Build a Spectroscope

Caution: Extreme care is needed in handling the razor blades!!!!

1. Watch your teacher's demonstration.
2. Tape any seams that may allow stray light to enter your box.
3. Cut a square 1" x 1" hole for the diffraction grating on the left side of the box. The left edge of the diffraction grating should be ½ inch in from the left edge of the box.
4. Cut a "C"-shaped piece of manilla folder to create a slot for your diffraction grating. Tape it over your diffraction grating hole and make sure that your grating will slip in and out easily.
5. Find the center of the diffraction grating. Using a ruler run a line to the other end of the box. Mark this spot.
6. Cut a 1 ½ " square hole in the end of the box opposite the diffraction grating.
7. Using 2 pieces of tape, tape over that hole leaving a vertical gap of less than 1/16"
8. Look at a light source through the diffraction grating. See where the spectrum falls on the inside of the box. Use a pencil or pen to poke holes until you have identified the edge of the purple end and the end of the red part of the spectrum.
9. Cut a long slot for the ruler where the spectrum falls on the inside of the box. The opening needs to be approximately ½" wide and approximately 4" long. **Make sure that your ruler goes well beyond the colors—both before the purple and past the red.**
10. Tape a scale (ruler) over the opening so that it may be read while looking through the diffraction grating.
11. Give it a try. If you are not seeing the colors on your ruler, you may have to rotate the diffraction grating 90 degrees.

Calibrating your Spectroscope

1. Using your spectroscope observe the spectrum of mercury (Hg). Record the colors (really good description) and where the color is on your ruler/scale.
2. Use LoggerPro to graph the actual wavelength against the colors read on your spectroscope. Label your data set and put on a title. Record this data in your journal…

Mercury:	violet	__________	=	404 nm
	blue	__________	=	436 nm
	green	__________	=	546 nm
	yellow	__________	=	579 nm (actually 3 yellows centered at 579)
	orange	__________	=	615 nm
	red	__________	=	691 nm

You **will not** see all of these. Record the ones you do see and use those to create your calibration graph.

3. Under the ***Analyze*** menu select either ***Linear fit*** or ***Curve fit*** depending on whether it looks linear or curved. Then click on ***Interpolate*** (also in the ***Analyze*** menu). Use this to analyze the "mystery gas" light sources.

Mystery Gases

- For each of the mystery gases, record the colors and the scale values as you did for mercury. Then use your graph to convert to wavelength. Use the spectra at tinyur.com/shafferspectra2 Determine the identity of your mystery gases.

Finishing off this activity:

- Calculate the frequencies (v) of the emission lines for the mercury lines you saw.
- Calculate the energy (E) for each frequency.
- You are done! You have now quantized Mercury. The spectral lines you have measured correspond to electrons falling from higher energy levels. These are the boundaries of the orbitals present for the mercury atom.

Spectroscopes, Light, and Quantum Theory

There are 2 key relationships we need to understand…

wavelength x frequency = speed of the wave

$$\lambda \times \nu = c$$

$c = 3.0 \times 10^8$ m/s (= speed of light in a vacuum)

ν = the number of peaks that pass a given point in 1 second (hertz)

λ = the distance between the consecutive peaks or troughs of a wave

Example: Find the frequency of green light having a wavelength of 555 nm.
Rearrange the equation above to get: First convert nanometers (nm) into meters (m) so move the decimal point 9 places to the left…555 nm = 0.000000555 m

$$\nu = c/\lambda$$

$= (3.0 \times 10^8 \text{ m/s})/(0.000000555 \text{ m})$

$= 5.4 \times 10^{16}$ ^{1}/s (aka "Hertz", (Hz))

The other key relationship is…

Energy of a wave = Planck's Constant x frequency of the wave

$$E=h\nu$$

E = energy of a photon, emitted or absorbed

h = Planck's constant = 6.63×10^{-34} Joule·seconds

ν = frequency (see above)

Example: What is the energy of the light in the above example?

$$E=h\nu$$

$= (6.63 \times 10^{-34} \text{ Joule·seconds})(5.4 \times 10^{16} \text{ Hz})$

$= 3.58 \times 10^{-17}$ Joules

Combined, the two relationships are…

$$E=hc/\lambda$$