Lab 1 – Determination of Heat Capacity Ratios by the sound velocity method

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# Sample Calculations

1. Relating the heat capacity ratio *γ* to the speed of sound, *c*, in a particular gas with bulk modulus *B*, and molar mass *M*:
   1. . Since ,
   2. Squaring both sides yields
   3. From the ideal gas law , . Therefore,
   4. Rearranging gives
   5. Rearrange the definition of equilibrium density to , and substitute this relationship back into the previous equation to yield
2. Calculating the time it took sound to travel through a tube of Argon and then using that to determine the heat capacity ratio:
3. Value of for CH2FCF3 assuming no vibrational contribution:
4. Value of for CH2FCF3 given full vibrational contribution:
5. Value of for Ar from theoretical Cv and Cp from literature4
   1. Cp = 20.79
   2. Cv =

# Error Analysis

1. Population mean confidence interval for Δt, the time it took sound to travel from the aluminum membrane to the detector through CO2,
   1. from analysis.py
   2. from analysis.py
   3. from the lookup table with 4 degrees of freedom

# Data and Results

1. Measured quantities:
   1. Tube length = (104.5 ± 0.2) cm
   2. Room temperature = (23.0 ± 0.2) cm
2. The following table lists 95% confidence intervals for the time it took sound to travel from the aluminum membrane to the detector through the various gaseous media:

|  |  |
| --- | --- |
| Gas | Δt |
| CH2FCF3 | (6.0 ± 0.24) ms |
| CO2 | (3.83 ± 0.07) ms |
| Air | (3.12 ± 0) ms |
| Ar | (3.26 ± 0.08) ms |
| N2 | (3.1 ± 0) ms |
| He | (1.09 ± 0.014) ms |

1. The following table lists the sound velocity and heat capacity ratios for each gas. Note: there would normally be uncertainties associated with these data, but those were not included.

|  |  |
| --- | --- |
| Gas |  |
| CH2FCF3 | 1.26 |
| CO2 | 1.33 |
| Air | 1.23 |
| Ar | 1.67 |
| N2 | 1.29 |
| He | 1.49 |

1. The following table lists theoretical values for with and without vibrational contributions:

|  |  |  |
| --- | --- | --- |
| Gas | With Vibrational Contribution | Without Vibrational Contribution |
| He | 1.67 | 1.67 |
| CH2FCF3 | 1.08 | 1.33 |
| CO2 | 1.22 | 1.4 |
| N2 | 1.33 | 1.4 |
| Ar | 1.67 | 1.67 |

1. The following table lists Cp values from literature3,4 and calculated values for :

|  |  |  |  |
| --- | --- | --- | --- |
| Gas | Cp () | Cv () |  |
| Ar | 20.79 | 12.471 | 1.67 |
| CH2FCF3 | 84.56 | 99.768 | 0.85 |
| CO2 | 37.03 | 37.413 | 0.99 |
| N2 | 29.12 | 24.942 | 1.17 |
| He | 20.79 | 12.471 | 1.67 |

# References

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