



Determination of the Molar Volume of Gas

Topical Unit of Instruction: Gases or Moles

Teacher's Edition

Rehab
the
LAB

Introduction

The only harmful product of this lab is the excess HCl which can be neutralized and then disposed of down the sink. The Cu wire does not react and can be reused indefinitely.

Time

50 minutes for data collection

50 minutes for calculations

Objectives

1. To collect a gas by displacement of H₂O.
2. To calculate the molar volume of a gas at standard temperature and pressure.

Preparation

1. Measure 1.00 m of Mg ribbon and find its mass. If you have a balance sensitive to at least 0.001 g, use it. Give this mass to students before you start the lab.
2. Since the thickness of Mg ribbon varies from vendor to vendor, you will have to determine the approximate length needed to yield pieces of about 0.040 g. The pieces don't have to be pre-cut real perfectly—a little variation is good!
3. Cut the Cu wire into ~ 25 cm lengths.
4. To make 200 mL of 6.0 M HCl, fill a 200 mL volumetric flask about 1/3 full of distilled H₂O. Working in a fume hood with goggles on, measure 100.0 mL concentrated HCl and slowly pour into flask. Swirl. Allow to cool to room temperature and dilute to volume. You may want to add a few drops of food color so students can watch it sink through the H₂O.
5. Do this lab yourself before you do it with the students. Personal experience is so helpful on this one. Also, you may need to adjust the Mg ribbon lengths. It is preferable to produce as much H₂ as possible, but if the gas volume produced goes beyond the measurements on the gas measuring tube, you will have a disaster.

Typical Results

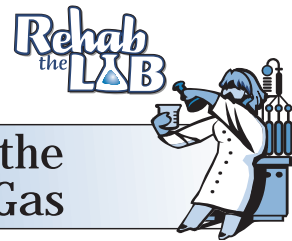
Data Table:

Mass of 1.00 m of Mg ribbon:	~ 0.980 g
Length of Mg ribbon:	~ 4.2 cm
Room Temperature:	~ 22° C
Barometric Pressure:	759 mm Hg
Volume of Collected Gas:	42.1 mL

Materials

(For a class of 32 students working in pairs)

- 16 gas measuring tubes (50 mL)
- 16 ring stands
- 16 utility clamps
- 16 large beakers (400 or 600 mL)
- 16 graduated cylinders (10 mL)
- 16 thermometers
- classroom barometer
- 16 1-hole rubber stoppers (to fit gas measuring tubes)
- 1 large deep container of H₂O (2 L graduated cylinder, battery jar or deep bucket will work)
- 16 rulers
- 16 pre-cut pieces of Mg ribbon ~ 0.040 g
- 16 pieces of fine Cu wire ~ 25 cm
- 200 mL 6.0 M HCl



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Analysis and Calculations

- $\text{Mg(s)} + 2\text{HCl(aq)} \rightarrow \text{MgCl}_2\text{(aq)} + \text{H}_2\text{(g)}$
- $100.0 \text{ cm} = 4.2 \text{ cm}$ $X = 0.041 \text{ g Mg used}$
 0.980 g $X \text{ g}$
- $0.041 \text{ g} = 0.0017 \text{ moles of Mg}$
 24.3 g/mole
- 1 mole of Mg produces 1 mole of H_2 , so 0.0017 moles of H_2 should have been produced.
- $759 \text{ mm Hg} \times 101.3 \text{ kPa/atm} = 101.2 \text{ kPa}$
 760 mm Hg/atm
- $P_t = P_{\text{H}_2} + P_{\text{H}_2\text{O}}$
 $101.2 \text{ kPa} = P_{\text{H}_2} + 2.6 \text{ kPa}$
 $98.6 \text{ kPa} = P_{\text{H}_2}$
- $P_1 V_1 = P_2 V_2$ $P_1 = 98.6 \text{ kPa}$ $P_2 = 101.3 \text{ kPa}$
 T_1 T_2 $V_1 = 42.1 \text{ mL}$ $V_2 = ?$
 $T_1 = 22^\circ = 295 \text{ K}$ $T_2 = 273 \text{ K}$

 $(98.6 \text{ kPa})(42.1 \text{ mL}) = (101.3 \text{ kPa})V_2$
 295 K 273 K

 $37.9 \text{ mL} = V_2$
- $37.9 \text{ mL} = 0.0379 \text{ L}$
 $1,000 \text{ mL/L}$
- $0.0379 \text{ L} = X \text{ L}$
 $0.0017 \text{ moles} \quad 1 \text{ mole}$

 $X = 22.3 \text{ moles/L}$

Disposal

- Have students pour excess HCl (with $\text{MgCl}_2\text{(aq)}$) from gas measuring tubes into a large container. Neutralize with base to a pH between 6 and 9, and pour down drain with lots of H_2O .
- Collect Cu wire, rinse, and reuse.

Hints

- You'll have to look up the vapor pressure of H_2O at your room temperature in a handbook to give to students.
- Remind students to be especially careful of the 6.0 M HCl. It is nasty!
- Remind students to be careful with gas measuring tubes. To clean them, suggest students rinse the beaker, repeatedly fill the tube with clean H_2O from the beaker, and then dump. It is likely that the tubes will NOT fit in the sink under the faucet, and students could easily break one if they attempt to clean it directly under the faucet.
- Check Mg ribbon for oxidation. Do not measure or use any Mg segment that has oxidized.

