Laboratory 3

Atomic Spectroscopy

Objectives

- Use spectroscopic techniques to explore the spectra of excited gases
- Use a known spectrum to calibrate a wavelength scale
- Use a hydrogen spectrum to determine energies of Balmer series electron transitions
- Calculate the Rydberg constant based on spectral measurements

Equipment and Materials

- Spectral tubes with voltage source
- Spectroscope
- Ruler

Introduction

The relationship between color, wavelength, and frequency of visible light will be examined using a handheld spectroscope. The visible emission spectrum of atomic helium will be analyzed with a spectroscope. The spectrum will be used to calibrate a wavelength scale which will then be used to measure wavelengths in an atomic hydrogen spectrum. Based on the hydrogen atomic spectrum, the energy levels of the initial and final states for the atoms will be determined, and a numerical value of the Rydberg constant will also be calculated.

Anywhere you see a numbered step in *italics* you should be recording information in your lab notebook.

PART I. ATOMIC SPECTRA

Observation

1. Hold a white piece of notebook paper near the window so that it is catching light from outside. Point the end of your spectroscope towards the light reflecting off the paper and look through the diffraction grating. *Record your observations of the spectrum and draw what you see in your lab notebook.*

2. Now, point the end of your spectroscope towards the fluorescent lights in the ceiling and look through the diffraction grating. *Record your observations of the spectrum and draw what you see in your lab notebook. Take the time to note any differences seen between the two spectra.*

Discussion

1. In the discussion portion of your lab report, talk about the differences seen between the two spectra and what leads to the type of spectrum seen by each.

PART II. FINDING THE RYDBERG CONSTANT

Data Collection

Your TA will be performing the apparatus setup for this portion of the experiment; however, all the measurements will be done by you.

1. Your TA will project the helium spectrum seen in the spectroscope by using a webcam attached to a spectroscope. Be sure that the 0 point of the mounted tape measure is on the bright line in the middle of the projection.

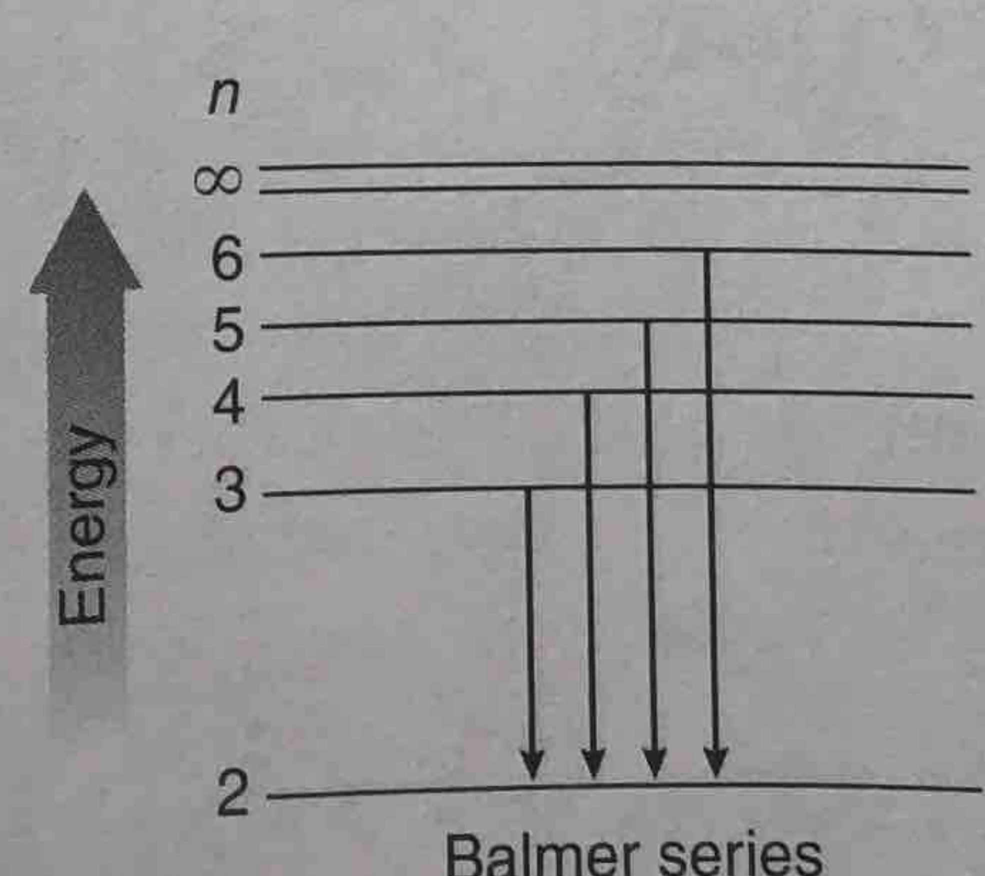
2. To the nearest millimeter, record the distance of the center of each major line in the spectrum as measured on the ruler. You should see 6 major lines. *Set up a table in your notebook to record the wavelength, color, and the distance measurement (mm).* The wavelengths (nm) of the major lines are: 447.1, 471.3, 492.2, 501.5, 587.5, 667.8

3. Once the whole class has had an opportunity to record the helium spectrum measurements, your TA will set up a different gas tube that contains hydrogen gas. *Measure the four major lines in the hydrogen spectrum in the same manner as you did for the helium tube. Record your data in a table similar to step 2 in your lab notebook.*

Data Analysis

1. Calibrate your scale by plotting the measurement of the helium lines in mm on the x-axis and each line's wavelength, in nm, on the y-axis. You can use Excel or your calculator for this graph. Find the equation of the line using a linear model. ***Be sure to note the equation of your line in your lab report.***

2. Using the equation of your line and the measured values (in mm) for the hydrogen spectrum lines, calculate the values for your hydrogen spectrum wavelengths.



Because your spectral lines for hydrogen are visible, they are part of the visible spectrum. Remember that this means the excited electrons are transitioning from a higher energy level down to the n=2 level.

3. Calculate the energy associated with each of the four transitions observed for hydrogen using your wavelengths. This value corresponds to the ΔE for an electron transition from a higher n-level to the n=2 level. You will also need to determine the starting n-level for each transition (the ending n-level is always 2).

4. Using the Rydberg equation, the value for ΔE calculated above, and your values for the starting and ending n-levels, calculate a value for the Rydberg constant (in Joules) for each of your spectral lines. Calculate the average for your four values.

5. Determine a %error for your value of the Rydberg constant using this method. The value of the Rydberg constant can be found in your text.

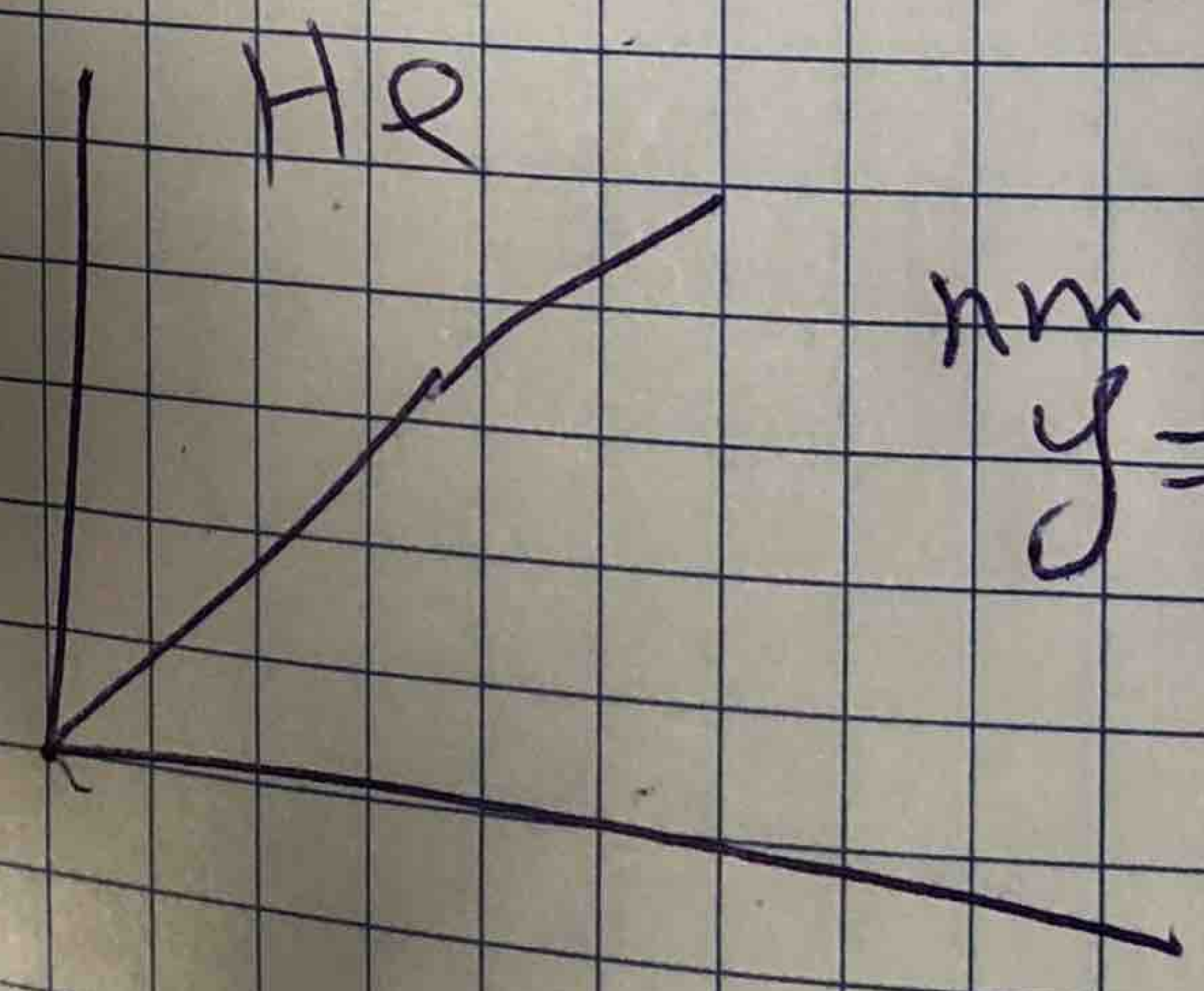
6. Determine a way to graph your data using the Rydberg equation to find the value of the Rydberg constant (in Joules). Report the %error for this technique. In your lab report, discuss which method (averaging or graphing) gave a lower %error and why you think that is.

He

λ	cm1	cm2	avg		
447.1	35.4	35.7			
471.3	40.6	41.0			
492.2	43.0	43.4			
501.5	45.4	45.6			
587.5	54.5	55.2			
667.8	63.6	64.3			

H

λ	cm1	cm2	avg
?	37.1	36.1	
?	39.4	38.2	
?	44.4	43.3	
?	62.6	61.0	



cm nm

nm $\frac{nm}{cm}$

$y = mx + b$

$E = \frac{ch}{\lambda}$