

**Title:** Gas Laws

**Subject:** Science

**Grade level:** High School 10, 11 or 12

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**Lesson Plan Summary:** In this lesson, students will learn about the behavior of different gasses by conducting two experiments. In the first experiment, they will use balloons to analyze the effects on temperature on gasses, and in the second they will measure amount of gas carbon dioxide gives off when baking soda reacts with vinegar. At the end of this lesson, students will be able to identify and explain various Laws of Chemistry, including Charles' Law, Boyle's Law, Avogadro's Law and the Universal Gas Law.

**Objectives:**

The student knows the variables that influence the behavior of gases. The student is expected to:

- Describe interrelationships between temperature, particle number, pressure, and volume of gases contained within a closed system **§112.45. Chemistry (7)(A)**
- Illustrate the data obtained from investigations with gases in a closed system and determine if the data are consistent with the Universal Gas Law. **§112.45. Chemistry (7)(B)**

**Introduction:**

1. Start class by asking students if they have ever received a helium balloon for their birthday. After the students have answered, ask them whether their balloons suffered any changes. Did the level of inflation change? Can they recall anything that seemed to have an effect on the balloon, such as temperature or age?
2. Write Charles' Law on the board or overhead and have students copy it. Give the equation that relates the volume with the temperature of a gas. Summarize this law as follows: as temperature increases, volume increases (like the balloon). As temperature decreases, volume decreases, because volume and temperature are directly proportional. Discuss how this relates to helium balloons.
3. Ask the students what happens when they push on a balloon. Does it expand, or contract?
4. Write Boyle's Law on the board or overhead and have students copy it. Give the equation that relates volume with the pressure of a gas. Explain that, at a constant temperature, as pressure increases, volume decreases and as pressure decreases, volume increases. Pressure and volume are also directly proportional.
5. Ask the students what happens when they inflate a balloon with too much or too little air. Let the students answer and explain that the balloon's volume depends on the number of air molecules added to it.
6. Write Avogadro's Law on the board or overhead and have students copy it. Give the equation that relates the number of moles with volume.
7. Write the Universal Gas Law on the board and ask students to copy it. Give the equation and the constant values.

8. Ask the students to summarize the gas properties in order to review gas behaviour and lead the class to explain how gases behave at different temperatures and pressures by applying the gas laws.

### **Lab Demonstration: Applying Gas laws**

#### *Experiment 1: Charles' Law*

##### **Objective**

Analyze gas behavior at different temperatures.

##### **Materials**

- two rubber balloons which are the same size but different colors (blue and red)
- tape measure
- 2 beakers
- hot water
- ice
- thermometer

##### **Procedure**

1. Inflate the balloons so they are as close to the same size as possible.
2. Measure the circumference of each balloon and record the values.
3. Assuming the balloon is a sphere, calculate the volume of each balloon ( $4\pi r^3/3$ ).
4. Record the volume values.
5. Place the red balloon inside a beaker with hot water (80-90° C).
6. Use the thermometer to take the water temperature and record it.
7. Place the blue balloon inside a beaker with ice and water (4-10 °C)
8. Use thermometer to take the water temperature and record it.
9. Leave the balloons in their beakers for 30 minutes.
10. Remove each balloon and measure their circumferences of each balloon  
Calculate the volumes of the balloons.
11. Write down the difference in values.
12. Use the Charles' Law formula to calculate the volume of each balloon and compare the theoretical values with the lab values.
13. Give conclusions.

#### *Experiment 2: Avogadro's Law*

##### **Objective**

Analyze the amount of gas carbon dioxide gives off when baking soda reacts with vinegar.

##### **Materials**

- 4 rubber balloons
- tape measure
- pipette (or plastic medicine dropper)

- vinegar
- baking soda
- triple-beam balance

### **Procedure**

1. Label each balloon with the numbers 1, 2, 3 and 4, respectively.
2. Measure 1 g of baking soda and add it to balloon #1.
3. Measure 2 g of baking soda and add it to balloon #2.
4. Measure 3 g of baking soda and add it to balloon #3.
5. Measure 4 g of baking soda and add it to balloon #4.
6. Using the dropper or pipette, add 5 ml of vinegar to each balloon.
7. Immediately after adding the vinegar, off each balloon.
8. Shake the balloons.
9. Measure the circumferences of each balloon.
10. Calculate the volume values of each balloon and record all values.
11. Make a graph of the balloon volume versus the number of grams.
12. Calculate the mass of CO<sub>2</sub> and number of moles in each balloon.
13. Using Avogadro's Law formula, calculate the volume of each balloon and compare the theoretical values with the lab values.
14. Give conclusions.

### **Assessment**

- Use the following terms to build a concept map that organizes the gas laws: Boyle's Law, Charles' Law, Avogadro's Law, pressure, volume, temperature, and number of moles.
- Make a poster that illustrates the gas laws with their equations, variables involved and one example for each (suggest the students use pictures from the laboratory).