

Ideal Gas Law at Constant Temperature (Simulation)

Purpose:

We will study the behavior of gas and compare with the Ideal Gas Law $PV=NkT$.

Useful Information:

$1\text{atm}\approx 10^5\text{Pa}$, $k = 1.38\times 10^{-23}\text{J/K}$

Procedure:

1. Google “PhET” and click on the first search result. This should take you to the homepage of the Physics Education Technology. Alternatively you can enter the following address to the web browser directly:
<http://www.colorado.edu/physics/phet/web-pages/index.html>
2. Click on “Simulations” and then choose from the tabs on the left “Heat & Thermo”. Scroll down to the “Gas Properties” simulation, double click it to start the program.
3. Click on “Measurement Tools” on the right and select “Layer tool”, “Ruler” and “Species information”.
4. Play with the simulation a little to get a feeling of what it does. Note that you can select either heavy or light species of gas from the pump. At the end you can click the “Reset” button at the bottom to start again.

Constant Pressure:

1. Under “Constant Parameter” on the right, select “Temperature”. This will keep the temperature of the box fixed.
2. Pump in some particles of both types. Record the temperature T and the number of total number of particles N_{total} in Table 1 below using the information on the right column of the program. We will keep the number of particles the same in all the cases below.
3. Record the volume and pressure in Table 2 below. Next try different volume by compressing or expanding the box to complete the table. In computing the volume ($width \times height \times depth$), you may use the assumption that the depth of the box is 250nm and the height is 5.3nm . The width of the box can be measured directly from the simulation.

Table 1

$N_{light} =$	$N_{heavy} =$
$N_{total} =$	

Table 2

$T =$			
Width (nm)	Volume (10^{-24}m^3)	Pressure (atm)	1/Pressure (atm^{-1})

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4. After completing Table 2, choose “None” under “Constant Parameter”. Add or remove some heat to change the temperature. If the number of particles has changed due to leaking, add some more to restore the number to the case before. Select “Temperature” under “Constant Parameter” after the changes are made.

5. Repeat step 3 and 4 to complete all the tables below for different temperatures. Remember to keep the number of particles fixed.

Table 3

$T =$			
Width (nm)	Volume ($10^{-24}m^3$)	Pressure (atm)	1/Pressure (atm^{-1})

Table 4

$T =$			
Width (nm)	Volume ($10^{-24}m^3$)	Pressure (atm)	1/Pressure (atm^{-1})

Table 5

$T =$			
Width (nm)	Volume ($10^{-24}m^3$)	Pressure (atm)	1/Pressure (atm^{-1})

Data Analysis:

1. Plot the 4 sets of data on the same P vs V graph. In this graph you want to pick the option in the beginning that connects all the points with a smooth curve (they will not line up in a straight line here). Do not forget to write on the graph the units of the x and y axes. Label clearly on the graph which curve corresponds to each table. Which has the highest temperature? Which has the lowest?

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2. Plot the 4 sets of data on the same V vs $(1/P)$ graph. Label clearly on the graph which line corresponds to each table. We expect the data to line up on a straight line this time, so add the trendline at the end to find the slopes.
3. Find the slope for each line. What is the unit of the slope?
4. Convert the unit of the slope to $m^3 Pa = J$, using the fact that $1 atm \approx 10^5 Pa$.
5. Use $PV = NkT$ and the slope to compute the Boltzmann's constant for each line. Are your values close to the true value?
6. If I increase N_{total} , what will happen to the slope of the lines?