**Experiment 1:**

Kinetic Theory of Gasses

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**Purpose**: The purpose of this lab is to experiment and explore with a simulator and see the relationships involved with the Ideal Gas Law and translational kinetic energy. Specifically, the Boltzmann Constant and Gas Constant will be calculated from mass, pressure, volume, and temperature.

**Data**:

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Number of Particles (N)** | **Pressure** | **Temp.** | **Width** | **Pressure** | **Volume** | **Boltzmann** | **Average KE** | **Gas Constant** | **Blue (Heavy)** |
| **P (atm)** | **T (K)** | **W (nm)** | **P (Pa)** | **V (m3)** | **kB (J/K)** | **KAvg (J)** | **R (J/mol-K)** | **Average** |
| 1000 | 84.6 | 325 | 15.0 | 8.57E+06 | 5.250E-25 | 1.3847E-23 | 6.7505E-21 | 8.3360E+00 | 8.305919245 |
| 900 | 84.6 | 332 | 13.8 | 8.57E+06 | 4.830E-25 | 1.3856E-23 | 6.9005E-21 | 8.3416E+00 | **Std. Deviation** |
| 800 | 84.6 | 338 | 12.4 | 8.57E+06 | 4.340E-25 | 1.3758E-23 | 6.9755E-21 | 8.2826E+00 | 0.033223770 |
| 700 | 84.6 | 339 | 10.9 | 8.57E+06 | 3.815E-25 | 1.3781E-23 | 7.0077E-21 | 8.2962E+00 | **Standard Error** |
| 600 | 84.6 | 340 | 9.4 | 8.57E+06 | 3.290E-25 | 1.3825E-23 | 7.0505E-21 | 8.3224E+00 | 0.013563547 |
| 500 | 84.6 | 350 | 8.0 | 8.57E+06 | 2.800E-25 | 1.3715E-23 | 7.2006E-21 | 8.2566E+00 | **%-Difference** |
|  |  |  |  |  |  |  |  |  | 0.000491066 |

Table 1: Heavy particle data

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Number of Particles (N)** | **Pressure** | **Temp.** | **Width** | **Pressure** | **Volume** | **Boltzmann** | **Average KE** | **Gas Constant** | **Blue (Heavy)** |
| **P (atm)** | **T (K)** | **W (nm)** | **P (Pa)** | **V (m3)** | **kB (J/K)** | **KAvg (J)** | **R (J/mol-K)** | **Average** |
| 1000 | 76.9 | 296 | 15.0 | 7791892.5 | 5.250E-25 | 1.3820E-23 | 6.1361E-21 | 8.3197E+00 | 8.328425381 |
| 900 | 76.9 | 300 | 13.9 | 7791892.5 | 4.865E-25 | 1.4040E-23 | 6.3179E-21 | 8.4520E+00 | **Std. Deviation** |
| 800 | 76.9 | 301 | 12.2 | 7791892.5 | 4.270E-25 | 1.3817E-23 | 6.2384E-21 | 8.3178E+00 | 0.069877798 |
| 700 | 76.9 | 292 | 10.4 | 7791892.5 | 3.640E-25 | 1.3876E-23 | 6.0777E-21 | 8.3533E+00 | **Standard Error** |
| 600 | 76.9 | 298 | 9.0 | 7791892.5 | 3.150E-25 | 1.3727E-23 | 6.1361E-21 | 8.2639E+00 | 0.028527492 |
| 500 | 76.9 | 298 | 7.5 | 7791892.5 | 2.625E-25 | 1.3727E-23 | 6.1361E-21 | 8.2639E+00 | **%-Difference** |
|  |  |  |  |  |  |  |  |  | 0.002217254 |

Table 2: Light particle data

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Number of Particles (N)** | **Pressure** | **Temp.** | **Width** | **Pressure** | **Volume** | **Boltzmann** | **Average KE** | **Gas Constant** | **Particle Type? (Light/Heavy)** |
| **P (atm)** | **T (K)** | **W (nm)** | **P (Pa)** | **V (m3)** | **kB (J/K)** | **KAvg (J)** | **R (J/mol-K)** |
| 700 | 55.6 | 307 | 15.0 | 5633670 | 5.250E-25 | 1.3763E-23 | 6.3379E-21 | 8.2853E+00 | Heavy |
| 600 | 48.0 | 307 | 15.0 | 4863600 | 5.250E-25 | 1.3862E-23 | 6.3835E-21 | 8.3450E+00 | Heavy |
| 500 | 40.0 | 307 | 15.0 | 4053000 | 5.250E-25 | 1.3862E-23 | 6.3835E-21 | 8.3450E+00 | Heavy |
| 400 | 32.0 | 307 | 15.0 | 3242400 | 5.250E-25 | 1.3862E-23 | 6.3835E-21 | 8.3450E+00 | Heavy |
| 300 | 23.7 | 307 | 15.0 | 2401402.5 | 5.250E-25 | 1.3689E-23 | 6.3037E-21 | 8.2406E+00 | Heavy |
| 200 | 15.9 | 307 | 15.0 | 1611067.5 | 5.250E-25 | 1.3775E-23 | 6.3436E-21 | 8.2928E+00 | Heavy |

Table 3: Heavy particle data with held temperature

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Height (m)** | **Depth (m)** | **Conversion** |  | **Accepted Values** | |  | KE |
| 4.00E-09 | 8.75E-09 | 1 atm = |  | **kb (J/K)** | 1.38E-23 |  | 6.9809E-21 |
|  |  | 101,325 |  | **R (J/mol-K)** | 8.31E+00 |  |  |
| **Area (m2)** | 3.50E-17 | Pascals (Pa) | | **NA (--)** | 6.02E+23 |  |  |
|  |  | 1 AMU= |  |  |  |  |  |
|  |  | 1.66E-27 |  |  |  |  |  |
|  |  | kg |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
|  |  | 1nm -> m | 1E-09 |  |  |  |  |

Table 4: Constants and other reference information

**Calculations**:

**Discussion**:

From collection of pressure, temperature, and volume measurements, and controlling the number of particles in the simulation, accurate readings were collected to calculate the Gas Constant. Using averaging functions, the value of R was found to be 8.305 J/mol-K experimentally, with an error of 0.0136. This is quite close to the accepted value of the 8.31, there is only a .0005% difference. This is expected since it is a simulation.

The experimental data passes the precision accuracy test, so the data is reliable. There is minimal error source, measurements are of computerized data so it is all extremely precise and accurate.

**Conclusion & results**:

Rexp = 8.31 +- 0.01 J/mol-K

%diff = 0.0005%

With a percent difference of only 1% the results of the experiment are reliable. The experimental results line up with the expected values. Most values were predictable and are well within expected boundaries. Any error was overall negligible for this reason. I would not have expected there to be much error involved due to the nature of the experiment being run via computer code the data should be random error free, the only source for systematic error is how many digits are displayed on the simulation’s readings.

**Questions**:

1.) They are close together which is exactly expected, R should be a constant

2a.) Temperature is a measurement of motion of particles. At zero kelvin there is no motion.

2b.) As the temperature rose so did the pressure, the container was not strong enough to withstand all the pressure and “burst”.

3a.) Kavg,heavy = 6.9442E-21 J

Kavg,light = 6.9442E-21 J

These values are the same, and that shows the mass of the particles doesn’t have an impact on this property.

3b.)