# Pre-Lab Information

Purpose Explore the relationship between the temperature and volume of a gas, as described by Charles’ Law.

Time Approximately 45 minutes

Question What is the effect of a gas’s temperature on its volume?

Hypothesis If a fixed amount of gas is heated, then the volume will increase because the heat will cause the molecules of gas to move faster and further apart. Also, the value of *V/T* should be constant and the graph of *V* vs. *T* should be a straight line.

Variables *Independent Variable:* temperature; *Dependent Variable:* volume  
*Constants:* pressure and number of molecules

Summary You will measure the volume of gas inside a tube subjected to several different temperatures between 0 and 100°C.

# Safety

* Always wear safety glasses, a lab apron, and gloves while performing an experiment.
* Do not use any equipment unless you have been trained and approved by your teacher.
* Use caution when working with the hot plate.
* Use beaker tongs or oven mitts to move hot beakers from the hot plate.
* Be careful while measuring the height of gas in the capillary tube, which will also get very hot.
* Report all accidents—no matter how big or small—to your teacher.
* Keep your work area clear of all materials except those needed for the experiment.

# Lab Procedure

1. **Gather Materials**

|  |  |  |
| --- | --- | --- |
| * Hot plate * Tweezers * Oven mitts or tongs * Thermometer * Hot pad | * Caliper * 600 ml beaker * Metric ruler * 2-3 rubber bands * Ice | * Water * Wire gauze * Capillary tube containing oil trapped near top of tube |

1. **Measure the Radius of the Capillary Tube**

A capillary tube has the shape of a cylinder, so its volume can be determined using the formula for a cylinder’s volume, *V* = *πr*2*h*. You will measure the height, *h*, later. To find the radius, measure the diameter with a pair of calipers and divide by 2. Estimate the final significant digit.

1. **Prepare the Capillary Tube**
   1. One end of the capillary tube should already be closed. You will create a moveable oil stopper at the open end of the tube. As the volume of gas increases due to changes in temperature, the oil stopper will rise.
   2. Connect the ruler to the capillary tube using rubber bands so that the bottom of the tube is at the “0” of the ruler.

**How to Succeed with the Capillary Tube**

* Do not allow water to get inside the tube or let oil flow to the bottom.
* Always immerse the tube so it is in the water to at least the top of the oil.
* Ensure that the bottom of the capillary tube always aligns to the “0” mark on the ruler.
* Do not touch the capillary tube to the glass of the beaker, which may be hotter than the water bath.
* If something goes wrong with the tube during the lab, start over with a new capillary tube.

1. **Measure the Volume of Air Near 5°C**
   1. Use the 600 mL beaker to prepare a water bath with 400 mL of ice water.
   2. Place the capillary tube, still attached to the ruler, in the water bath. (You may wish to use tweezers or tongs to keep the tube immersed in the bath.)
   3. Wait 2-4 minutes for the gas in the tube to reach the temperature of the water bath.
   4. Place the thermometer in the water and record the temperature in degrees Celsius.   
      (Estimate the final significant digit.)
2. Measure the height of the column of gas in the tube. (Estimate the final significant digit.)
   1. Use the measurements to convert the temperature to Kelvin and to compute the volume of the gas. Pay attention to significant figures.

**Substeps for Steps 5–9:**

1. Use tongs to put the beaker (with tube and thermometer) on the hot plate.
2. Turn on the hot plate and heat the water to the desired temperature. (Use the thermometer to check periodically.)
3. Once you reach the desired temperature, use tongs to remove the beaker from the hot plate.
4. Record the temperature in degrees Celsius. (Estimate the final significant digit.)
5. Measure the height of the column of gas in the tube. (Estimate the final significant digit.)
6. Use the measurements to convert the temperature to Kelvin and to compute the volume of the gas. Pay attention to significant figures.
7. **Measure the Volume of Air Near 20°C**
8. **Measure the Volume of Air Near 40**°**C**
9. **Measure the Volume of Air Near 60**°**C**
10. **Measure the Volume of Air Near 80**°**C**
11. **Measure the Volume of Air Near 100**°**C**

As time permits, or as your teacher directs, you can measure volume at additional temperatures. Before repeating the experiment at additional temperatures, consider ways to improve the results of the experiment. Add all additional data points to the data table.

1. **Dispose of All Material as Directed by Your Teacher**

# Data

Record your data either in the space below or in your lab notebook.

Radius of the tube: cm

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Data Collected** | | | **Calculations** | |  |
|  | **Temperature  of gas  (°C)** | **Height of the column of gas (cm)** | **Temperature of gas (K)** | | **Volume of gas (cm3)** | **Ratio *V/T* (cm3/K)** |
| Near 0°C |  |  |  | |  |  |
| Near 20°C |  |  |  | |  |  |
| Near 40°C |  |  |  | |  |  |
| Near 60°C |  |  |  | |  |  |
| Near 80°C |  |  |  | |  |  |
| Near 100°C |  |  |  | |  |  |
| Additional |  |  |  | |  |  |
| Additional |  |  |  | |  |  |
| Additional |  |  |  | |  |  |
| Additional |  |  |  | |  |  |
| Additional |  |  |  | |  |  |
| Additional |  |  |  | |  |  |

\*Convert from °C to Kelvin by adding 273 to the Celsius value.

\*\*Be sure to pay attention to significant figures. Approximate *π* as 3.14.

Use a calculator that does scatterplots and regression to do the following analysis of the data:

* Make a scatterplot of temperature (K) vs. volume (cm3).
* Use a regression calculator to determine the equation of the line of best fit for this scatterplot.
* Determine *R*. A value close to 0 indicates that there is not a linear relationship. A value near +1 indicates that the data are strongly linear.
* If the Volume-intercept is close to 0, volume and temperature (in K) are proportional.