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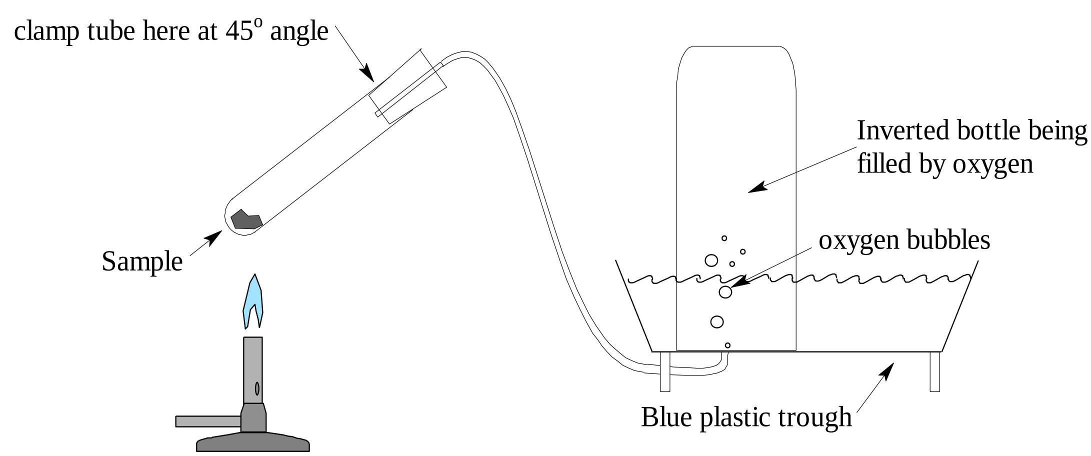
Experiment #12: Molar Volume of a Gas and Percentage of $KClO_3$ in an Unknown Sample

In this experiment, you will collect a gas by displacement of water and measure its volume when its pressure has been equalized with the atmospheric pressure. Then, you will calculate the molar volume of a gas. In the second part of the experiment, you will determine the percent of potassium chlorate contained in an impure sample consisting of $KClO_3$, KCl, and MnO_2 catalyst.

The molar volume of a gas is simply the volume that one mole of an ideal gas occupies at one atmosphere of pressure and 0 ^oC. Although oxygen is not an ideal gas, it will come very close to the ideal value of 22.4 L/mole.

Procedure

1. Obtain a clean, dry Pyrex test tube. Weigh and record its mass. Obtain the unknown sample assigned to you by your instructor and record its number. Weigh about 1.0 gram sample of your unknown on a weighing boat. (You need to know the exact amount, but it does not have to be exactly 1.000 g.) Transfer this sample to the test tube and record the total mass.



2. Set up the apparatus as shown above. Fill the provided wide-mouth bottle with water and slide the glass plate over its mouth. While securely holding the glass plate, invert the bottle and place its mouth under the water level in the trough. Remove the glass plate and set the mouth of the bottle over the opening in the bottom of the trough. No air should be in the bottle at this time.

3. After the set up is complete and you are certain there are no leaks, gently heat the test tube, slowly at first, then more strongly to obtain a moderate rate of evolution of oxygen gas. If white vapors appear in the test tube, stop heating until they disappear from the test tube. Continue heating until all the oxygen gas has been liberated. When the gas stops bubbling into the bottle, shut off the Bunsen burner and REMOVE THE RUBBER STOPPER FROM THE TEST TUBE IMMEDIATELY. Do this carefully as the test tube will be hot. When the test tube has cooled, weigh and record its mass.

4. Equalize the pressure of the collected gas with the atmospheric pressure by raising or lowering the bottle in the water trough to get the water level inside the bottle equal to the water level outside the bottle. When the levels are equal, securely place a glass plate over the mouth of the bottle and remove it from the water, taking care not to allow any water to leave the bottle. Invert the bottle to an upright position and remove the glass plate. Measure the volume of gas in the bottle and record this value.

   (<u>Note</u>: If you cannot equalize the pressure in the trough, the bottle must be transferred to a larger container of water without allowing any air to enter the bottle. Place the glass plate over the mouth of the bottle while it is under water. While securely holding the glass plate over the mouth of the bottle, transfer the bottle to the larger container of water; once the mouth of the bottle is again under water, remove the glass plate and follow the procedure above to equalize the pressure.)

5. Record the temperature**.** Note that the oxygen gas collected should be at the same temperature as the water.

6. Finally, record the atmospheric pressure in the room. A barometer is an instrument that is filled with mercury in an upside-down tube, above which is a vacuum and below a pool of mercury. To correctly read the pressure from the barometer in the room, first look at the bottom of the instrument and adjust the mercury level to just touch the triangular metal point. Next, while at eye level, adjust the top of the barometer so that the slider stops at the top of the meniscus. You may need to use a step stool to maintain eye level. Notice for mercury the meniscus is convex, the opposite of water which is concave. Read the barometer in millimeters of mercury on the right side (left side is inches of Hg). The atmospheric pressure is generally between 730 to 760 mm Hg (or torr) in our area. A common mistake is to miss the 700 mm Hg value since the instrument leaves out the 100's place between the intervals so the other numbers are clear to read.

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Data and Calculations

1. Unknown sample number ____________________________
2. Mass of test tube: ____________________________
3. Mass of test tube and sample *before* heating: ____________________________
4. Mass of test tube and sample *after* heating: ____________________________
5. Mass of sample in the tube *before* heating: ____________________________
6. Mass of residue in test tube *after* heating: ____________________________
7. Mass of oxygen gas released: ____________________________
8. Volume of oxygen gas at room temperature: ____________________________
9. Atmospheric pressure: ____________________________
10. Vapor pressure of water: ____________________________
11. Temperature of water: ____________________________

Questions (to be completed while in the laboratory)

1. Calculate the pressure of the collected oxygen gas (i.e. correct for the vapor pressure of water).

2. How much volume would the gas in question #1 occupy at STP?

3. Determine the moles of oxygen gas collected from the experimental mass of the oxygen gas.

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4. Use questions #2 and #3 to determine the molar volume (i.e. how many Liters/mole the gas would occupy at STP).

5. Determine the % error of your molar volume from that of an ideal gas.

6. Along with oxygen gas, potassium chloride is also formed from the potassium chlorate. Write a balanced equation for the reaction. Also describe the purpose of the MnO_2. Do you suspect that this "filler" is necessary for this particular reaction? Briefly explain why or why not.

7. Calculate the number of grams of potassium chlorate in your original sample.

8. Determine the mass percent of $KClO_3$ in your original sample. (Remember that the sample was not pure $KClO_3$ but has varying amounts of other compounds)

9. What would happen if you didn't remove the stopper from the hot test tube?

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Post-lab Questions

1. A sample of an unknown metal chlorate weighing 1.725 g is heated until all of the oxygen is driven off. The residue remaining in the container weighs 0.859 g. Calculate the percentage of oxygen in this metal chlorate.

2. 340 mL of oxygen gas are collected by displacement of water at 33 ^{o}C and 742 torr, where the vapor pressure of water at this temperature is known to be 37.8 torr.

   A. What is the pressure of the oxygen gas?

   B. Determine the volume of the oxygen gas at STP.