#7 The Balmer Lines of Hydrogen and the Rydberg Constant

Pre-Lab Report

Lab section:

Name & Surname:

Table #:

***Before the Lab* complete this page YOURSELF! Hand it in *in the first 5 min*. of the session PERSONALLY!**

You MUST justify your answers and show all steps. NO COPYCAT answers, or NO credits!

Please read the relevant presentation on PHYS LAB Website.

In this experiment spectrum of the hydrogen gas is going to be studied by using a spectrometer and a diffraction grating.

Q1. Write down the final and initial state numbers for each color that we are going to observe. i.e. n_i and n_f for red, green and violet spectrum lines. **Justify your answers, show calculations if needed or no credits!**

Q2. Write down the formula for wavelength in terms of Rydberg constant R, n_i and n_f.

(3rd and 4th Questions are on the next page!)

Q3. How can you be sure that $n_f=2$ for every case you observe. **Justify your answers, show calculations if needed or no credits!**

Q4. Do the dimension analysis for Rydberg constant by using the expression for it. **Show your derivation / formulae below explicitly or no credits!**

$$R = \frac{me^4}{8ch^3\varepsilon_0^2}$$

1

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***Complete this report YOURSELF except DATA taking parts! Use a pencil for plots only and a pen for the rest!* Show your work clearly, NO COPYCAT analysis allowed, or NO credits!**

OBJECTIVE : To observe the Balmer line spectra series of Hydrogen and to determine the Rydberg constant for hydrogen using a grating spectrometer.

THEORY : Elements emit light at characteristic wavelengths when they are excited through heating, electrical discharge, etc. In 1885, Balmer observed some of the lines in the Hydrogen spectrum and noticed that a group of them could be described by

$$\lambda = B\frac{n_2}{n_2 - 4}.$$

When Bohr put forward his model for the Hydrogen atom, it was easy to show that the Balmer lines are produced by the photon emissions when excited hydrogen atoms decay to the second energy level from upper levels. Since Bohr model gives the relationship between the wavelength of the emitted light when an electron moves from an energy level n_i to n_f and the principal quantum numbers n_i and n_f:

$$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

where R is the Rydberg constant that can be expressed as

$$R = \frac{me^4}{8\varepsilon_o^2 h^3 c}$$

where m is the mass of the electron. You may show that the Balmer lines are obtained when n_f=2 and n_i=n.

PROCEDURE :

1. Adjust the zero position of the spectrometer so that it is equal to the absolute zero. Align the collimator and the telescope such that you can see the slit clearly and sharply through the telescope. Next, adjust the cross-hair so that it is on the slit. Then, fix the telescope and rotate the body until the zero positions of the body and the telescope are aligned. Finally, fix the body and release the telescope to move freely.

2. Mount the diffraction grating carefully on the spectrometer.

3. Using the discharge tube containing hydrogen gas as the light source, determine the wavelengths of the Balmer lines in the hydrogen spectrum. Calculate the Rydberg constant for each of the determined wavelengths. Calculate the actual value of the Rydberg constant using the equation above and compare with your average experimental result.

3

HYDROGEN SPECTRUM LINES

A) For Red Spectrum Line

Angle of spectrum line θ_{left} = ...

Angle of spectrum line θ_{right} = ...

Average angle θ_{ave} = ...

B) For Green Spectrum Line

Angle of spectrum line θ_{left} = ...

Angle of spectrum line θ_{right} = ...

Average angle θ_{ave} = ...

C) For Violet Spectrum Line

Angle of spectrum line θ_{left} = ...

Angle of spectrum line θ_{right} = ...

Average angle θ_{ave} = ...

4

CALCULATIONS:

Description / Symbol			Calculation (show each step)	Result
Diffraction Grating Constant	d	=	. . . .	. . . .
Wavelength for the Red Line	λ_{red}	=	. . . .	. . . .
Wavelength for the Green Line	λ_{green}	=	. . . .	. . . .
Wavelength for the Violet Line	λ_{violet}	=	. . . .	. . . .

5

A) For Red Spectrum Line

Initial state n_i = ...

Final state n_f = ...

Rydberg constant R_{red} = ...

. . . .

B) For Green Spectrum Line

Initial state n_i = ...

Final state n_f = ...

Rydberg constant R_{green} = ...

. . . .

C) For Violet Spectrum Line

Initial state n_i = ...

Final state n_f = ...

Rydberg constant R_{violet} = ...

6

RESULTS:

Description / Symbol		**Calculation (show step by step)**	**Result**
Average value of Rydberg constant R_{EV}	=	. . . .	. . . .
		. . . .	
Calculated value of Rydberg constant R_{CV}	=	. . . .	. . . .
		. . . .	
		. . . .	
% Error for *R*	=	. . . .	. . . .

Consult to the resources for this experiment from PHYS LAB Website:

PHYL202 Intro

Presentation #7

PHYL202 Lab Book