

AP Chemistry	Flame Test Lab: This WILL be put into your lab notebooks!!	Name _____ Date _____
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	AH1: Use laboratory observations to confirm the presence of subatomic particles.
	AH2: Explain the electromagnetic spectrum in terms of the relationships between energy , wavelength , and frequency . (6B)
	AH3: Calculate relationships between wavelength , frequency , energy & speed of light using (6C): $c = \lambda \nu$ $E = h\nu$ [h = Planck's constant]

Objectives:

In this experiment, the student will

- observe the colored flames produced when solutions containing metal **cations** (positively charged atoms) are heated.
- compare the colors of the emitted (given off) flames to the wavelength and the frequency of the visible spectrum.
- calculate the energy released by the metal cation.
- determine the identity of an unknown based on color, wavelength and energy released.

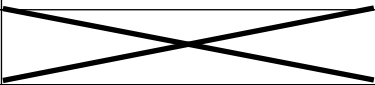
Safety:

- **Wear goggles and aprons.**
- **Shoulder length air must be tied back.**
- Clear area of all books & papers. Use caution with Bunsen burners.
- Do not hold wooden splint with bare hands.
- Metal ions including Ba^{2+} and Cu^{2+} can be toxic. Do not inhale vapors.
- Wash hands when finished with lab.

Part I Procedure:

1. Light the Bunsen burner.
2. Wet the glass stir rod under running water. Dip the glass stir rod in the salt, making sure some of the salt sticks to the stir rod. Place the tip of the stir rod with the salt in the Bunsen burner flame. *If the salt starts to melt, do not allow it to drip into the Bunsen burner. Remove the stir rod from the flame and allow the salt to solidify. You may then return the stir rod to the flame if needed.*
3. Record the flame color.
4. Clean the stir rod with water and wipe with a paper towel.
5. Repeat for all other metal ions and the unknown.
6. Determine which metal cations match your unknown based on color.
7. Turn off the Bunsen burner and clean up your area.

Data Table:

Metal Cation	Name of Metal Cation	Color of Flame	Colored sketch of flame(use colored pencils)
Na⁺			
Li⁺			
K⁺			
Cu⁺²			
Ba⁺²			
Sr⁺²			
Ca²⁺			
Unknown # _____			

Data Analysis:

1. Which metal solution generated a colored flame with the most energy? Why is this true?
2. Which metal solution generated a colored flame with the least amount of energy? Why is this true?
3. Arrange the 7 metal ion solutions from low energy to high energy (increasing order of energy).

_____ < _____ < _____ < _____ < _____ < _____ < _____
 low energy high energy

Part II

4. Frequency and wavelength of light are indirectly related to each other, meaning if wavelength increases, then frequency must decrease. The product of frequency (ν) times wavelength (λ) is equal to the speed of light(c), which is a constant at 3.00×10^8 m/s. Given either frequency (ν) or wavelength (λ) the other variable can be calculated using the following:

$$c = \lambda(\nu)$$

- a. Red light has the wavelength of 6.50×10^{-7} meters. What is the frequency of this wave?

b. Violet light has a frequency of 7.35×10^{14} waves /sec or Hertz (Hz). What is the wavelength?

5. Arrange the 7 metal ion solutions from low frequency to high frequency (increasing order).

_____ < _____ < _____ < _____ < _____ < _____ < _____

6. How are frequency and energy related (directly or indirectly)? Explain your reasoning.

7. What is the identity of the unknown metal cation? Defend your decision.

Part III

8. Albert Einstein and Max Plank determined the mathematical relationship between the frequency of light as it relates and the energy of light.

Energy in Joules(J) $E = h(\nu)$ → frequency(ν) has units of waves/s (which is a Hertz, or (Hz))
↓ Planck's constant (h) = 6.63×10^{-34} J(s)

a. If the frequency of red light is 1.60×10^{14} Hz, how much energy (J) does each photon (packet of light energy) contain?

b. What is the frequency (ν) of light which has 8.33×10^{-22} Joules of energy?

Part IV

Background Information:

Chemists began studying colored flames in the 18th century and soon used "flame tests" to distinguish between some elements. When elements are burned different colored flames are generated. Although some of the flames appear similar in color, their light can be resolved (separated) with a prism into distinctly different bands of colors on the electromagnetic spectrum (ROYGBIV). These bands of colors are called atomic line spectra, and they are UNIQUE to each element. They could be described very much like the "fingerprint" of the element.

Niels Bohr studied the line spectrum for hydrogen, and wondered what the specific line spectrum had to do with the structure of the atom. He postulated (hypothesized) that an electron can have only specific energy values in an atom, which are called energy levels. Bohr believed that the energy levels for electrons were quantized, meaning that only certain, specific energy levels were possible.

How does an electron move between energy levels? By gaining the right amount of energy, an electron can move, or undergo a transition, from one energy level to the next. We can explain the emission of the light by atoms to give the line spectrum like this:

1. When an atom is excited, a low energy electron (ground state) will absorb a specific (quantum) of energy and jump to a higher energy level (excited state).
2. An electron in a high energy level (excited state) undergoes a transition (movement) to a low energy level (ground state). The transition is instantaneous & complete.
3. In this process, the electron loses energy, which is emitted as a photon (a particle which behaves like a wave and contains a specific amount of energy).
4. The energy difference between the high energy level and the low energy level is related to the frequency (color) of the emitted light.

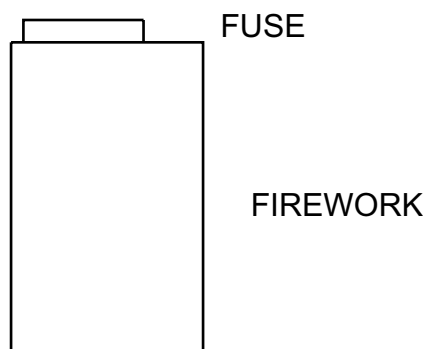
Conclusion Questions: Answer in complete sentences.

1. Why do the metal solutions need to be heated in the flame before the colored light was emitted?

2. How does the energy absorbed by a ground state electron relate to the energy emitted by the photon of light? How do you know this?

3. Suppose you were a firefighter and you were called to a chemical plant fire. Upon arrival you see a bright violet/purple flame. What metal ion is probably burning? Justify your reasoning.

4. Ariel fireworks contain gunpowder and chemicals that produce colors. Design a firework that would initially burn yellow, then red and finally green. Assume the first chemical to be burned should be placed nearest the fuse end of the cylinder. Determine which compounds should be used and draw the design of the firework.



Compound Name	Chemical Formula
magnesium nitrate	$\text{Mg}(\text{NO}_3)_2$
copper (II) nitrate	$\text{Cu}(\text{NO}_3)_2$
lead (II) nitrate	$\text{Pb}(\text{NO}_3)_2$
potassium nitrate	KNO_3
strontium nitrate	$\text{Sr}(\text{NO}_3)_2$

5. The amount of money in a student's pocket is always "quantized." Only a very specific quantity of money is present, regardless of what that quantity is. Furthermore, there are quantities of money that can never exist, for example, 17.5¢. Describe how the electron energy levels of an atom are "quantized." Use information from the lab in your explanation.

6. How much energy, in Joules, is contained in blue light that has a wavelength of 486.1 nm ($4.861 \times 10^{-7} \text{ m}$)?