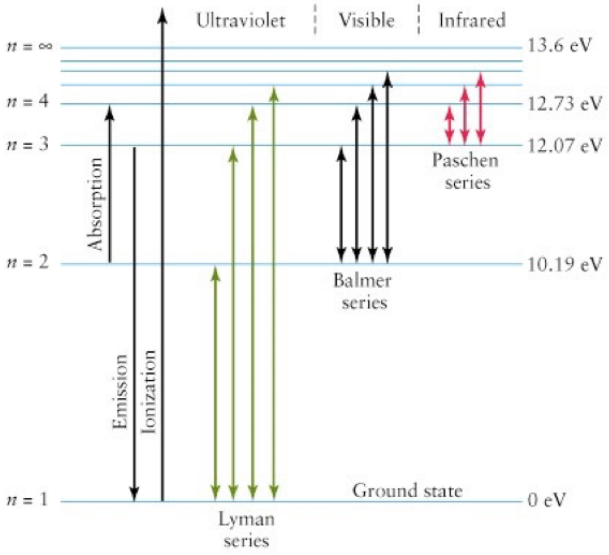
Lab 1: Emission Line Spectra

Introduction: When a low density gas is heated up, electron transitions between energy levels cause light to be emitted at specific wavelength/frequencies. The wavelengths of emitted light are exclusively determined by the **energy difference** between the energy levels of the material doing the emitting. So, for example, a low density gas tube filled with hydrogen will have a very different pattern of emission lines than a tube filled with nitrogen. In fact, scientists use the pattern of lines from low density gas to determine the chemical makeup of gas clouds in space or chemicals created in the lab. Similarly, some art restorers use the same fundamental science to determine the materials artists used in creating their work (or identifying forgeries).

Because of the relationship between the energy of photons and their wavelengths, we can use the wavelength of photons to understand the energy level transitions of the atomic species that created the light. Well-defined energy level diagrams, such as the one for hydrogen below, exist for all elements. The **difference** between the energy levels are, effectively, "chemical fingerprints," unique to each element. Because of the relationship between energy and frequency (or wavelength) of light, we can identify atoms based solely on the light they emit.



$$E = h\nu = hc/\lambda$$

Setup: You will be presented with five gas tubes. Your job is, solely with a diffraction grating and a poster of the emission spectra of different elements, to determine the element in the glass tube.

Instructions/Procedure:

You will note that you will not see the emission lines when you look directly at the lamp, but rather looking to the side (note that, if you look very carefully you should see a second,

fainter set of the lines even further from the center. These are the same lines repeated over again and are not new lines to be considered when you're trying to identify the elements.)

For each of the five elements you are presented with, please follow the following procedure.

1. Look at the lamp ***without the diffraction grating*** and write down: What colors are the dominant colors of the emission lamp? Draw a guess of the kind of spectrum you expect to see when you look at it with the diffraction grating. Carefully label your sketch, noting which side is red and which side is blue.

2. Look again at the lamp, this time using the diffraction grating. Take care to note the presence of any faint emission lines (our light perception is not so great at the extremes of our vision, so you'll have to look carefully for violet or deep red light). Draw a second sketch, showing which lines are actually present. Make sure to label your lines clearly for the **brightness** of the lines. Also, take some care to note the **spacing** between lines. While you won't be able to give a quantitative measurment of the spacing (i.e. in nanometers), you should give a *relative* spacing. For example, note if one of the spacings is twice as large as another or half as large, etc. Note and describe any differences between the actual spectrum you reproduced here and the hypothesized spectrum you drew in Step 1.

3. Use the emission line periodic table poster to identify possible chemical composition. A possibly useful hint: it is likely that some lines that you see may be **blends** of more than one line. So, don't be fooled if you noted one bright line and the poster represents it as several fainter lines. Write down your conclusion for the element in each tube and describe the evidence that supports this conclusion.

The emission pattern of elements is partially dictated by the elements, but also by how *ionized* an element is. We represent un-ionized elements with a single roman numeral – e.g. "Na I". Elements that have lost one electron are represented by the roman numeral for 2 – e.g. "Na II". Elements that have lost two electrons are represented with the roman numeral for three (e.g. "Na III"), and so on.

4. Use the AtomTrace Elements Database (https://www.atomtrace.com/elements-database/) to look up information about your spectrum. Click in the element on the periodic table that represents your element. A "one dimensional" spectrum will appear below the periodic table. Below that, under "List of Lines," click the entry for "NIST." You will be left with a huge list of lines of all different strengths. Using your mouse, hover over the strongest few lines one the 1D spectrum and identify their central *wavelength*. Look up the wavelength on the table, and record the ionization species (i.e. "Na I" vs "Na II" vs "Na III") and the wavelength of the line.