### University of Arizona

# Materials Science and Engineering

## MSE 110: Solid State Chemistry

##### Atomic Spectra and Balmer’s Experiment

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#### Atomic Spectra and Balmer’s Experiment

**Introduction**

For the Atomic Spectra and Balmer’s Experiment lab, our goal was to identify the atomic spectrum of Helium and Hydrogen through their respective discharge lamps and a spectrometer. The purpose behind this experiment was to develop an understanding of De Broglie’s principle of particles, and how they have quantum behavior under the correct circumstances, those being of small mass and having a high velocity. Measuring the atomic spectrum also gives us information as to the photons emitted by an atom and the various energy levels present in a respective atom e.g. 3, 4, 5… From the data collected by the spectrometer, Rydberg’s constant can be derived to give us an equation of the following:

The Rydberg constant produces a quantitative value of the difference in energy levels that results in the wavenumber for the different energy levels. The whole idea behind finding these respective energy levels is to determine where their electrons exist and on what wavelength/wavenumber. This then tells us how much energy is being produced when the electron jumps from one level down to another. We can then determine other values like frequency, intensity, etc.

###### Experimental Procedure

1. Two discharge lamps: helium and hydrogen.
2. Use a spectrometer and hold the end about an inch away from the lamp.
3. Record data using Spectrometer software.
4. Export data to Excel.
5. Find six highest peaks for helium and three highest for hydrogen.

###### Experimental Results

|  |  |  |  |
| --- | --- | --- | --- |
| **Wavelength(nm)** | **Wavelength (m)** | **Energy Resolution (Joules)** | **Energy Resolution (eV)** |
| 389 | 0.0000389 | 5.11E-21 | 0.0319 |
| 447 | 0.0000447 | 4.45E-21 | 0.0277 |
| 502 | 0.0000502 | 3.96E-21 | 0.0247 |
| 588 | 0.0000588 | 3.38E-21 | 0.0211 |
| 668 | 0.0000668 | 2.98E-21 | 0.0186 |
| 707 | 0.0000707 | 2.81E-21 | 0.0175 |
| 400 | 0.00004 | 4.97E-21 | 0.031 |
| 800 | 0.00008 | 2.48E-21 | 0.0155 |

Table above are the values calculated for Helium. Data includes the energy resolution at each wavelength in Joules and eV, as well as each of the wavelengths where the highest peaks were. This was calculated through the following equation:

Where h is Planck’s constant: 6.626x10^34, c is the speed of light: 3x10^8. To convert Joules to eV, a constant of 6.24x10^18 was used.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Wavelength (m)** | **Energy Level** | **1 / lambda** | **(1/4 - 1/n^2)** | **Rydberg Constant** |
| 6.57E-07 | 3 | 1522070.015 | 0.138888889 | 10958904.11 |
| 4.86E-07 | 4 | 2057613.169 | 0.1875 | 10973936.9 |
| 4.34E-07 | 5 | 2304147.465 | 0.21 | 10972130.79 |

Table above includes data collected and calculated for Hydrogen. Included data: three highest peaks, their respective energy level, and using the formula stated earlier in the Introduction, the wavenumber, and Rydberg’s constant.

###### Discussion and Conclusions

The data collected was within reasonable error of the wavelength resolution shown on the spectrometer. For example, Rydberg’s constant was fairly close for all three levels calculated, showing that it was fairly accurate, however, there was some error in either the calculation or collection of data that threw it off and did not get precise results across the board. For calculation, the numbers might have been rounded off early, and for the data collecting, our wavenumber/wavelength might be inaccurate as it was difficult to capture the best possible data due to how finicky the software was. For Helium, comparing the results collected with the table from NIST, we see that the data collected was off by +- 0.5 for all the highest peaks. This is reasonable enough to account for the fact that when recording the data, the only way possible to get a quick snapshot of the data was to rely on human reflexes to capture and pause the data at the right time. This obviously took several tries and involved adjusting several settings to determine whether or not the data was reliable enough to use.

From the data collected, it is plausible to determine that we have somewhat proved De Broglie’s principle by showing that there are electrons that exist on different levels, and when prompted, there is an energy discharge when they travel from one energy level down to another. This is shown by the intensity vs. wavelength graphs where the peaks correspond to the energy produced and the respective wavelengths that this occurs at corresponds to the various energy levels as shown in the tables above.