Pre-Lab: Gas Laws

In this pre-lab we will learn three basic principles regarding how gases behave. These "gas laws" will be crucial for understanding stars in this week's Activity.

STEP 1: Go to the following URL:

https://phet.colorado.edu/sims/html/gas-properties/latest/gas-properties_en.html

Or, go to phet.colorado.edu and hover over "Simulations" and click on "Physics". When the next page loads, select "Heat & Thermo" only on the left submenu, then scroll down and click on the "Gas Properties" simulation.

Click on the simulation image to start it. Once the simulation opens, double click on the "**Energy**" applet.

STEP 2: Using the mouse, pump the handle once or twice.

Notice in the right-hand pane (you may need to click the green plus sign next to Particles to expand it) you are shown how many gas particles (in this case of the "Heavy Species") are inside the box.

You can use the right and left arrows to add or remove particles from the box: the single arrow adds/removes 1 particle and the double arrow adds/removes 50 particles. Use these arrows until you have somewhere between 150 and 200 particles in the box.

Wait until the gas particles bounce around enough that they settle into a state of uniform random motion.

Looking at the thermometer at the top of the box, what is the current temperature of the gas in Kelvin?

Looking at the pressure gauge near the thermometer, what is the current pressure of the gas in atmospheres (atm)? (Note: 1 atmosphere = the air pressure exerted by the Earth's atmosphere at sea level)

STEP 3: On the top left of the simulation is a box called Average Speed. When expanded it shows you the average speed of particles in the box.

Write down the current average speed of the gas particles. (The average speed will fluctuate slightly, so just pick a speed that's somewhere in the middle of the range).

STEP 4: Take mental note of how often the particles are bouncing off each other and the walls of the box. Now, beneath the box, turn on the heater. Let the gas in the box warm up to at least 600 K, then turn the heater off.

Looking at the top left pane again, what happens to the average speed of the gas particles as the temperature goes up? What happens to how often they are bouncing off each other in the box as the temperature goes up?

Complete the following sentence:

Principle #1: The average speed of the particles that make up a gas is

_____ proportional to the temperature of the gas.

Temperature defined

The above principle is really the *definition* of temperature. **Temperature** is nothing more than a *macroscopic* measure of the *average speed* of an object's microscopic particles.

In which gas are the atoms moving faster (on average), a gas of hydrogen atoms with a temperature of 1000K or a gas of hydrogen atoms with a temperature of 2000K? Use Principle #1.

STEP 5: Click the Reset button on the bottom right. In the bottom navigation pane, click on "**Explore**". Pump the handle (or use the Particles pane) to put 150 to 200 particles of gas in the box. Wait for the particle motions to randomize. Write down the current temperature (K) and approximate pressure (atm).

Grab the handle on the left side of the box and use that to drag the wall to the right. What happens to how often the gas particles are bouncing off each other in the box? What happens to the pressure?

When the volume of the box decreased, did the pressure increase or decrease?

Now grab the handle and pull the wall to the left, watching what happens to the pressure.

When the volume of the box increased, did the pressure increase or decrease?

Use your observations above to complete the following sentence:

Principle #2: The volume of a gas is _____

proportional to the pressure of the gas.

Historical Aside: The above principle (which is now a subset of the ideal gas law) was first discovered by the French chemist and physicist, Joseph Louis Gay-Lussac, in the early 1800's. He also deduced, among other things, the fact that water is made up of two parts hydrogen and one part oxygen (i.e., water is H_2O).

If you decrease the volume enough, can you blow the lid off the box? Try it!

Pressure can be thought of as the tendency of a gas's particles to spread out.

How does this make sense with respect to your previous observation with regards to blowing lid the lid off the box?

STEP 6: Reset the simulation again and put 150 to 200 particles in the box. Wait for the particles to randomize. Now drag the wall to the right again (without blowing off the lid). What happens to the temperature of the gas as the wall moves to the right?

This happens because you are transferring energy into the box by moving the wall to the right. Who or what is providing the input energy in the case of this simulation?

Complete the following sentence:

> **Principle #3:** If something pushes (or pulls) on a gas to make its volume smaller, its temperature _____.

STEP 7: Go back to this Pre-Lab assignment on Canvas and answer the questions there. You do not need to turn in this document. To get credit for completing this Pre-Lab, just answer the questions on Canvas instead.