EXPERIMENT 19   GAS STOICHIOMETRY AND THE GAS LAWS

Introduction: The relationship between the physical properties of a gas, and the moles, is given by the "Ideal Gas Law," $P V = n R T$, where n = number of moles, R = the ideal gas constant: 62.4 L torr mole^{-1}K^{-1}. In this experiment, the theoretical yield of gas, will be compared to the experimental yield. The reaction of aluminum with hydrochloric acid produces hydrogen:

$$2 \text{ Al (s)} + 6 \text{ HCl (aq)} \longrightarrow 3 \text{ H}_2 \text{ (g)} + 2 \text{ AlCl}_3 \text{ (aq)}$$

The number of moles of hydrogen will theoretically be equal to $^3/_2$ x the moles of Al used.   In this lab, approximately 0.0067 moles of Al will be used such that about 0.01 mole of hydrogen may be produced.   The actual yield of hydrogen can be plugged into the Ideal Gas Law, and the of water (the amount of water vapor in the gas).

Materials:	Chemicals:
250- and 500-mL Florence flasks, 400-mL beaker **or** 250-mL graduated cylinder, rubber tube/stopper assembly	Aluminum wire 6 M (dil) HCl tap water

Procedure: Connect a large (500-mL) Florence flask with a smaller (250-mL) flask as shown, with about 500 mL of water in the large flask. The second piece of tubing is placed in a beaker or directly into a large graduated cylinder.   Blow out the air in the second tube so that the tube now contains water. (Your instructor will demonstrate.)

- Cut a piece of aluminum wire (see instructor for sample length – it may be pre-cut)
 The wire will weigh 0.15 - 0.19 g
  Weigh the wire to **4** decimal
  places on an analytical balance and
  curl it up. Place it in the bottom of
  the smaller flask.
  - Pour about 50 mL of dil (6M)
    HCl into the flask and quickly
    insert the stopper with tube. As
    the reaction proceeds, water
    will be displaced in the large
    flask by the H$_2$.
  The volume of water in the
  beaker equals the volume of gas

fill this tube with water

make sure stoppers fit snugly

Al + HCl
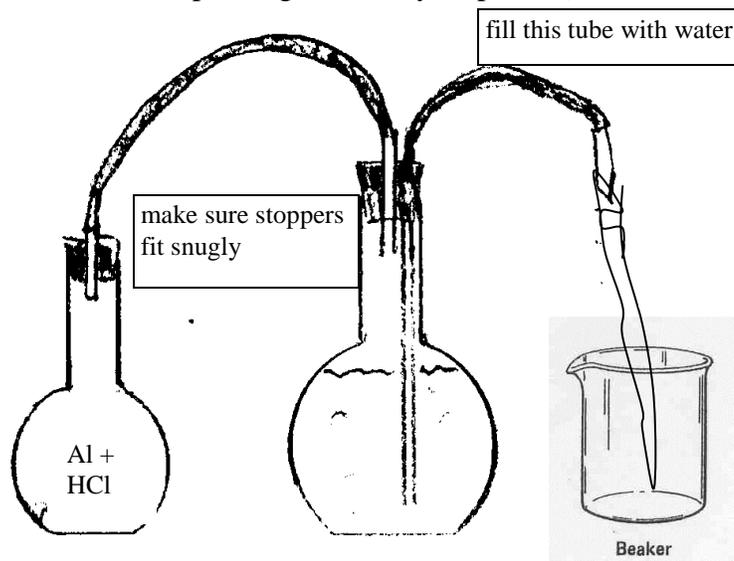
Beaker

- When no more gas evolves, and all the Al wire has been consumed, cool the reaction flask (the smaller one) by immersing it in a large beaker of water for a few minutes, Measure the temperature of the water, then measure the volume of water collected in the beaker either by pouring the water into a large cylinder or by weighing the 400 mL beaker with and without water. If you are weighing the beaker with the water – use the high capacity balance and record the mass to the nearest 0.1 or 0.01 mL – this is sufficient. Never place a heavy item on the analytical balance.
- Record the barometric pressure, and the water vapor pressure at the recorded temperature

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Gas Stoichiometry and the Gas Laws   Section _____   Date _____

Data and Calculations:
weight of Al wire: _____   moles of Al used _____   (watch sig figs)

theoretical yield (moles) of hydrogen: _____   (Show calculation setup.)

volume of water collected _____   (This is also the volume of gas produced.)

atmospheric pressure: _____ torr   (This is the total pressure of the gas mixture , see barometer.)

temperature of the water: _____^{o}C = _____ K

vapor pressure of water _____ torr
(Read from a table in a reference book, at the water temperature.)
(Subtract this value from the atmospheric P to obtain the pressure of dry hydrogen gas.)

pressure of dry hydrogen   _____ torr   (barometric pressure minus vapor pressure)
(This is the pressure of just the hydrogen; use this value in the PV=nRT.)

Using PV = nRT, calculate the moles of hydrogen produced: _____   (Show set-up.)   (Make sure to use units consistent with the value of R you use.)

Now calculate the % error, using the actual moles obtained and comparing to the theoretical moles calculated from the moles of aluminum used.

 % error =   <u>actual moles **-** theoretical moles</u> x 100   =
                         theoretical moles

Questions:
1. If the amount of gas collected had not been corrected for the presence of water vapor, what effect would this have had on the calculated value of actual moles of hydrogen?

2. This experiment would also work using another reactive metal such as zinc. If you had used the same number of grams of Zn as you did Al in this experiment, would you have obtained more or less hydrogen? Illustrate with an equation and calculation. (answer on the backside) There are two reasons – explain.