AST101: Our Corner of the Universe
Lab 8: Spectroscopy (II)

Name:

Student number (SUID):

Lab section:

Group Members:

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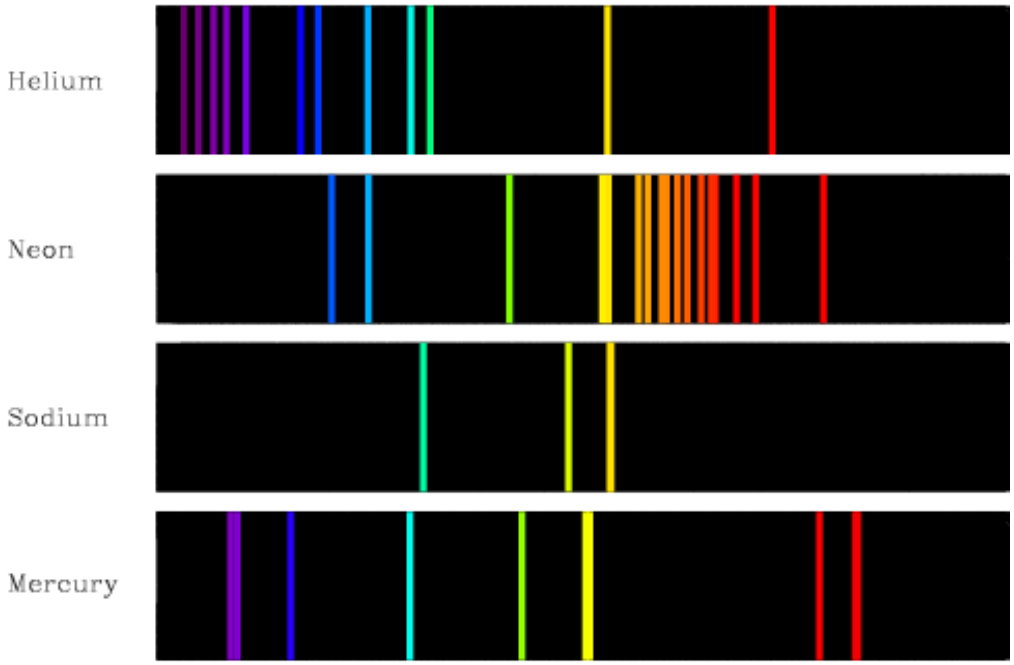
1 Objectives

- To determine the colors in an atom's emission/absorption spectrum based only on knowledge of its energy levels
- To gain experience determining chemical composition from emission spectra

This reference will be helpful!



(Hydrogen is not on here – you'll have to figure it out on your own!)

The sodium source we have may produce some other lines as well, because of mixture with other elements. You'll recognize sodium by an extremely intense orange line.

2 Identifying Sources

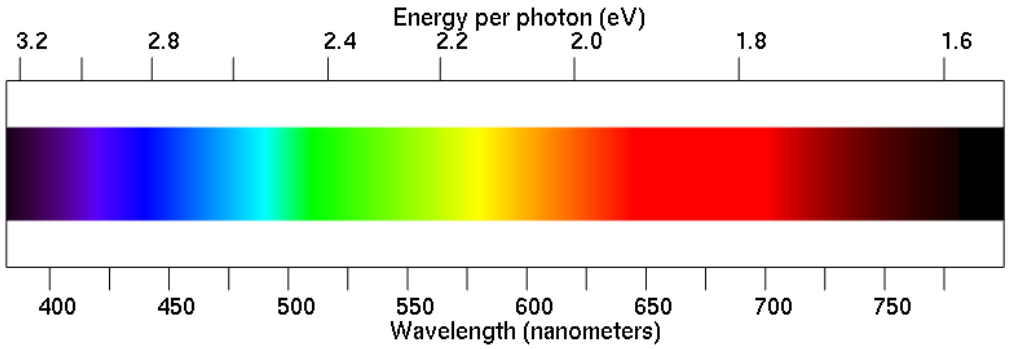
There are various objects in the room that generate emission spectra. One of them is hydrogen, which doesn't match any of the examples on your reference; the others are helium, neon, sodium, and mercury.

Your group should circle around to all of the tables and look at the different sources. Look at each source and label the position of the emission lines on the spectra as closely as you can. (Notice that the scale in your spectrometer is marked in both nanometers and eV/photon, but that the colors are likely in the opposite order as what I've shown below. That's okay; you can plot this either way.)

Draw the positions of the emission lines as precisely as you can, even if you don't need to do so in order to identify the gas in question; you'll need a record of their energies and wavelengths for the second part of this lab.

It will probably be easiest if you measure where all the lines are first, and then try to figure out which element is which. Remember, one of them is hydrogen, which isn't on your reference; in the next section, you'll calculate its emission spectrum from scratch.

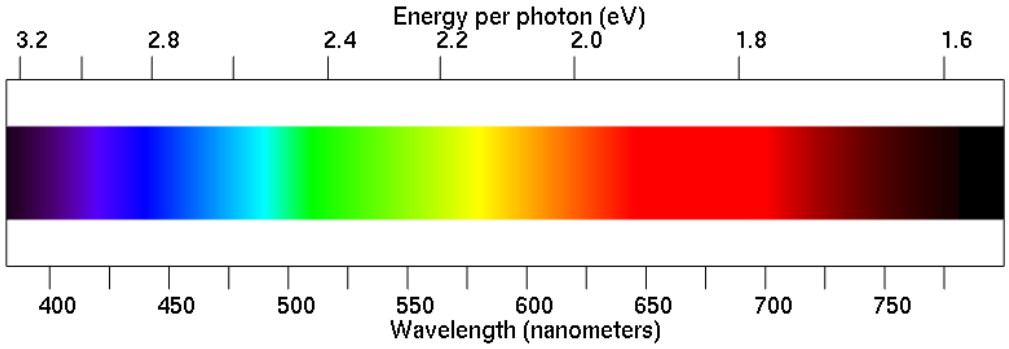
Source A



What color does this appear?

What element is it?

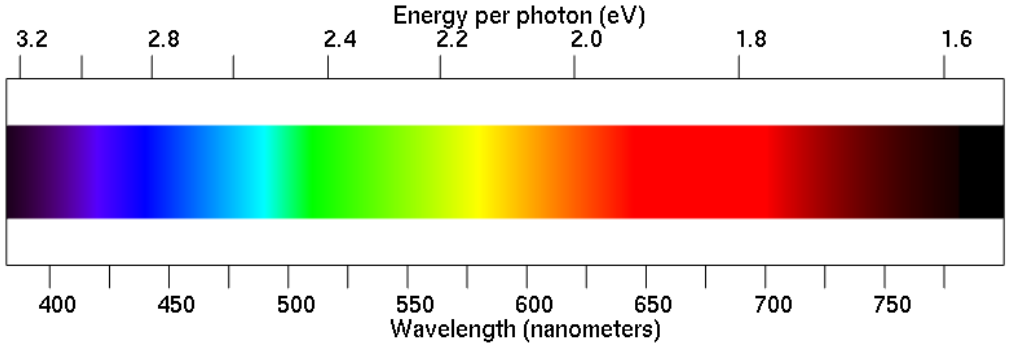
Source B



What color does this appear?

What element is it?

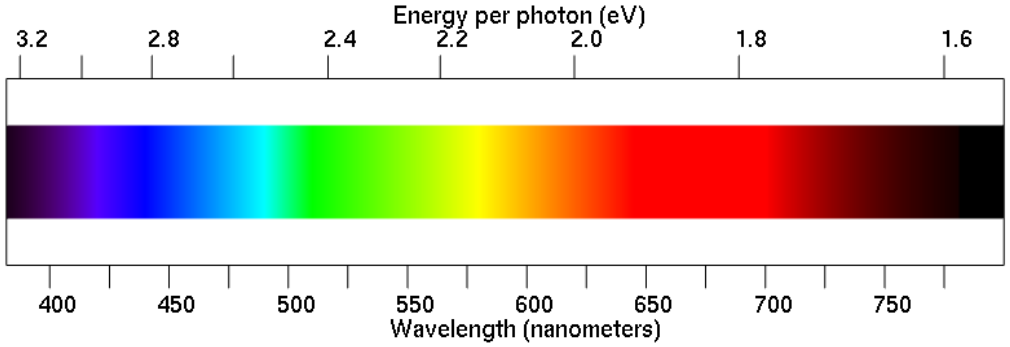
Source C



What color does this appear?

What element is it?

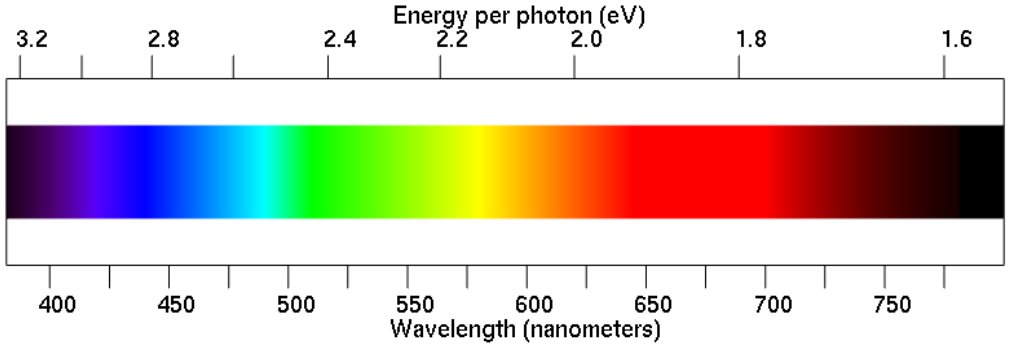
Source D



What color does this appear?

What element is it?

Source E



What color does this appear?

What element is it?

Predicting the Colors of Hydrogen

In class we learned about *atomic energy levels*. In general, the formula for the energy levels of atoms is very complicated (and there are lots and lots of them!)

But hydrogen is simple. Its energy levels follow a pattern:

$$\text{Energy of level n} = 13.6 \times \frac{n^2 - 1}{n^2} \text{ electron volts (eV).}$$

We name these levels by writing $n =$ and then a number. So $n = 1$ is the lowest, $n = 2$ is the next one, and so on.

An "electron volt" is just a very small amount of energy useful for talking about atoms. There are 2.6×10^{22}) eV in a food-Calorie.

The law of conservation of energy tells us how atoms changing energy levels will relate to light:

- If an atom jumps to a **higher** energy level, it needs to **take** energy from something, and so it must **absorb** a photon with energy equal to the difference
- If an atom jumps to a **lower** energy level, it needs to **give** energy to something, and so it must **produce** a photon with energy equal to the difference

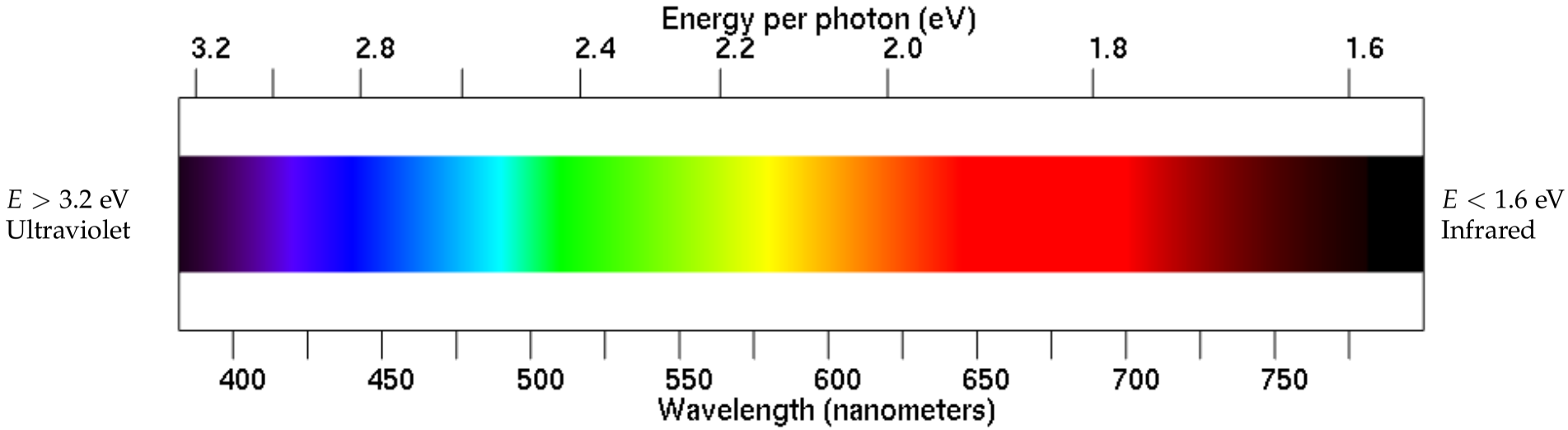
Remember that each color goes with photons of a specific energy. So this means:

If you know the energy levels of an atom, you can figure out its emission spectrum by calculating all the different differences between them!

On the next page, I've calculated the energies for the first five energy levels of hydrogen. (You won't need to use the formula above; I've done it for you.)

Below, I've given you the amounts for the first five energy levels of hydrogen. You can fill out the table and predict the colors that hydrogen can emit and absorb. Label those colors on the spectrum with your pencil... then find the hydrogen lamp in this room and see if it matches!

Higher energy level (to the right)	**n=5 13.06 eV**		**n=4 12.75 eV**		**n=3 12.09 eV**		**n=2 10.20 eV**	
Lower energy level (below)	Energy	Color	Energy	Color	Energy	Color	Energy	Color
n=1, 0 eV	13.06-0=13.06	Ultraviolet						
n=2, 10.20 eV							-	-
n=3, 12.09 eV					-	-	-	-
n=4, 12.75 eV	13.06-12.75=0.31	Infrared	-	-	-	-	-	-



Now you can go find the hydrogen lamp in the room and label it on your previous pages.

3 What's in the Room Lights?

The lights in Holden Observatory work on the same principle as the gas discharge tubes, so by looking at their spectrum, you should be able to deduce what element is in them.

However, there are a few things that might confound the spectrum that you're seeing:

- Colored glass might reduce or eliminate certain spectral lines. For instance, red glass allows only red light to pass through it, and blocks other colors. Another sort of tinted glass might block blue and allow other colors to pass. However, remember that *colored glass can never create new lines that aren't part of the element's spectrum*.
- The gas in the room lights also emits a lot of ultraviolet light in addition to the visible colors. This light is useless to our eyes. However, the tubes are coated in *phosphors*, which have a molecular structure that causes them to absorb ultraviolet and re-emit *broad* spectrum light in the visible. Remember that these phosphors don't create new *lines*; they only add broad bands of color on top of the lines from the actual element in the tubes.

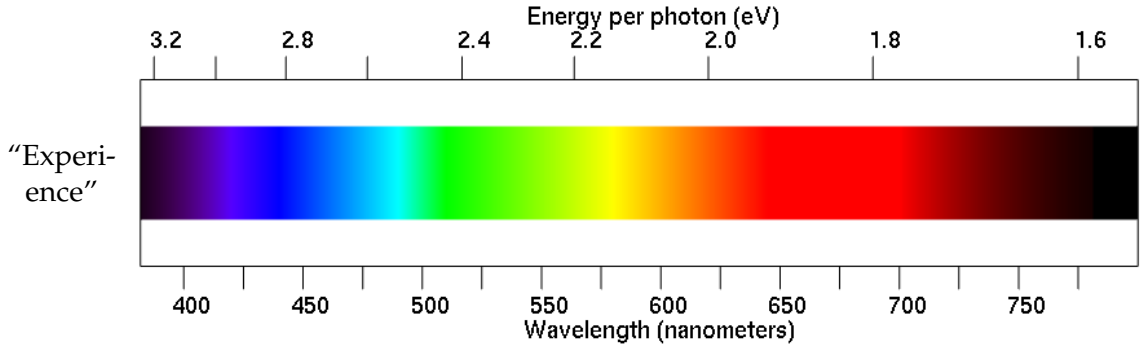
Looking back at your measurements from the discharge tubes, determine what gas is in the lights in the room

4 What's In The Sign?

The "Experience Physics" sign outside the auditorium has four different colors: pink, white, blue, and red. Now you'll go do some detective work to figure out what they are. Walk over to the Physics Building.

Remember: Some of the tubes use phosphors that generate *broad bands* of color in addition to the narrow spectral lines produced by the gas itself. Don't get distracted by these: look only at the thin lines in the spectrum.

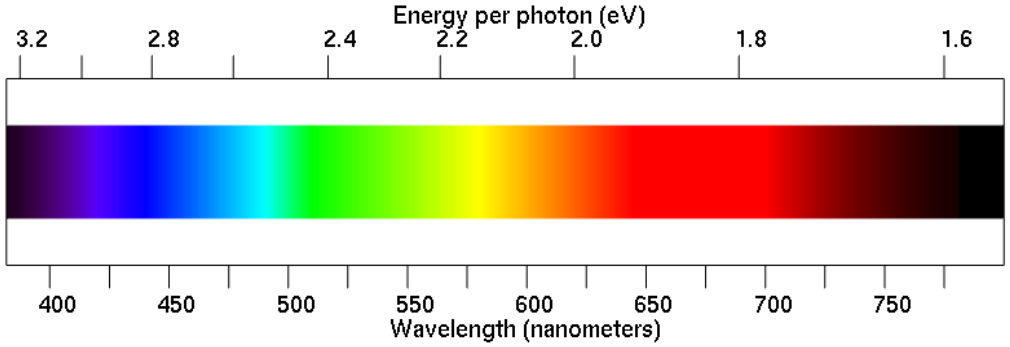
Based on what you did before, what elements are used in the different tubes?



What color does this appear?

What element is it?

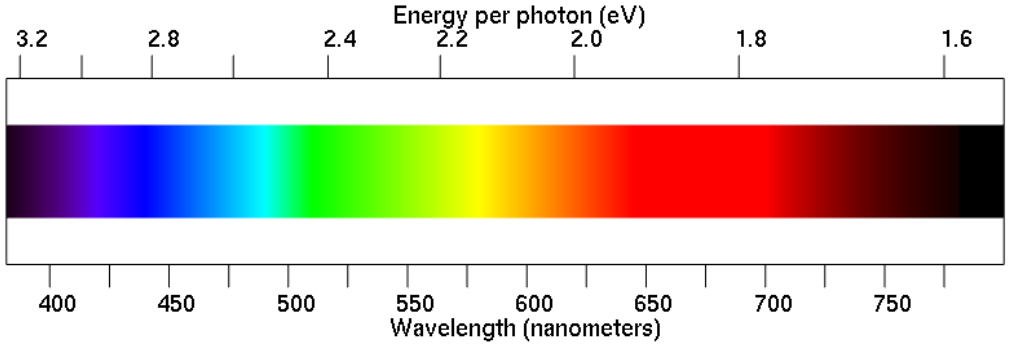
"Physics"



What color does this appear?

What element is it?

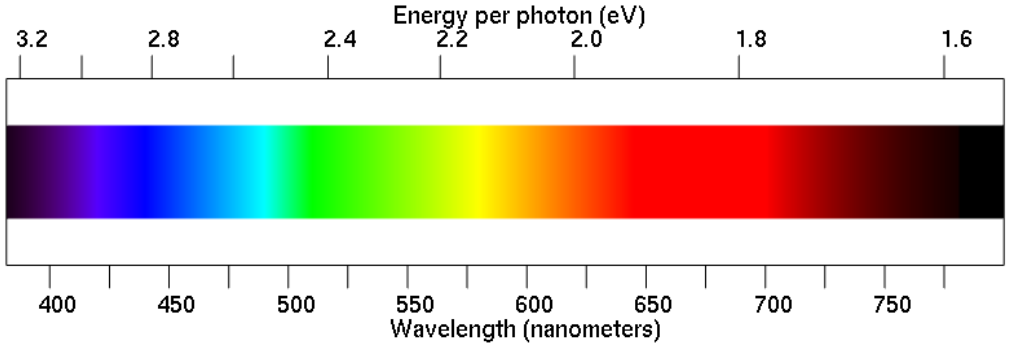
Yellow



What color does this appear?

What element is this?

White

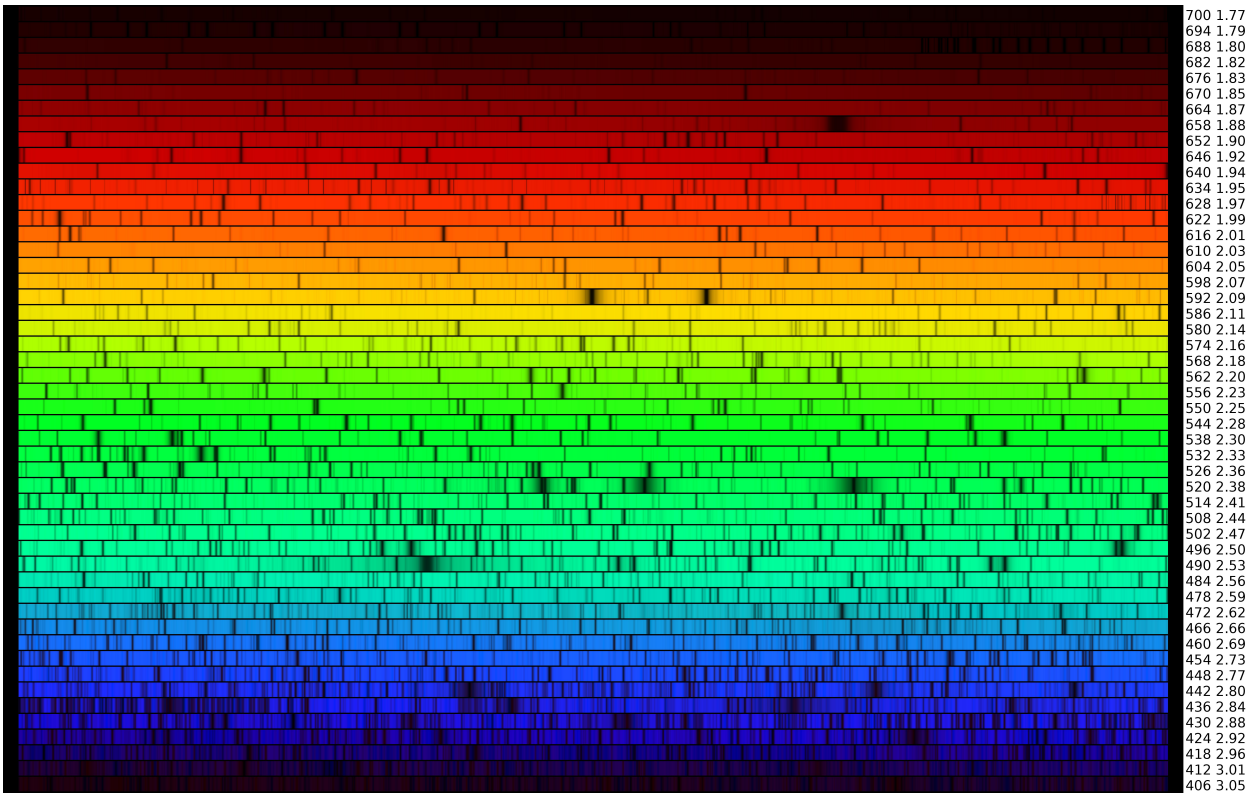


What color does this appear?

What element is this?

5 The solar spectrum

Here is that high-resolution image of the solar spectrum from class. It is broken into stripes; each one is 6 nm wide. The scale to the right of the image shows the wavelength (in nm) and the photon energy (in eV).



Try to match some of the lines you measured (or calculated, for hydrogen) with the features shown above in the Sun's spectrum. Notice that some elements like mercury aren't very common in the Sun.

Try to find:

- The absorption line corresponding to the $n = 3 \rightarrow n = 2$ transition in hydrogen
- The absorption line corresponding to the $n = 4 \rightarrow n = 2$ transition in hydrogen
- The yellow line that you saw in the sodium lamp and in the reference. Notice that this is really *two* lines, close together; you can see this in the detailed solar spectrum.)

Circle these features as you find them.

If you have a nighttime lab, go look at the street lights in the parking lot next to Holden. Figure out what element is in them!