Student's Name: Student's Name:

_____ _____

Lab day & time: _____ Date: _____

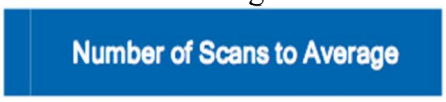
Spectral Analysis (E11) - Data Sheets and Procedure

Activity 1: Continuous Spectrum of an Incandescent Bulb. *(1.5 p.)*

1.1. Read about the equipment setup and a brief tutorial explaining the main features of the "Spectrometer" application. These two segments are located right behind the Theory section. We are going to use the USB connection, not the Bluetooth wireless connection between the spectrometer and the computer. Make sure that the spectrometer is ready and the software is running.

1.2. Check if the spectrometer is indicating proper connection to the computer. The top menu toolbar at the top of the spectrometer window should show the "Connected" icon  instead of the "Error" icon  . If you see the "Error" icon, check the USB connection, make sure that the green "USB Status LED" is continuously on and restart the software. Do NOT select wireless (Bluetooth) connection even if it was suggested by the software.

1.3. Plug in and turn on the incandescent bulb. Move the end of the light probe to be ~2 cm from the bulb, but without touching the bulb. Adjust the position of the probe clamp up or down the stand as needed. The thin black cable connecting the end of the probe with the spectrometer is a fiber optics cable. Please, **handle the fiber optics cable gently**! Do not pull it and do not bend it more than it is necessary. These cables are very fragile. For better results, you should use the lab stand with a clamp to hold the light probe in a steady position (not shown on the picture).

1.4. Click on "**Analyze Light**" button to activate the correct mode. Observe the spectrum of the incandescent bulb. First, click on the icon  to start recording data. Select the numbers of scans for calculation of the average scan 

to 5. Do not use the "Smoothing" option. Next, click on the "Auto Set" button to adjust the integration time (i.e., the sensitivity) of the spectrometer.

1.5. You should see a graph showing the light intensity versus the light wavelength (i.e., the light spectrum) for the incandescent bulb. This should be a continuous spectrum with all visible wavelength having a nonzero intensity, but not exactly the same intensity for all

wavelengths. Once you see a stable spectrum, stop recording by clicking on the following icon:  .

1.6. To prepare for printing of the spectrum, click on the "Take Journal Snapshot" icon  . The journal should open automatically. If not, then click on the "Show Journal Snapshots" icon  .

1.7. **Print** the observed spectrum using the printer icon located in the journal, just below the spectrum image.

1.8. Look at the spectrum and answer the following two questions.

Can humans see all frequencies of radiation coming out of the incandescent bulb?

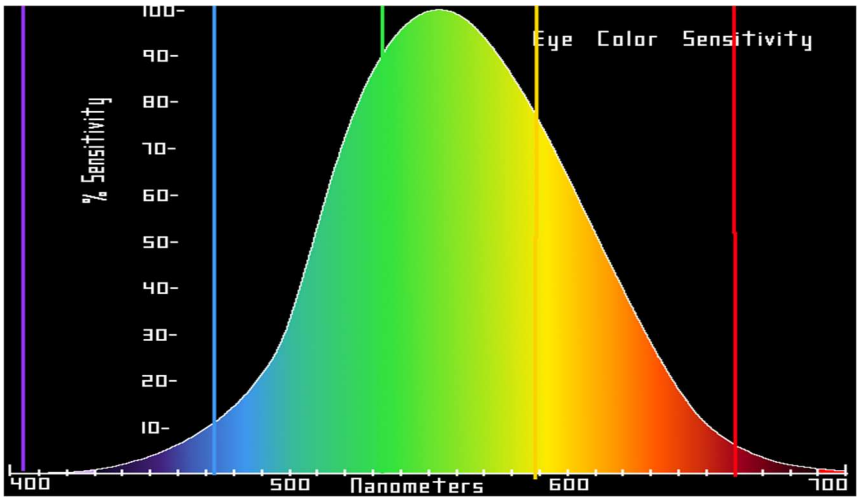
_____

_____

Where is more invisible radiation from the bulb – in ultraviolet or in infrared?

_____

_____



1.9. Carefully hold the green filter (the same one that we used in the "Photoelectric Effect" experiment) and observe the change of the spectrum shape with the green filter in between the incandescent lamp and the light probe. Briefly, describe your observations. What the green filter does to the continuous spectrum of light?

1.10. There is a significant part of the incandescent bulb spectrum to the right of the red color. This spectrum is in the infrared part of the electromagnetic waves spectrum. Could you correlate this with relatively low efficiency of incandescent bulbs? Please, explain it below.

_____

_____

_____

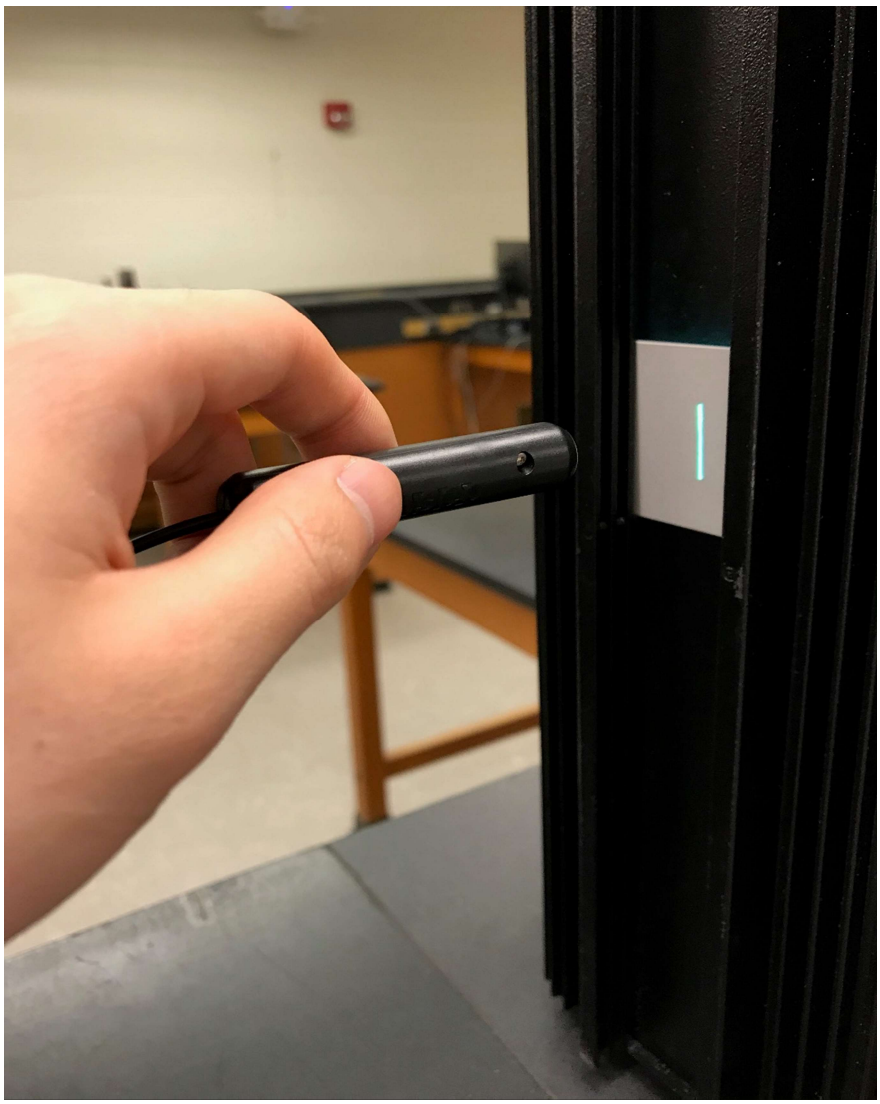
_____

_____

1.11. Turn off and disconnect the incandescent bulb. Be very careful, as the bulb enclosure **could be hot**!

Activity 2: Spectrum of Mercury Lamp. *(1 p.)*

In this activity, we will observe the spectrum of mercury lamp. It is the same lamp as we used in the "Photoelectric Effect" experiment.

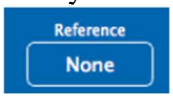


2.1. Plug in the mercury lamp and let it warm up for at least 2 minutes.

2.2. Set the light probe approximately 2 cm in front of the slit in the mercury lamp. Adjust the position of the probe clamp up or down the stand as needed. Make sure that the light from the mercury lamp is shining on the light probe.

2.3. The thin black cable connecting the end of the probe with the spectrometer is a fiber optics cable. Please, **handle the fiber optics cable gently**! Do not pull it and do not bend it more than it is necessary. These cables are very fragile.

2.4. Observe the spectrum of mercury lamp. Use the same method as previously.

2.5. Once the spectrum is ready change the reference spectra from "none" 

to one that has the best fit with the observed spectrum. The following reference spectra are available: Hydrogen, Helium, Argon, Xenon, Mercury, Sodium, and Neon. To select the reference spectrum, use icons with arrows located next to the reference spectra window.

Which element has the best fit: _____

2.6. Measure the wavelengths of the four lines from the visible range of the spectrum. The fifth line is in the near ultraviolet and cannot be measured by our spectrometer. To make more accurate reading zoom in (click on the wavelength scale below the spectrum and slide it). You may also use the "Add Coordinate Tool" to read the values of the wavelength λ.

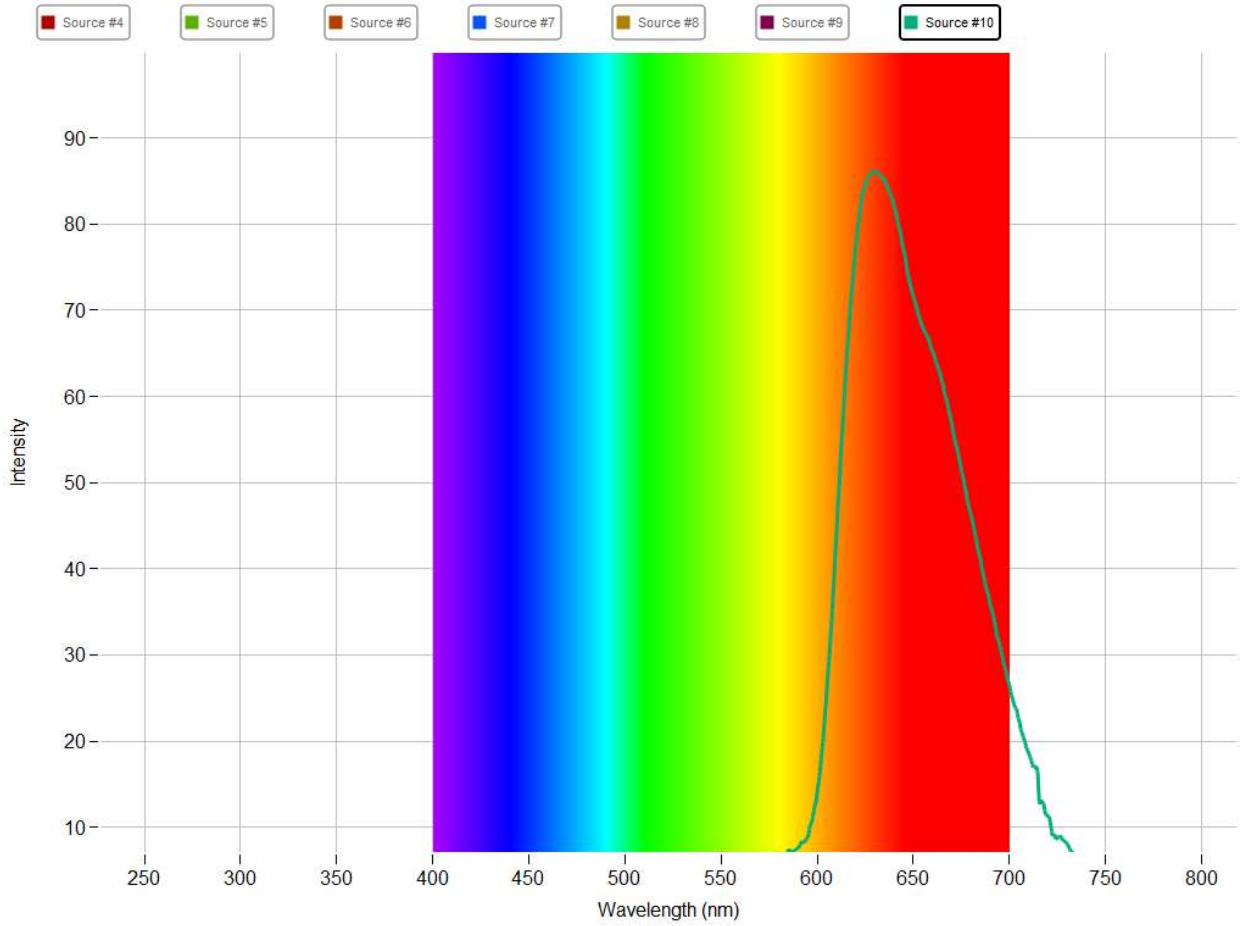
Color	**Yellow**	**Green**	**Blue**	**Violet**	**Ultraviolet**
Accurate Frequency (Hz)	$5.187*10^{14}$	$5.490*10^{14}$	$6.879*10^{14}$	$7.409*10^{14}$	$8.203*10^{14}$
Accurate Wavelength λ (nm)	578	546	436	405	366
Observed Wavelength λ_{exp} (nm)					Not observed
The difference: $\Delta\lambda = \lambda - \lambda_{exp}$ (nm)					Not observed

Keep in mind that the accuracy of our spectrometer (specified by the manufacturer) is approximately equal to ±2 nm.

2.7. **Print** the mercury gas spectrum with the reference spectrum lines and label the four observed lines with color names like in the data table above.

2.8. Turn off and disconnect the mercury lamp. Be very careful, as the **bulb enclosure could be hot**!

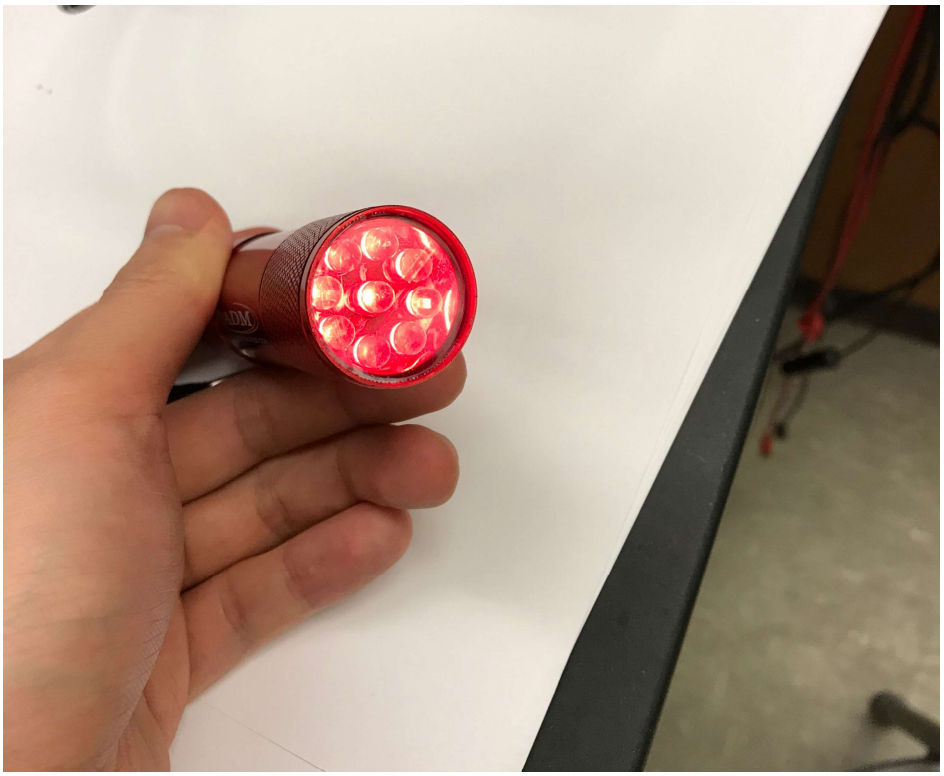
2.9. Check the sample spectrum shown below.



Based on the observed spectrum, decide which of the following sources was the most likely "unknown" light source: bright sunlight, Helium gas, Hydrogen gas, Mercury lamp, "black light" UV lamp, green-blue-light flashlight, red-light flashlight?

_____

2.10. Use the same experimental setup and the same software to observe the spectrum of light emitted by the red flashlight that we used in the previous experiment (E10). Is the red flashlight spectrum similar to the sample spectrum in step 2.9?



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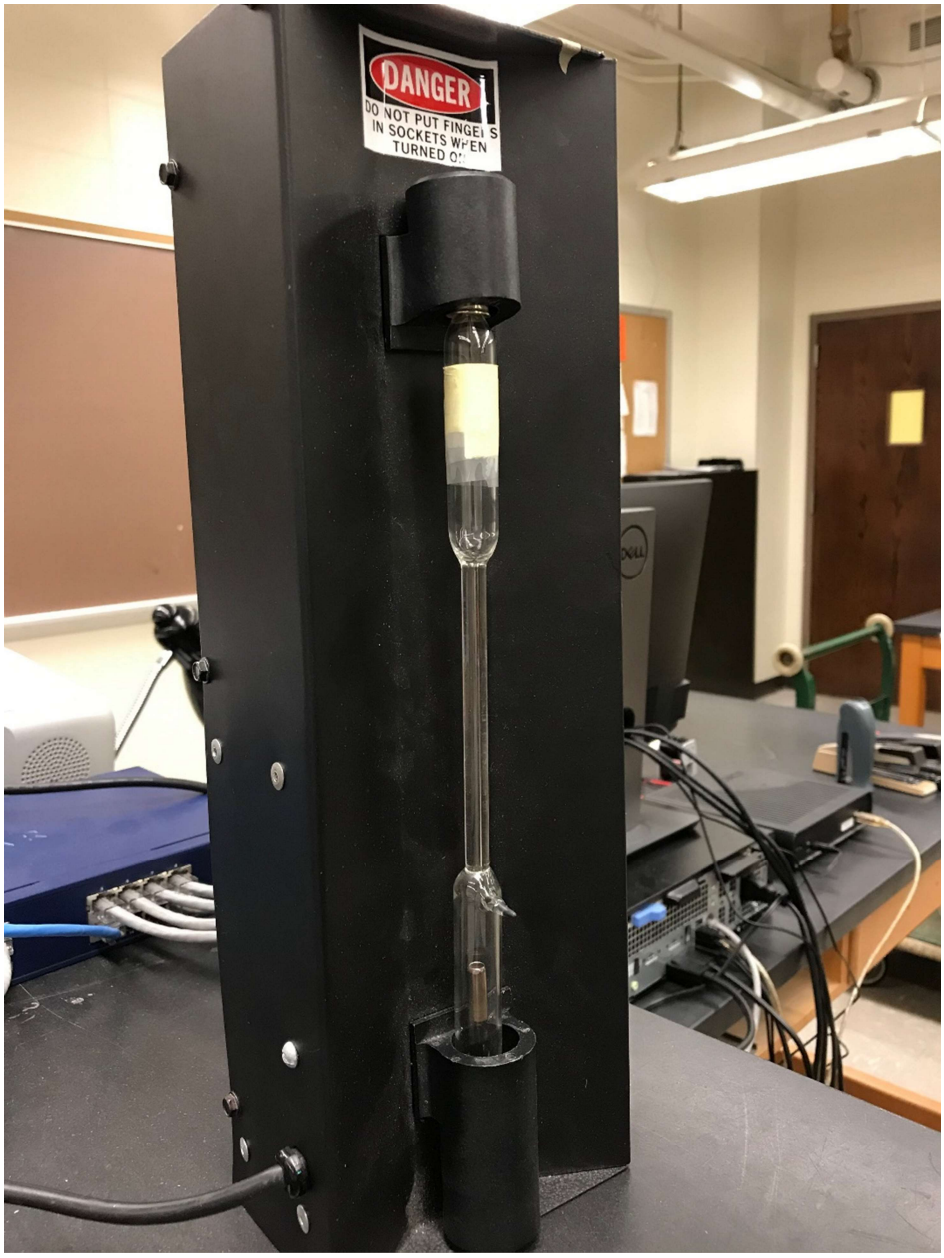
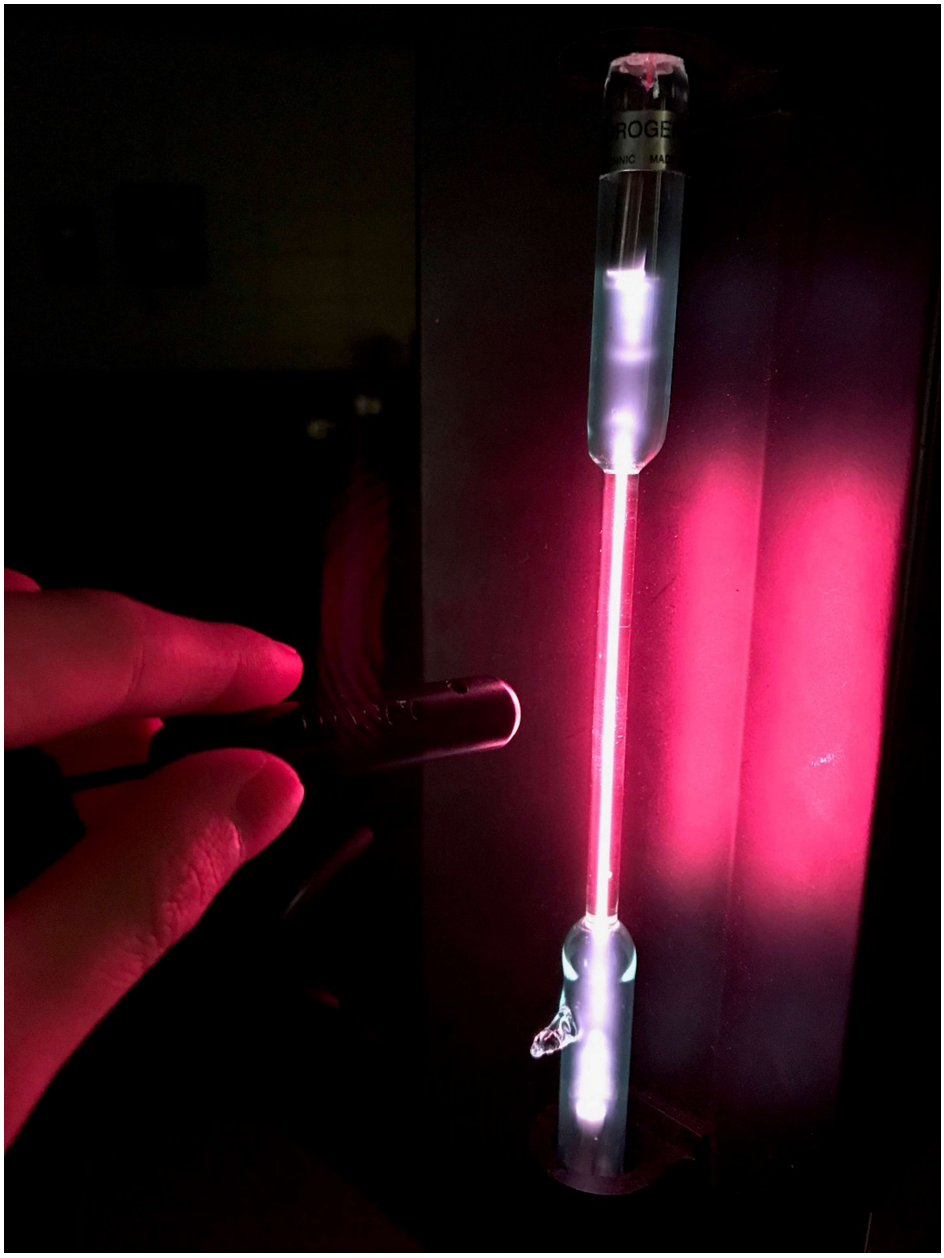
Activity 3: Hydrogen Gas Spectrum. *(1.5 p.)*

3.1. Turn on the hydrogen spectral tube holder and wait ~2 minutes until the lamp warms up. **Do not touch the tube with your fingers! High voltage** is used to activate the hydrogen gas atoms and the tube **gets hot** very quickly.



3.2. Set the light probe approximately 1 - 1.5 cm in front of the hydrogen tube. Adjust the position of the probe clamp up or down as needed. **Make sure that the light from the hydrogen tube is shining on the light probe, but the probe <u>does not touch</u> the hot hydrogen tube**.



3.3. Observe the spectrum of the hydrogen gas. Use the same method as previously. Since the intensity of light emitted by the tube containing hydrogen is much smaller than that for other light sources, you should adjust the "Integration Time" (= sensitivity) to get a nice spectrum.

3.4. Once the spectrum is ready change the reference spectra from "none" to the one that has the best fit with the observed spectrum. The following reference spectra are available: Hydrogen, Helium, Argon, Xenon, Mercury, Sodium, and Neon. To select the reference spectrum, use icons with arrows located next to the reference spectra window.

Which element has the best fit: _____

3.5. Measure the wavelengths of the three brightest lines in the hydrogen spectrum. To make more accurate reading zoom in (click on the wavelength scale below the spectrum and slide it). You may also use the "Add Coordinate Tool"  to read the values of the wavelength λ.

3.6. Calculate the experimental value of the Rydberg constant for each of the three lines and then calculate the average, measured value of the Rydberg constant. Use equations 6 and 7 from the theory section.

Color	**red**	**green blue**	**dark blue**
Initial orbit: n_i	**3**	**4**	**5**
Final orbit: n_f	**2**	**2**	**2**
Measured wavelength λ_{exp} (nm)			Very low intensity - not observed
Experimental value of the Rydberg constant R (nm^{-1})			Not observed

Average experimental value of the Rydberg constant (from step 3.6)

R = _____ (nm^{-1}) = _____ (m^{-1})

3.7. **Print** the hydrogen gas spectrum with the reference spectrum lines.

3.8. Turn off the hydrogen spectral tube.

3.9. Exit the "Spectroscopy" application and turn off the spectrometer using the ON/OFF button. Do not save any changes.

Complete the lab report and return it to the lab TA.