Flame Test Lab

(Honors Chemistry)

**BACKGROUND**

Every atom consists of a nucleus with tiny electrons whizzing around it. The further away from the nucleus they are, the more energy the electrons have. If a metal is heated, the electrons get enough energy to jump higher away from the nucleus. When they fall back closer to the nucleus, they give off this extra energy as light.

Different metals produce different colored light. If we look at the color of the light made when a solution of metal is heated in a flame, we can tell which metal is there. By placing atoms of a metal into a flame, electrons can be induced to absorb energy and jump to an excited energy state, a quantum jump. They then return to their ground state by emitting a photon of light. The amount of energy in the photon determines its color; red for lowest energy visible light, increasing through the rainbow until finally violet for the highest energy visible light. Photons outside the visible spectrum may also be emitted, but we cannot see them.

The arrangement of electrons in an atom determines the size of the quantum jump and thus the energy and colors of the collection of photons emitted, known as the emission spectrum. In this way, the emission spectrum serves as a “fingerprint” of the element to which the atoms belong. We can view the emission spectrum of colors all at once with the naked eye. It will appear to be one color, which we will carefully describe. It is also possible to separate the colors of the emission spectrum by using a spectroscope, which bends light of different energy levels differently.

**PRE LAB QUESTIONS**

1. List the colors of the visible spectrum in order of increasing wavelength. *(Lowest 🡪 Highest)*
2. List the colors of the visible spectrum in order of increasing energy. *(Lowest 🡪 Highest)*
3. List the colors of the visible spectrum in order of increasing frequency. *(Lowest 🡪 Highest)*
4. What is meant by the term frequency of a wave?
5. What are units of frequency?
6. Describe the relationship between frequency and wavelength.
7. When you perform the flame test on two metal solutions, they produced different color light. What would you conclude about the two metals present in the solutions?
8. When you perform the flame test on two metal solutions, they produced the same color light. What would you conclude about the two metals present in the solutions?
9. List the safety precautions associated with using a Bunsen burner.

**MATERIALS**

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| --- | --- | --- |
| Bunsen Burner | NaNO3 |  |
| Striker/Flint | KNO3 |  |
| Wooden sticks | Ca(NO3)2 |  |
| Beaker for Chemicals | Ba(NO3)2 |  |
| Beaker with Water | Sr(NO3)2 |  |
| Cobalt Glass | LiNO3 |  |
| Unknown samples | Cu(NO3)2 |  |

**PROCEDURE**

1. You will be starting at 1 of the 8 stations listed in the data table.
2. You will have 3 minutes per station to perform your flame test(s).
3. You will then rotate to the next station when your teacher tells you to rotate.
4. Each group will light the Bunsen burner at the station at which they are start the lab. The burners will remain lit until the end of the experiment.
5. Flame Test Procedure:
	1. Take a wooden splint that has been soaking in clean water.
	2. Dip it into the dry chemical until the chemicals are sticking to the wooden splint.
	3. Place the chemical into the flame of the Bunsen burner and observe the light emitted.
	4. When the flame changes color and it appears that the wooden splint is now burning, place the burnt end of the wooden splint into a beaker of water to extinguish the flame.
	5. At stations 1 and 2, you must perform the flame test twice. You must observe the light emitted with the naked eye and by looking at the flame through the cobalt glass.
	6. Preform steps a-e at all 8 stations.
	7. Each group is responsible for cleaning the table at their last station and turning off the Bunsen burner.

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| **Data Table 1** |
| **Station** | **Compound** | **Metal** **Ion** | **Flame Color** | **Notes** |
| 1 | NaNO3 | Na+ |  |  |
| NaNO3 (Cobalt Glass) | Na+ |  |  |
| 2 | KNO3 | K+ |  |  |
| KNO3 (Cobalt Glass) | K+ |  |  |
| 3 | Ca(NO3)2 | Ca2+ |  |  |
| 4 | Ba(NO3)2 | Ba2+ |  |  |
| 5 | Sr(NO3)2 | Sr 2+ |  |  |
| 6 | LiNO3 | Li+ |  |  |
| 7 | Cu(NO3)2 | Cu2+ |  |  |
| 8 | Unknown “C” |  |  |  |
| 8 | Unknown “G” |  |  |  |

**POST LAB QUESTIONS:**

1. List the two metal ions that produced the most easily identified colors. Which colors were they?
2. Which two metal ions produced colors that were not easily identified? Explain why each was difficult to identify.
3. Why do you think different chemicals emit different colors of light?
4. Which element produced the brightest color? What did it look like?
5. How did you determine you unknowns? Use data from the lab to support your answer.
6. Would flame test be useful for detecting metal ions present in a mixture of metal ions? Explain why or why not using a mixture of Ca(NO3)2, LiNO3, Sr(NO3)2.
7. Were you able to see different colors for each of the metals? Why or why not?
8. How do you know the flame color produced is coming from the metal and not the non-metal present in the chemical compound? Use data to support your answer. *(Hint: what did all the samples have in common?)*
9. Why were different metals able to emit different colors of light?
10. Why do you think the chemicals have to be heated in the flame first before the colored light is emitted?
11. Colorful light emissions are applicable to everyday life. Where else have you observed colorful light emissions?
12. Propose at least one possible method for improving the accuracy of the results in this lab experiment.
13. From what you know about photons and quanta of energy, explain why the bright colors were so bright. *(Remember, a photon is the amount of energy released when particles carry the minimum amount of energy needed to produce light. That minimum amount of energy is called a quanta of energy.)*
14. A green line of wavelength 4.86 x 10-7 m is observed in the emission spectrum of hydrogen:
	1. Calculate the frequency (ν) of the green light using the wavelength (λ) and the speed of light.
	2. Calculate the energy of one photon of this green light. Ephoton = *h*ν
15. The energy of colored light increases in the order of red, yellow, green, blue, violet. Using the data you collected from the lab, list the metal ions in order of energy released from lowest to highest. Think carefully about the colors before answering. *(1 is the lowest energy, 7 is the highest energy)*

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1 2 3 4 5 6 7