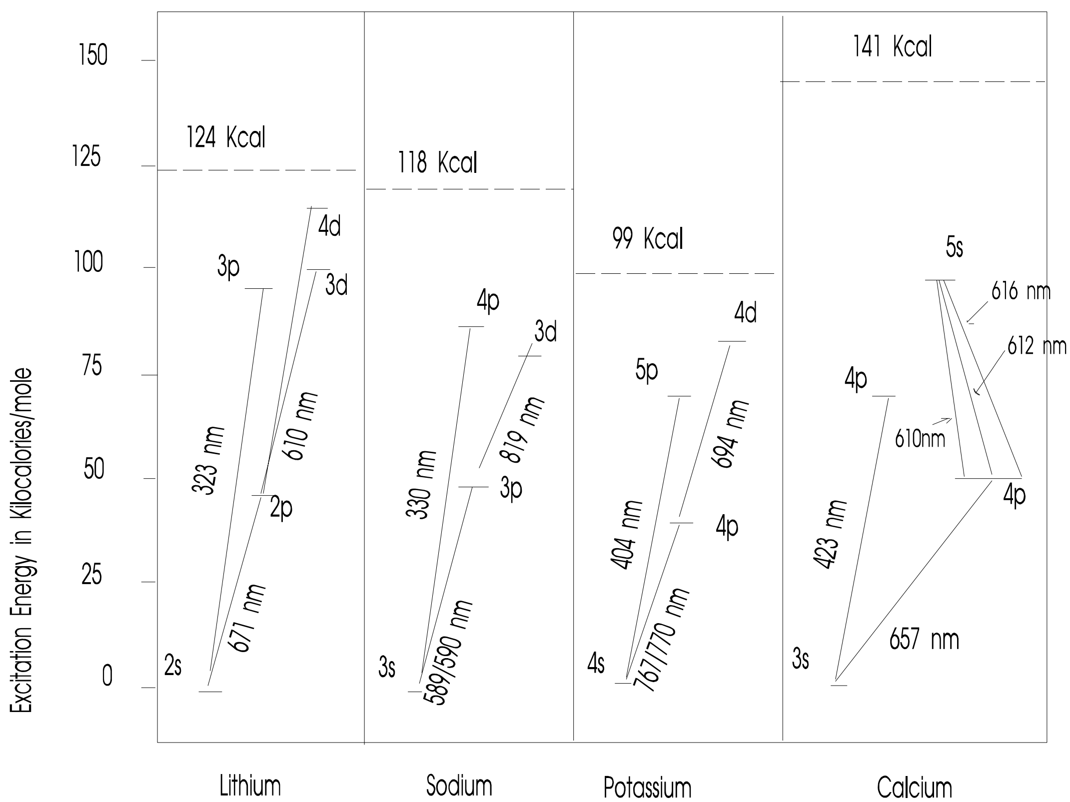
# THE FLAME TEST OF THE ELEMENTS

The atomic spectrum of an element results when sufficient energy is supplied to volatilize its atoms, causing some of the electrons to move into higher energy states, called "excited states." The lifetime of the excited state is short, and the electrons return spontaneously, in discrete steps, to their lower energy levels. Each of these steps involves the loss of a finite amount of energy in the form of short bursts called "photons". Since each element has its own peculiar number of protons and electrons, and each element has a large number of possible excited states, there are many paths that a electron may following in returning to the unexcited or "ground state". These paths may be represented by a collection of lines of light in a spectroscope called the element's "emission spectrum."

The following energy-level diagrams illustrates some of the possible electron transitions for a few of the elements studied in this experiment. The wavelengths are given in nanometers (nm). The ionization energy is indicated by the dashed line at the top of the energy-level diagram.

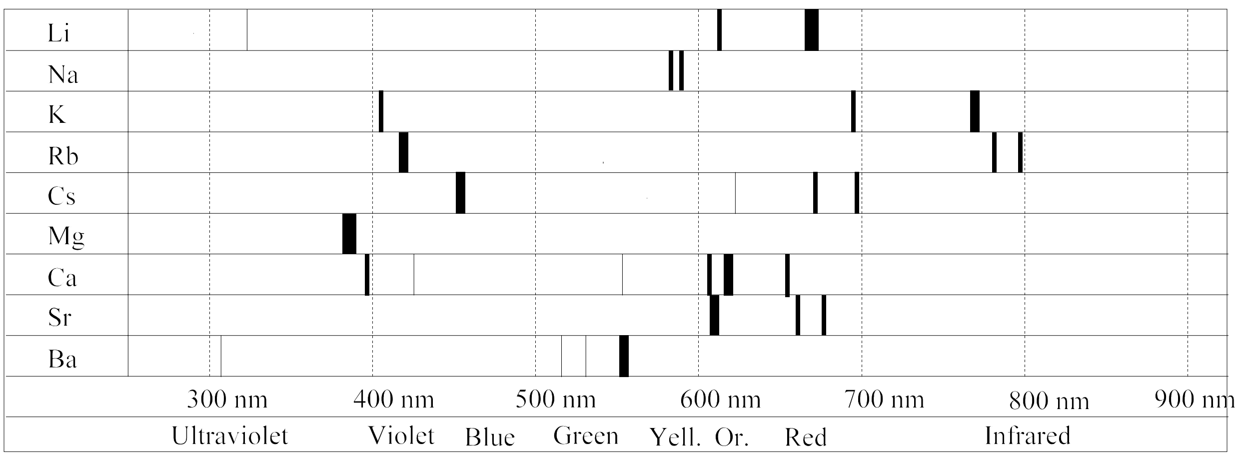
Table 1. The Energy-Level Diagram for Selected Alkali (IA) and Alkaline Earth(IIA) Elements.



Basically, there are two methods for exciting atoms to produce the spectra of the elements. Electrical excitation is one of these, where the needed energy is provided by a high voltage spark to a sample of the material between electrodes. Excitation may also be brought about by heating a sample in a hot flame. You have all observed the bright yellow color imparted to a flame when glass tubing is heated. This yellow colored flame arises from excited sodium atoms in the glass. The energy produced by Bunsen burners is a good deal lower than that obtained by electrical methods, and in fact, usually only the IA and IIA elements can be made to produced visible light with an ordinary laboratory burner. Hotter flames are necessary to excite most of the remaining elements.

Table #2 illustrates the relationship between the color and intensity of the spectra lines produced by the IA and IIA elements. The most intense line will have the widest block. For example, the brightest spectral line of lithium will have a wavelength of roughly 670 nm and one of the weakest lines will have a wavelength of 325 nm.

Table 2. Flame Spectra of the Alkali and Alkaline-Earth Elements

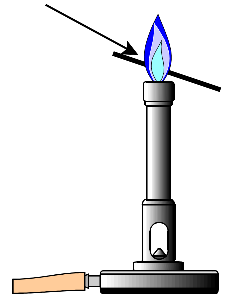



In this experiment, you will observe the characteristic colors imparted to a flame by a number of different elements, and use your observations to identify the "unknown" element in a
sample.

**Materials:**

Microburner, vials containing tooth picks dipped in salt solutions of lithium, sodium, potassium, magnesium, calcium, barium, and strontium compounds, cobalt glass plate, test tube or vial containing an "unknown" substance.

**Procedure:**




1. Using Table #2, predict the color of the flame produced when each of your test solutions is heated in a Bunsen burner. Place your prediction on your data table.

2. Remove a tooth pick from its vial and touch the very bottom edge of a microburner flame. Avoid burning the tooth pick. Record the flame coloration and any other observations on your data table.

   **NEVER** return the toothpicks to its container. Always discard all toothpicks whether or not they are still usable. There are two reasons for this rule. The salt on your fingers contaminates the original solution with sodium or there is always a chance that you will but a toothpick in the wrong container.

3. The sodium flame test is so sensitive that even a trace of sodium ion gives a characteristic fluffy yellow coloration. Traces of sodium get into solutions as a result of contact with glassware or from the salt (sodium chloride) in the perspiration on your skin. The net result is that every substance will give a positive test for the sodium ion. The question is not whether sodium is absent or present, but whether it is present in small or large amounts.

   The fluffy yellow sodium flame may cover up the color due to another ion. In particular, it will mask the lavender color of the potassium flame. A blue cobalt blue glass will absorb the yellow light from the sodium flame but will transmit the violet light from potassium. Therefore, repeat each observation with the blue cobalt glass, and record your results on your data table.

4. Perform both flame tests on each of the remaining test solutions. Finally, perform each flame test on your "unknown" substance.

**QUESTIONS:**

Q1. According to your observations, which metal ion is present in your "unknown" sample? Explain you rationale.

Q2. What is the purpose of the blue cobalt glass?

Q3. Explain briefly how the colored flames where produced in this experiment.

Q4. Why does the potassium flame appear violet when its most intense radiation has a wavelength of roughly 770 nm?

Q5. What are some useful applications for the colored flame produced when the alkali and the alkaline earth elements are heated?

Q6. What is the meaning of the term "ionization energy"? How could you observe the spectra of elements with higher ionization energies such as hydrogen or helium?

**DATA TABLE:**

Number of the unknown substance: ___________________

| Element | Flame Color as Predicted From Table #2 | Flame Color as Viewed Directly | Flame Color as Viewed through the Cobalt Glass |
|---|---|---|---|
| Lithium | | | |
| Sodium | | | |
| Potassium | | | |
| Rubidium | | | |
| Cesium | | | |
| Magnesium | | | |
| Calcium | | | |
| Strontium | | | |
| Barium | | | |
| Unknown #1 | XXXXXXXXXXX | | |
| Unknown #2 | XXXXXXXXXXX | | |

Emission Spectrum of Potassium Chloride

Emission Spectrum of Strontium Chloride