# CHEMISTRY LAB: THE COMBINED GAS LAW

**What to turn in**: Hypothesis, Data Table 1, Data Table 2 , Calculations (5), Error Analysis (including % error), Conclusion, Questions 1-6

## Background Information

Both solids and gases must often be handled in the same experiment. The amount of solid used or produced can be determined by measuring the mass of the material on a balance. However, it is difficult to find the mass of a gas. You can trap the gas and measure its volume in a eudiometer tube. Remember, the volume occupied by one mole of any gas at standard temperature and pressure (STP) equals 22.4 L. We will use this conversion factor in this experiment.

In this experiment you will determine the volume of gas evolved in a reaction between magnesium metal and hydrochloric acid, and from your results determine how many liters of gas would be produced under STP conditions. Your experimental results will then be compared to the results predicted by Avogadro's hypothesis. You will need to convert room temperature and pressure to standard conditions (STP) in order to compare your results.

## Objectives

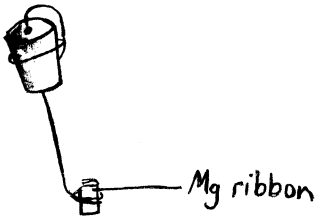
- To review gas laws
- To collect a gaseous product, measure the volume of the gas collected, and convert the volume to standard conditions (STP)
- To calculate the molar relationship between the solid magnesium consumed and the gas produced

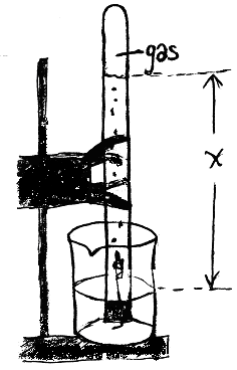
## Materials

| | | |
|---|---|---|
| Beakers | Copper wire | Graduated cylinder |
| Ring stand | Tap water | Ruler |
| Buret or utility clamp | Rubber stopper | Scissors |
| Magnesium ribbon | Gas measuring tube (eudiometer) | Electronic balance |
| 3 M hydrochloric acid | | Funnel (optional) |

## Procedure

1) Fill a 400 or 600 mL beaker about one-half full of tap water. Let stand until the water temperature adjusts to room temperature.
2) Record the room temperature and barometric pressure in Data Table 1: (d) and (f).
3) Cut a piece of magnesium ribbon about 5 cm long, or obtain an already prepared piece. Be sure the ends are cut squarely. Measure to 0.1 cm (tenths). Measure the mass of the Mg ribbon on the electronic balance.
   Record the length and mass of the Mg ribbon in Data Table 1: (a) and (b).
4) Obtain a piece of copper wire about 15 cm long. Fold or tie one end around the Mg ribbon. Fold the ribbon so it fits inside the gas measuring tube. Insert the wire through a one-hole stopper so that the ribbon is hanging down from the stopper.
5) Prepare a ring stand with a buret or utility clamp to hold the gas measuring tube (eudiometer).



6) Slowly pour about 20 mL of 3 M hydrochloric acid into the tube.
*CAUTION: Dilute hydrochloric acid will cause mild burns.*
7) Holding the tube at a slight angle, fill it completely with tap water from the beaker. Pour the water slowly down the side of the tube so the water will mix with the acid as little as possible.
8) Refill the beaker 1/2 with tap water.
9) With the tube completely full of water, insert the magnesium ribbon and stopper about 3 or 4 cm into the tube. The excess water should overflow. Be sure there is too much water.
10) With your finger over the hole in the stopper, invert the tube into the beaker of water. Clamp the tube in place.
11) When all Mg has reacted and the evolution of gas has stopped, tap the tube gently to dislodge all gas bubbles.
12) Read how much gas was produced inside the tube, in mL. Record the volume of gas evolved in Data Table 1: (g) to 0.1 mL (tenths).
13) Using a ruler, measure "x" in millimeters (see drawing on previous page), from the water level in the eudiometer to the top water level in the beaker. Record in Data Table 1: (h).
14) Disassemble your setup. Solutions can be rinsed down the sink.

| **DATA TABLE 1** | **TRIAL 1:** | **TRIAL 2:** |
|---|---|---|
| *** = calculations must be shown, with proper sig.figs and units.* | | |
| a) length of magnesium ribbon | _____ cm | _____ cm |
| b) mass of magnesium ribbon | _____ g | _____ g |
| c) **moles of magnesium used | _____ mol | _____ mol |
| d) room temperature, Celsius | _____ °C | _____ °C |
| e) **room temperature, K ($T_1$) | _____ K | _____ K |
| f) barometric pressure ($P_{ATM}$) | _____ mm Hg | _____ mm Hg |
| g) volume of gas collected ($V_1$) | _____ mL | _____ mL |
| h) "x" | _____ mm $H_2O$ | _____ mm $H_2O$ |
| i) x / 13.6 | _____ mm Hg | _____ mm Hg |
| j) water vapor pressure ($P_{H_2O}$) | _____ mm Hg | _____ mm Hg |
| k) **corrected pressure of dry gas ($P_1$) | _____ mm Hg | _____ mm Hg |
| l) standard temperature ($T_2$) | _____ K | _____ K |
| m) standard pressure ($P_2$) | _____ mm Hg | _____ mm Hg |
| n) **volume of hydrogen gas at STP ($V_2$) | _____ mL | _____ mL |
| o) **volume of hydrogen from 1 mol Mg at STP | _____ mL | _____ mL |

**DATA TABLE 2**

balanced chemical equation: _____

| | NAME | FORMULA |
|---|---|---|
| solid metal reactant | _____ | _____ |
| aqueous acid reactant | _____ | _____ |
| gaseous product | _____ | _____ |
| product in solution | _____ | _____ |

**HELPFUL HINTS for Data Table 1 are on the next page!**

**HELPFUL HINTS for Data Table 1**

(c) Convert mass to moles

(e) Use K = C + 273.15

(f) The teacher will provide this value, which is the atmospheric pressure at the time

(h) Measure "x" with a ruler, measure in mm, which is the distance between the water level in the beaker and the water level in the tube

(i) "x/13.6" converts this value to a mercury equivalent, since mercury is 13.6 times denser than water

(j) Water vapor pressure: look this up in the CRC Handbook or use handouts provided

(k) $P_1 = P_{ATM} - P_{H_2O} - (x/13.6)$ Data Table steps f - j – i

(n) Use the combined gas law to calculate the volume that would be occupied by the gas at STP $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

(o) From your calculations, a fractional part of a mole of Mg (step c) was determined. Use this information to calculate the volume of hydrogen gas produced if *one mole* of magnesium reacted with excess hydrochloric acid at STP:

$\frac{\text{your } V_2\text{, in mL}}{\text{your \# of moles}} = \frac{\text{? mL}}{\text{1 mole}}$ OR $\frac{\text{(step n)}}{\text{(step c)}} = \text{answer}$

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**Error Analysis**: include percent error = $\frac{|\textbf{ ACTUAL – THEORETICAL }|}{\textbf{THEORETICAL}} \times 100$

THEORETICAL VALUE = 22.4 L = 22,400 mL of gas at STP

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**Questions**

1) When the tube is inverted, why doesn't the reaction occur immediately?
2) Why is copper wire a good substance to use to hold the ribbon?
3) Why should the tube be filled completely with water before inversion?
4) How could you test if the gas was actually hydrogen?
5) When the gas is collected, why do we assume it is "wet"?
6) Explain how Dalton's Law of Partial Pressures is used in this lab.