample to burn until the color fades. Stop burning when it smells like a campfire or color becomes orange. Try not to allow any of the solids to fall into the barrel of the Bunsen burner.
6. Immerse the wooden stick in the beaker with tap water.
7. Repeat steps 4-6 for the remaining known metal salts and the unknown metal salt.
8. To clean up, throw wet sticks into trash, rinse out and replace beaker, organize other materials, and wipe up counter. Be seated for lab clean up check and work on lab calculations and questions.
9. Identify your unknown element by comparing your unknown color to the known colors emitted by the metals.

DATA TABLE:

Metal Salt	Name of Metal	Color of Flame
Unknown		

DATA ANALYSIS TABLE:

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

CALCULATION SECTION: Show work for all calculations placed into data analysis table.

POST LAB QUESTIONS:

1. Describe what an excited state is for electrons and how they become excited.
2. Describe what is meant by ground state. Write the electron configuration for Mg in the ground state.
3. Rank the metals in order of increasing energy emitted as their electrons returned to ground state.
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

CONCLUSION: Follow conclusion guidelines. Include colors, wavelengths, and energy for specific data.