REDACTED STUDENT NAME

CHEM 3615

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Joule-Thomson Coefficient of Carbon Dioxide

**Introduction**

For ideal gases enthalpy is dependent on temperature. Under constant temperature conditions chemists can calculate the energy of a gas. For this to work the gas must also expand adiabatically without doing work. Ideal gases under these conditions exhibit no change in internal energy. Non-ideal gases however, do not be in the same fashion. When a real gas under go adiabatic expansion, there happens to be a small change in temperature. Using an insulated set up with a porous plug to allow equilibration of the gas, and keeping a constant enthalpy the change in temperature over pressure gives us what is called the Joule-Thomson coefficient. This coefficient is very helpful in understanding the behaviors of real gases.

**Methods**

The first step was to set the correct configurations for Capstone and calibrate the temperature probes. With this setup we were able to record the change in temperature and pressure of Carbon Dioxide running through the apparatus. With the CO2 tank connected to the apparatus and the temperature probes on each side of the porous plug, the apparatus was flushed clean from the atmospheric gases. Then we started recording the data from different pressures. In our specific lab we had issues with the Capstone program and didn’t not have correct measurement quantities. We needed to measure small changes in temperature, but the program was set to measure larger differences, and was not sensitive enough to record accurate changes. The data was collected from 4.2 atm down to 0.4 atm in about intervals of 1 atm. In the data used (provided by Dr. Rowley) for calculations the starting point was 2.15 atm, decreased at intervals of 0.5 down to 0.51 atm.

**Results**

Starting from the top range of values down to the bottom values an average was taken at every 0.5 difference giving values seen in **table 1**

**Table 1**

|  |  |
| --- | --- |
| Temperature (K) | Pressure (Bar) |
| -1.650 | -2.326 |
| -0.930 | -1.493 |
| -0.639 | -1.023 |
| -0.304 | -0.511 |

Then plotting the line between these points we get a slope of change in temperature (K) over change in pressure (bar). The slope is equal to the Joule-Thomson Coefficient; seen in **graph 1.**

**Graph 1**

This plot gives an experimental Joule-Thomson coefficient of 0.741. To compare the accuracy of the experiment the coefficient was also calculated with Van Der Waals constants and **equation 1.**

With this equation the Joule-Thomson coefficient came out to be 0.908. Which is different from the experimental value. There is a point in this experiment where if we began to increase the temperature the Joule-Thomson coefficient would be negative, the point at this temperature is called the inversion temperature and can be calculated with **equation 2.**

Using this equation, we get a value of 2051K. This is the temperature at which the JT coefficient becomes a negative value.

**Conclusion**

From this experiment we worked with real gases and found the Joule-Thomson coefficient. The comparisons from calculated, experimental, and literature values can be seen in **table 2**

**Table 2**

|  |  |  |
| --- | --- | --- |
| JT coefficient (K/bar) | Calculated JT (K/bar) | Lit Value (K/bar) |
| 0.7408 | 0.9083 | 1.091 |

The experimental value varied significantly from the calculated and literature values. The original values that our lab obtained were off because of equipment and operator errors. For the second set of data received there could have been the same errors but that is just speculation. All the questions to the lab was answered in the methods section. This was a great lab that helped us understand behaviors of real gases that expand adiabatically.

**References**

(1) Roebuck, J. R., Murrell, T. A., and Miller, E. E. (1942) The Joule-Thomson Effect in Carbon Dioxide. *J. Am. Chem. Soc.* *64*, 400–411.