EXPERIMENT STUDY NOTES: BALMER LINES & RYDBERG CONSTANT

1. Objective

To study the visible spectral lines of hydrogen, calculate the Rydberg constant, and compare it with the theoretical value (1.097×10^7 m^{-1}).

2. Theory

When an atom is given energy, its electrons get excited to higher states. When falling back to lower states, the atom emits photons. The Balmer series involves transitions where the final state is $n_f = 2$, which produces photons in the visible light spectrum.

The Rydberg Formula

The wavelengths of the spectral lines for the Balmer series of hydrogen are given by:

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

where λ is the wavelength, R is the Rydberg constant, n_i is the initial state (3 for Red, 4 for Blue-Green, 5 for Violet), and n_f is the final state (always 2 for Balmer series).

Diffraction Grating

A diffraction grating diffracts incoming light into various orders. We will observe the first-order ($m = 1$) spectrum. The diffraction angle (θ) is related to the wavelength by:

$$d \sin\theta = m\lambda \tag{2}$$

where d is the spacing between the slits on the grating. For a grating with 600 lines/mm, $d = \frac{1}{600}$ mm.

3. How to Read the Spectrometer Angle

Reading the exact angle from the spectrometer requires combining the main (outer) scale and the precision (inner) scale.

1. **Main Scale Reading:** Find where the zero of the inner scale points on the outer scale. Note the value just before the zero mark (e.g., 12.5°).
2. **Precision Scale Reading:** Find the exact line on the outer scale that perfectly aligns with a line on the inner scale. Note the value from the outer scale (e.g., 15).
3. **Calculation:** The outer scale divides 0.5° into 30 divisions (meaning 1 division = 1/60 degree). Add the precision reading divided by 60 to your main reading.
4. *Example Calculation:* $12.5° + \frac{15}{60}° = 12.75°$.

4. Experimental Procedure

1. Switch on the power supply to the hydrogen discharge tube and observe the visible spectral lines through the spectrometer.
2. Measure the diffraction angles for the first-order spectral lines corresponding to the Red, Blue-Green, and Violet lines.
3. For better accuracy, read the angle from both the left (θ_L) and right (θ_R) sides of the central maximum, and calculate the average (θ_{avg}).
4. Use the diffraction formula to calculate the wavelengths of the observed lines.
5. Calculate the Rydberg constant R using the measured wavelengths and the Rydberg formula for each color.
6. Find the average calculated R and compute the percentage error against the theoretical value.

Important Notes for Your Applied Exam

How to prepare for the lab session:

- **Formulas are Provided:** You do not need to memorize the formulas or constants. A **Reference Formulas** box will be provided at the top of your exam paper.
- **Data Sheet Grading:** You will be graded directly on the accuracy of your readings, sig figs, units, and your calculations shown on the Extra Sheet.