Gas Pressure and Volume Relationships*

MoLE Activities

To begin this assignment you must be able to log on to the Internet (the software requires OSX for mac users). Type the following address into the location-input line of your browser:

http://introchem.chem.okstate.edu/DCICLA/GLHeNeAr.htm

This will load the Gas Simulation. Once you have the simulation running your screen will look like what is shown in left hand section of Figure I. below.
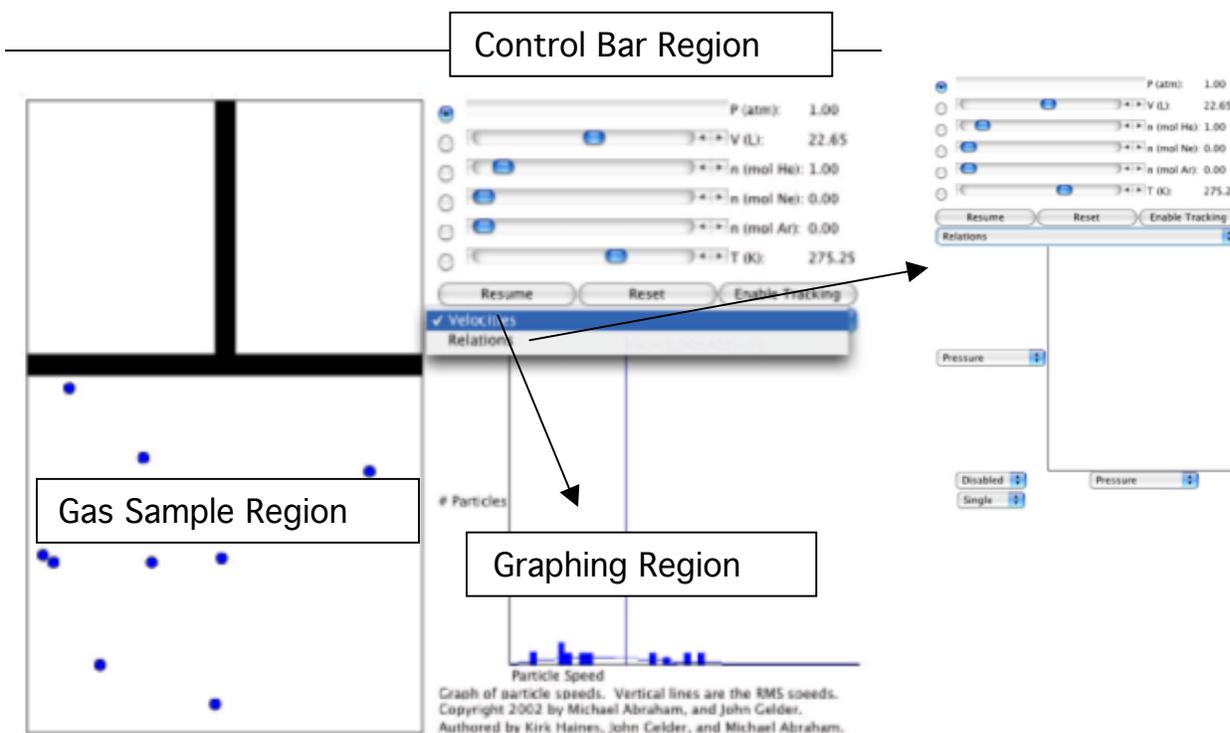

Figure I.

There are three important regions that require some discussion. The Gas Sample Region has the most activity. It is a container with a plunger. To explore the behavior of the gas sample you can change the variables located in the Control Bar Region. The Control Bar Region shows five scrollbars: pressure (in units of atmospheres), volume (in units of liters), mol of gas (one for

He gas one for Ne gas, and the other for Ar gas), and temperature (in units of Kelvins). To the left of each scrollbar is a radio button. When selected, that particular variable (called the dependent variable) is calculated based on the value of the other four variables. In the default mode the pressure scrollbar's radio button is selected so the pressure of the gas sample is calculated.

As a simple exploration try moving each of the scrollbars and observe the effect on the gas sample. These effects will be addressed in more detail in this experiment.

There are three buttons immediately below the Control Bar Region. The Pause button will suspend the motion in the gas sample, the Reset button returns the program to the default conditions, and the Enable Tracking button turns a red tracking line on and off.

Below the Pause Button is a fourth button different from the previous three in that it is a dropdown menu. Clicking and holding the mouse button will reveal two choices: Velocities (default), and Relations (graphing).
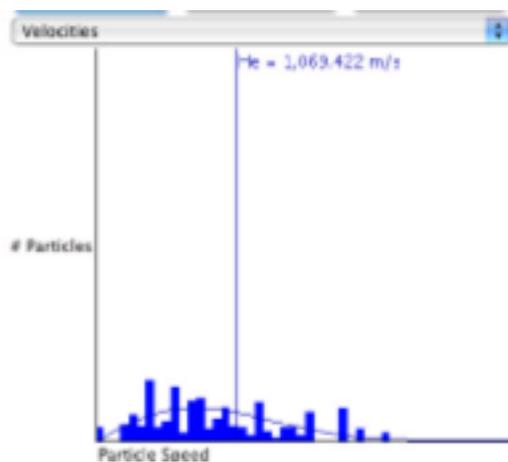

Figure II.

The default mode is Velocities. The Speed Distribution Region shows a plot of the speed distribution in the gas sample (see Figure II.). The y-axis of this plot represents the number of particles. The x-axis represents the range of velocities starting at zero. The bars in this plot represent the velocities of the particles in the Gas Sample Region. As the velocities of the particles change, the plot is redrawn. The smooth curved line in the plot represents the ideal distribution of the velocities for the gas sample. A vertical line represents the average (root-mean-square average) speed of the sample. This line is the same color as the particles. Observe the behavior of this region while changing each of the variables in the Control Bar Region. If you click on the Enable Tracking button, you can follow the path of a particle in the Gas Sample Region. The length of the tail represents a fixed unit of time, and consequently can be used as a measure of the speed of the particle. This same particle is identified as a red line, labeled with the actual speed (in meters/second), in the speed distribution plot. If you pause the motion of the particles, you can click on different particles to get a measure of their speeds.

A second choice from the drop down menu is the Relations view. This choice reveals an xy graph with a dropdown menu on each axis. Selecting the dropdown menu on either axis provides a list of the variables shown in the Control Bar Region. The two buttons, Enable and

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Multiple are used when plotting pairs of variables. If you select pressure for the y-axis and volume for the x-axis, and then select "Enable," these same variables are activated in the Control Bar Region. By scrolling the volume slide bar in the Control Bar Region you will trace out a plot that will look similar to Figure III.
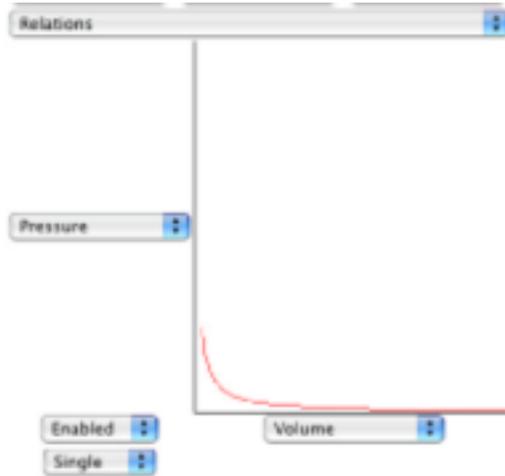

Figure III.

The Multiple Button allows two or more plots to be superimposed. Select Pressure and Volume as the variable to be plotted on your graph. Then select the Multiple button and adjust the temperature to 400 K. Select the Enable button and scroll the Volume slide bar. Select the Disable button and change the temperature to 200 K. Select the Enable button and scroll the Volume slide bar. Repeat this process for the minimum temperature. You will see a graph that looks similar to Figure IV.
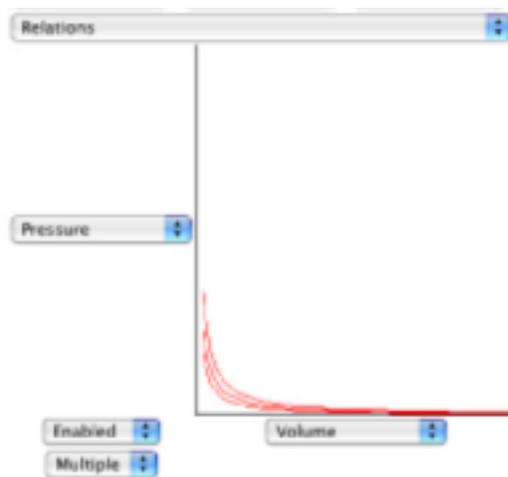

Figure IV.

Got the hang of it? If you have any questions check with another student in the class, your instructor.

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Gas Pressure and Volume Relationships

Name_____   Lab Section_____

Problem Statement: How are the pressure and volume of a gas sample related?

I. Data Collection:

    A. Open the Gas Law Simulation program and observe and describe, in the space below, the activity in the Gas Sample window. Consider using some or all of the following terms in your description: particles, atoms, molecules, collisions, speed, energy, force.

    B. Adjust the amount of helium in the Gas Sample Window to three or four particles and enable the tracking function and trace the path of a particle from one side of the screen to the other in the box below. Explain any changes in speed or direction that you observe.

    Explanation:

C. Record the values for pressure, volume and temperature on the digital read-outs of the Control Bar window.

D. Observe the action in the Speed Distribution window. Relate what you see with the behavior of the objects in the Gas Sample window.

Click the Pause button and sketch and label the graph in the space below.

E. Using the controls in the Control Bar window, fix Pressure as a dependent variable by clicking on its radio button. Change the volume of the container using the Volume slider bar and observe what happens to the pressure of the system as the number of moles of gas and temperature of the gas are held constant.
i) Describe your observation about the relationship of pressure and volume. Also describe the behavior of the particles in the container as you change the Volume slidebar.

ii) While changing the Volume sliderbar how is the average speed of the particles in the container affected? (Answer in a complete sentence.)

iii) While changing the Volume sliderbar does the temperature of the contents of the container change? (Answer in a complete sentence.)

iv) Provide an explanation, in terms of the particles and their behavior, that explains why the pressure changes as a result of changing the volume of the container.

F. Collect five additional observations of volume/pressure relationships and record all of your data in the following table.

Data Table

Pressure (atm)	Volume (L)
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

II. Data Analysis:

What patterns are shown in these data? It might be helpful to graph the data. Try to come up with an algebraic equation that expresses the pattern you found.

III. Interpretation and Conclusions:

    A. How are the pressure and volume of a gas sample related?

    B. Mental Model - Draw a picture(s) that explains how the pressure and volume of a gas sample are related at the level of atoms and molecules, and that illustrates the observations you made in the experiment. In words, explain how your picture(s) illustrate(s) this relationship.

    C. Using your data, predict the pressure of a gas sample at a volume of 100L. Show how you made your prediction.