

The Molar Volume of a Gas

In this experiment, you will determine the molar volume of a gas by conducting a chemical reaction that produces a gas, as shown in the reaction equation below.



You will react a known mass of solid magnesium with an excess of hydrochloric acid, in a sealed vessel, and use the pressure change to calculate molar volume at STP.

OBJECTIVES

In this experiment, you will

- Measure the gas production of a chemical reaction by a pressure change.
- Determine the molar volume of the gas produced in the reaction.
- Calculate the molar volume of a gas at STP.

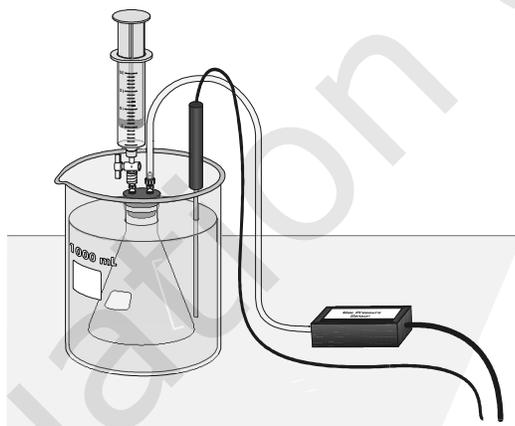


Figure 1

MATERIALS

Vernier computer interface
computer
Vernier Gas Pressure Sensor
Temperature Probe
600 mL or one liter beaker
10 mL graduated cylinder
125 mL Erlenmeyer flask

1.0 M hydrochloric acid, HCl, solution
small beaker for HCl solution
magnesium ribbon
20 mL gas syringe
plastic tubing with two Luer-lock connectors
rubber stopper assembly with two-way valve
balance, ± 0.001 g precision

PRE-LAB EXERCISE

Obtain the 125 mL Erlenmeyer flask that you will use for the experiment. Determine and record the available volume of the flask that the hydrogen gas will occupy as it is produced from the reaction of the solid magnesium and the hydrochloric acid solution. Account for the following items when you determine the volume of your flask:

- A 125 mL flask does not have a volume of precisely 125 mL.
- During the experiment, you will seal the flask with a rubber stopper and the stopper will occupy some of the volume of the flask.
- You will add 5 mL of solution (1.0 M HCl solution) to the flask.

PROCEDURE

1. Obtain and wear goggles.
2. Obtain a ~0.010 g piece of magnesium ribbon. Measure and record its mass to the nearest 0.001 g. Place the piece of magnesium ribbon in a clean and dry 125 mL Erlenmeyer flask.
3. Prepare a room temperature water bath in a large beaker. The bath should be deep enough to completely cover the gas level in the Erlenmeyer flask.
4. Connect a Gas Pressure Sensor to Channel 1 of the Vernier computer interface. Connect a Temperature Probe into Channel 2 of the interface. Connect the interface to the computer with the proper cable.
5. Use the clear tubing to connect the white rubber stopper to the Gas Pressure Sensor. (About one-half turn of the fittings will secure the tubing tightly.) Twist the white stopper snugly into the neck of the Erlenmeyer flask to avoid losing any of the hydrogen gas that will be produced in the reaction (see Figure 1). **Important:** Close the valve on the white stopper by turning the white handle so it is perpendicular with the valve stem.
6. Obtain a small amount of 1.0 M hydrochloric acid. **CAUTION:** *Handle the hydrochloric acid with care. It can cause painful burns if it comes in contact with the skin.* Draw 5 mL of HCl solution into the 20 mL syringe. Thread the syringe onto the two-way valve on the white stopper (see Figure 1). Submerge the Erlenmeyer flask into the water bath. Position the Temperature Probe in the water bath so that the tip of the probe is not touching the beaker.
7. Start Logger Pro 3 on your computer. Open the file “05 Molar Volume” from the *Advanced Chemistry with Vernier* folder.
8. With the flask still submerged in the water bath, click to begin data collection. After about 20 seconds, open the two-way valve directly below the syringe, press the plunger to add all of the 5 mL of HCl solution to the flask and pull the plunger back to its original position. Close the two-way valve.
9. Keep the flask immersed in the water bath as the reaction proceeds. Data collection will stop after 5 minutes. You may click to end data collection *before* 5 minutes have elapsed.
10. Carefully remove the white stopper from the flask to relieve the pressure in the flask. **Important:** Do not open the two-way valve to release the pressure in the flask.

11. Examine the pressure data to determine the change in pressure, ΔP , during the reaction. In addition, determine the mean temperature of the water bath during the reaction. Record these values in your data table.
12. From the Experiment menu, choose Store Latest Run to save your data.
13. Rinse, clean, and dry the flask for a second trial. Obtain a new piece of magnesium ribbon and place it in the flask. Repeat the necessary steps to conduct the second trial.
14. Follow the same procedure to conduct a third trial.

DATA TABLE

	Trial 1	Trial 2	Trial 3
Mass of Mg (g)			
Volume of flask (mL)			
Maximum pressure (kPa)			
Initial pressure (kPa)			
Pressure change, ΔP (kPa)			
Temperature (K)			

DATA ANALYSIS

1. Calculate the moles of each piece of magnesium ribbon that you used.
2. Calculate the molar amount of hydrogen gas that was produced in your reactions.
3. Calculate the volume of one mole of hydrogen gas (molar volume) at STP.
4. Compare your calculated molar volume, at STP, with the accepted molar volume of an ideal gas at STP, 22.4 L/mol. If the values do not compare well, suggest possible sources of experimental error.

Vernier Lab Safety Instructions Disclaimer

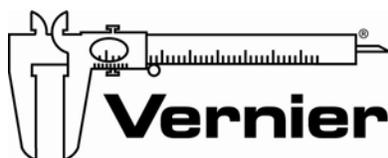
THIS IS AN EVALUATION COPY OF THE VERNIER STUDENT LAB.

This copy does not include:

- Safety information
- Essential instructor background information
- Directions for preparing solutions
- Important tips for successfully doing these labs

The complete *Advanced Chemistry with Vernier* lab manual includes 35 labs and essential teacher information. The full lab book is available for purchase at:

<http://www.vernier.com/cmat/chema.html>



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