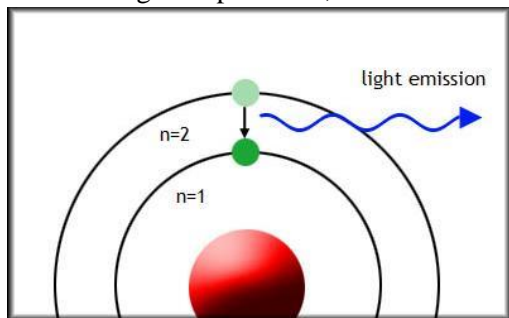


## Honors Chemistry Lab #7: Flame Tests

### Background information:

The normal electron configuration of atoms or ions of an element is known as the “ground state.” In this most stable energy state, all electrons are in the lowest energy levels available. When atoms or ions in the “ground state” are heated to high temperatures, some electrons may absorb enough energy to allow them to “jump” to higher energy levels. In this case the electrons were able to get to a higher energy level by absorbing heat energy from the Bunsen burner flame. The element is then said to be in the “excited state.” This excited configuration is unstable, and the electrons “fall” back to their normal positions of lower energy (ground state). As the electrons return to their normal levels, the energy that was absorbed is emitted in the form of electromagnetic energy. Some of this energy may be in the form of visible light. The color of this light can be used as a means of identifying the elements involved. Since each atom has a unique arrangement of electrons, each gives a unique color. Such analysis is



known as a flame test.

To do a flame test on a metallic element, the metal is first dissolved in a solution and the solution is then held in the hot, blue flame of a Bunsen burner. This test works well for metal ions, and was perfected by Robert Bunsen (1811 – 1899). Many metallic ions exhibit characteristic colors when vaporized in the burner flame.

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, the Speed of Light equation as proposed by Einstein is used to convert the energy of the emitted photon to its wavelength. A particle of light, known as a photon, has an energy  $E$ . The energy of a single photon of visible light is tiny, barely enough to disturb one atom; we use units of “electron-volts”, abbreviated as eV, to measure the energy of photons. Photons of red light have low energies, while photons of blue light have high energies.

**Equations and Variables:** Equations have been modified to remove scientific notation for purposes of complete calculating solutions by hand. The speed of light has been modified from  $c = 2.998 \times 10^8$  m/sec to 3000 nm/s and Planck’s constant has been modified from  $6.626 \times 10^{-34}$  J s/ photon to 40 kJ s/mol. The energy  $E$  of a photon is proportional to the wave frequency  $f$ ,  $E = h f$ , where  $f = \frac{c}{\lambda}$ , this is further simplified as:

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

### Pre-lab questions:

P1. What is behind the color of fireworks?

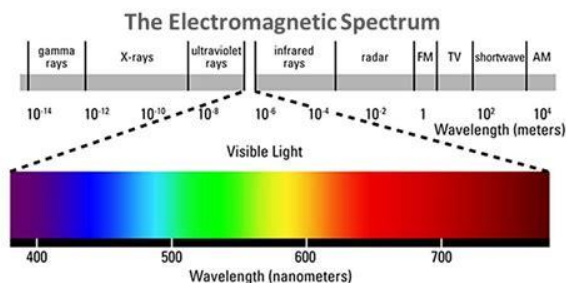
P2. What happens to an electron when energy is added?

P3. What is released when an electron loses energy?

P4. What determines the frequency (color) of photons?

### Goals:

- Describe how atoms create colored light
- Identify the unknown solution



**Materials:**

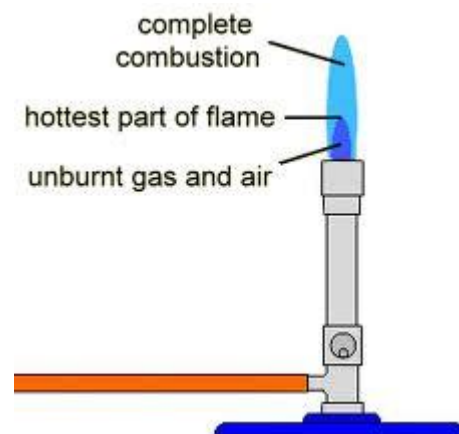
- Bunsen burner
- Striker
- Q-tips/Splinters
- Sodium Chloride
- Calcium Chloride
- Lithium Chloride
- Strontium Chloride
- Potassium Chloride
- Zinc Chloride
- Copper II Chloride
- Cobalt II Chloride
- Unknown

**Safety:**

- Tie long hair and sleeves back.
- Goggles must be worn during the experiment.
- Do not hold the Q-tip into the flame for an extended period of time - it will catch fire!
- Most of the chemicals used in the experiment are irritants. Wash hands at the end of the experiment.

**Procedure:**

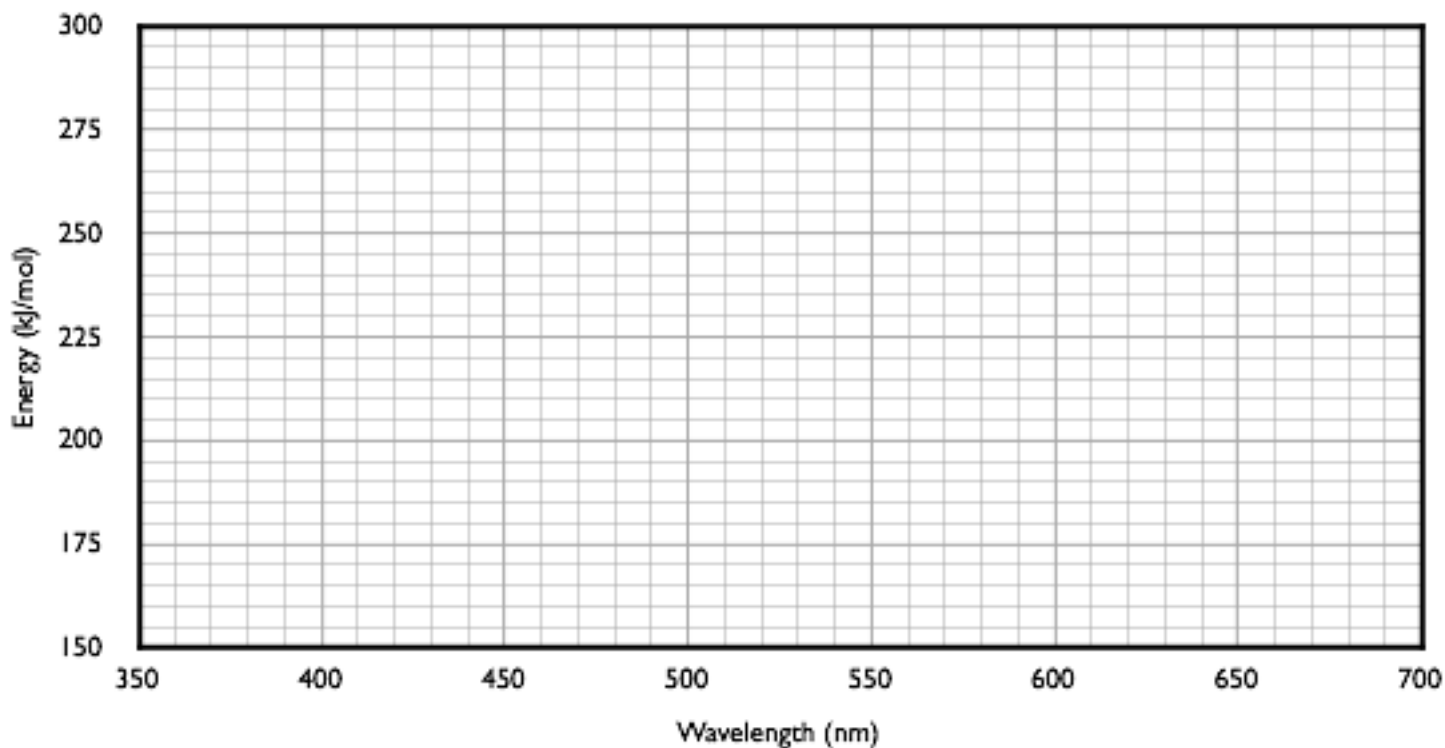
1. Begin by lighting your Bunsen burner. CAUTION: Be sure long hair and sleeves are tied back away from the open flame.
2. Take one of the Q-tips/Splinter on table and dip it into the salts in the vials/beakers. Read the labels carefully!
3. Hold the Q-tip/ Splinter into the hot part of the flame of your Bunsen burner (blue flame). View the color through spectroscope and document the wavelength CAUTION: Do not hold the Q-tip/Splinter into the flame for too long or it will catch on fire. Record your observation in your data table.
4. Repeat this process for the following substances. Be sure to record your results in the data table.
5. To test for your unknown, use the vial marked as the unknown and the Q-tips/ Splinter that are placed near your lab station.
6. Clean up your lab station by throwing away all used Q-tips. WASH HANDS THOROUGHLY

**Data Table:**

Salt Solution	Ion	Observations (Flame Color)	Wavelength (nm)	Energy (KJ/mole)
Sodium Chloride (NaCl)				
Calcium Chloride (CaCl <sub>2</sub> )				
Lithium Chloride (LiCl)				
Cobalt II Chloride (CoCl <sub>2</sub> )				
Potassium Chloride (KCl)				
Zinc Chloride (ZnCl <sub>2</sub> )				
Strontium Chloride (SrCl <sub>2</sub> )				
Copper Chloride (CuCl <sub>2</sub> )				
Unknown				

## Post Lab Analysis

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



### Graph Analysis

1. What do you notice about the graph?
2. What does this say about the electromagnetic spectrum? What end of the spectrum has high energy? Which end has low energy?

1. How do electrons give off light? Explain thoroughly what happens.
2. What specifically happened to the electrons inside the metal atoms to cause them to produce the colors of the light we saw?
3. Why do different elements have different flame test colors?
4. What was the unknown solution? How do you know?
5. Why were each of the six metal ions ( $\text{Li}^+$ ,  $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ , and  $\text{Cu}^{2+}$ ) bonded to the same negative ion ( $\text{Cl}^-$ ), and not different negative ions? What is this known as in an experiment?
6. Is the color of the flame a test for the metal or the chloride in each of the compounds? How do you know?
7. Discuss some possible sources of error in your flame tests such as characteristics of the materials you used, that would possibly obscure your ability to correctly identify a color.
8. Some commercially available fireplace logs burn with a red and/or green flame. On the basis of your data, what elements could be responsible for these colored flames?
9. Explain how you think fireworks get their colors now that you understand the emission spectra?

*Firework Design: Design your own firework, including the shape, color, chemicals needed and the calculated frequency and energy of each. Draw and color it in the box*

