Gas Pressure and Volume Relationships

Name_____ Lab Section_____

Log on to the Internet. Type the following address into the location-input line of your browser:

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

This will load a Particulate Simulation. Once you have the simulation running your screen will look like what is shown in Figure 1 below. If you haven't already done so, read the Particulate Simulation section of the Introduction to MoLEs Activities to learn how to use the simulation.
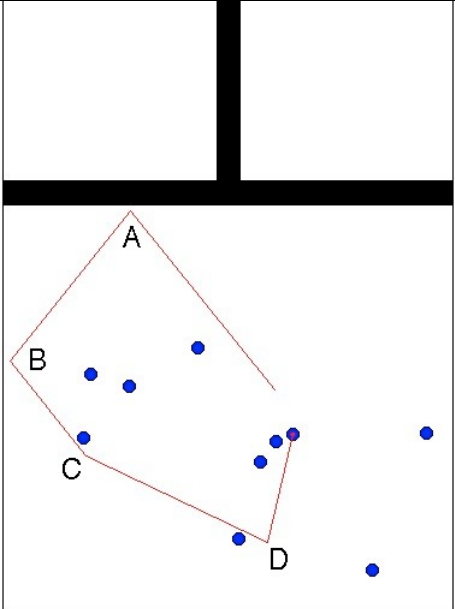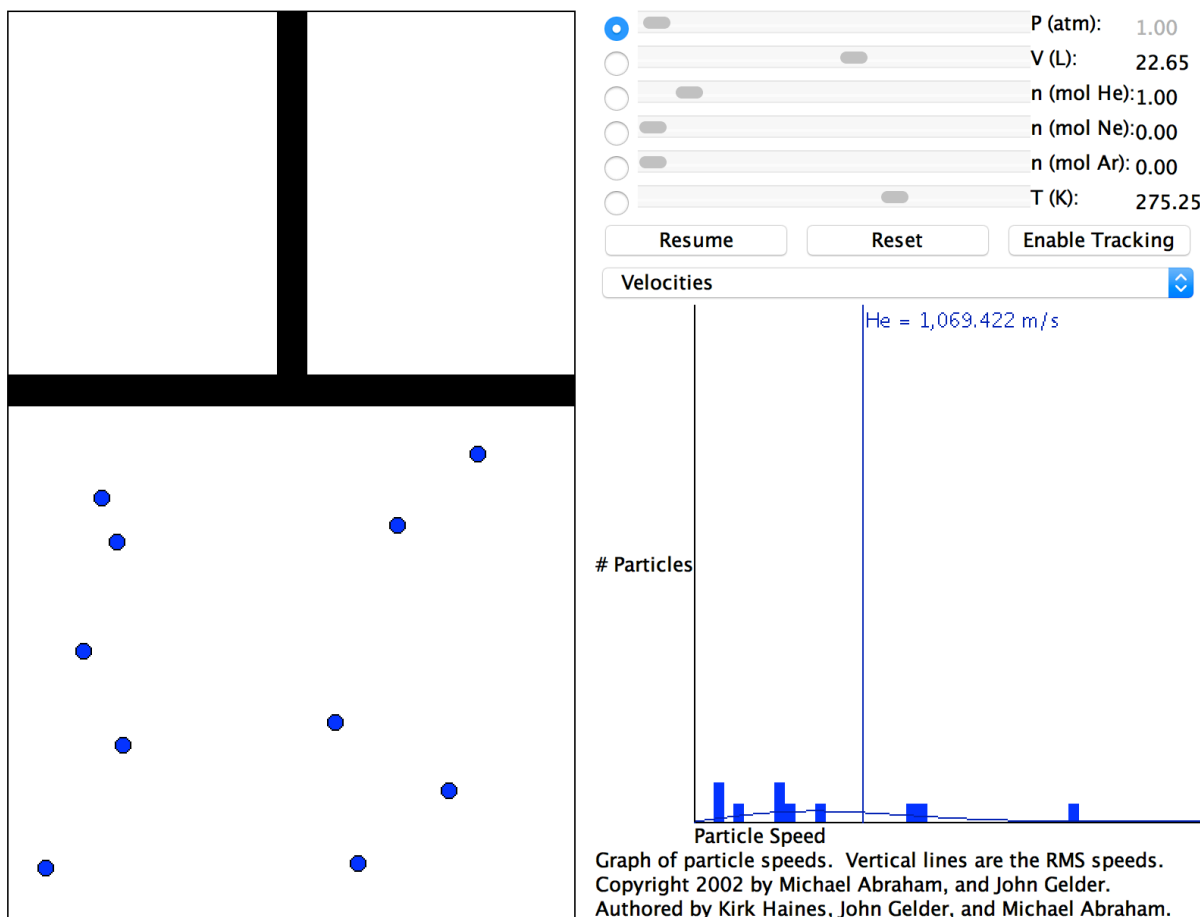

Figure 1.

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.

Atoms/particles are moving around the container (in straight-line motion), colliding with other atoms/particles and with the walls of the container. The atom's/particle's speed and direction changes when colliding with another atom/particle, but only the direction changes when colliding with the walls of the container. When colliding with another particle the kinetic energy of the particles change, so the energy changes with collisions between particles, but the total energy is conserved. The force of the collision with the walls of the container accounts for the pressure exerted by the gas.

B. Enable the tracking function and trace the path of a particle from one side of the screen to the other in the space below. Explain any changes in speed or direction that you observe.

	The particle collides with the wall of the container at point A and changes direction, however the velocity of the particle does not change with the collision with the wall of the container. The same behavior is observed when the particle collides with another wall at point B. There is a change in direction, but not in the velocity. The velocity is the same before the collision with the wall at point B as the velocity after the particle collides with the wall. However, at point C both the particle's direction and velocity change when colliding with another particle. This behavior is observed a second time at point D. The particles direction and velocity change when colliding with the particle. It is also interesting to note that in collisions at point C and D, the direction shift is not as predictable or as symmetric as the collisions at points A and B. Also the change in velocity that occurs at points C and D are different.

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

After clicking on the Reset button the digital read-outs are:
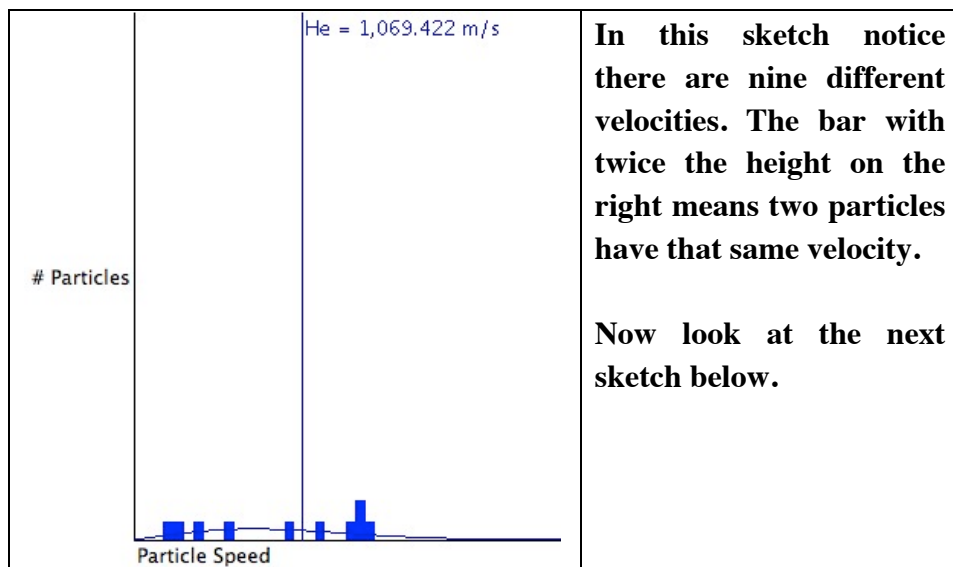**P(pressure) = 1 atm**
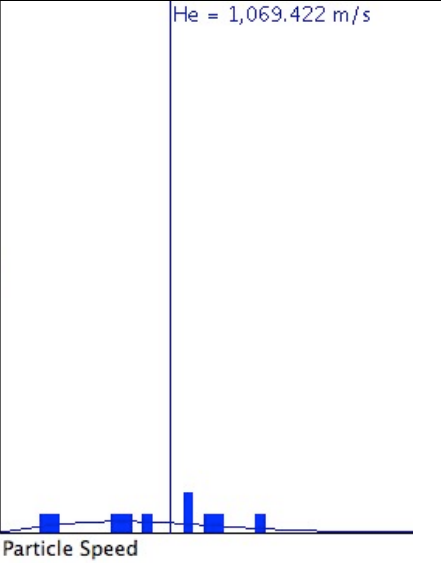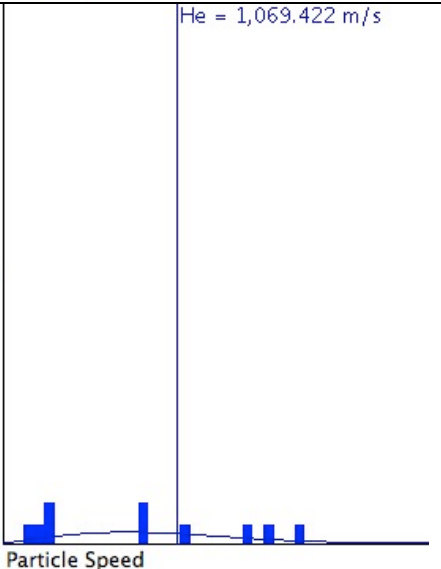**V (volume) = 22.65 L**
n (mole) = 1 mol (of He)
T (temperature) = 275.25 K

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

In the Velocities window bars are used to represent the different velocities of all of the particles in the sample. When particles collide their velocity change, so the bars fluctuate in height and in position along the x-axis. When the height decreases that means a particle no longer has that velocity (it has collided with another particle). If the height increases that means a particle now has that velocity after colliding with a particle. Along the x-axis are different velocities, so the bar for a particular particle will move from different velocity value to a new velocity value after every collision with another particle. It is interesting to note that with ten particles in the container there are usually 7 to 10 different bars representing 7 to 10 different velocities. So particles of a gas do not have the exact same velocity at all times, the velocity of a sample of gas particles has a range, with some particles moving slowly and other particles moving rapidly.

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

He = 1,069.422 m/s # Particles Particle Speed	**In this sketch notice there are nine different velocities. The bar with twice the height on the right means two particles have that same velocity.** **Now look at the next sketch below.**

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He = 1,069.422 m/s # Particles Particle Speed	**Notice in this sketch there are again nine different velocities, but most of the velocities are different from the ones in the sketch above. Also notice there is one pair of particles with the same velocities.**
He = 1,069.422 m/s # Particles Particle Speed	**In this third sketch there are eight different velocities, again different from the velocities in the two sketches above. Also in this sketch there appear to be two pairs of particles each different velocities.**

Watching the Velocity Window, the bars are constantly changing indicating that the distribution of the particles velocities is constantly changing in the sample. Each change occurs when particles collide with each other. A particle's velocity remains constant until it collides with another particle

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. Also observe what happens in the Speed Distribution window. Explain how the activity in the Gas Sample window accounts for your observations.

As the volume is decreased it is observed that in the Velocity Window the distribution of

particle velocities is changing much more rapidly. The bars are going up and down and moving left and right more quickly. This is happening because as the volume of the container is decreased there is less space for the particles to move, and the distance between collisions with other particles is much smaller. So there are many more collisions with other particles. Since collisions with other particles cause a change in velocity for each particle we observe that the distribution of velocity changes more frequently. Notice that the average velocity remains constant, it is constant independent of the volume. The observed pressure increase, as the volume decrease, at constant moles and temperature can be understood in terms of the increasing number of collisions with the walls of the container. Decreasing the volume also decreases the surface area and the distance between collisions with the walls of the containers. More collisions with the container walls results in a higher pressure.

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)
0.57	40.00
0.75	30.00
1.00	22.65
1.13	20.00
1.51	15.00
2.26	10.00
4.53	5.00

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.

The pattern in the data shows that as the volume decreases the pressure increases. There is an inverse relationship between pressure and volume. Below is a graph of pressure versus volume for the data above.

Mathematically we can summarize the relationship as P·V = constant (when T and moles are constant.)

Pressure

Enabled   Volume
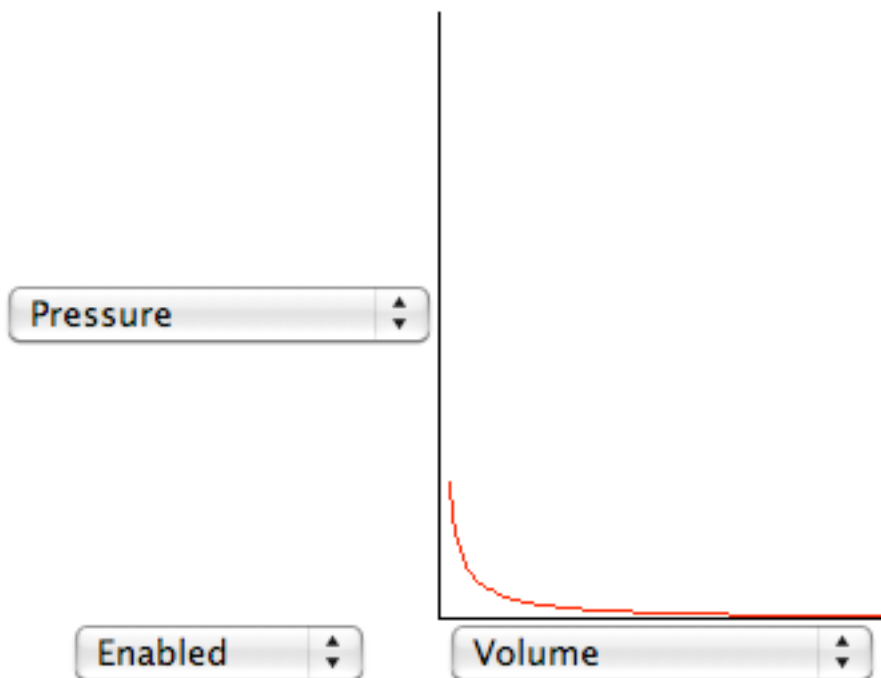
Pressure (atm)	Volume (L)	Constant (L·atm)
0.57	40.00	22.8
0.75	30.00	22.5
1.00	22.65	22.7
1.13	20.00	22.6
1.51	15.00	22.7
2.26	10.00	22.6
4.53	5.00	22.7

The average for the constant is 22.7 L·atm

III. Interpretation and Conclusions:

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

Pressure is inversely related to the volume of a gas. As the volume of a container decreases the pressure increases, while the temperature and moles of gas remain constant.

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.

	In this first diagram the volume of the container is 22.65 L and the pressure is 1.00 atm. In the second container, below, the volume is 8.68 L and the pressure is 2.61 atm. **As the volume is reduced the pressure increases. When we look at the two diagrams we can understand that the pressure goes up when the volume goes down because in the container with the smaller volume the distance the particles must travel is smaller than in the container with the higher volume.** **If particles travel a shorter distance between collisions with the walls of the container**
	Then there are more collisions with the walls of the container when the volume is smaller. More collisions means higher force against the walls of the container, which means higher pressure.

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

From Part II. We concluded that P·V = 22.7 L·atm, so if we have a container at the same temperature and number of moles of gas as was in the container that we made our measurement in I. F.

P · 100 L = 22.7 L atm

$$P = \frac{22.7 \text{ L atm}}{100 \text{ L}} = 0.227 \text{ atm}$$