



1-7: The Rydberg Equation

When a sample of gas is excited by applying a large alternating electric field, the gas emits light at certain discrete wavelengths. In the late 1800s two scientists, Johann Balmer and Johannes Rydberg, developed an empirical equation that correlated the wavelength of the emitted light for certain gases such as H₂. Later, Niels Bohr's concept of quantized "jumps" by electrons between orbits was shown to be consistent with the Rydberg equation. In this assignment, you will measure the wavelengths of the lines in the hydrogen emission spectra and then graphically determine the value of the Rydberg constant, R_H .

1. Start *Virtual ChemLab*, select *Atomic Theory*, and then select *The Rydberg Equation* from the list of assignments. The lab will open in the Quantum laboratory. The *Spectrometer* will be on the right of the lab table. The hydrogen emission spectra will be in the detector window in the upper right corner as a graph of intensity vs. wavelength (λ).
2. How many distinct lines do you see and what are their colors? _____

3. Click on the **Visible/Full** switch to magnify only the visible spectrum. You will see four peaks in the spectrum. If you drag your cursor over a peak, it will identify the wavelength (in nm) in the x-coordinate field in the bottom right corner of the detector window. Record the wavelengths of the four peaks in the visible hydrogen spectrum in the data table. (Round to whole numbers.)
4. The Rydberg equation has the form $\frac{1}{\lambda} = R_H \left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right)$ where λ is the wavelength in meters, R_H is the Rydberg constant, n_f is the final principal quantum (for the Balmer series, which is in the visible spectrum, $n_f = 2$), and n_i is the initial principal quantum number ($n = 3, 4, 5, 6, \dots$). Calculate from your experimental data the wavelength in meters and $1/\lambda$ in m^{-1} . Record your answers in the data table.

Data Table

	λ (nm)	λ (m)	$1/\lambda$ (m^{-1})
Line #1 (left)			
Line #2			
Line #3			
Line #4 (right)			

5. The formula for the determination of energy is $E = hv = hc/\lambda$ where h is Planck's constant and c is the speed of light. *What is the relationship between wavelength and energy?*



6. Of the four measured hydrogen spectrum lines recorded on the previous page, which line corresponds to the transition $n = 3$ to $n = 2$, and from $n = 4$ to $n = 2$, and so on from $n = 6$ to $n = 2$?

7. Calculate the value of $\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$ for the transitions $n = 6$ to $n = 2$, $n = 5$ to $n = 2$, $n = 4$ to $n = 2$ and $n = 3$ to $n = 2$. Match the values for these transitions and record them with the appropriate reciprocal wavelength in the results table.

Results Table

Transition n_i to n_f	$\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$	$1/\lambda$ (m^{-1})

8. The Rydberg equation, $\frac{1}{\lambda} = R_H \left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$, is in the form of $y = mx + b$ where $1/\lambda$ corresponds to y , $\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$ corresponds to x , and $b = 0$. If you plot $1/\lambda$ on the y -axis and $\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$ on the x -axis, the resulting slope will be the Rydberg constant, R_H .

Using a spreadsheet program or a piece of graph paper, plot your experimental data and determine the value of the Rydberg constant. _____

9. The accepted value for R_H is $1.0974 \times 10^7 \text{ m}^{-1}$.

Determine the % error using the formula:

$$\% \text{ Error} = \frac{|\text{your answer} - \text{accepted answer}|}{\text{accepted answer}} \times 100$$

% Error =