Experiment 2:
Atomic Spectra

Instructor Notes and Lab Preparation

Chemicals and Equipment:

6 M HCl
1 bottle of mossy zinc
1 striker
2 Petri dishes w/opening labeled as unknown 1 & unknown 2
2 coffee cans w/opening for flames
Spectroscopes
Helium lamp labeled as helium
Sodium flame (NaCl) labeled as unknown 1
Lithium (LiCl) flame labeled as unknown 2
Hydrogen lamp labeled as unknown 3
Krypton lamp labeled as unknown 4
Mercury lamp labeled as unknown 5
2 Bunsen burners with vacuum tubing

Setup:

On each of the two front lab benches, set up one flame unknown. Place the unknown salt in the Petri dish. Cover and place the Bunsen burner over the opening in the Petri dish. Then cover with the coffee can. When ready to start experiment, place a few pieces of zinc and a few mL of HCl in the Petri dish, cover, and light the Bunsen burner. Place one lamp on each of the remaining four lab benches.

Place the zinc, HCl, striker, and spectroscopes on the front counter.

Example Coffee can flame set-up and lamp set-up

Spectroscopes are inexpensive (< $10) and are available from both Fisher Scientific and Sargent-Welch as well as many other sources. Lamps and bulbs can also be bought from Fischer Scientific and bulbs are available for many other elements as well.

Instruction Notes:

We generally set up five unknown light sources for this lab. Every other semester, I change a few of the sources to keep the experiment fresh. As mentioned above, there are a variety of light bulbs available for the lamps and most of the alkali metals and alkaline earth metals can be vaporized using mossy zinc and HCl to produce colored flames.

Having the students calculate their own wavelengths in the pre-lab and then determine the identity of those elements in the lab really exemplifies the use of spectrometry for identification of materials both near and far.

Points to Stress:

We ask the students to work in pairs to assure that the measurements taken are reproducible. This introduction to the necessity of reproducibility in science should be pointed out. Another important point is the introduction of the need to calibrate instrumentation. To this point, we have assumed that the instruments and equipment being used are in good condition and operating correctly. This experiment is the first time the fallacy of that assumption is explained and corrected. The creation of a calibration graph is an important tool that the students will need in future experiments and should not be overlooked as a teaching point in an effort to complete the rest of the lab.

Potential Problems:

The majority of the problems associated with this lab come from inappropriate use of the spectrometers. Make sure the students are aligning the slit in the spectrometer, not the grating,
with the light source. Also, too much ambient light will make the lines of the source difficult to see. Keep the light in the lab dim if at all possible. Unfortunately, you cannot turn off all the lights because then the calibration lines in the spectrometer are invisible as well. Goggles make the reading of the spectrometers more difficult. I generally allow students to work around the lamp sources without the goggles, but because of the acid, have them use the goggles around the flames.

Pre-Lab Key

Experiment 2

Pre-Laboratory Assignment

Name: ____________________________ **Date:** __________________

Instructor: ____________________________ **Sec. #:** ___________

Show all work for full credit.

1) Some of the elements that may be used in this experiment are listed below. For each element write the complete electron configuration.

   a. Helium **$1s^2$**

   b. Hydrogen **$1s^1$**

   c. Mercury **$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 4f^{14} 5s^2 5p^6 5d^{10} 6s^2$**

   d. Krypton **$1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6$**

e. Sodium **$1s^2 2s^2 2p^6\ 3s^1$**

f. Lithium **$1s^2 2s^1$**

2) What makes the wavelength of the N=4 to N=2 transition for hydrogen different from an N=4 to N=2 transition for mercury? How is this difference related to the spectra we observe? Explain.

The spacing between energy levels is unique in each atom based on the number of protons in the nucleus and the shielding that each electron feels. Thus the distances between the shells vary and therefore the wavelength of light emitted or absorbed varies based on this difference in energy and distance.

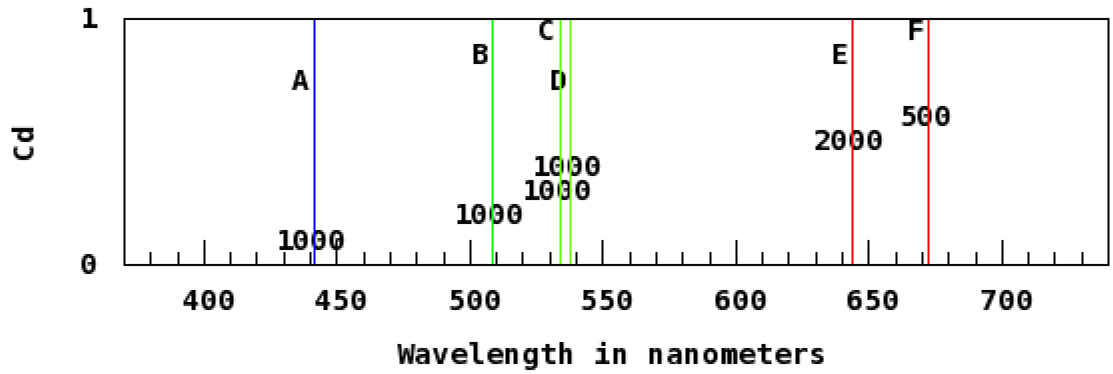
3) You have just carried out the calibration of your spectroscope's diffraction grating and you get the values shown in the table for the visible emission lines of helium. Plot these values and produce a calibration graph that can be used to correct the values in the table below:

Color	**Spectrometer Reading**
Violet	5.3
Blue	5.7
Green	6.1
Yellow	6.8
Orange	7.7
Red	8.3

Spectrometer reading	Corrected Wavelength (nm)	Color of the Emitted Light	Frequency (hz)
6.5			
5.4			
7.9			
4.6			
8.5			

4) The following atomic line spectra display six of the more prominent lines observed in the visible region for the indicated element. The number by each line represents the relative intensity. A photograph of the actual spectrum of the element may show many more lines, or sometimes fewer lines, depending on the overall intensity of the spectrum. If two lines are within 1 nm of each other, they are shown as a single line. You can find a complete listing of the lines for each element at the NIST (National Institute of Standards and Technology) Atomic Spectra Database.

Some spectral lines of Cadmium:



Identify the line in the spectrum of Cd with each of the following characteristics:

a. Light with a photon energy of 2.953×10^{-19} J/photon. **F (672.18 nm)**

b. Light with a photon energy of 185.8 kJ/mol. **E (643.85 nm)**

c. Light with a frequency of 5.574×10^{14} s^{-1}. **C (537.84 nm)**

Post-Lab Key

Experiment 2

Post-Laboratory Questions

Name: ____________________________ **Date:** __________________

Instructor: _____________________________ **Sec. #:** ___________

Show all work for full credit.

1. What is the difference between an emission spectrum and an absorption spectrum?

   An emission spectrum is produced when an atom is excited by an input of energy, which promotes electrons into higher energy shells. As the atom relaxes back into its normal configuration, energy is released as photons at energies (wavelengths) distinct to the atom's electronic configuration. An absorption spectrum is produced when light passes through a medium that absorbs photons (radiation) of certain wavelengths (energies). Not all wavelengths of the light are absorbed. The spectrum that is produced by those absorbed is called the absorption spectrum.

2. In this experiment you compared your findings to known line spectra for the unknowns. The lines given were only the few "strongest" lines in the visible spectrum. Explain what is meant by the "strongest" lines and why some lines are stronger than others.

   Within the electronic configurations of each atom there are many paths that will allow the atom to "relax" when returning from an excited to relaxed or normal state. Some of those paths are more common than others resulting in a higher number of emissions of that wavelength. The larger the number of emissions of a particular wavelength the stronger the line will appear in its spectrum.