

Lab #8

Spectroscopy

1. Objectives

To use an optical spectrometer and a grating to observe and measure the atomic emission spectra of two elements, Hydrogen (H) and Cadmium (Cd).

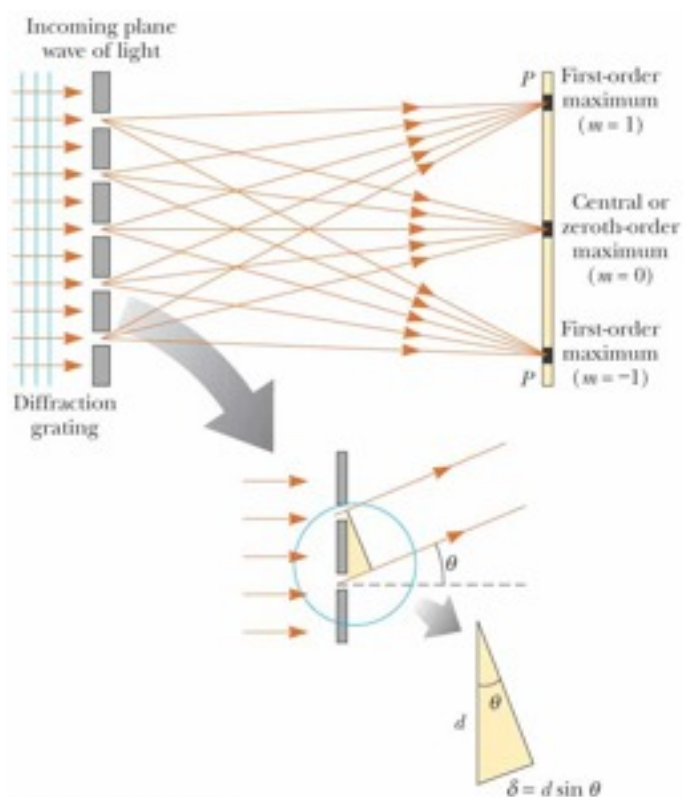
2. Apparatus

Spectrometer, grating, discharge tubes, high-voltage power supply.

3. Theory

Visible spectra produced by a grating

When white light is passed through a grating, the central portion (zeroth-order) remains white, but after a “dark zone”, the light spreads out into a continuous spectrum of all visible colours in 1st order. This will be seen as a continuous band of light, with each colour occurring at a different angle, as determined by the grating equation: $\sin \theta = \lambda/d$ ($m = 1$). After another “dark zone”, the pattern will repeat in 2nd order, with the angles this time being determined by the equation $\sin \theta = 2\lambda/d$ ($m = 2$). Each band of colours will start with violet at small angles and go to red at larger angles.



When the light comes from an excited sample of a specific chemical element or compound, only some colours (wavelengths) will be present, but they will occur at the same angles at which these colours show up with white light. The only difference is that instead of a continuous band of all possible colours, the pattern will be a series of separate “lines” with darkness between them. In this experiment you will locate these emission lines and determine their corresponding wavelengths.

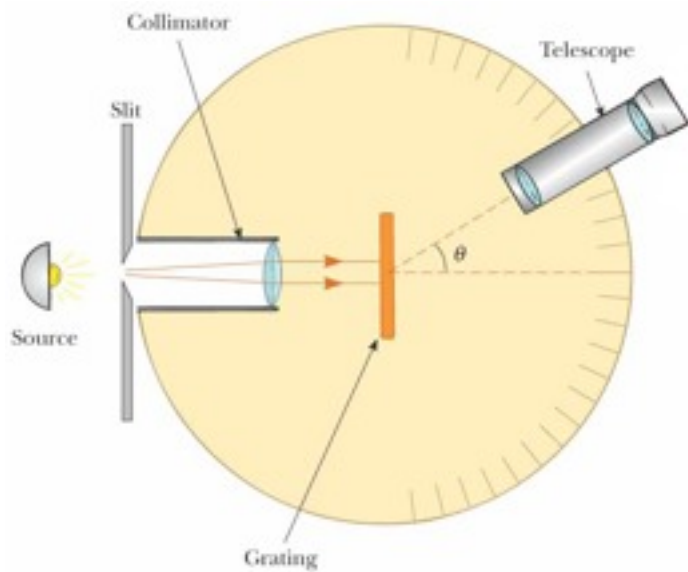
4. Procedure

Some fine-tuning is needed for the spectrometer, *be sure to get your setup checked by the teacher before making measurements of angles.*

Calibrate the spectrometer with a source of known wavelength.

You will use a hydrogen source in order to calibrate your diffraction grating. Hydrogen emits several visible wavelengths part of what is called the Balmer series. We will use the H- α line, the red emission line of Hydrogen, with a wavelength of 6562.81 \AA^* .

We use this known λ to find the d -value of the grating. Record the position angles for this colour in 1st and 2nd order (4 angles: 2 right, 2 left).



Measure the spectrum of a source of unknown wavelengths.

Insert **THE SAME GRATING** as used above into the cadmium (Cd) spectroscop. Cadmium produces 5 visible wavelengths, Red, green, Blue/Green, Blue and Violet. (The violet can be a bit hard to see, but it's there so find it! It will be easier to find if you start with the red line and work inwards toward the violet.)

Record the position angles for all wavelengths in 1st order **only** (10 angles: 5 right, 5 left.)

The entire Cd spectrum is repeated in 2nd order, find these lines to see what they look like, and how they differ in appearance from the 1st order lines, but no actual measurements are required.

Can you observe any 3rd order lines?

5. Analysis

Determine the d -value of the grating using Hydrogen

Use the H- α results from part 1 to find the values of θ_1 and θ_2 . Then use each of these angles in the grating equation to obtain 2 estimates for the d -value of the grating.

Find the average of these 2 estimates and use this as " d " in all the remaining calculations. Compare your average d -value with the manufacturer's value, which may be calculated by

* A. N. Cox, editor (2000). Allen's Astrophysical Quantities. New York: Springer-Verlag

noting that your grating has a label saying “6000 lines/cm”. This means that it has 6000 openings per centimetre. This use of the term “lines” should not be confused with the emission lines themselves.

Determine the unknown wavelengths produced by Cadmium.

Use the Cadmium results from part 2, along with the d -value found in part 3, to calculate the wavelength of each colour in the Cd spectrum. Compare your results with the values given below.

Colours	Wavelength (Å)
Red	6438 Å
Green	5086 Å
Blue/Green	4800 Å
Blue	4678 Å
Violet	4406 Å

Additional problems:

Prove that only 2 orders should occur for H- α line when using this particular grating.

For Cd, using this grating, all of the 1st and 2nd order wavelengths should be visible, but only part of the 3rd order spectrum should be. Determine which of the 3rd order wavelengths can be seen.

Logbook preparation:

When you are preparing for an experiment, it is a good idea to build tables in advance, such that you only have to fill them with your data when you are in the lab. Here is an example of such a table for this experiment:

Colour	Order	θ_{right}	θ_{left}	$\theta = 1/2(\theta_R - \theta_L)$	d (Å)	d_{avg} (Å)	d_{theo} (Å)
Red	1						16 667
Red	2						

Colour	Order	θ_{right}	θ_{left}	θ	λ (Å)	λ_{theo} (Å)
Red	1					6438
Green	1					5086
B/G	1					4800
Blue	1					4678
Violet	1					4406