Name: ____________________________________

Section Day: _______________Time: _______

Chem 132.L11. Reaction Ratio of Magnesium and Hydrochloric Acid

Introduction

The purpose of this experiment is to investigate the percent yield for the reaction of two common chemicals, magnesium (Mg(s)) and hydrochloric acid (HCl(aq)). The equation for the reaction performed here is:

$$Mg(s) + 2\ HCl(aq) \rightarrow MgCl_2(aq) + H_2(g) \qquad (1)$$

where the products are magnesium chloride, which is soluble in water, and hydrogen gas.

Your goal is to calculate the theoretical yield of H_2 (g) produced based on the amount of Mg(s) you begin with, perform the experiment and determine the actual yield of H_2 and then calculate the percent yield of the reaction.

Procedure

Obtain a piece of magnesium ribbon approximately 4.5 cm long. Weigh the magnesium ribbon to the nearest 0.001 g, and record the mass below. Use the molar mass of magnesium to calculate the moles of magnesium employed in the reaction.

→Weight of Mg ribbon ____________g

a. Calculation of the theoretical yield of H_2 (g)

Using the mass of Mg ribbon, you can calculate the theoretical volume of H_2 (g) produced using the following path:

$$\text{mass of Mg} \rightarrow \text{moles of Mg} \rightarrow \text{moles of } H_2 \rightarrow \text{liters of } H_2 \text{ at p \& T} \qquad (2)$$

For the first step, you need the molar mass of Mg. For the second step, you need to utilize the balanced chemical equation above to compare the moles of Mg used to the moles of H_2 produced. For the last step, the ideal gas law must be used

$$pV = nRT \qquad (3)$$

where p is the pressure of a gas sample in atm; V is the volume of the sample in L; n is the moles of gas in the sample; R is the gas constant, whose value is $0.0821\ \frac{L \cdot atm}{mol \cdot K}$; and T is the absolute temperature of the gas in K. We want to find the volume of gas, so we rearrange the equation to give

$$V = \frac{nRT}{p} \qquad (4)$$

Take the temperature of the room in degrees Celcius and convert the temperature to Kelvin. Record the value in the spaces below. Conversion factors that you will need in this experiment include 1 atm = 760 torr; 1 L = 1000 mL; and $T_K = T_{°C} + 273$.

→Temperature of the room ________________°C

→Temperature of the room T=____________ K

So if we know the pressure, temperature, and moles of a gas sample, we can find the volume of the gas. Using the path given in (2), calculate the number of moles of H_2 produced (first two steps) and record the value in the space provided below. Show your work.

→Moles of H_2 theoretically produced n=______________ moles

→Gas constant R= 0.0821_______ $\frac{L \cdot atm}{mol \cdot K}$

The calculation of the pressure of the gas requires correction for the fact that the hydrogen will be collected over water. As the hydrogen gas is collected, water vapor is produced by evaporation and mixes with the hydrogen. Hence the total pressure of the gas collected includes the pressure of hydrogen (p_{hyd}) and the vapor pressure of water (p_{water}). The sum of these pressures is approximately equal to atmospheric pressure (p_{atm}). The relationship between these pressures is given by Dalton's Law of Partial Pressures, which states that the total pressure of a mixture of gases is equal to the sum of the individual pressures, which implies that:

$$p_{atm} = p_{hyd} + p_{water} \tag{5}$$

Solving for p_{hyd} gives:

$$p_{hyd} = p_{atm} - p_{water} \tag{6}$$

Your instructor will provide you with p_{atm}, and values for p_{water} are provided in Table 1 below. Be sure to use the vapor pressure of water that corresponds to the temperature of the gas.

→p_{atm} ________________mmHg

→p_{water} ________________mmHg

→p_{hyd} ________________mmHg

→p_{hyd} p=______________atm

Table 1: Vapor pressure of water (p_{water}) as a function of temperature.

Temp. (°C)	p_{water} (mmHg)	Temp. (°C)	p_{water} (mmHg)
15	12.8	21	18.7
16	13.6	22	19.8
17	14.5	23	21.1
18	15.5	24	22.4
19	16.5	25	23.8
20	17.5	30	31.8

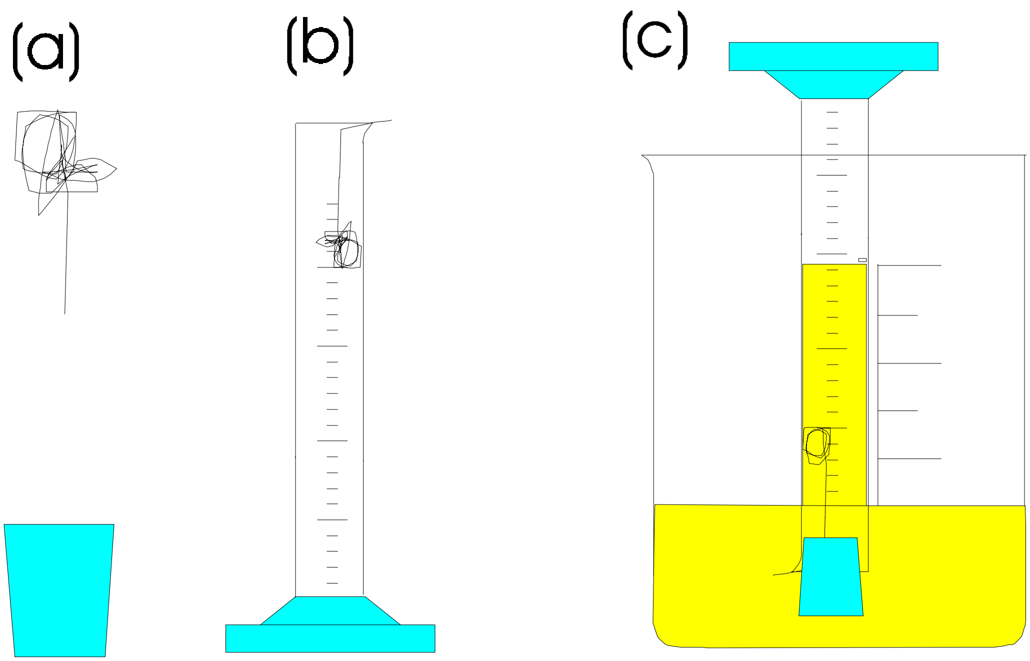
Using all of the data (p, n, R, and T), use equation (4) to calculate the theoretical volume of H_2 produced in liters. Show your work and provide your answer in the space provided.

→Volume of H_2 theoretically produced V=____________ L

b. Determination of actual yield of H_2 (g)

Compress your sample of Mg into a compact bundle, and wrap it in all directions with about 20 cm of fine copper wire, forming a small basket or cage, leaving 5 cm of the copper wire straight as a handle. The cage should have no openings through which small pieces of magnesium ribbon can escape (Figure 1a).

Figure 1. Assembly of apparatus.



Set up a ring stand and utility clamp in position to hold a 50-mL graduated cylinder, which will be used to collect and measure the volume of the hydrogen produced in this reaction. Fill a

400-mL beaker about two-thirds full of tap water. Place it near the ring stand. Incline the graduated cylinder slightly, and pour in about 10 mL of 6 M HCl. **CAUTION: Hydrochloric acid is a corrosive material that may cause serious skin and eye damage. Wear your safety glasses at all times**. Slowly fill the cylinder to the top with tap water, rinsing down any acid that may be on the side of the tube so that the liquid in the top of the tube will contain very little acid. Dislodge any bubbles clinging to the side of the tube by tapping the tube gently.

Hold the copper cage by the handle, and insert it about 3 cm down into the cylinder (Figure 1b). Hook the wire over the edge of the tube, and hold it in place by inserting the rubber stopper into the graduated cylinder. Make certain no air is entrapped in the tube. Cover the hole in the stopper with your finger and invert the tube in the beaker of water as shown in Figure 1c. Clamp the cylinder in place. As the acid is more dense than the water, it will eventually sink to the bottom and react with the magnesium.

After the reaction stops, let the apparatus cool to room temperature (about 5 minutes). Dislodge any bubbles clinging to the sides of the tube. Read and record the volume of the gas liberated (Figure 1c).

→Volume of H_2 gas actually produced ________________ mL

→Volume of H_2 gas actually produced ________________ L

c. Calculation of Percent Yield

To calculate the percent yield of the reaction, use the percent yield equation given below:

$$\%\text{ yield} = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100$$

→Percent yield of the reaction ________________

Questions

1. Convert R from $0.0821\ \frac{\text{L}\cdot\text{atm}}{\text{mol}\cdot\text{K}}$ to units of $\frac{\text{mL}\cdot\text{torr}}{\text{mol}\cdot\text{K}}$. Show your work.

2. If you fail to wait for the reaction mixture to cool before making your volume measurement will your percent yield be higher, lower or the same as what you calculated? Explain your reasoning.

3. Hydrogen (H_2) gas is not very soluble in water. If it were, would your percent yield be higher, lower or the same as what you calculated? Explain your reasoning.