Title: Charles' Law with Balloons

Grade Level and Course: 9-12 High School Chemistry; 8th grade physical science

Materials:
- 1000 mL beaker
- Graduated cylinder
- Ice
- Whiteboard marker
- Ruler
- Hotplate
- Water Balloon
- Digital Thermometer
- Tongs

Instructional Resources Used: (concept maps, websites, think-pair-share, video clips, random selection of students etc.)
- Think-pair-share video clips, pre-determined lab groups of 2-3 students, virtual lab practice [http://jersey.uoregon.edu/vlab/Piston/](http://jersey.uoregon.edu/vlab/Piston/)
- Video clips [http://www.youtube.com/watch?v=xeh86NwQdXA&NR=1](http://www.youtube.com/watch?v=xeh86NwQdXA&NR=1)
  - Students will watch video. Students will record their observations and then share with their group member. They will then report out with teacher recording all comments on the board for later reference.

California State Standards: (written out)

Grade 8 Physical Science:
- 3d. Students know the states of matter (solid, liquid, gas) depend on molecular motion.
- 3e. Students know that in solids the atoms are closely locked in position and can only vibrate; in liquids the atoms and molecules are more loosely connected and can collide with and move past one another; and in gases the atoms and molecules are free to move independently, colliding frequently.

Grades 9-12 Chemistry:
Gases and Their Properties
- 4. The kinetic molecular theory describes the motion of atoms and molecules and explains the properties of gases. As a basis for understanding this concept:
  a. Students know the random motion of molecules and their collisions with a surface create the observable pressure on that surface.
  c. Students know how to apply the gas laws to relations between the pressure, temperature, and volume of any amount of an ideal gas or any mixture of ideal gases.
  e. Students know how to convert between the Celsius and Kelvin temperature scales.
  g. * Students know the kinetic theory of gases relates the absolute temperature of a gas to the average kinetic energy of its molecules or atoms.

Investigation and Experimentation
Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing the content in the other four strands, students should develop their own questions and perform investigations. Students will:
   b. Identify and communicate sources of unavoidable experimental error.
   c. Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.
   d. Formulate explanations by using logic and evidence.

Lesson Objectives:
   • Students will successfully perform the lab, record data and interpret results to confirm or reject experimental hypothesis.
   • Students will be able to apply volume and temperature concepts to real world applications.
   • Students will be able to predict and solve for missing quantities in the Charles’s Gas Law equation.

Differentiation Strategies to meet the needs of diverse learners:
   • English Learners: In mixed ability groupings, students will be asked to define the term kinetic theory and then perform the lab. Students will draw the procedures, labeling materials.
   • Special Education:
     o Have students watch you tube video http://www.youtube.com/watch?v=iSK5YIsMy4c&feature=related.
     o As the reactions are performed, ask and record what the student expects to happen and why.
     o Place students into pre-arranged lab groups that have been designed to maximize student time on task and understanding.
   • GATE: Based on temperature of the water, have the students calculate what the new volume will be. Run percent error based on calculated and experimental values.

ENGAGE
   • Describe how the teacher will capture the students’ interest.
   • What kind of questions should the students ask themselves after the engagement?
     o Place bar of soap in the microwave, turn it on for 30 seconds and then remove it.
     o Ask the students:
       a. What caused the soap to expand?
       b. Has the soap undergone a chemical reaction? How do you know?

EXPLORE
   • Describe the hands-on laboratory activity that the students will be doing.

Students will be exploring how a change in temperature will affect the volume of a balloon when pressure remains constant. They will first find the volume of a balloon in room temperature water using the displacement method of volume measuring. Students will mark the water level in a beaker of water with and without the balloon in the water. The difference in water levels will be the volume of the balloon. They will then perform at least two
more trials, one with colder water and one with warmer water.

- List the “big idea” conceptual questions that the teacher will ask to focus the student exploration.
  a. Does the temperature of water have a direct correlation to volume?
  b. At the molecular level, how does the velocity of the air molecules compare at different temperatures?

EXPLAIN
- What is the “big idea” concept that students should have internalized from doing the exploration?
  When gases are exposed to different temperatures, the gases will absorb or lose energy. This will make them move faster thereby striking the inside of the balloon more frequently with more force.

- List the higher order questions that the teacher will ask to solicit student explanations for their laboratory outcomes, and justify their explanations.
  a. Using kinetic molecular theory, explain why the balloon’s volume changes.
  b. Would using a pure gas like O₂ or N₂ change the experiment? Why or why not?
  c. Why must temperature be converted to the Kelvin scale?

EXTEND
- Explain how students will develop a more sophisticated understanding of the concept.
  Using the formula of kinetic energy, \( E_k = \frac{1}{2}mv^2 \) and their understanding of kinetic molecular theory, students will write a two paragraph paper. The first paragraph will explain why changing the mass of the gas molecule, (number of moles remains constant) must result in the change of velocity and how this will relate to volume if pressure is to remain constant. The second paragraph will apply the information for the first paragraph to explain Charles’s Law in terms of temperature and kinetic energy.

- How is this knowledge applied in our daily lives?
  Students will work in groups of two to research an application of Charles’s Law, and present it to the class in power point. For differentiation, students can build a poster with the concept in picture form.

EVALUATE
- How will the student demonstrate their new understanding and/or skill?
  Students will correctly answer benchmark questions on Charles’s Law, kinetic molecular theory and chapter test. Further understanding will be shown by the extend paper.

- What is the learning product for the lesson?
  a. Successful completion of the lab.
  b. Correctly answering the lab questions.
  c. Accurate completion of the graph and presentation board.
  d. Extend paper.

Background Knowledge for the Teacher:
When the gas laws are discussed, the kinetic molecular theory must first be
addressed for students to understand “why” not just “it does”. Gas molecules have very small intermolecular forces. There is “space” between them, which not only allows for compression but the ability to do work without a reaction. As molecules of a gas bounce off a surface, they create a pressure. Pressure can be increased by increasing the velocity of the molecules i.e., increasing temperature or by increasing the number of gas molecules. However, if the number of gas molecules remains constant and the pressure is to remain constant, volume must increase.

Student pages are attached.
Charles’ Law with Balloons

Standards Addressed:
• Grade 8 Physical Science: 3d, 3e
• Grades 9-12 Chemistry: 4a, c, e, g; I&E b, c, d

Introduction:
In this lab, you will be attempting to prove Charles’ Law \( \frac{V_1}{T_1} = \frac{V_2}{T_2} \), which explains the relationship between the volume and temperature of a gas. You will do this by observing the way gases in a balloon react under varying temperature conditions (hot, cold and room temperature) and graphing the results to determine the relationship between volume and temperature.

Materials:
1000 mL beaker  Hotplate
Graduated cylinder  Water Balloon
Ice  Digital Thermometer
Whiteboard marker  Tongs
Ruler

Procedure:
1. Blow up a balloon to about the size of a baseball
2. Fill a 1000 mL beaker about half full with tap water and make a mark the outside of the beaker at the waterline using whiteboard marker
3. Submerge the balloon in the beaker and hold it under water for 3 minutes using tongs to keep balloon in the water
4. Take the temperature of the water using the digital thermometer in units of \(^\circ C\) and record value in data table
5. Mark the new waterline on the side of the beaker and remove balloon
6. Fill graduated cylinder with water and record the water volume as “initial volume”
7. Pour water from the graduated cylinder into the beaker until you reach the second waterline mark. (you may have to refill this several more times, so make sure to keep track of how much water is being added to reach the mark) Once you have reached this mark, record the new volume of water in the graduated cylinder as “final volume”
8. Empty beaker and remove waterline marks
9. Fill beaker about one-quarter full with ice. Add water till about half full
10. Repeat steps 3 through 9 for cold water bath.
11. Fill the beaker about half full with water and heat at setting 6 for about 5 minutes.
12. Repeat steps 3 through 9 for hot water bath

Name____________________________
Charles’ Law with Balloons

I. Purpose

II. Procedure/Materials (draw pictures showing procedure, labeling materials)

III. Prediction
IV. Observations/Data

Observations

Data Table

<table>
<thead>
<tr>
<th></th>
<th>Ice Bath</th>
<th>Room Temperature</th>
<th>Hot Water Bath</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature in (°C)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature in (K)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial Volume (mL)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Volume (mL)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume of balloon (mL)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

V. Analysis:

1. Convert each temperature in °C to K and record in data table. **Show calculations**

2. Using the attached graph, label **Temperature (K)** on the x-axis and **Volume (mL)** of balloon on the y-axis. Include a **title** for you graph. Plot your 3 data points on the graph.
   What would you expect the volume of the gas to be when the temperature is 0 K? Include this value as a 4th data point and draw a best-fit line through all 4 points using a ruler.
3. Find the slope of the line – What does this value represent?

4. What is the relationship between temperature and volume? Explain why this occurs based on what you know about properties of gases.

5. Assume you heated the water up to 100°C. Using the slope of your line, what would you expect the volume of the balloon to be? Show calculation
6. A hot air balloon rises when the gas inside the balloon is heated. It returns back to the ground when cooled down. Knowing that density is mass/volume and assuming that the mass of the gas in the balloon does not change, explain why this occurs based on the relationship between temperature and volume.

7. Where are possible sources of error in this experiment? If you were to perform this experiment again, how would you change it to obtain more accurate data?

VI. Conclusion