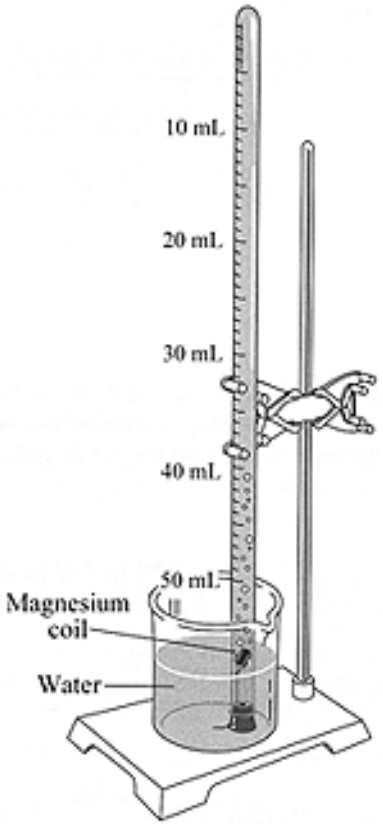
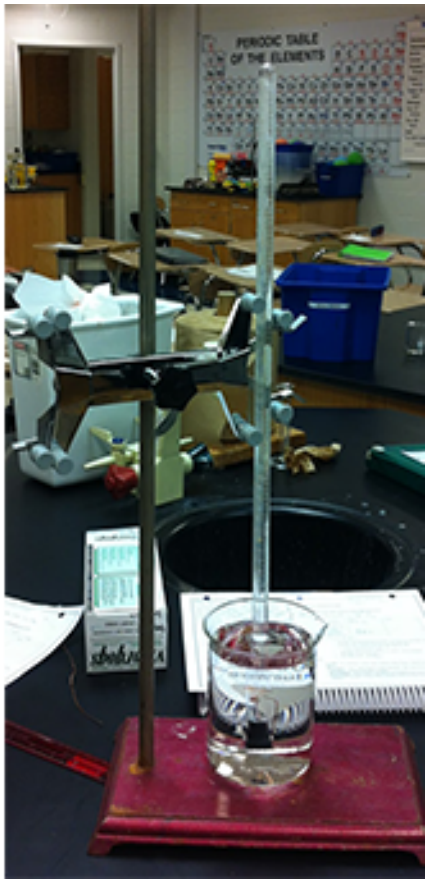
Exp 08: Gas Stoichiometry





Your job is to use gas stoichiometry to find out the unknown mass of piece of magnesium. You'll do this by reacting it with acid and determining the moles of gas produced.

Before doing this experiment, you will test the process with a piece of zinc of known mass to calculate the known molar mass of zinc. This will give you the opportunity to test your technique and the process.

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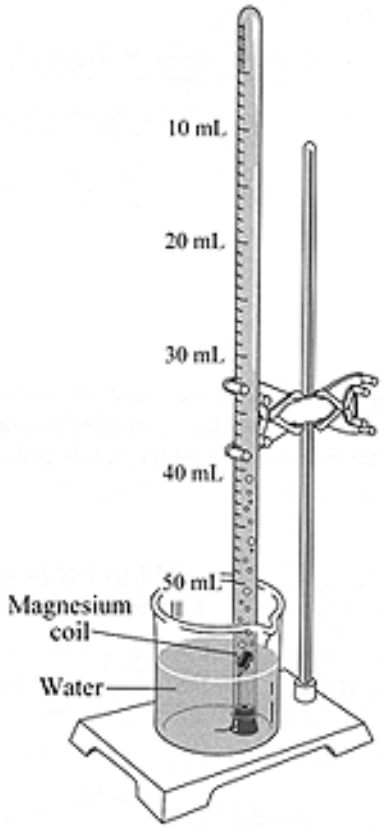
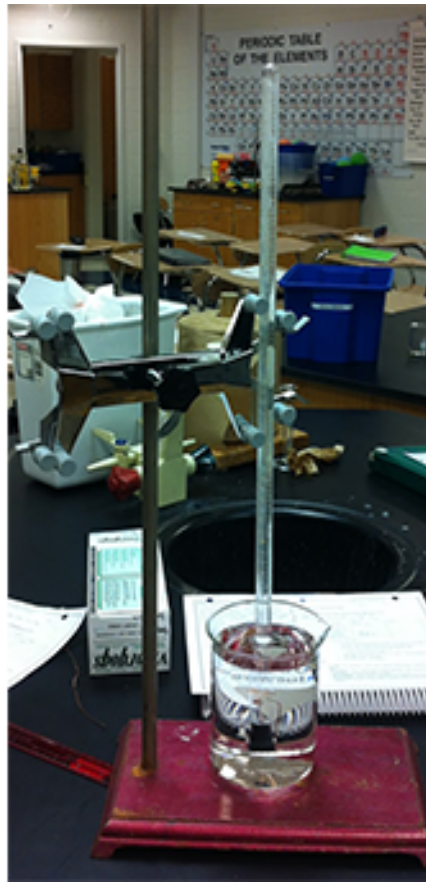
SETUP

- Put about 250 mL of deionized water into the 400 mL beaker. Attach the buret holder to a ring stand and set the beaker under it.
- Obtain a small piece of zinc, weigh it (use an analytical balance with accuracy to 4 places) and record the mass (it must be between 0.1000 – 0.0700 g).
- Make a cage around the piece of zinc using the copper foil. This cage must be tight enough so that the zinc can't fall out when it has reacted and becomes small. If it is too tight, the reaction will be very slow. Thread the copper wire through the copper foil cage and then through the rubber stopper (the foil cage should be on the small side of the stopper). The copper cage should be about 3 inches from the edge of the stopper.
- Pour approximately 25 mL of dilute (3.0 M) hydrochloric acid into a clean 50 mL eudiometer. This is excess acid. The HCl (aq) may have a small additive to color it red. Carefully and slowly fill the rest of the eudiometer completely with deionized water so as to avoid mixing of the water and the acid. If the acid has been colored red you will see the layer of clear water on top of the red acid.
- Insert the zinc sample into the eudiometer and press the stopper closed. When inserting the rubber stopper, let the excess water come out through the hole. Make sure no air is trapped in the tube as it will later be measured as hydrogen gas causing error.

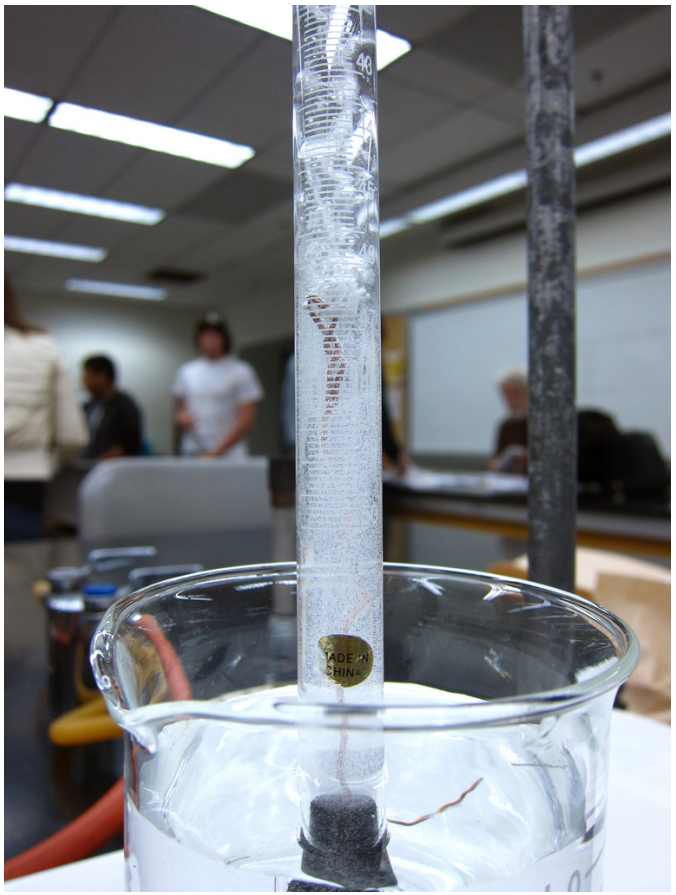




Exp 08: Gas Stoichiometry

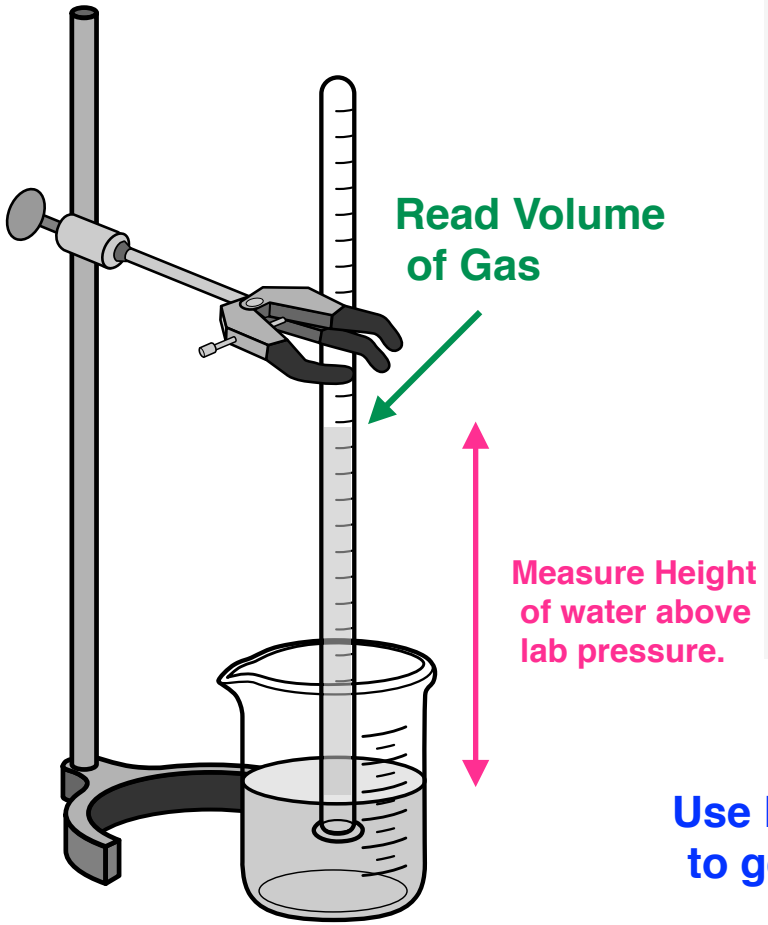
EXPERIMENT

- Cover the hole in the stopper with your finger and invert the eudiometer into a large beaker partly filled with water and clamp it to a ring stand using a buret clamp.
- The acid solution, being denser than water, will flow down the eudiometer and react with the zinc producing hydrogen gas. The reaction will start slowly and speed up it progresses. Bubles of hydrogen gas will appear around the metal and float to the top of the eudiometer. The pressure of the gas will force the water level in the eudiometer down. The zinc will take 15-25 minutes to react completely. When you repeat this step with magnesium, the magnesium will be consumed in less than 5 minutes.
- When the bubbles stop the reaction is complete. When it is complete, let the apparatus set for 1-2 minutes. Free any hydrogen bubbles adhering to the sides of the tube or copper wire by tapping the apparatus. Then read and record to the nearest 0.1 mL the volume of gas liberated. You can be read this volume directly from the eudiometer. Also, measure and record the difference in pressure between the eudiometer and lab. This is the difference in height of the water level in the eudiometer and beaker.
- From the volume of hydrogen and the ideal gas law calculate the moles of hydrogen. From the moles of hydrogen and the balanced chemical reaction calculate the moles of zinc. From the mass and moles of zinc, calculate the molar mass of zinc.



Exp 08: Gas Stoichiometry

DATA



Collecting Data (Obervations & Measurements):
Record the ID of your unknown sample of magnesium and the weight of your zinc sample.

Ukn Mg # _____

Zinc Weight _____ grams

Record the barometric pressure of the lab: _____ inches Hg

Zn Experiment:

vol H_2 gas _____ mL

$P_{DIFFERENCE}$ between lab and eudiometer _____ cm of Acid Solution

Temperature of experiment _____ °C

Vapor Pressure of Water (P_{H2O}) at that temperature _____ mmHg (from the included table)

Mg Experiment:

vol H_2 gas _____ mL

$P_{DIFFERENCE}$ between lab and eudiometer _____ cm of Acid Solution

Temperature of experiment _____ °C

Vapor Pressure of Water (P_{H2O}) at that temperature _____ mmHg (from the included table)

Use Barometer in Lab to get Lab Pressure.

Exp 08: Gas Stoichiometry

CALCULATIONS

- C1 - The pressure of the laboratory (P_{LAB}) will be determined by a nautical barometer. These devices use inches of mercury as unit of measurement. Convert this number into mmHg. You'll need the following conversion factors: 1 inch = 2.54 cm (exactly); 1 cm = 10^{-2} m (exactly); and 1 mm = 10^{-3} m (exactly). Use dimensional analysis.

- C2 - For the Zinc experiment, you measured the difference in pressure between the lab and the eudiometer by measuring the difference in level of the liquid inside and outside the eudiometer. That difference, recorded in cm of the acid solution, needs to be converted into mmHg. You'll need the conversion factor 0.722 mmHg = 1 cm of acid solution (this is a measured value).

- C3 - Find the pressure of the mixture of gases inside the eudiometer (P_{MIX}). You know the pressure in the lab (P_{LAB}) and you know the difference in pressure between the lab and the eudiometer (P_{LAB}). Now that both pressures are in mmHg, subtract the difference from the lab pressure to calculate the pressure of the gas mixture.

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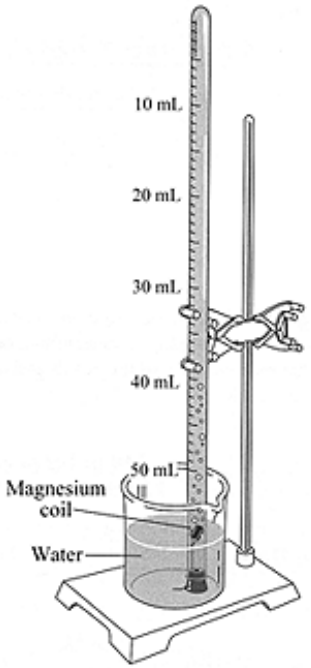
CALCULATIONS

- C4 - Dalton's law of partial pressures states the total pressure inside the eudiometer is equal to the sum of pressures exerted by each gas in the mixture. The pressure of water vapor in the eudiometer can be found in the table on the front page of the experiment, it requires you to know the temperature of that water. The only other gas in the mixture is the hydrogen gas you prepared. Calculate the partial pressure of hydrogen in the eudiometer ($P_{HYDROGEN}$).

- C5 - The volume of gas produced in the experiment can be read directly from the eudiometer. That value will be in mL. Convert this value to L of gas.



VAPOR PRESSURE OF WATER AT DIFFERENT TEMPERATURES

Temp (°C)	Vapor Pres (mm Hg)	Temp(°C)	Vapor Pres (mm Hg)
0	4.6	25	23.5
5	6.5	26	25.2
10	9.2	27	26.7
15	12.8	28	28.3
16	13.6	29	30.0
17	14.5	30	31.8
18	15.5	35	42.2
19	16.5	40	55.3
20	17.5	45	71.9
21	18.6	50	92.5
22	19.8	55	149.4
23	21.1	60	233.7
24	22.4	65	760.0

Exp 08: Gas Stoichiometry

CALCULATIONS

- C6 - You now know the volume of gas produced (C5), the pressure of that gas (C4) and the temperature of the gas (assume it's the same as the water in which it was produced). Use the ideal gas law to calculate the number of moles of gas produced.

IDEAL GAS LAW: $P V = n R T$

- C7 - Using the balanced equation for the chemical reaction and the moles of hydrogen gas produced, calculate how many moles of zinc was consumed in this reaction.

$$Zn + 2\ HCl_{(aq)} \rightarrow H_{2\,(g)}\uparrow + ZnCl_{2\,(aq)}$$

- C8 - Divide the grams of zinc you used by the number moles of zinc you calculated to find out the molar mass of zinc. In your conclusions section, report this number and the percent error between this and the known molar mass of zinc.

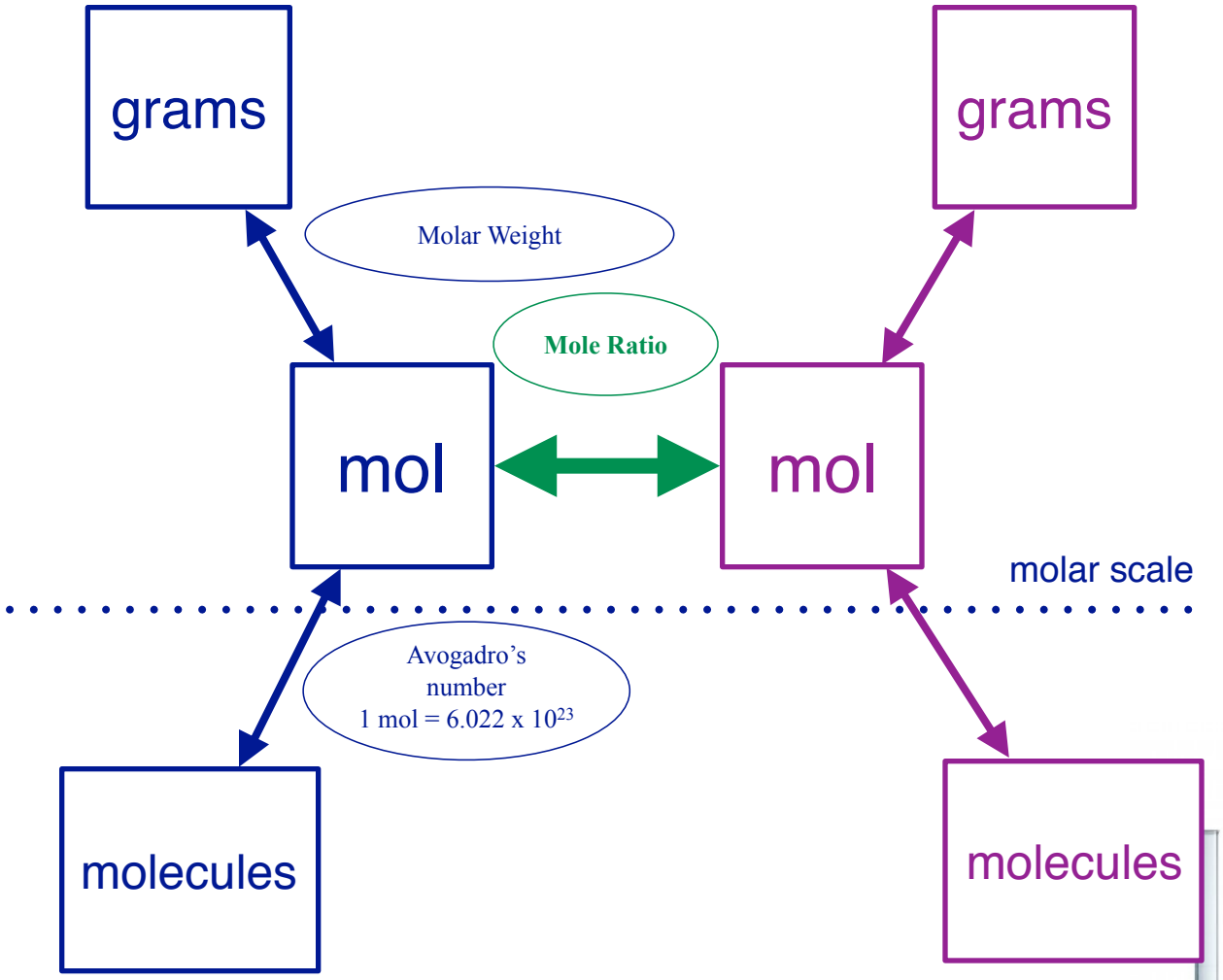
Exp 08: Gas Stoichiometry

CALCULATIONS

- C9-C14 - Repeat the calculations C2-C7 above to determine the number of moles of magnesium consumed in your second experiment.

- C15 - Using the moles of magnesium from C14, calculate the mass of your unknown piece of magnesium. Report the unknown number and final mass in your conclusions.

Stoichiometry



Stoichiometry

Important:

— Molar Weight is Different for Each Substance

— Molarity is Different for Each Solution

grams

Molar Weight

grams

Molarity

Mole Ratio

L (sol'n)

mol

mol

L (sol'n)

molar scale

Avogadro's number
1 mol = 6.022×10^{23}

molecules

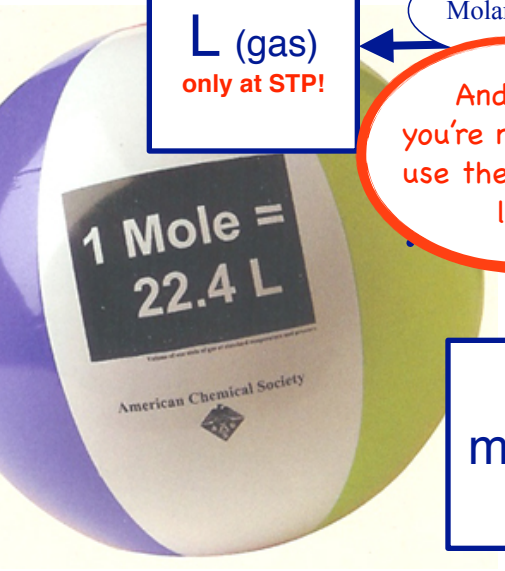
molecules

Important:

— Don't confuse stoichiometry with dilution problems!

Molar Volume

Only works at STP!



grams

L (sol'n)

Molar Weight

Molarity

L (gas)
only at STP!

Molar Volume

mol

And when you're not at STP use the ideal gas law!

molecules

Avogadro's number
1 mol = 6.022×10^{23}

Mole Ratio

grams

L (sol'n)

mol

L (gas)
at STP

molar scale

molecules

Questions?