Concepts in Physics

Lab 5: Line Spectra

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Introduction

When a low pressure gas in a glass tube is excited by the input of a large amount of energy, the atoms or molecules that make up the gas become excited. When the molecules return to their unexcited state, they give of a just few particular frequencies (colors) of light. The particular frequencies of light emitted by a particular gas are called its *emission spectrum,* which acts like a "fingerprint" for that gas because it can help a scientist uniquely identify that gas.

Incandescent light, on the other hand, is the kind of light you get from a filament in an ordinary light bulb. With incandescent light, the colors you get depend not on the substance, but only on the temperature of the substance. While the emission spectrum of an excited gas consists of a number of discrete frequencies (colors) of light, the spectrum of an incandescent light consists of a broad, continuous band of frequencies.

During this experiment you will make use of a device known as a diffraction grating spectrometer. A diffraction grating splits a single beam of light into the many colors which it contains. The spectrometer is just a device for extracting quantitative information from the spectrum, such as the wavelength of the various lines in the spectrum. The device you will use is similar to the experimental apparatus used by spectroscopists for almost two centuries to study the line spectra of the elements. These line spectra played a crucial role in the development of the atomic theory of matter and quantum mechanics.

Activity 1: The Experiment

Put a spectrum tube containing mercury (Hg) in a spectrum tube power supply and turn it on. The tube will glow with a bluish light. Bring the spectroscope to a position directly opposite the tube and adjust the position until the vertical lines you see are as bright as they get.You should see bright, colored bars of light. These are the same lines of the line spectrum of mercury that you can observe by looking at the lamp with a diffraction grating near your eye.

Now start noticing the lines and try to measure and note their wavelengths. Write these down. I want each lab partner to do this separately, in turn, *without* knowing what each other observes at first. Then you should compare notes and negotiate and re-measure as needed to get what you think are the most accurate set of measurements.

Then turn off the spectrum tube power supply and replace the tube containing mercury with a tube containing a different gas. Repeat this procedure for measuring the unknown wavelengths of spectral lines for this new gas, and record your measurements for at least five spectral lines.

Finally, repeat the process for two more different gases.

To hand in for activity 1

Complete tables for each of your four gases, listing the color and wavelength of each spectral line.
Also hand in answers to the following:

- How close were your wavelength measurements to the accepted values of wavelengths for the various gases, as listed in the last table? (If your gas is not in the table, do some online searching.) What factors do you think might have contributed to any differences, and how might they have affected your measurements?
- For what practical purpose do you suppose this experimental technique might be used? Spectroscopic techniques of the kind you applied in this lab are routinely used by scientists, by government, and in business. Can you think of any examples where or how they might be applied?

Color	**Accepted λ (nm)**			
	Helium	**Mercury**	**Neon**	**Krypton**
Purple	439	405		423
Purple	447	436		432
Purple				437
Purple				446
Purple				450
Blue	469	492		
Blue	492			
Green	502	546	534	557
Green			540	
Yellow	588	577	585	587
Yellow		579	588	
Yellow			603	
Orange		607		
Red	668		616	646
Red			627	
Red			638	
Red			640	
Red			651	
Red			660	

Don't be overly literal-minded about the colors. A line listed as yellow might look somewhat like orange to you, a purple line may be more bluish in your judgment etc.