

Flame Test Lab

Purpose: In this experiment, you will observe the colors emitted by various known metal ions. Using this information, you will perform flame tests to identify unknown metallic elements in other samples.

Variables:

Independent: Type of compound (BaCl₂, LiCl, KCl, CuCl₂, SrCl₂, NaCl, U (unknown), Salt Substitute, and Flame Crystals)

Dependent: type of flame color produced

Constant: temperature of hottest part of flame to heat substances

Materials: BaCl₂, LiCl, KCl, CuCl₂, SrCl₂, NaCl

U (unknown), Salt Substitute, Flame Crystals, wood splint, ceramic spot plate, distilled water, nichrome wire

Procedure

1. Obtain a ceramic spot plate.
2. Use a wood splint to add dry chemical to each of six spots. Cut off (or break off) the splint each time. Don't contaminate (mix) the solids. You will need to record which chemical you put in each spot or well.
3. Add a few drops of distilled water to each spot.
4. Clean your nichrome wire by holding it briefly under running tap water. Let it cool (count to 15) and then put it briefly in the flame.
5. Test the first solution as follows. Dip the wire in the solution. Test by placing the wire in the hottest part of the flame (at the top of the inner blue cone). Record your observation.
6. Clean the wire loop as above and repeat the test procedure for the second solution. Repeat for all six known compounds. Record your observations.
7. Test your unknown. Prepare a small amount of unknown as you did for the known compounds. On the basis of flame color, identify your unknown.
8. Test the salt substitute as above. Identify the essential element in salt substitute based on flame color. Record your observations.
9. Make a solution, in a small beaker, of flame crystals. Filter out the solid. Test the filtrate as above. Decide what element is in the flame crystals.
10. As usual, wash your hands with soap and water before leaving the lab.

Safety Rules: Do not eat while doing lab.

Do not horseplay or play, smell, eat with the chemicals.

Data Table:

Ion	Flame Color
barium, Ba ²⁺	yellow
lithium, Li ⁺	blood-orange red

copper, Cu^{2+}	green, yellow, blue
strontium, Sr^{2+}	bright dark-red
potassium, K^+	light pink
sodium, Na^+	orange
potassium, K^+ (cobalt glass)	purplish pink (magenta)
sodium, Na^+ (cobalt glass)	purple-blue
unknown, U	orange, green, white
salt substitute	light orange-pink
flame crystals	green

Post lab Questions:

1. **List the elements that the produced the most easily identified colors.**

The elements that produced the most easily identified flame colors include Lithium, Strontium, Copper and Potassium. The colors produced from these elements were easy to identify because they produced a striking contrast to the yellow background flame produced by the nichrome wire, which was used to carry the substance from the dish into the flame to observe the color.

2. **Which elements are least easily identified? Explain.**

The elements that were least easily identified were barium and sodium because they produced yellow and orange flame colors that were similar to the background flame produced by the nichrome wire, making them hard to differentiate between the background flame given off from the nichrome wire and that of the flame produced by the substance.

3. **Which element produces the most intense color?**

The elements that produced the most intense color were potassium and sodium because these two elements produced bluish purple flames. Violet light has highest frequency waves meaning that the number of photons to strike a surface would be greater than if a red wavelength were to strike the same surface. The higher the number of photons to strike a surface, which in this case is the human eye, the more intense the light will be.

4. **When you heat the solutions in a flame, is one atom converted into another? Explain what happens to produce each color based on the modern view of the atom.**

During this reaction, a transmutation did not occur. The reason for the bright colors were because of the electrons jumping to a higher energy state and coming down. According to the quantum mechanical model of the atom, when atoms absorb energy, electrons in the atom get excited, and will move to higher energy levels. The electrons will then lose energy to become more stable by emitting light to return to lower energy levels. By shifting between energies, no transmutation has occurred.

5. **Would flame tests be useful for detecting metal ions present in a mixture of metal ions? Explain.**

Our group believes that flame tests are useful in detecting metal ions present in a mixture of a metal ion. According to the textbook, each atomic emission spectrum acts as a fingerprint for each unique element. The light emitted by each atom generates a specific frequency that corresponds to the atomic emission spectrum of that element.

6. **Can a flame test be used to detect non-metal atoms? Explain how your data supports your answer.**

A flame test cannot be used to detect non-metal atoms because some non-metal atoms emit a non-visible light. This is because nonmetals are usually extremely stable and take more energy to jump to higher energy levels. For example, beryllium has four electrons with the electron configuration $1s^2 2p^2$. This shows us that beryllium is not fully stable because its energy sublevels are not fully filled. Because of these missing electrons, the electrons of beryllium are able to jump to higher energy levels without much energy needed. Neon however, has fully filled energy sublevels, thus an electron would need to acquire much more energy to jump to higher energy levels. The energy then emitted would be of much higher energy thus emitting a higher frequency because energy emitted from an electron is directly proportional to its frequency. The frequency emitted is greater than the range of frequencies of visible light so the human eyes are unable to detect the light that is being emitted.

7. **The energy of colored light increases in the order red, yellow, green, blue, violet. List the metallic elements used in the flame tests in increasing order of the energy of the light emitted.**

The metallic elements used in the flame tests in increasing order of the energy of the light emitted: strontium, lithium, barium, copper, sodium

8. **What is the purpose of using the cobalt glass in the identification of sodium and potassium?**

In the identification of Cobalt glass is used to filter out the yellow background light from the nichrome wire that is used to ignite the individual substances.

9. **What is in your unknown, U? (It can be either $BaCl_2$ or $LiCl$.) How do you know?**

We predict that our unknown is barium because the flame color produced by barium is most similar to the flame color produced by the Unknown. Barium was yellow and the unknown is orange green white.

10. **What is in the salt substitute? Use your data to support your answer.**

The salt substitute contain the elements potassium and strontium. From the above data, we observe that the flame colour produced by the salt crystals were a light orange pink which corresponds to the flame colour produced by potassium, which was a flamingo pink, and sodium, which was orange.

11. **What is in the flame crystals? Use your data to support your answer.**

The flame crystals contain copper as the crystals produced a green flame, as did the copper flame.

12. **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?**

The elements responsible for these colored flames are copper and strontium. Copper produces a green flame, and strontium produces an orange red flame, both are found in some fireplace logs.

13. **Aerial fireworks contain gunpowder and chemicals that produce colors. What element would you include to produce crimson red? Yellow? Green?**

Lithium and potassium are all elements that produce a crimson red flame. Copper produces a green flame and barium produces a yellow flame.

Summary:

In the Flame Test Lab, we observed that when heated in the flame, barium emitted yellow, lithium emitted blood orange red, copper emitted green yellow blue, strontium emitted bright dark red, potassium emitted light pink, sodium emitted orange, potassium with the cobalt glass emitted purplish-pink, and sodium with the cobalt glass emitted purple-blue flame color. We know that for visible light, the order of increasing energy is ROYGBIV (red, orange, yellow, green, blue, indigo, violet), with red having the lowest frequency and violet having the highest frequency. From the website with the brightest band on atomic emission spectrum, strontium is red, lithium is red, barium is yellow-green, copper is green, potassium is greenish-blue-purple, and sodium is blue-purple. Since our data correlates with the website, we conclude that the order of increasing energy is lithium, strontium, barium, copper, potassium(with cobalt glass), and sodium(with cobalt glass). When looking at a brightest band on the atomic emission spectrum and it is being compared to a flame test, factors that can cause major difference in presumed colors all come down to our own error along with the error of our fellow classmates from different periods. One factor that could cause a major difference would be that group members did not know how to properly read a brightest band atomic emission spectrum, unsure as whether to go by the thickness of the line or by the number of lines per color. Another factor that could contribute to these differences is if the flames that we thought corresponded to a specific element, actually did not go with that element. This could happen through particles of a couple elements getting into one vial. For example, as we watched the flame of the copper substance we observed the colors: green, yellow, blue. This is a broad spectrum for only one element, this substance may have accidentally had other elements mixed into its vial.

The wavelength gets shorter as you move down a group of the periodic table and the frequency increases. For example, our group tested out lithium, sodium, and potassium. For the flames, we observed that lithium produced a red orange flame, sodium produced a yellow-orange flame, and potassium produced a magenta flame. The preceding elements are all in the Alkali Family. The colors produced correspond with the electromagnetic spectrum, ranging from red to magenta. From the textbook, we know that red light corresponds to longer wavelengths and violet corresponds to shorter wavelengths. Our claim is also demonstrated in the electromagnetic spectrum as the elements *coincidentally* fall in ROYGBIV order on the visible light spectrum. Lithium, sodium, and potassium all fall beneath each other in the periodic table, so our group concluded that as you travel down a family in the periodic table, the frequency increases. In addition, because frequency is inversely proportional to wavelength, wavelength decreases as you move down a group. This pattern also suffices for group 2, the alkaline earth metal: barium had the higher frequency while strontium had the next lower frequency.

Our group also claims that potassium and sodium were the most reactive of all elements that we tested. From the periodic table, we observe that potassium and sodium have fairly large atomic sizes meaning that it would be easier to remove an electron from a potassium and sodium ion because the pull of the positively charged nucleus is less than the shielding of the inner electrons. Also, potassium and sodium have just one valence electron to give away before forming an octet and becoming very stable. The frequency of the light emitted by the electron is directly proportional to the energy change of the electron, we can conclude that violet and blue light have two of the highest

frequency which means that the electron would need to have jumped to higher energy levels to emit the light proportional to the wavelength. For example, noble gases are extremely stable because they have a full ring of electrons, or 8 valence electrons. We also know that potassium and sodium are in the alkali metal family and they want to become stable like noble gases. This means that they are the most reactive.

Based on our data, we conclude the flame crystals contain copper ions. From the experiment, the flame crystals produced a green colored flame and the copper ion sample also produced a green flame. Period 1, Group 2's data also supports this claim because their flame crystals produced a green flame and their copper ion sample produced a green flame as well. Because of this two sets of data, we conclude that copper ion must be in the flame crystals.

According to the experiment, the salt substitute contains potassium ions. Our data shows that the salt substitute produces a light orange-pink flame and the potassium ion without cobalt glass sample produces light pink flame. Period 3, Group 2's data says the salt substitute produced a peach orange flame color and the potassium ion without cobalt glass sample produced a flame with peach orange color as well. For verification purposes, we checked out a company called "NuTek Salt" that makes salt substitutes. They mentioned that salt substitutes "maintain great taste and experience never before seen levels of sodium reduction replaced by potassium, a necessary nutrient" (NuTekSalt.com). Here, they explicitly state that potassium is used in salt substitute. By the evidence from our group, Period 3, Group 2's group, and *NuTek Salt*, we can conclude that potassium ions are indeed in salt substitutes.

An error source is the contaminated sample within the vial. Before proceeding with our experiment, we curiously observed the samples in the vials and found that there were specks of green copper crystals in a vial containing white sample. It was obvious to tell the prominent green speck from the rest of the white sample, but it does not come with such ease with other white samples. For example, the sodium ion sample is white, but the potassium ion sample is also white. If the sodium sample was somehow mixed with the potassium sample from another period (possibly when the wooden sticks were being broken off), we wouldn't have seen nor known about the contamination. This contamination would've changed the flame color, therefore leading to inaccurate data.

References:

"Our Salt." *NuTek Salt*. N.p., n.d. Web. 29 Nov. 2015.

"Periodic Table." *Periodic Table*. N.p., n.d. Web. 29 Nov. 2015.