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Lab Partner _________________________________ Student ID # _______

CHEM 142 Experiment #1: Atomic Emission

Goals of this lab:

- Utilize a variety of instruments to take measurements of the atomic emission of hydrogen gas.
- Analyze the results from different measurement devices.
- Calculate the percent error of your measured values from known literature values
- Evaluate the different measurements and results and compare the advantages and disadvantages of each approach.
- Using experimentally determined values, predict future possible observations. Test the accuracy of these predictions and compare predicted values to observed results.
- Apply the concepts of atomic emission to the task of identifying unknown compounds.
- Appraise the accuracy of flame tests versus other identification methods. Recommend possible alternative methods for identifying unknowns. Defend this recommendation.

Your lab report will be graded on the following criteria using a poor/good/excellent rating system (see the Self-Assessment on the "Reporting Your Results for Exp #1" page of the lab website for more details):

- All calculations are clear and accurate, with proper use of significant figures, units, etc.
- Observations made in lab are careful and accurate. Unexpected or unusual results are repeated to ensure accuracy.
- Evaluations of measurement approaches are clear, well-structured, and supported with clear and reasonable arguments.
- Predictions and unknown identifications in the lab are reasonable given data gathered.
- The lab report is completed neatly with calculations shown in detail.

***Note: In-lab reports should be handwritten during the lab session on the hardcopy printout of the report template you are required bring with you to lab. Do not type or rewrite answers after the lab session into electronic versions of the report.*

By signing below, you certify that you have not falsified data, that you have not plagiarized any part of this lab report, and that all calculations and responses other than the reporting of raw data are your own independent work. Failure to sign this declaration will result in 5 points being deducted from your lab score.

Signature: ____

This lab is worth 60 points: 10 points for notebook pages, 50 points for the lab report
(Do NOT include your notebook pages when you scan your report for upload into Gradescope.)

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Part I.A.: Qualitative Observations and Spectroscope Measurements

1. Neatly transfer the data from your notebook to Table 1-1 for the three spectral lines of longest wavelength. Look carefully to see as many spectral lines as possible and record the wavelength, color, and qualitative intensity (dim, bright, very bright, etc.) of each line. You will complete the fourth column after Question 4.

Table 1-1. Hydrogen lamp emission lines from a spectroscope.

Color of hydrogen lamp emission	*Wavelength (nm)*	*Intensity (how bright?)*	*Calculated R_H value*

2. In Table 1-1, which electron transition (give the wavelength) represents the smallest change in energy? How do you know?

3. Since the hydrogen atomic emission lines that appear in the visible region of the spectrum represent a $n_f = 2$, what transition does your answer to #2 represent (show as $n_i \rightarrow n_f$)?

4. Using your data from Table 1-1 for the longest wavelength, calculate R_H (the Rydberg constant for hydrogen) in units of m^{-1}. Show your calculation clearly with correct units and significant figures.

5. Using the same type of calculation as in #4, complete the fourth column in Table 1-1. Find the average value of R_H from the data in Table 1-1.

Average R_H value from spectroscope measurements: $\boxed{}$

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Part I.B: Spectrophotometer Measurements of Hydrogen Emission and the Balmer-Rydberg equation

6. Now that we have an experimentally determined value for R_H, we can predict other emission lines that we were not able to observe with the limited scale of the spectroscope. For hydrogen, predict the wavelength (in nm) of the next unobserved transition.

7. Once you have calculated your predicted wavelength, check with your TA to see if you are on the right track. Your TA should initial your report before you continue with the rest of Part I.

TA initials: __________________

Let us now see if our calculations match experiment! Go back to the lab manual and complete the requested measurements.

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8. Neatly transfer the wavelength (λ) data from your notebook to Table 1-2, identify the n_i values, and provide the requested calculation results (all in decimal form, e.g., 1.250 instead of 1¼, with 4 sig figs). In your lab notebooknotes, show your calculations for $\frac{1}{\lambda}$ and $\frac{1}{n_i^2}$ for the longest recorded wavelength. *(Hint: for ease of plotting the data in Q13 provide the results of your 1/λ calculations in Table 1-2 using units of " x 10^{-3} nm^{-1}".)*

Table 1-2. Hydrogen lamp emission lines from a USB spectrometer.

λ *(nm)*	n_i	$\frac{1}{\lambda}$ (x 10^{-3} nm^{-1})	$\frac{1}{n_i^2}$

9. Does your wavelength prediction in Q6 match the experimental data you recorded?

10. The literature value for the longest visible-region spectral line for hydrogen is 656.3 nm. Calculate the percent error for your longest wavelength emission line for hydrogen recorded using the spectroscope and using the USB spectrophotometer.

$$\% \text{ error } = \frac{|x_{measured} - x_{literature}|}{x_{literature}} \times 100$$

Spectroscope	Spectrometer

11. Compare the two % error values you calculated in Q10 and give a reasonable explanation for any differences. Discuss, specifically, how the instruments you use differ in terms of accuracy.

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12. In Q4, you used the known n_f value and one of the recorded data points to determine the value of the Rydberg constant, R_H. Another approach would be to rearrange the Balmer-Rydberg equation into the equation of a line (*y* = *mx* + *b*) such that all of the wavelengths you recorded and the corresponding n_i values can be used to determine the value of R_H rather than relying on a single data point.

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

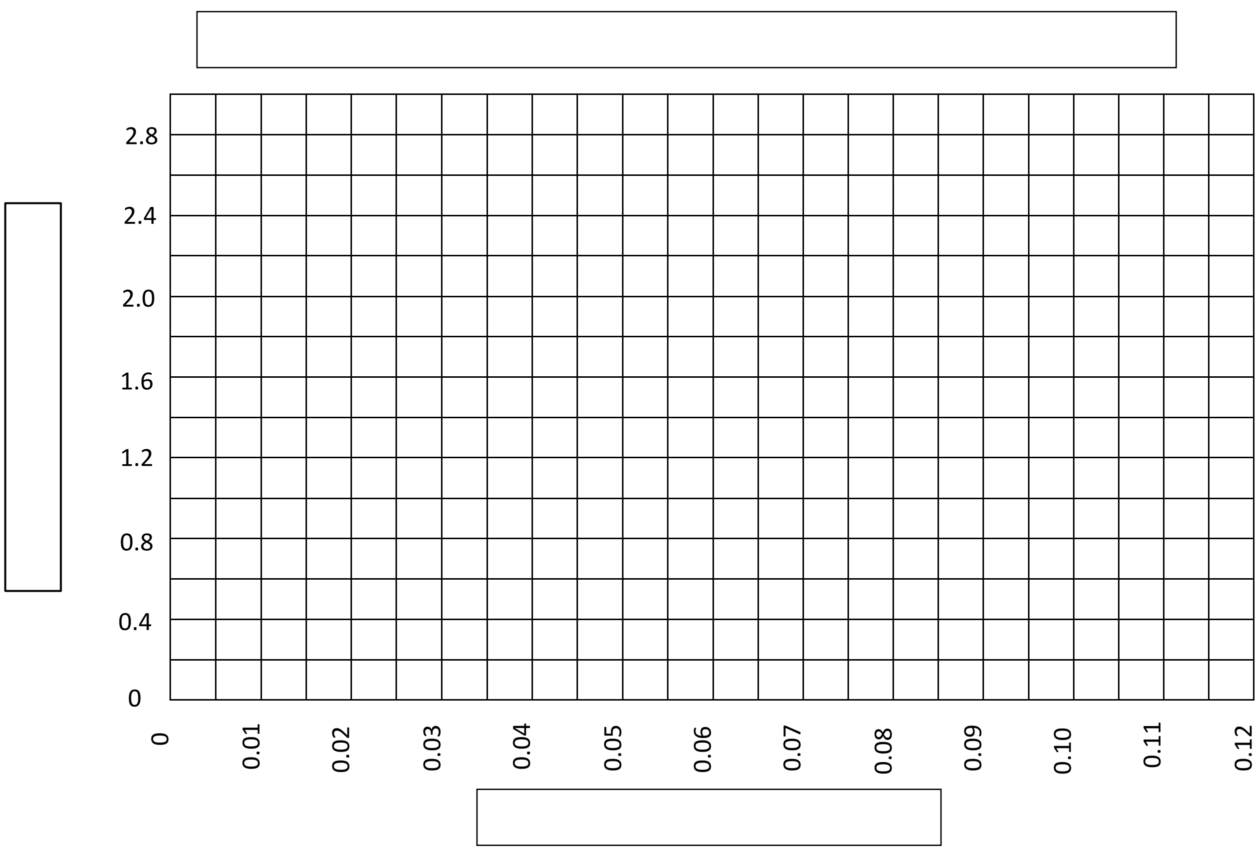
$$\frac{1}{\lambda} = -R_H\left(\frac{1}{n_i^2}\right) + \frac{R_H}{n_f^2}$$

Provide expressions for the data plotted on each axis, as well as the slope and y-intercept, both of which can be used independently to calculate the value of the Rydberg constant.

y-axis: __________________________ *x-axis*:______________________

slope: __________________________ *y-intercept*: _______________________

13. Create a hand-drawn plot your data from Table 1-2 using the graph paper below (use a straight-edge or ruler!). In the boxes provided, clearly label your axes and title the plot.



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14. Graphically determine the slope and y-intercept of your hand-drawn plot. (Remember: *slope = rise/run*). Calculate R_H (in m^{-1}) from the graphically determined slope and y-intercept. Show your data and calculations.

Graphically-determined slope: ______________________________

Graphically-determined y-intercept: _________________________

R_H from the *slope*:

R_H from the *y-intercept*:

Average R_H value from slope and intercept values: $\boxed{}$

15. Outside of the lab session, use Excel to create a plot of your data and record here the slope and y-intercept that Excel calculates for the trendline. (If necessary, format the trendline label to increase the number of significant digits visible.) You should NOT attach the graph.

What values are on the x-axis? ___________________

What values are on the y-axis? ___________________

slope from Excel: _______________________ R_H from the *slope*: ____________________

y-intercept from Excel: __________________ R_H from the *y-intercept*: ________________

Average R_H value from slope and intercept values: $\boxed{}$

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16. Record and compare the *three* average values you have determined for R_H with the literature value 1.097×10^7 m^{-1}. Show your work for the % error calculations.

Table 1-3. Experimentally determined R_H values and % Error.

Value of RH	% Error from literature value
R_H from Q5	
R_H from Q14 (hand-drawn plot)	
R_H from Q15 (Excel plot)	

17. Discuss benefits and drawbacks for the three approaches for determining an accurate value for R_H (i.e., single data point, slope of plot, y-intercept of plot). Which method would you recommend to someone hoping to get the most accurate value? Why?

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Part II: Observing atomic emission of metal salts with the flame test

18. Neatly transfer the data from your notebook to Table 1-4.

Table 1-4. Flame test results and observations.

Sample solution	*Color of solution*	*Color of flame*	*Metal ion responsible for color of flame*
$CuCl_2 \cdot H_2O$			
$BaCl_2$			
LiCl			
$SrCl_2$			
KCl			
KNO_3			
Unknown A			
Unknown B			
Unknown C			

19. Compare your results table with two other groups. Did all three groups reach consensus on these observations? If not, which ones were different? Why do you think they might have been different? (Be specific. "Human error" is not an acceptable answer.) Please provide the station numbers for the two groups you talked with to compare your results.

Your station #: _______ Comparison station: _______ Comparison station: _______

20. Suggest a better method for determining the identity of these unknown solutions. Why would it be better? Are there any disadvantages to using the method you recommend?