Activity: Gas Laws

Summary
In this activity, students will examine gas laws by carrying out several computer simulations.

Resource Type: Activity
Grade Level: High school

Objectives
By the end of this lesson, students should be able to
- Use simulations to better understand the behavior of gases.
- Understand how pressure, temperature, volume, and molecular weight affect how particles in a gas behave.

Chemistry Topics
This lesson supports students’ understanding of
- Gas laws
- Rate of effusion

Time
Teacher Preparation: 15 minutes
Lesson: 1 class period

Materials
- A computer with internet access

Safety
- No specific safety precautions are needed for this experiment.

Teacher Notes
- Answer to Part III, what is a manometer? A manometer is a pressure measuring instrument. A very simple manometer is a liquid held in a U-shaped tube where the measured pressure is applied to one side of the tube whilst the reference pressure (that of the atmosphere) is applied to the other. The difference in liquid level represents the applied pressure. (Definition from Wikipedia, the free internet encyclopedia.)

For the Student

Student Activity Sheet: Gas Laws

Lesson
Go to the following web site:
http://www.chem.iastate.edu/group/Greenbowe/sections/projectfolder/animations/index.htm
Find the section labeled **Gas Laws**. You are now ready to begin your lab simulations.

**PART I**

**Boyle’s Law:** Click on Boyle’s Law experiment no graphs (student version).

In this experiment, the materials list consists of a syringe, a pressure gauge, and a choice of four gases. Collect volume vs. pressure data and plot for air and one other gas (O₂, H₂, or He). Data should be collected at 10, 15, 20, 25, and 30 mL.

<table>
<thead>
<tr>
<th>Volume (mL)</th>
<th>Pressure (Air)</th>
<th>Pressure ( )</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 mL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 mL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 mL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 mL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 mL</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

___ 1) On the basis on this experiment, what is the relationship of pressure to volume?

  a) direct proportion and an equation of \( P_1 V_1 = P_2 V_2 \)
  b) inverse proportion and an equation of \( P_1 V_1 = P_2 V_2 \)
  c) direct proportion and an equation of \( P_1 / V_1 = P_2 / V_2 \)
  d) inverse proportion and an equation of \( P_1 / V_1 = P_2 / V_2 \)

**PART II**

**Charles’ Law:** Click on Charles’ Law experiment - simulation 2.3.02.

This experiment has a syringe attached to a heating and cooling device. Change the thermostat to a high temperature around 400 K and observe the data plotted on the computer monitor. After a temperature value is obtained, change the
thermostat to a lower temperature, around 200 K. Draw a general plot of volume vs. temperature on the graph below.

___ 2) One the basis of this experiment, what is the relationship between volume and temperature?
   a) direct proportion and an equation of \( V_1 T_1 = V_2 T_2 \)
   b) inverse proportion and an equation of \( V_1 T_1 = V_2 T_2 \)
   c) direct proportion and an equation of \( \frac{V_1}{T_1} = \frac{V_2}{T_2} \)
   d) inverse proportion and an equation of \( \frac{V_1}{T_1} = \frac{V_2}{T_2} \)

___ 3) On the basis of the Boyle’s Law and Charles’ Law experiments, predict the relationship of pressure to temperature?
   a) direct proportion and an equation of \( P_1 T_1 = P_2 T_2 \)
   b) inverse proportion and an equation of \( P_1 T_1 = P_2 T_2 \)
   c) direct proportion and an equation of \( \frac{P_1}{T_1} = \frac{P_2}{T_2} \)
   d) inverse proportion and an equation of \( \frac{P_1}{T_1} = \frac{P_2}{T_2} \)

PART III
Manometer: Click on Manometer Experiment - simulation 2.3.02.

   Before you start, what is a manometer?

In this activity, you have a simple manometer with a pressure applied to each side of the manometer. Vary the pressures on each side and determine its effect.

___ 4) When the pressure on the left side of the manometer is increased, the liquid level
   a) rose on the left side.
   b) lowered on the left side.
   c) did not change.

___ 5) When the pressure on the left side of the manometer was decreased, the liquid level
   a) rose on the left side.
   b) lowered on the left side.
   c) did not change.
6) When the pressures on both sides were minimized, the liquid level
   a) was greater on the left side.
   b) was lowered on the left side.
   c) became equal on both sides.

PART IV
Graham’s Law (Effusion): Click on Effusion Experiment Version 4 Flash 12.11.01.

In this experiment, a syringe is filled with a gas that is allowed to effuse into an evacuated flask. Your group must choose the volume at which you will investigate the rate of effusion for the seven gases. Your choice will effect the time and quality of your results. You must analyze all seven available gases. Clock each gas to determine the time required for the gas to effuse. Make sure that all gases are placed in the syringe at the same volume (temperature and pressure are constant for this experiment) and then allowed to escape through the pinhole at the end of the needle.

<table>
<thead>
<tr>
<th>Gas Identification</th>
<th>Volume (mL)</th>
<th>Time (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oxygen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Xenon</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Krypton</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas Y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas Z</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) Which gas escapes from the syringe fastest? ___________
   Which gas escapes from the syringe slowest? ___________
   What caused these gases to vary in speed of effusion?

2) How is the molecular weight of a gas related to the time it takes for it to escape from a pinhole in a container?

3) How is the molecular weight of a gas related to its rate of escape?

4) Determine the molecular weight of the unknown gases. Determine molecular weight for unknown gases using Graham’s law and the data that you have collected.
   a) Gas X has a molecular weight of ___________.
   b) Gas Y has a molecular weight of ___________.
   c) Gas Z has a molecular weight of ___________.