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Quiz Section Ax

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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.

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: _____

Wendy He

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.)

Part I.A.: Qualitative Observations and Spectroscopy 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 |
|---------------------------------|-----------------|-------------------------|----------------------------------|
| purple | 420 | bright | $1.1 \times 10^7 \text{ m}^{-1}$ |
| blue | 480 | very bright | $1.1 \times 10^7 \text{ m}^{-1}$ |
| red | 660 | very bright | $1.1 \times 10^7 \text{ m}^{-1}$ |

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

660 nm represent the smallest change in energy, because it has the longest wavelength with contain the smallest energy.

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 $n_i \rightarrow n_f$)?

$$n_i = 3 \rightarrow n_f = 2$$

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.

$$\frac{1}{660 \text{ nm}} = -R_H \left(\frac{1}{9} \right) + \left(\frac{R_H}{4} \right) \cdot 4.2 \times 10^7 \text{ m}^{-1} = -R_H \left(\frac{1}{25} - \frac{1}{4} \right)$$

$$\frac{1}{660 \text{ nm}} = -R_H \left(\frac{1}{9} - \frac{1}{4} \right)$$

$$4.2 \times 10^7 \text{ m}^{-1} = \frac{R_H \cdot 21}{100}$$

$$R_H = 1.1 \times 10^7 \text{ m}^{-1}$$

$$\frac{1}{6.6 \times 10^7 \text{ m}} = \frac{5R_H}{36}$$

$$R_H = 1.1 \times 10^7 \text{ m}^{-1}$$

$$\frac{1}{4.2 \times 10^7 \text{ m}} = -R_H \left(\frac{1}{36} - \frac{1}{4} \right) \quad R_H = 1.1 \times 10^7 \text{ m}^{-1}$$

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 spectroscopy measurements:

$$1.06 \times 10^7 \text{ m}^{-1}$$

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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 spectroscope. For hydrogen, predict the wavelength (in nm) of the next unobserved transition.

$$\frac{1}{\lambda} = -1.1 \times 10^7 \text{ m}^{-1} \left(\frac{1}{36} - \frac{1}{4} \right)$$

$$\lambda = 4.09 \times 10^{-7} \text{ m} = 4.09 \times 10^2 \text{ nm}$$

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: A.R

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., 1.25 instead of $1\frac{1}{4}$, with 3 sig figs). In your lab notebook, 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 $1/\lambda$ calculations with units of " $\times 10^{-3} \text{ nm}^{-1}$ ".)

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

| $\lambda \text{ (nm)}$ | n_i | $\frac{1}{\lambda} (\times 10^{-3} \text{ nm}^{-1})$ | $\frac{1}{n_i^2}$ |
|------------------------|-------|--|-------------------|
| 410.20 | 6 | 2.44 | 0.027 |
| 433.80 | 5 | 2.31 | 0.04 |
| 485.40 | 4 | 2.06 | 0.063 |
| 659.10 | 3 | 1.52 | 0.111 |

9. Do your wavelength predictions match the experimental data you recorded?

Yes, it matches

10. Calculate the percent error between the longest wavelength emission line for hydrogen recorded using the spectroscope to the corresponding signal measured with the USB spectrophotometer. Assume the wavelengths measured with the spectrometers are the known (i.e., "theoretical") values in your calculation.

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

$$\frac{|410.2 - 409.1|}{409.1} \times 100 = 0.27\%$$

11. Give a reasonable explanation for the % error you observe. Discuss, specifically, how the instruments you use differ in terms of accuracy.

Because I use the eye to estimate the data. the angle I saw it and the light inside the spectrometer is different. So the error happened.

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.

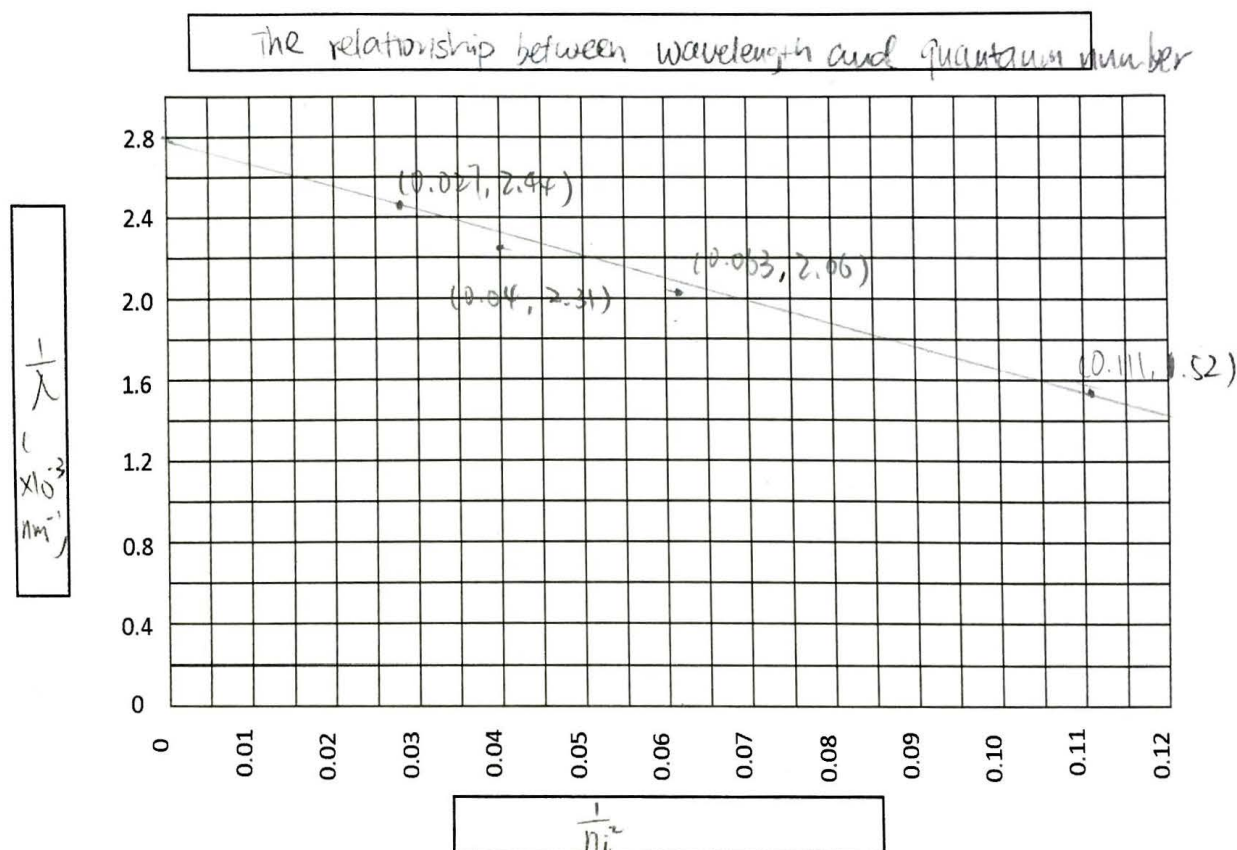
y-axis: $\frac{1}{\lambda}$

x-axis: $\frac{1}{n_i^2}$

slope: $-R_H$

y-intercept: $\frac{R_H}{n_f^2}$

13. Now plot your data from Table 1-2 using the graph paper below (use a straight-edge or ruler!). In the boxes provided, be sure to 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: $\text{slope} = \text{rise/run}$). Calculate R_H (in m^{-1}) from the graphically determined slope and y-intercept. Show your data and calculations.

$$m = \frac{(1.52 - 2.44)}{(0.111 - 0.027)} = -1.095$$

Graphically-determined slope: $-1.095 \times 10^7 \text{ m}^{-1}$ Graphically-determined y-intercept: $2.8 \times 10^{-3} \text{ nm}^{-1}$

$$0x + y = 2.8$$

 R_H from the slope:

$$R_H = 1.095 \times 10^7$$

$$\frac{(2.31 - 2.44)}{0.04 - 0.027} = -1.0 \times 10^7 \text{ m}^{-1}$$

$$\frac{2.06 - 2.31}{0.063 - 0.04} = -1.87 \times 10^7 \text{ m}^{-1}$$

$$\frac{1.52 - 2.06}{0.111 - 0.04} = -0.761 \times 10^7 \text{ m}^{-1}$$

 R_H from the y-intercept:

$$\frac{1}{410.2} = 0x + \frac{R_H}{4} \quad R_H = 9.75 \times 10^{-3}$$

Average R_H value from slope and intercept values:

$$R_H = 0.932 \times 10^7 \text{ m}^{-1}$$

15. Outside of lab, use Excel to create a plot of your data and record here the slope and y-intercept that Excel calculates for the trendline.

What values are on the x-axis? $\frac{1}{n^2}$ What values are on the y-axis? $\frac{1}{\lambda}$ slope from Excel: $-1.1004 \times 10^7 \text{ m}^{-1}$ R_H from the slope: 1.1004y-intercept from Excel: 2.7455 R_H from the y-intercept: 9.75×10^{-3} Average R_H value from slope and intercept values:

$$R_H = 1.10 \times 10^7 \text{ m}^{-1}$$

16. Record and compare the *three* average values you have determined for R_H with the literature value $1.097 \times 10^7 \text{ m}^{-1}$. Show your work for the % error calculations. $\% \text{ error} = \frac{|X_{\text{measured}} - X_{\text{theoretical}}|}{X_{\text{theoretical}}} \times 100$

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

| Value of R_H | % Error from literature value |
|----------------------------------|--|
| R_H from Q5 | $\frac{ 1.06 \times 10^7 - 1.097 \times 10^7 }{1.097 \times 10^7 \text{ m}^{-1}} \times 100$ $= -3.37\%$ |
| R_H from Q14 (hand-drawn plot) | $\frac{ 0.932 \times 10^7 - 1.097 \times 10^7 }{1.097 \times 10^7 \text{ m}^{-1}} \times 100$ $= -15.04\%$ |
| R_H from Q15 (Excel plot) | $\frac{ 1.10 \times 10^7 - 1.097 \times 10^7 }{1.097 \times 10^7 \text{ m}^{-1}} \times 100$ $= 0.27\%$ |

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?

The benefits in Q5 is students can see the different color line on a ruler directly. the drawback is the angle you see might affect the data recorded. The benefit in Q14 is you can find the average number that will minimize the difference in data. the drawback is the line of best fit is not hundred percent accurate and the data only close to actual number. The benefit on Q15 is that computer has a specific way to calculate the slope and y-intercept. the drawback is the data you put in need careful look that might affect the final result. I recommend the third method because the computer will always have the most accurate data.

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.

| Metal salt | Color of aqueous solution | Color of flame | Ion responsible for color of flame |
|-------------------|---------------------------|----------------|------------------------------------|
| CuCl ₂ | light blue | blue green | Cu ²⁺ |
| BaCl ₂ | white | light green | Ba ²⁺ |
| LiCl | light yellow | bright red | Li ⁺ |
| SrCl ₂ | creamy light yellow | orange | Sr ²⁺ |
| KCl | light yellow | light purple | K ⁺ |
| KNO ₃ | yellow | purple | K ⁺ |
| Unknown A | blue | green | Cu ²⁺ |
| Unknown B | blue | red green | Cu ²⁺ , Li ⁺ |
| Unknown C | yellow | purple | K ⁺ |

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.

We did not in the same sense about the flame color about unknown B. station 1 saw a red, green and purple color. our group did not see the purple the reason might be the time we put into the flame is not long enough, so we did not observe the purple change.

Your station #: 4 Comparison station: 1 Comparison station: 3

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?

I think we can use the Metal activity order list to find the element, if we assume unknown A has Cu²⁺ in it because the solution is blue, then we can put iron metal into the solution and see whether it has precipitate formed. The disadvantage of this method is it's time consuming and need really carefully and accurate record. so the error using this experiment might bigger than test color directly.