

Lab Session 10, Experiment 9: Charles' Law

The purpose of this experiment is to study the changes in the volume of a gas with changes in temperature at constant pressure.

9A Experiment

1. Use a thoroughly dried 125 mL Erlenmeyer flask for this experiment. If it is not dry, rinse the flask with a small amount of acetone or ethanol and place it upside-down on a paper towel to dry.
2. Fit the flask with a one-hole rubber stopper inserted with a short piece of dry glass tubing. Add rubber tubing to the end of the glass tube and assemble the apparatus as shown in Figure 10.1, using the 125 mL flask and a 400 mL beaker. Be sure that the stopper fits tightly in the flask, the glass tubing fits tightly in the rubber stopper, and the rubber tubing fits tightly on the glass tubing. (The latter may require a hose clamp or wire winding.) Leave a 1 cm gap between the bottom of the flask and the beaker.

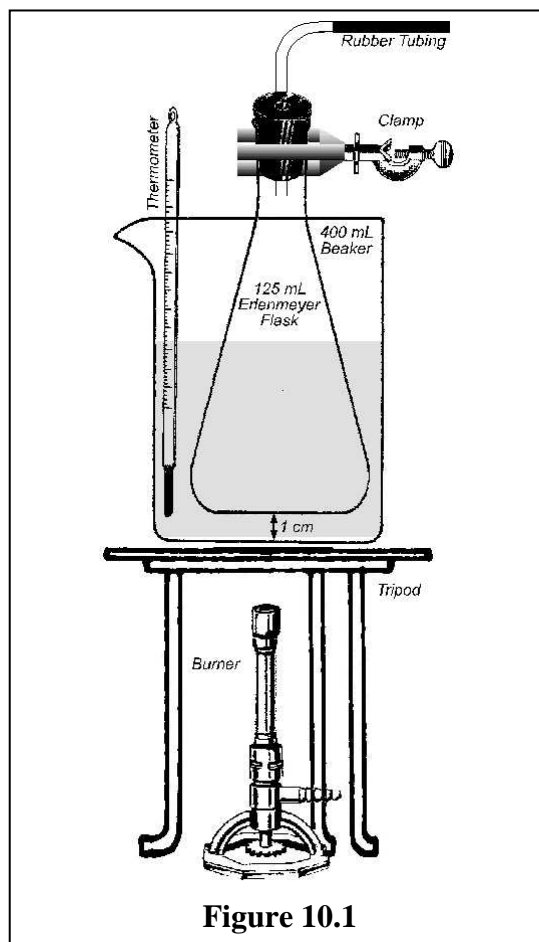


Figure 10.1

3. Pour water into the beaker until as much of the flask is covered as possible.
4. Using a Bunsen burner, heat the water in the beaker until it boils and then continue to heat for 5 minutes. At this point determine the temperature of the water by means of a 110 °C thermometer. Read the thermometer while its bulb is immersed in the water and record the reading as entry (c) in the data table below. Make sure the thermometer does not touch the beaker.
5. After the water in the beaker has been boiling for about 5 minutes, place a screw clamp (or a pinch clamp) on the rubber tubing. While the water is still boiling, close the clamp in order to make the flask airtight. Turn off the Bunsen burner by closing the gas valve at its base, then turn off the gas at the bench gas cock.
6. Loosen the ring stand clamp, remove the flask from the beaker, and immerse it in the water in the stoppered end sink nearest your work area. It should be cooled upside-down in the sink for about 5 minutes, with the stopper and tubing completely immersed in water throughout this period. At the end of this time, loosen the screw clamp while the end of the tube is completely submerged and let water be forced into the flask.
7. Holding the rubber tubing closed with your fingers, remove the flask from the sink, and determine the volume of the water in the flask by pouring it into a 100 mL graduated cylinder. Record this volume as entry (a) in the data table.

8. Determine the temperature of the water in the sink and record it as entry (d) in the data table. Your instructor may opt to prepare ice/water baths in the end sinks, in which case the temperature should be close to 0°C. You should measure it with your thermometer and record it anyway.
9. To determine the volume of gas (air) used in the beginning, it is necessary to accurately determine the volume of the Erlenmeyer flask. *Completely* fill the flask with water and place the rubber stopper (and tubing) in its previous position. Remove the stopper and measure the volume of the water in the flask with a 100 mL graduated cylinder. Record this volume as entry (b) in the data table.

(a) Volume of water forced into the flask	mL	
(b) Initial volume of the air (measured volume of the flask/stopper)	mL	
(c) Initial temperature of the air (temperature of the hot water)	°C	K
(d) Final temperature of the air (temperature of the water in the sink)	°C	K
(e) Final volume of the air [(b)–(a)] (measured volume of the flask minus the volume of water forced into the flask)	mL	

To summarize, a given volume of air was taken at the temperature of boiling water. The air was cooled, causing it to contract. The new volume was determined experimentally.

9B Exercise

The accuracy of the experimental determination of the final volume (entry (e) in the data table) can be checked by calculating this volume with Charles' Law. Change the temperature reading into the absolute (Kelvin) scale and enter your data into the following formula:

$$\frac{\text{Initial volume (mL)} \times \text{Final Temperature (K)}}{\text{Initial Temperature (K)}} = \text{Final Volume (mL)}$$

Your calculations:

$$\underline{\hspace{10em}} \times \underline{\hspace{10em}} = \underline{\hspace{10em}}$$

Complete the following table.

(a) What was the experimental final volume?	mL
(b) According to Charles' Law, what should have been the final volume?	mL
(c) What is the difference between the experimental and calculated volumes?	mL
(d) Assuming the calculated volume to be correct, determine the percent error of the experiment.	%

Report Form 9: Charles' Law

Name _____

Partner _____ Section # _____

9A Experiment

(a) Volume of water forced into the flask	mL	
(b) Initial volume of the air (measured volume of the flask/stopper)	mL	
(c) Initial temperature of the air (temperature of the hot water)	°C	K
(d) Final temperature of the air (temperature of the water in the sink)	°C	K
(e) Final volume of the air [(b)–(a)] (measured volume of the flask minus the volume of water forced into the flask)	mL	

9B Exercise

(a) What was the experimental final volume?	mL
(b) According to Charles' Law, what should have been the final volume?	mL
(c) What is the difference between the experimental and calculated volumes?	mL
(d) Assuming the calculated volume to be correct, determine the percent error of the experiment.	%