Name_____ Section_____ Date_____

CONCEPTUAL PHYSICS: Hewitt/Baird | **Tech Lab**

Heat, Temperature, and Expansion | Kinetic Theory Simulation

Bouncing Off the Walls

Purpose

To control and observe the behavior of gas particles (atoms or molecules) as modeled in a simulation to investigate properties of gas such as temperature and pressure

Apparatus

computer PhET simulation: "Gas Properties" (available at http://phet.colorado.edu)

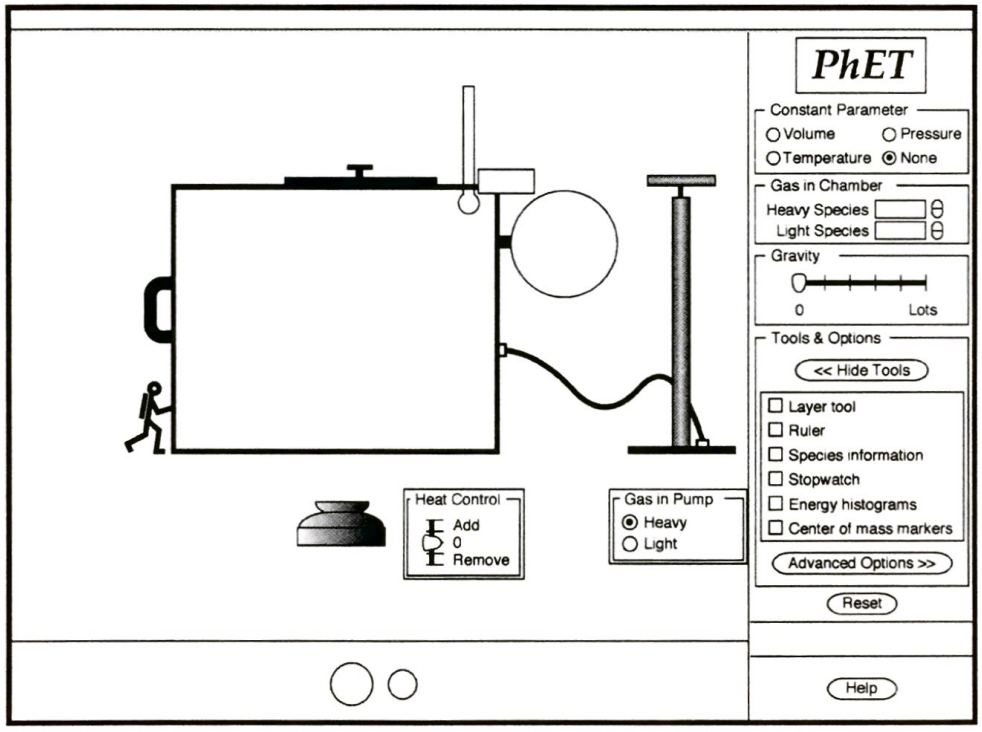
Discussion

Kinetic molecular theory explains the large-scale characteristics of gases in terms of the behavior of the atoms and molecules that make up the gas. The Gas Properties simulation lets you see the individual particles in motion. It gives you control of a chamber of gas and lets you see the effects of the changes you make.

Setup

Step 1: Start the computer and login. Open the PhET simulation, "Gas Properties."

Step 2: In the on-screen control panel, click the Measurement Tools button.



Step 3: Add labels to the figure above for each item listed below.

Thermometer *Pressure gauge* *Heat source/sink* *Gas pump*
Chamber lid *Play/pause* *"Scubie" (the volume adjuster)*

More curriculum can be found in Pearson Addison Wesley's **Conceptual Physics Laboratory Manual: Activities · Experiments · Demonstrations · Tech Labs** by Paul G. Hewitt and Dean Baird. ISBN: 0321732480

Procedure

PART A: SIMULATION MECHANICS

Remember that any time you need to, you can use the on-screen reset button to return to the initial setup.

Step 1: Determine two distinct methods by which you can add particles to the chamber.

a. Method 1: Use the pump. How do you manipulate the pump handle to get the *greatest* number of particles into the chamber in ***one*** stroke?

b. Describe Method 2: How can you ***precisely*** control the number of particles injected into the chamber? (Method 2 does not involve direct use of the pump.)

Step 2: How can you release particles from the chamber (***without*** breaking the chamber)?

a. Method 1:

b. Method 2 (*completely* different from Method 1):

Step 3: How can you add heat to the gas? How does the simulation illustrate this?

Step 4: How can you remove heat from the gas? How does the simulation illustrate this?

Step 5: How can you compress the gas (decrease its volume)?

Step 6: How can you expand the gas (increase its volume)?

PART B: THE NATURE OF THE IDEAL GAS LAW

Step 1: What happens to the pressure in the chamber if you heat the gas?

_____

Step 2: What happens to the temperature in the chamber if you compress the gas?

_____

Step 3: Locate the "Constant Parameter" section of the on-screen control panel. Lock the temperature. Use "Scubie" to slowly compress the gas. What happens to temperature, and what action is taken (by the simulation) to maintain constant temperature?

_____

_____

Step 4: Lock the pressure. (Doing so releases the lock on temperature.) Add heat. What happens to pressure, and what action is taken (by the simulation) to maintain constant pressure?

_____

_____

PART C: RELATIONSHIP BETWEEN THE GAS VARIABLES OF TEMPERATURE, VOLUME, AND PRESSURE.

Tire pressures, sinus headaches, cabin pressure in airplanes, even hairspray bottles - all find their explanation in the properties and laws of gas molecules. Four important properties of gases- pressure, temperature, volume, and amount (in moles) - are used to define the behaviors of gas molecules. Using the **Gas Properties** simulation from the PhET program, you and your partner will first define each property and then compare the properties to one another.

1. List the four "things" in the simulation that you can change or vary:

   _____ _____ _____ _____

2. Using the "Constant Parameter" section to the right of the simulation. Hold first volume constant. Adjust the amount of gas molecules and the temperature and observe what is happening to the pressure of the system.
3. Repeat the process above with "temperature" held constant.
4. Based on your observations, define the first property of gas molecules- ***pressure***.

5. Repeat Steps 2-4, holding pressure and temperature constant and defining ***volume***.

6. Repeat Steps 2-4, holding pressure and volume constant and defining ***temperature***.

7. How does the amount of gas molecules present affect the three properties above (pressure, volume, temperature)?_____
8. Using your observations and the simulation, predict the relationship between temperature and pressure (direct proportion or an indirect proportion). _____

9. Make sure the constant parameter is clicked on volume. Click the Light Species on the gas pump. Make sure gravity is set on 0. In the area under "Gas in Chamber" (top right) add 100 "Light Species" in the gas chamber. Next, under "Tools & Options" click on "Measurement Tools" and check "Stop Watch"

Step 1: Press "Start" on the timer. Let it run for 10 seconds and then press the Pause button on the simulation.

Record the temperature and range of pressure that is on the screen in the chart below.

Temperature (K)	Range of Pressure (Atm)

10. Describe what is happening in the container: (think about the speed and location of the gas particles)

_____

_____

Step 2: Reset the timer and then press "Start."
Now move the arrow in the "Heat Control" box up until it is even with add. Hold the arrow in place for 10 seconds and then press the Pause Button on the Simulation.

Notice what happens to the Temperature and Range of Pressure. Record the numbers in the chart below.

Continue doing this for 50 seconds, stopping every 10 seconds. Be sure to press the Play Button each time and then the "Start" button on the timer. **Record data in the following table.**

Time (Seconds)	Temperature (K)	Range of Pressure (Atm)
10		
20		
30		
40		
50		

11. Using your observations and the simulation, predict the relationship between volume and pressure (direct proportion or an indirect proportion). _____
12. Make sure the constant parameter is clicked on temperature. Click the Light Species on the gas pump. Make sure gravity is set on 0. In the area under "Gas in Chamber" (top right) add 160 "Light Species" in the gas chamber. Next, under "Tools & Options" click on "Measurement Tools" and check "Stop Watch"
13. Adjust the volume by moving the man. Calculate your new volume by clicking on the "Measuring Tools" and checking the "Ruler" and "Layering tool" box. (Assume the width of the box is 10 nm and measure the length and height). V = length x width x height

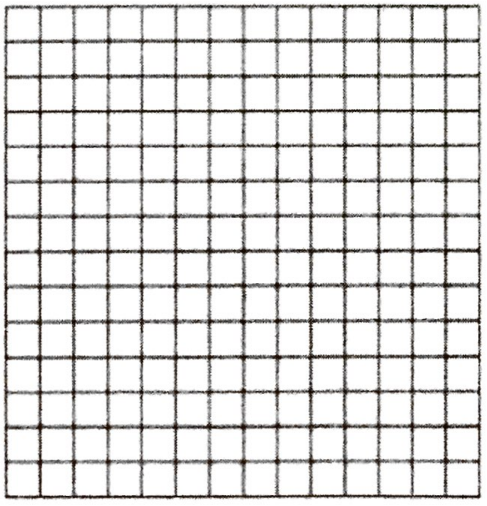
14. Record your new volume and pressure in the chart below.

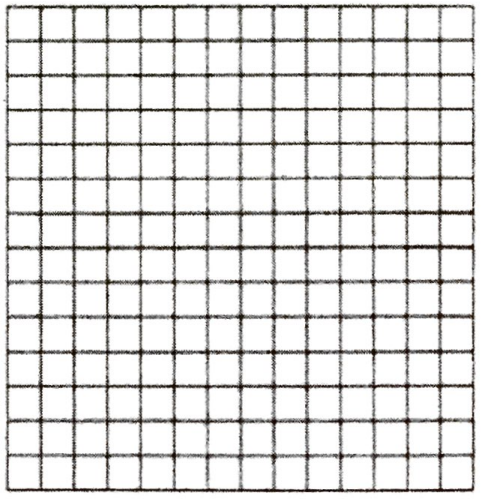
Time (Seconds)	Pressure (atm)	Volume (nm^3)
10		
20		
30		
40		
50		

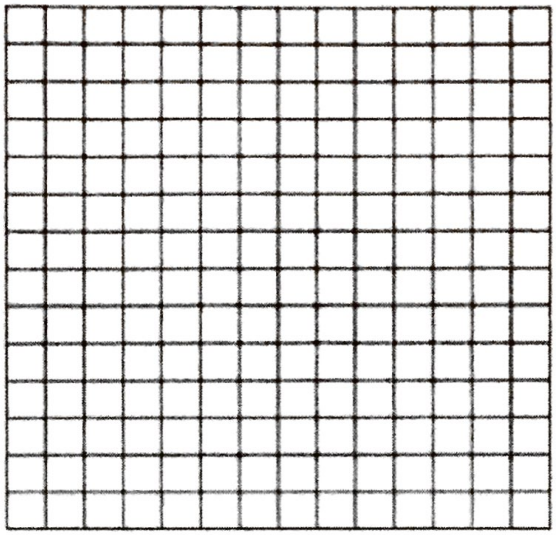
15. Using your observations and the simulation, predict the relationship between temperature and volume (direct proportion or an indirect proportion). _____
16. Now hold **pressure** constant.
17. Choose to either add or remove heat. Click on Pause to make your measurements every 10 seconds. Calculate the new volume and record the new temperature and volume in the chart below.

Time (Seconds)	Volume (nm^3)	Temperature (K)
10		
20		
30		
40		
50		

18. Create three quick graphs using the three data tables above. Include tiles and labels for each.







19. Do your graphs support your three predictions made in steps 8, 11, and 15? If not why?

20. Using your knowledge of everyday life, the book, and the internet, provide the real-world situations that describe the relationships you discovered for each of the following and use your reference sheet to describe which law supports this:

a.) pressure and temperature

b.) volume and pressure

c.) temperature and volume