Name: ___________________________________ **Period:** ____

Lab on Spectra of Flames

Purpose

To discover that elements give off a very discrete set of colors whenever heated. This is a way of identifying elements, and some elements give off this spectra easier than others.

Background

When the outer electrons of any element are lifted to a higher energy state, they are free to drop back to a lower energy state of give off light of discrete colors. In this lab, we will only see the colors in the visible spectrum and learn that what we normally see is a mixture of these colors blended into a single flame. In some cases, we will have to block the spectra from some dominant impurities, such as sodium, in order to see weaker spectral lines from another element. These discrete colors were the main proof scientists had in the 1920s that electrons must be resonating in a very limited number of orbits around the nucleus.

Materials

Meeker burner	Lighter
2 pieces cobalt blue glass	Wooden stir sticks (splints)
Safety glasses	Hand-held spectroscope
Various nitrate salts	Various chloride salts

Safety

Safety glasses must be worn at all times. Some of the salts are poisonous if taken internally. If you get any on your skin, wash immediately. **If you have long hair, tie it back into a tail.**

Procedure A

After putting on your goggles, fire up the Meeker burner and try to get a good **all blue flame**. Using one of the wet wood splints, pick up a very small amount of a solid **nitrate salt and place it into and out of the flame quickly.** If you missed the color, try it again. The color you will get if the splint catches fire is **not** what you are looking for. After you have convinced yourself of the color of the burning salt, try the flame test again while looking through the spectroscope. Write down what the colors looked like on the data table on the back of this page. Go on and continue to do this for all the other nitrates (a metal combined with the nitrate anion, NO_3^-). **Use a new wood splint each time you check a different salt. Throw your waste in the trash cans, not in the sink!**

Procedure B

You may not be convinced that the colors you are seeing are coming from the metal ion and not from the nonmetal portion (nitrate). The simplest way to be sure is to take a chloride salt (a metal combined with the chloride anion, Cl^-) of those elements and test it the same way as in Procedure A. Write your observations into the data table.

Salt Name And Formula	Flame Color (by eye)	Flame Color(s) (through spectroscope)
Barium chloride [$BaCl_2$]		
Barium nitrate [$Ba(NO_3)_2$]		
Sodium chloride [NaCl]		
Sodium nitrate [$NaNO_3$]		
Potassium chloride [KCl]		
Potassium nitrate [KNO_3]		
Calcium chloride [$CaCl_2$]		
Calcium nitrate [$Ca(NO_3)_2$]		
Lithium chloride [LiCl]		
Lithium nitrate [$LiNO_3$]		
Strontium nitrate [$Sr(NO_3)_2$]		
Copper nitrate [$Cu(NO_3)_2$]		
Iron nitrate [$Fe(NO_3)_3$]		
Nickel nitrate [$Ni(NO_3)_2$]		
Unknown Salts		
#1		
#2		
Using Cobalt Blue Glass In Front Of Your Eyes	**By eye**	**Through cobalt glass**
Mixture of potassium nitrate and sodium nitrate		

Procedure C

Using the mixture of potassium nitrate and sodium nitrate, examine flame colors as in Procedure A. The observations should be written in above. Now, place two cobalt blue pieces of glass on top of each other and observe the flame colors again. See what difference this makes in terms of what colors you can see. Be sure to write this in the table.

Procedure D

Two unknown salts are provided. Perform flame tests on both and using the data from what you have seen of the other elements, try to decide which metal is present.

Questions (5 points each)

1. Is the flame coloration test testing for the metal ion (ex. Na or Ba) or is it getting its color from the nonmetal portion (ex. Nitrate-NO_3) of the compound? Explain your reasoning.

2. Using the answer above, explain why the sodium chloride and sodium nitrate both imparted the same spectral colors.

3. Looking at the flames (without the spectroscope), did any of the metal salts have **similar** colors? Which ones and which general colors?

4. Did these metals look the same using the spectroscope? Explain your answer fully.

5. What colors dominated when the sodium and potassium salts were mixed? What element does this color correspond to?

6. What color must be blocked by the cobalt blue glass?

7. Now that you have examined pure salts and seen their colors, would this be a good test for the presence of a single atom of an element? That is, would you recommend it for low level concentrations and using the unaided human eye? Would it be a sensitive enough test? Explain your reasoning.

8. Let us suppose that the colors you see in the spectroscope are due to heat knocking the outer electrons of the atoms into higher energy levels. Then the light is given off when they fall back again. What colors of the rainbow could we expect if any internal electron could jump up to **any** higher level and fall back to **any** lower level giving off photons of light?

9. Since the colors of light given off are limited to a very few discrete lines, what does this say about the possibilities of the electrons jumping up and then down (i.e. Can they jump to any higher level they wish and then jump down in any fashion? Explain.

10. It takes different amounts of energy to knock off electrons of different elements. This amountof energy is not the same for all elements. Therefore, some atoms have electrons that are easily removed and some atoms have electrons that are extremely difficult to remove. In which general type of elements do we find it easier to remove the outer electrons, metals or nonmetals? Explain.

11. At the turn of the last century, scientists found something that could not be explained. They found that if you used light energy to excite atoms (move an electron up into a higher orbit), the color employed was all that was important. That is, if you used a lower energy color, it didn't matter how much of this wrong color you applied, the atom would not get excited (absorb the energy) and then give it back. In other words, adding more amplitude (more photons of the wrong frequency) just didn't work. The first person to understand why you had to use colors above a certain energy threshold was Albert Einstein. For this, he received his one, and only, Nobel Prize. What is the name of this phenomenon, and why must this energy threshold be tied into the idea of not how many photons there are, but to the color? Free point for first group in class to tell me the name of the phenomenon.

12. Which metals were most likely to be the two unknowns when you looked at the spectra?

Unknown #1: Unknown #2:

13. In what Groups on the periodic table were the metals that gave us the best colors? Explain.

14. At the same time, what Groups on the periodic table did not produce much color? Explain.

15. What colorful and patriotic use can be made of these various salts?