

CHEMISTRY I LAB: THE COMBINED GAS LAW (THE MOLAR RELATIONSHIP INVOLVING MASS AND VOLUME)

What to turn in:

Hypothesis	Data Table 1	Data Table 2	Calculations (5)	Questions #1-6
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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 measure gas volume and use this value to calculate the mass of the gas. Therefore, it is necessary to know the quantitative relationship between the molar mass and the molar volume of a gas. Avogadro's hypothesis explains the relationship between the molar volume, the molecular mass, and the actual mass of a sample gas. This hypothesis states that equal volumes of gases under the same temperature and pressure contain equal numbers of molecules. Also, the volume occupied by one mole of any gas at standard temperature and pressure (STP) equals 22.4 L.

In this experiment you will determine the volume of hydrogen gas evolved in a reaction between magnesium metal and hydrochloric acid, and from your results determine the mass of hydrogen gas produced. 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

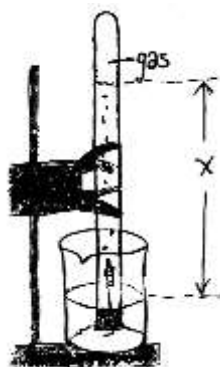
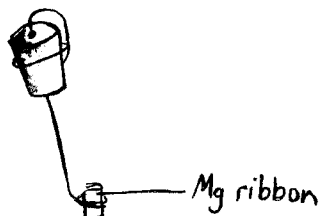
- To review gas laws
- To collect a gaseous product, measure the volume of the gas collected, and convert the volume to standard conditions (STP)
- To calculate the molar relationship between the solid magnesium consumed and the hydrogen gas produced

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. Be sure the ends are cut squarely. 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).
- 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.
- 14) Rinse all glassware.

<u>DATA TABLE 1</u>	<u>TRIAL 1:</u>	<u>TRIAL 2:</u>
<i>** = calculations must be shown, with proper sig. figs and units.</i>		
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	_____ mm
i) x / 13.6	_____ mm Hg	_____ mm Hg
j) water vapor pressure (P _{H₂O})	_____ 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

HELPFUL HINTS for Data Table 1

- (c) Convert mass to moles
- (e) Use $K = C + 273$
- (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

MORE →

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

(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:

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

DATA TABLE 2

balanced chemical equation: _____

	<u>NAME</u>	<u>FORMULA</u>
solid metal reactant	_____	_____
aqueous acid reactant	_____	_____
gaseous product	_____	_____
product in solution	_____	_____

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.