

GASES

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INTRODUCTION

Carbon dioxide, CO₂, is produced when an antacid tablet is added to an acidic solution, for example:



In this procedure, the carbon dioxide gas generated by the reaction is trapped and the volume of gas is measured by downward displacement of water in a graduated tube.

When performing calculations you will use the ideal gas law:

$$PV = nRT$$

where $R = 62.364 \text{ L Torr mol}^{-1} \text{ K}^{-1}$ or $0.08206 \text{ L atm mol}^{-1} \text{ K}^{-1}$, P is the pressure of the gas, V is the volume of the gas, n is the number of moles of the gas, and T is the temperature of the gas in kelvin.

In this experiment, you will also use Dalton's law of partial pressures, which states that the sum of the partial pressures of all the different gases in a mixture is equal to the total pressure of the mixture:

$$P_{\text{Total}} = P_{\text{Gas1}} + P_{\text{Gas2}} + \dots$$

In this experiment, the total pressure of the gas in the reaction apparatus (above the liquid) is the sum of the partial pressure of CO₂ and the partial pressure (vapor pressure) of water:

$$P_{\text{Total}} = P_{\text{CO}_2} + P_{\text{H}_2\text{O}}$$

The vapor pressure of H₂O at various temperatures is listed in the table on Page 6 of this handout.

PROCEDURE

1. Measure the mass of an entire Alka-Seltzer tablet and record the value.
2. Break an Alka-Seltzer tablet in half and wrap one half tightly in aluminum foil.
3. Practice breaking the other half into pieces that are between 0.1 and 0.2 g. When you can do that easily, put all **the little pieces** into 250 mL beaker containing 125 mL of 0.2 M HCl. Stir until bubbling ceases. This is your "apparatus" fluid.
4. Pour the "apparatus" fluid into the leveling bulb. Alternately raise and lower the bulb until all the air has been expelled from the connecting tubing and no more bubbles rise in the graduated buret tube.
5. Pour 5.0 mL of 6 M HCl into an extra-large test tube. Stopper the test tube.

PLAN THE NEXT FEW STEPS CAREFULLY AND DO THEM QUICKLY. THE ANTACID IS MOISTURE SENSITIVE.

6. Take the foil-wrapped half of your tablet over to the balance and break off one piece that is between 0.100 and 0.200 g and record the exact mass. Using this size piece will allow you to generate a measurable amount of gas. Tightly rewrap the remaining chunk for repeat experiments.

MAKE A LOOP FROM A 20 CM LENGTH OF THREAD AND SLIPS THE WEIGHED PIECE OF TABLET SNUGLY INTO IT.

7. Open the test tube and raise the leveling bulb until the liquid level in the buret is between 0 and 2 mL. Clamp the leveling bulb in this fixed position. Carefully suspend the tablet by a thread until it hangs approximately 2 cm above the surface of the acid in the test tube and insert the stopper tightly. The thread should be pinched in place between stopper and neck of the test tube.
8. Lower the leveling bulb about 10 cm below its original position.

IF YOUR SYSTEM IS GAS TIGHT, THE LIQUID LEVEL IN THE BURET WILL DROP BUT REMAIN ABOVE THE LEVEL IN THE BULB. IF THE SYSTEM IS NOT GAS TIGHT, CHECK FOR LEAKS AND/OR GET HELP FROM YOUR INSTRUCTOR.

9. Now raise the bulb until the two liquid levels match. The buret reading should be between 1 and 5 mL. **If the level is below the 5 mL mark, your system has a leak. Start again at step 7.** If the buret reading is in the correct range, record it to the nearest 0.1 mL and go on to the final steps. Restore the leveling bulb to its previous position in STEP 7.
10. Tilt the test tube so that the acid contacts the suspended piece of antacid tablet. Be sure that the tablet slips out of the loop and drops into the acid. As gas is released, the liquid level in the buret will fall, a downward displacement. Lower the bulb to keep pace with it. This precaution minimizes errors caused by leaks.

11. Swirl the test tube gently until the liquid level in the buret stabilizes. Bring the level of the fluid in the bulb to the same level as in the buret. When the two levels are the same the pressure of the gas is the same as the atmospheric pressure in the laboratory. Read and record the volume of gas in the buret.

12. FINAL CHECK

Raise the bulb to the position in Step 11. The liquid in the buret should not rise continuously. If it does, the results are not valid.

13. Repeat the experiment using the same "apparatus" fluid but with a clean test tube, fresh acid, and another piece of tablet.

WHEN YOU HAVE FINISHED THE EXPERIMENT, FLUSH THE ENTIRE SYSTEM WITH DI WATER.

Correction Factors

When gases are collected in aqueous systems, water vapor is always present. Thus, the pressure due to water must be subtracted (Dalton's Law) from the total pressure. The vapor pressure of H₂O at various temperatures is listed in the table on Page 6 of this handout.

Bubbling the CO₂ through the "apparatus" fluid that is already saturated with the gas captures most of the CO₂ from the tablet. However, some CO₂ dissolves in the 5.0 mL of acid in the generator flask. Based on this, assume that 4.00 mL of gas dissolves in the acid.

Alka-Seltzer is a product of the Bayer Corporation of Elkhart IN, 46515.

Vapor Pressure of Water	
Temperature (Celsius)	Pressure (torr)
0	4.58
5	6.54
10	9.21
12	10.52
14	11.99
16	13.63
17	14.53
18	15.48
19	16.48
20	17.54
21	18.65
22	19.83
23	21.07
24	22.38
25	23.76
26	25.21
27	26.74
28	28.35
29	30.04
30	31.82
35	42.2
40	55.3
45	71.9
50	92.5
55	118.0
60	149.4
65	185.5
70	233.7
80	355.1
90	525.8

