Chem 1 Hour\_\_\_\_\_ Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
Dr. Wexler  
Lab: Charles’s Law (HS-PS1-3)  
Date \_\_\_\_\_

**Background:**   
Jacques Charles first showed the relationship between temperature and volume of a gas in 1787. His work showed that gases expand in a linear manner as the temperature is increased and contract linearly as the temperature is decreased, provided the pressure is kept constant.

The graphical plot of the temperature versus volume of a gas produces a straight line. If several different gases are studied and the temperature-volume data is plotted, the extrapolations of these straight-line graphs all intersect at the same temperature, -273°C. The Kelvin equivalent of this temperature is expressed a 0K, or absolute zero. The mathematical expression to change Celsius temperature to Kelvin is: K = C° + 273.

The relationship between Kelvin temperature and the volume of a gas is expressed as Charles’s Law: The volume of a confined gas, at a constant pressure, is directly proportional to its Kelvin temperature.

Mathematically, Charles’s Law is: V1/T1 = V2/T2

In this expression, V is the volume, T is Kelvin temperature, 1 indicates initial conditions, and 2 indicates final conditions.

**Objectives:**Predict how the volume of a gas will change when the temperature is raised.  
Calculate what the change in volume of a gas should be when the temperature is raised.  
Make and use graphs to predict the volume of the gas at different temperatures.  
Experimentally determine the change in volume of a gas when the temperature is raised.

**Special Materials:**Large test tube with rubber stopper  
1000mL beaker  
100mL graduated cylinder  
Hot plate  
Leather gloves  
Basin of room temperature water

**Prediction:**1. According to Charles’s Law, if the temperature of one liter of gas is raised from 25°C to 55°C, what will be the new volume? Show your calculations as follows:  
A. Rewrite Charles’s Law (V1/T1 = V2/T2)to solve for V2:

V2 =

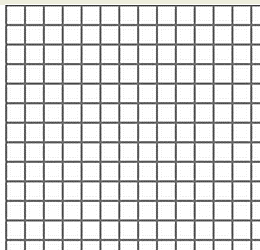
B. Convert 25°C to \_\_\_\_\_\_\_K = T1

C. Convert 55°C to \_\_\_\_\_\_\_K = T2

D. Solve for V2 given that V1 = 1L

2. Prepare a table and corresponding chart to show how the volume of a liter of gas will increase as it is raised from 0°C to 10°C, 20°C, 30°C, 40°C, 50°C, 60°C, 70°C, 80°C, 90°C, 100°C. Be sure to first convert degrees Celsius to degrees Kelvin.

|  |  |  |
| --- | --- | --- |
| **Temperature (°C)** | **Temperature (K)** | **Gas Volume** |
| **0** |  | **V1= 1L** |
| **10** |  | **V2 = \_\_\_\_L** |
| **20** |  | **V2 = \_\_\_\_L** |
| **30** |  | **V2 = \_\_\_\_L** |
| **40** |  | **V2 = \_\_\_\_L** |
| **50** |  | **V2 = \_\_\_\_L** |
| **60** |  | **V2 = \_\_\_\_L** |
| **70** |  | **V2 = \_\_\_\_L** |
| **80** |  | **V2 = \_\_\_\_L** |
| **90** |  | **V2 = \_\_\_\_L** |
| **100** |  | **V2 = \_\_\_\_L** |

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**Procedure:**

1. Measure and record the air temperature of the room in the data table.
2. Fill the test tube with water until it is full, then measure the volume with a graduated cylinder. This corresponds to the initial volume of air in the tube at room temperature.
3. Empty the tube.
4. Boil 300mL water in the 1000L beaker. Assume the temperature at high boil is 100°C.
5. Immerse the base of the test tube in the boiling water for about two minutes.
6. Insert the rubber stopper while the test tube is still in the boiling water.
7. Remove the stoppered test tube, cool for a few minutes in air then cool it all the way to room temperature in the basin of room temperature water.
8. Hold the test tube upside-down in the basin of water.
9. Remove the stopper and allow water to enter the tube. Adjust the position of the tube so that the water level in the tube is even with the water level in the beaker. Reinsert the rubber stopper. The air in the tube is now at atmospheric pressure. The volume of water that entered the tube is equal to the volume of air expelled from the tube when it was heated (due to expansion).
10. Remove the tube from the water right side up and remove the stopper.
11. Measure the volume of water in the tube using a graduated cylinder. This represents the increase in volume of air at 100°C.
12. Add this volume to the original test tube volume to calculate the total volume of air at boiling temperature.

**Results:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Trial 1 | Trial 2 | Trial 3 |
| Room temperature (°C) |  |  |  |
| T1: Room temperature (°K) |  |  |  |
| Temperature of boiling water (°C) |  |  |  |
| T2: Temperature of boiling water (K) |  |  |  |
| V1: Initial volume of air in test tube (mL) |  |  |  |
| Increase in volume of test tube air at boiling temperature (mL) |  |  |  |
| V2: Experimental total volume of air at boiling temperature (mL) (Initial + Increase = Total) |  |  |  |

**Calculate the average experimental volume (V2 exptl) for the three trials:**

**Analysis:**1. Use Charles’s Law to calculate the **expected** volume of air (V2 expected) at boiling. Show all calculations.

2. Calculate your % Error for this experiment: 100 x| V2 exptl – V2 expected |/ V2 expected   
Show all calculations:

3. Try to account for any significant deviation between the expected volume and the experimental volume, if any.

**Critical Thinking Question:**Explain why bottled gas containers are equipped with a relief valve.