Molar Volume of Carbon Dioxide

Reading assignment: Julia Burdge, Chemistry 3rd edition, Chapter 10.

Goals

To determine the molar volume of carbon dioxide gas and the amount of sodium carbonate in a sample.

Equipment and Materials

Analytical balance, 50-mL graduated cylinder, gas generator and gas collection tray, carbonate source, 3.0 M hydrochloric acid, Alka-Seltzer tablet.

Discussion

Carbonates react with acids to produce carbon dioxide gas. An example is the reaction between sodium carbonate and hydrochloric acid:

Na_2CO_3 (s) + 2 HCl (aq) $\rightarrow$ 2 NaCl (aq) + H_2O (l) + CO_2 (g)

The molar volume (V_M) of carbon dioxide can be found from by measuring the volume of the gas and the number of moles of the gas:

$$V_M = \frac{V_{CO_2}}{n_{CO_2}} \qquad \text{Equation 1}$$

In this experiment we will not be measuring the volume at standard temperature and pressure (STP). But we can calculate the volume at STP by taking into account a correction for temperature and pressure:

$$V(STP) = V_{exp}\left(\frac{273\,K}{T_{exp}}\right)\left(\frac{P_{exp}}{760\,mm\,Hg}\right) \qquad \text{Equation 2}$$

Where the "exp" subscripts refer to the experimental temperature and pressure acquired in the laboratory.

Procedure

SAFETY PRECAUTIONS
Safety glasses are required for this experiment. Hydrochloric acid is a strong acid and can damage clothing or skin. Students work in pairs on this experiment.

Sample Preparation

1. Prepare your sample of sodium carbonate by weighing out between 0.17 g and 0.18 g. Record the mass of your sample to 0.1 mg.

2. Carefully transfer your carbonate sample to a 75-mm test tube.

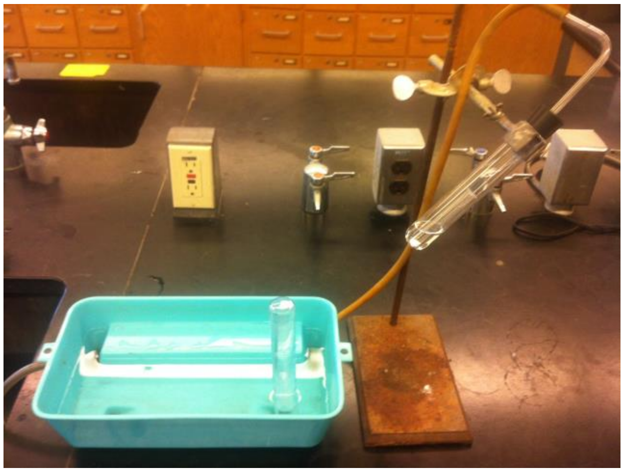
3. Pour 10 mL of 3.0 M HCl solution into a 200-mm test tube using a 10-mL transfer pipet.

4. Carefully slide the 75-mm test tube into the 200-mm test tube. Be sure not to allow any acid solution to enter the smaller test tube.

5. Place the two test tubes with the sample into a 100-mL beaker and weight the apparatus to the nearest 0.1 mg.

Gas Collection Apparatus

1. Fill the gas collection tray with one liter of tap water. Fill a 50-mL graduated cylinder with tap water and place it in the tray. Ensure that the cylinder is free of air bubbles and completely filled with water. Lay the cylinder horizontally in the tray.



2. Connect the one-hole rubber stopper to the 200-mm test tube and hold the test tube at least one foot above the working surface. If you lower the test tube, water may flow back from the tray into the test tube.

3. Drop one Alka-Seltzer tablet into the tray to saturate the water with carbon dioxide and wait for the reaction to stop.

4. Move the 50-mL graduated cylinder to a vertical orientation and slide it over to cover the hole in the tray where the carbon dioxide will escape.

5. Place one hand on the graduated cylinder to hold it in place.

6. Carefully remove the 200-mm test tube from the ring clamp. Gently agitate the tube up and down to cause the acid solution to flow into the smaller test tube. This will initiate the reaction. Carbon dioxide will displace water from the graduated cylinder.

7. Once you are certain that the reaction is complete and the volume of the gas has stabilized, measure the volume of the water displaced from the graduated cylinder. Record this volume.

8. If requested by your instructor, perform a second run of the experiment.

9. Clean up your work area and dispose of the chemicals in the sink.

Calculations

Show all calculations on a separate sheet of paper.

Data and Report Sheet

Name_________________________________ Section_______ Date_________

	Trial 1	Trial 2
1. Mass of sample (g)	____________	____________
2. Mass of generator + sample before reaction (g)	____________	____________
3. Volume of CO_2 (g) collected (mL)	____________	____________
4. Volume of CO_2 (g) collected (L)	____________	____________
5. Temperature of water (°C)	____________	____________
6. Barometric pressure (torr)	____________	____________
7. Vapor pressure of water (torr)	____________	____________
8. Pressure of dry CO_2 (g) (torr)	____________	____________
9. Mass of generator + sample after reaction (g)	____________	____________
10. Mass loss of generator = mass CO_2 evolved (g)	____________	____________
11. Volume of CO_2 (g) at STP (See Equation 2)	____________	____________
12. Moles of CO_2 (g) generated use the molar mass of CO_2 and the mass loss (10)	____________	____________
13. Molar Volume of CO_2 (g) at STP (L/mol) $\frac{\text{volume of } CO_2}{\text{moles of } CO_2}$	____________	____________

14. Ave molar volume of CO_2 (g) at STP (L/mol) ____________
(average of two runs)

Data and Report Sheet

Name__________________________________ Section_______ Date_________

Finding the Percent Na_2CO_3 in sample

	Trial 1	Trial 2
1. Moles of Na_2CO_3 in sample from mol CO_2 generated	_____________	_____________
2. Mass of Na_2CO_3 in sample (g)	_____________	_____________
3. Mass of original sample (g)	_____________	_____________
4. Percent Na_2CO_3 in sample (%)	_____________	_____________

5. Average percent Na_2CO_3 in sample (%) _____________

Calculations Sheet

Name__________________________________ Section_______ Date_________

Show all calculations on this sheet