Name _____ AP Chemistry

The Determination of the Value for Molar Volume

Objective

Using a chemical reaction that produces a gas, measure the appropriate values to allow a determination of the value for molar volume.

Brief Overview

The chemical reaction to be used is this:

$$Mg(s) + 2\ HCl(aq) \text{ ---> } MgCl_2(aq) + H_2(g)$$

This reaction has a 1:1 mole ratio between magnesium used and hydrogen produced. This will allow an easy determination of the moles of H_2 by determining the mass of Mg consumed in the reaction. The mass of Mg will be determined by comparing the length of ribbon used to the mass of one meter of ribbon. A hidden assumption of this lab is that two different lengths of the ribbon are uniform in width & thickness.

The gas will be collected "over water." This means that the gas produced is in contact with liquid water. The consequence of this is that the gas in the tube WILL NOT be pure H_2; it will have some water vapor mixed in. The mixture is usually called "wet gas" and its production is unavoidable. However, using Dalton's Law of Partial Pressures, we will be able to remove the water vapor's pressure, thereby recovering the "dry" hydrogen gas' pressure.

Corrections to the temperature and pressure at the time of the experiment will also be required, since the molar volume value we are seeking is measured at Standard Temperature and Pressure (STP). Using the Combined Gas Law, we will be able to make the necessary corrections.

Equipment and Reagents

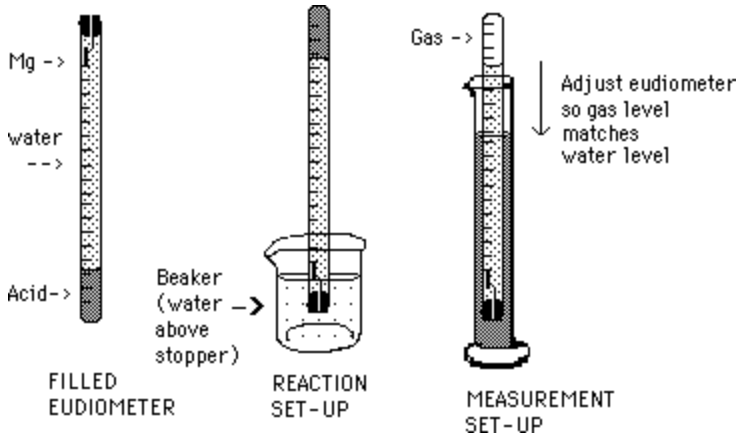
- 2 Liter Beaker or Battery jar
- 100 mL Eudiometer
- 30 cm piece of copper wire
- 1-hole stopper
- Small piece of magnesium ribbon (3 cm)
- 6 M hydrochloric acid
- The teacher will use a barometer and thermometer to determine the room pressure and temperature.

Procedure – Experiment Set-up

1) Fill the 2-Liter beaker 3/4 full with tap water.

2) Cut and record the exact length of the Magnesium it to the nearest 0.01 cm and record this value in your data table. Use and scale and determine the mass of the magnesium and place this in the table.

3) Fold the Mg ribbon a few times, then create the copper wire cage around it. Wind the wire in different directions, so there are many small openings rather than one or two big ones. Leave 4-5 cm or so of wire unrolled to act as a handle. See figure #1 below



4) Fill the gas measuring tube with 10 mL of acid

5) Fill the gas measuring tube to the top with tap water. Use the 150 mL beaker for this. Pour water slowly so that you wash acid drops near the open mouth of the tube downward. Stop pouring twice and rotate the tube part-way, so as to wash the entire inside of the tube. The Mg will immediately start reacting with any acid present, so make sure to rinse the acid downward. Fill the tube so full with water that the water actually bulges upward from the lip of the gas measuring tube. Use the distilled water bottle for the last few drops.

Procedure – Experimental Steps

A. Reacting the magnesium and hydrochloric acid

6) Place the copper wire cage in the open mouth of the gas measuring tube. The cage should be halfway from the mouth of the tube to the 50 mL mark on the tube, only 3-5 cm into the tube. Trap the wire handle against the gas measuring tube wall by inserting the rubber stopper into the tube. Be aware that, if there is some acid near the top, the Mg will start reacting immediately. If this happens, continue on to the next steps at a normal rate of work.

7) Place your finger over the rubber stopper holes and invert the gas measuring tube. DO NOT remove your finger until you are under the water level in the next step.

8) Place the inverted tube into the water in the battery jar, then remove your finger.

9) The acid is denser than the water. Watch as it drops down through the water and reaches the Mg ribbon. The reaction will start slowly. KEEP WATCHING!! When the reaction ceases, let everything sit for 2-3 minutes before continuing. Try to dislodge any bubbles that might be caught by the copper wire cage.

10) As you work, the teacher will read the barometer and thermometer. When the values are announced, record them in your data table.

B. Measuring the volume of gas produced

11) Covering the hole in the stopper with your finger, transfer the eudimeter to a large ungraduated cylinder that is full of water. Move the tube up and down until the level of the liquid inside the tube matches the level of the water in the cylinder. *This ensures that the pressure of the gases equals room pressure.* Record the level of gas in the eudiometer.

12) When the gas pressures are equalized, read the volume of gas from the scale on the tube. Read it to the closest 0.1 mL and record this value in your data table. Please note that zero is at the top of the tube. Read the value from the top down, not from the 50 mL mark going up.

III. Clean-up Steps

13) Pour all liquids down the drain, then rinse all glassware three times with tap water. When done rinsing, let the water run for 2 more minutes. If you got any of the liquid on your skin, rinse the area for 2 minutes. You do not need to dry the equipment, just place everything on paper towels on a part of the table toward the wall.

14) Dry the surface of the table and discard all used paper towels. Throw the wire cage in the trash. Do not keep it.

15) Remove goggles and aprons when directed to do so.

Data Table and Discussion

	Trial 1	Trial 2
Mg length (cm)		
Mass of Mg (g)		
Room temperature (°Celsius)		
Room pressure (atm)		
"wet" gas volume (mL) from experiment		

Determine the:

1) Moles of magnesium used.

Trial 1 Trial 2

2) Moles of hydrogen gas produced (use balanced equation)

Trial 1 Trial 2

3) Pressure of the "dry" hydrogen gas. (See - Vapor Pressure Data for Water)** Hint, for this you will have to factor out the pressure of H_2O vapor and use the room pressure.

Trial 1 Trial 2

4) Volume of "dry" hydrogen gas at STP **Hint, use the combined gas equation

Trial 1 Trial 2

5) Value (in liters/mole at STP) for molar volume. Use the data from your experiment.

Trial 1 Trial 2

6) Percent error. The true value for molar volume at STP is 22.414 L/mol.

Questions:

1. Where are some sources of error in this experiment?

2. Why did the water level in the Eudiometer and the 2-Liter beaker need to be the same?

3. Do you think a weaker acid could work in this experiment? Why or why not?

Vapor Pressure Data for H_2O

Temperature	kPa	Temperature	kPa
15	1.7056	65	25.022
16	1.8185	66	26.163
17	1.938	67	27.347
18	2.0644	68	28.576
19	2.1978	69	29.852
20	2.3388	70	31.176
21	2.4877	71	32.549
22	2.6447	72	33.972
23	2.8104	73	35.448
24	2.985	74	36.978
25	3.169	75	38.563
26	3.3629	76	40.205
27	3.567	77	41.905
28	3.7818	78	43.665
29	4.0078	79	45.487
30	4.2455	80	47.373
31	4.4953	81	49.324
32	4.7578	82	51.342
33	5.0335	83	53.428
34	5.3229	84	55.585
35	5.6267	85	57.815
36	5.9453	86	60.119
37	6.2795	87	62.499
38	6.6398	88	64.958
39	6.9969	89	67.496
40	7.3814	90	70.117

If you need to convert to atmospheres, divide number below by 101.325.