EXPERIMENT #8 **Name: ________________________**

PRE-LABORATORY ASSIGNMENT: **Lab Section___________**

1. The alkali metals are so reactive that they react directly with water in the absence of acid. For example, potassium reacts with water as follows:

$$2\ K(s)\ +\ 2\ H_2O(l) \rightarrow 2\ K^+(aq)\ +\ 2\ OH^-(aq)\ +\ H_2(g)$$

How many milliliters of hydrogen will be evolved over water when 4.52 g K reacts with an excess of $H_2O(l)$? (T = 23 °C, P = 758 torr, P_{H2O} = 21 torr)

2. A student dissolved 0.5212 g of an Al-Mg alloy in acid and collected 650 mL of hydrogen saturated with water vapor at 20 °C (vapor pressure of water = 17.5 torr). The barometric pressure was 763 torr.

(a) How many moles of hydrogen were evolved?

(b) How many grams of magnesium were in the alloy?

(c) What was the weight percent of aluminum in the alloy?

EXPERIMENT 8

MODIFIED ANALYSIS OF AN ALUMINUM-MAGNESIUM ALLOY

Aluminum and Magnesium react with solutions of strong acids as follows:

$$Mg(s) + 2\,H^+(aq) \rightarrow Mg^{2+}(aq) + H_2(g) \qquad (1)$$

$$2\,Al(s) + 6\,H^+(aq) \rightarrow 2\,Al^{3+}(aq) + 3\,H_2(g) \qquad (2)$$

If 1.00 g Mg is dissolved in, for example, concentrated hydrochloric acid, the amount of hydrogen evolved can be calculated as follows:

$$1.00\text{g Mg} \times \frac{1\text{ mol Mg}}{24.3\text{g Mg}} \times \frac{1\text{mol H}_2}{1\text{mol Mg}} = 0.0412\text{ mol H}_2$$

A similar calculation shows that 1.00 g Al evolves 0.0556 mol H_2 when dissolved. Since the same mass of each metal produces different amounts of hydrogen, it should be possible to react a known mass of an aluminum-magnesium alloy with excess acid, measure the amount of hydrogen evolved, and calculate the percentage composition of the alloy. In this experiment the volume of hydrogen evolved will be measured by displacement of water in a buret. The temperature of the gas should be equal to the temperature of the water, and the gas itself consists of hydrogen saturated with water vapor. To calculate the number of moles of hydrogen evolved, it is necessary to know the partial pressure of the hydrogen. By Dalton's Law:

$$P_{H_2} = P_{atm} - P_{H_2O} - P_{col.} \qquad (3)$$

Where P_{atm} is measured at the barometer, P_{H_2O} is the vapor pressure of water at the temperature of the experiment (Tables of the vapor pressure of water as a function of temperature are posted in the balance room.), and $P_{col.}$ is the pressure attributed to the column of water left in the buret.

The column pressure must be converted to mm of Hg from mm of H_2O. Since P = d × g × h, where d = the density of the liquid, g = the acceleration due to gravity, and h = the height of a column of liquid, the pressure due to a column of water in mm Hg is:

$$P_{col.}(mmHg) = \frac{h_{H_2O} \times d_{H_2O(l)}}{d_{Hg(l)}} \qquad (4)$$

The number of moles of hydrogen evolved is then calculated from the ideal gas law:

$$n_{H_2} = \frac{P_{H_2}V}{RT} \qquad (5)$$

The composition of the alloy can now be calculated as follows:

(a) Let m = mass alloy sample
X = the mass of magnesium in the alloy
Y = the mass of aluminum in the alloy

Such that: m = X + Y

The mass of Al in the alloy is therefore: Y = m - X

(b) The total number of moles of hydrogen produced by both the Al and Mg in the sample is given by:

$$n_{H_2(g)} = \left(X \times \frac{1\text{mol Mg}}{24.305\text{g Mg}} \times \frac{1\text{mol } H_2(g)}{1\text{mol Mg}} \right) + \left((m - X) \times \frac{1\text{mol Al}}{26.982\text{g Al}} \times \frac{3\text{mol } H_2(g)}{2\text{mol Al}} \right) \quad (6)$$

Since m has been measured and mol H_2 evolved has been calculated previously, this equation can easily be solved for X.

(c) Now the percentage composition of the alloy is just the following:

$$\%\ \text{Mg} = \frac{\text{g Mg in the sample}}{\text{g sample}} \times 100 = \frac{X}{m} \times 100 \quad (6)$$

$$\%\ \text{Al} = 100 - \%\ \text{Mg} \quad (7)$$

In this experiment you will learn the experimental procedure of collecting H_2 gas over water using a known metal.

EXPERIMENTAL

Known Mg metal sample:

Coil your weighed Mg metal strip and wrap it in a loop copper wire. Leave approximately 10 cm of wire straight then loop it through the holes of a rubber stopper. Secure the wire by twisting it back onto itself.

Obtain a 50 mL buret from the buret case. Handle the burets with care as they are delicate and expensive. Make sure that you rinse it well 3 times with ~20 mL of DI water since any residual acid or base from a previous experiment might interfere in this experiment. When you are finished with the burets, prince and store them with DI water. Before proceeding with the experiment, you need to measure the un-calibrated volume of the buret (the volume between the 50.0 mL mark and the top of the stopcock). Do this by adding some water to the buret and draining the water until the level falls to the 50.0 mL mark EXACTLY. Now, using a 10 mL graduated cylinder, drain the water until the level reaches the TOP of the stopcock. Read the volume obtained in the graduated cylinder as accurately as possible.

Using a funnel, pour into the buret 10.0 mL of concentrated hydrochloric acid. Be careful not to spill, splash, or drip any of the acid on your skin or clothes. After adding the acid, fill the buret completely with deionized water. ADD THE WATER SLOWLY so that you don't mix it with the acid you initially added. You "ideally" want a layer of acid and a layer of water on top. Insert the Mg metal sample about 4 cm into the buret, and clamp it there by the copper wire handle, using a one or two holed stopper. Make sure that NO air is trapped in the buret. Cover the stopper holes with your finger (use a piece of parafilm to protect your fingers from any contact with the acid). Invert the buret in a 400 mL beaker partly filled with water (about half full). Clamp the buret into place. The acid, having a greater density than water, will sink and diffuse toward the metal and begin the reaction. As the $H_2(g)$ is generated as one of the products of the reaction, it will collect at the top of the buret. Make sure that no gas bubbles are observed to escape from the metal end of the buret (may mean that your metal is too close to the end of the buret). If any gas escapes, you need to repeat the experiment. After complete dissolution of the metal and the reaction stops, let the apparatus cool to room temperature. Tap the sides of the buret lightly to release any hydrogen bubbles from the sides of the buret or the copper wire. Measure the volume of gas produced in the reaction. Without moving the buret, measure the difference in height of the water level in the beaker and in the buret (see figure) to use in your calculation of the H_2 gas pressure in the buret. This is similar to an open-ended manometer. The height difference between the water levels is the difference in the pressure of the gas compared to atmospheric pressure measured in mm H_2O.

Take the temperature of the gas by holding a thermometer in contact with the side of the buret. Raise the buret above the beaker water level, which will allow the rest of the solution to drain out of the buret. Rinse the beaker contents down the drain with plenty of water. Obtain the barometric pressure reading for the day. Perform a second trial with your known metal. You will need to rinse your buret thoroughly before performing each run to remove any residual acid.

Experiment 9 Data Sheet: Name: ______________________________

(Turn in this and the following only!!) Section: _________

Known Mg metal	***Trial 1***	***Trial 2***
Mass of Mg metal	_________ g	_________ g
Volume of uncalibrated buret region	_________ mL	
Volume of H_2 gas generated buret reading	_________ mL	_________ mL
Total volume of $H_2(g)$ including uncalibrated buret region.	_________ mL	_________ mL
Temperature of gas	_________ °C	_________ °C
Barometric pressure	_________ torr	_________ torr
Height difference of water in beaker and buret at the end of reaction	_________ mm	_________ mm

CALCULATIONS	*Trial 1*	*Trial 2*
Moles of known metal sample	_________ moles	_________ moles
Pressure of combined gases in buret	_________ torr	_________ torr
Vapor pressure of $H_2O(g)$ at T	_________ torr	_________ torr
Partial Pressure of $H_2(g)$ collected	_________ torr	_________ torr
Volume of $H_2(g)$ collected	_________ L	_________ L
moles of $H_2(g)$ collected	_________ moles	_________ moles

SUMMARY

Theoretical yield (moles) of $H_2(g)$	_________ moles	_________ moles
Percent Error between theoretical yield and actual yield:	_________ %	_________ %
Average % Yield:	_________ %	

You must show all calculations in a neat and orderly manner on the following page for credit.

Instructor date and initials: ________________________

Show your work here:

1. Balanced equation for reaction of the metal with HCl(aq):

2. Moles of metal in the sample:

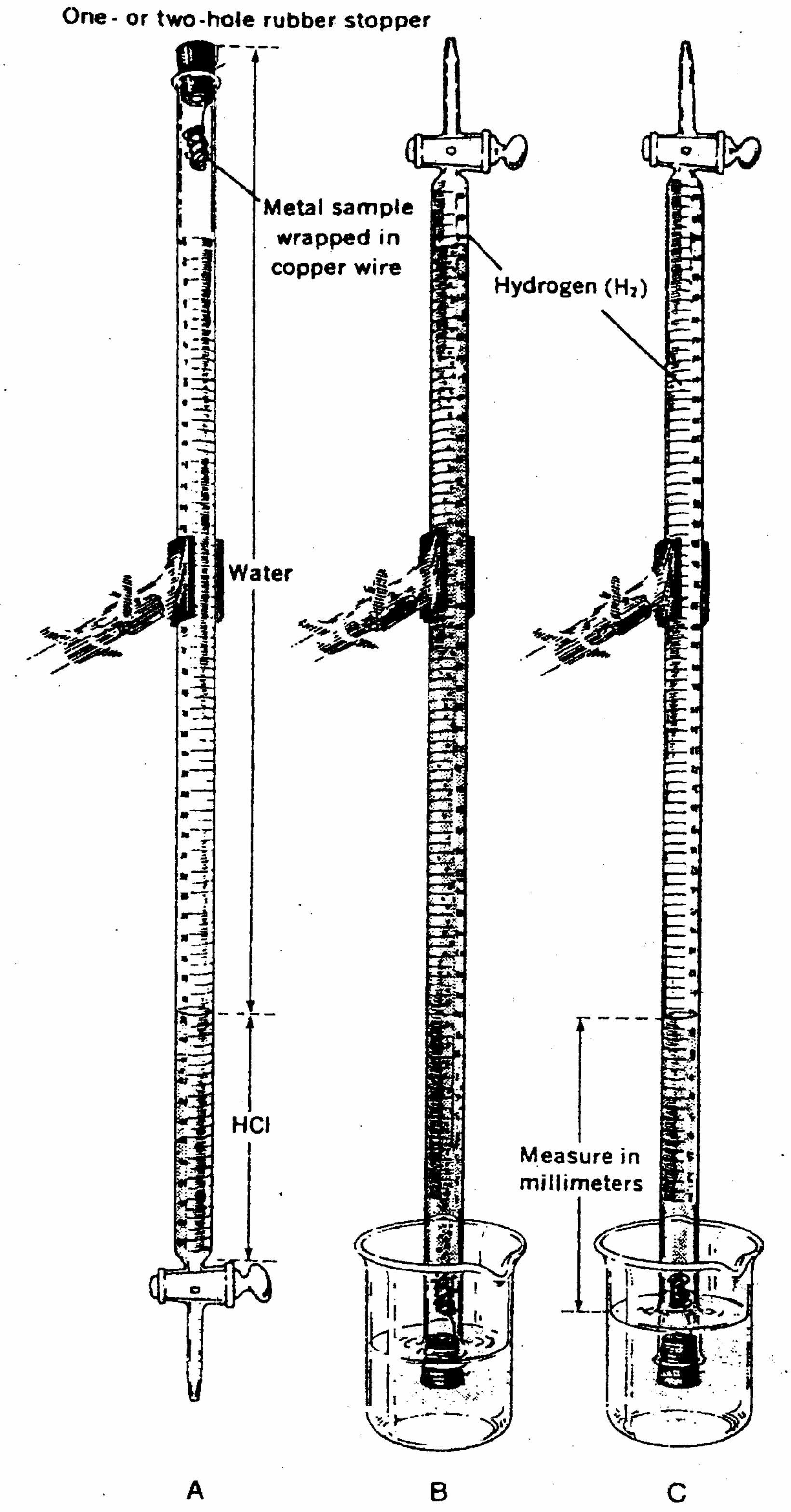
3. Pressure of H_2(g) collected:

4. Moles of H_2 (g) calculated from P_{H_2}

5. Theoretical yield (moles of H_2(g) from metal):

6. % error between theoretical and actual yields & % yield:

% error	% yield


One- or two-hole rubber stopper
Metal sample wrapped in copper wire
Hydrogen (H_2)
Water
HCl
Measure in millimeters
A
B
C