Course and Section________ Names ______________________________

Date____________ ____________________________________

ATOMIC SPECTRA EXPERIMENT

Introduction

In this experiment you will observe the spectra lines emitted by hydrogen gas and mercury gas contained in spectral tubes.

Equipment

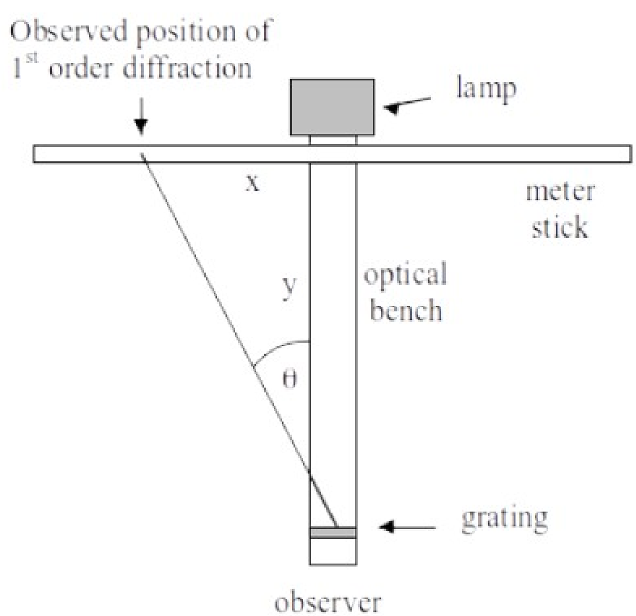
Optical bench, meter stick, diffraction grating, lamp power supply, hydrogen and mercury spectral tubes.

Theory

When a gas contained in the spectral tube (either *H* or *Mg*) is subjected to a high-voltage, the electrons in the atoms can be excited to higher energy levels within the atoms; when they return to their original levels electromagnetic radiation is emitted.
Some of this radiation is visible to the human eye and it is composed of distinct wavelengths. Using a diffraction grating is possible to separated the different wavelengths and observe them individually.

Procedure

The figure on the right illustrates the basic setup. In this the experiment you will observe three different spectral lines and measure the angle of diffraction θ of each line.



The relationship between the wavelength λ, the grating spacing d and the angle θ is

$$m\lambda = d\, sin\theta \qquad m=0, \pm 1, \pm 2, \ldots \quad (1)$$

where m is the order of diffraction which locates the maxima. In this experiment you can only see the first order, so m = 1.

PART 1 – Mercury

The goal is to find *d*, the the grating spacing .

Step 1. Set up the equipment as show in the previous figure. Set the lamp power supply as close as possible to one end of the optical bench and place the meter stick next to it, perpendicular to the optical bench. Hold the diffraction grating at the other end of the bench.

Step 2. Make sure the lamp power supply is off. Get the mercury spectral tube from the main desk and insert it vertically between the two tube holders of the lamp power supply.

Step 3. Turn on the lamp power supply. Look through the diffraction grating and try to individuate the mercury spectra lines: they look like vertical lines about 15 cm tall each. There are three of them on the left side of the lamp and three on the right side.
You will see also several other lines and colors coming from other light sources present in the room, try to ignore them.

Step 4. Start by focusing on one of the spectral lines. You want to locate the spectral line by measuring the distance *x*. At least two people are needed to take this measurement: one person (the observer) looks through the diffraction grating, the other holds a pencil and tries to match the location of the spectra line with the pencil. Only the observer can see the line and indicates where the pencil must be positioned.

Step 5. Repeat the measurement for the other two lines, and for both sides of the lamp. Use the tables below to collect your data.

Step 6. <u>Turn off</u> the lamp power supply when done taking all measurements.

Analysis

1. Yellow mercury line:

λ = 571nm	y (m)	x_{left} (m)	x_{right} (m)	x_{avg} (m)
Observer 1				

Use x_{avg} and y to calculate θ and sin θ. Calculate d using Eq. 1.

θ	*sin* θ	d

2. Green mercury line:

λ = 546 nm	y (m)	x_{left} (m)	x_{right} (m)	x_{avg} (m)
Observer 1				

Use x_{avg} and y to calculate θ and sin θ. Calculate d using Eq. 1.

θ	*sin* θ	d

3. Violet mercury line.

λ = 436 nm	y (m)	x_{left} (m)	x_{right} (m)	x_{avg} (m)
Observer 1				

Use x_{avg} and y to calculate θ and sin θ. Calculate d using Eq. 1.

θ	$sin\ \theta$	d

4. You have obtained three values of d. Calculate the average.

d_{avg} = ________ (m)

5. Check your diffraction grating and find the given value of d. You might have to use the number of line/mm depending on which kind of grating you are using.

d_{given} = ________ (m).

6. Calculate the % error of d_{avg} :

%error: =____

PART 2 – Hydrogen

The goal is to find the Rydberg constant R_H.

Step 1. Return the spectral tube of mercury and take the spectral tube of hydrogen. The set up is the same as part 1. First you will need to find the wavelengths of the three spectra lines.

Step 2. Switch with your lab partner the person looking through the diffraction grating. Insert the spectral tube of hydrogen and turn on the lamp power supply.

Step 3. Repeat the measurements of part 1 to find x_{left} , x_{right} and y.

Step 4. <u>Turn off</u> the lamp power supply when done taking all measurements.

Analysis

7. Red hydrogen line.

$\lambda_{accepted}$ = 656nm	y (m)	x_{left} (m)	x_{right} (m)	x_{avg} (m)
Observer 2				

Use x_{avg} and y to calculate θ and sin θ. Calculate $\lambda_{measured}$ using d_{given} and Eq. 1.

θ	$sin\ \theta$	$\lambda_{measured}$(nm)	λ *%error*

8. Blue hydrogen line.

$\lambda_{accepted}$ = 486 nm	y (m)	x_{left} (m)	x_{right} (m)	x_{avg} (m)
Observer 1				

Use x_{avg} and y to calculate θ and sin θ. Calculate $\lambda_{measured}$ using d_{given} and Eq. 1.

θ	$sin\ \theta$	$\lambda_{measured}$ (nm)	λ *%error*

9. Violet hydrogen line.

$\lambda_{accepted}$ = 436 nm	y (m)	x_{left} (m)	x_{right} (m)	x_{avg} (m)
Observer 1				

Use x_{avg} and y to calculate θ and sin θ. Calculate $\lambda_{measured}$ using d_{given} and Eq. 1.

θ	$sin\ \theta$	$\lambda_{measured}$(nm)	λ *%error*

The visible spectral lines of hydrogen are referred as the Balmer series. They are described by the empirical Rydberg formula

$$\frac{1}{\lambda} = R_H\left(\frac{1}{2^2} - \frac{1}{n^2}\right) \quad n = 3, 4, 5, \ldots$$

where n is the principal quantum number.

10. Identify, using online resources for example, which quantum number n is associated to the wavelengths you have calculated. Calculate the relative quantity necessary for the liner fit.

$\lambda_{measured}$(m)	n	$(1/2^2 - 1/n^2)$	$1/\lambda_{measured}$ (m)

11. Plot $1/\lambda_{measured}$ vs $(1/2^2 - 1/n^2)$ and find the numerical value of R_H from the slope.

R_H = __________ m^{-1}

12. The accepted numerical value is $R_H = 1.097 \times 10^7\ m^{-1}$. Calculate the %error

%error: =____

RETURN THE SPECTRAL TUBE AND MAKE SURE THE THE LAMP POWER SUPPLY IS OFF.