Experiment 18 - Determination of the Percent Oxygen in Air

Air is a mixture of gases – it contains nitrogen, oxygen, carbon dioxide, water vapor, and many other gases in smaller amounts. In this experiment, you will determine the percentage of oxygen gas (O_2) in a sample of air. Oxygen reacts with wet iron to produce iron oxides (such as rust). In this experiment, you will trap a sample of air in the presence of wet iron filings. You will allow the sample of air to react with the iron for a few days. Only the oxygen in the air will react with iron. As the oxygen gets used up, the volume of the air sample will decrease. You will then compare the original volume of air with the volume of air after the reaction has occurred. The difference in the two volumes is taken to be the volume of oxygen in the original sample. You will then be able to calculate the percent oxygen in air by volume.

Safety Precautions:

- Wear your safety goggles.

Waste Disposal:

- Used iron should go in one of the regular garbage cans, **not** the sink!

Procedure

1. Get an extra large test tube and a rubber band from the hood. Slip the rubber band around the test tube. Wet the inner walls of the test tube with deionized water, and sprinkle iron filings onto the wall so that as much of the inner surface as possible is covered with iron.
2. Fill a large beaker so that it is about two-thirds full of deionized water. Lower the test tube slowly and carefully into the beaker, open end down. Do not allow any bubbles to escape from the tube. The air sample is now trapped in the tube. The volume of air is equal to the volume of the test tube. (We are ignoring the small volume of water that enters the tube.)
3. Put the apparatus in your drawer or in the hood (labeled with your name and the class you are in) and leave it undisturbed until the next laboratory period. The oxygen in the sample will gradually react with the iron to form rust (Fe_2O_3). As the oxygen is used up, water will rise in the test tube to take its place.
4. At the next laboratory period, adjust the water levels inside and outside the tube so that they are equal. To do this, you can either add water to the beaker or raise the tube. Do not let any of the gas escape, or your experiment will be ruined! When the water levels are equal, move the rubber band to the water level. This will mark the volume of the residual gas when it exerts a pressure on the water inside the test tube that equals the pressure exerted by air on the water outside the cylinder. In other words, the trapped gas is neither compressed nor expanded.
5. When you have adjusted the rubber band so that it is at the water level and it stays securely in place, remove the tube from the beaker. To determine the volume of air remaining after the reaction, fill the test tube with water up to the level of the rubber band. Pour this water into a large graduated cylinder, and measure and record the volume. Dump out the water, but don't let any iron go down the sink. The solid iron or rust should go into the wastebasket.

6. Fill the test tube to the top with water, and then pour this water into the large graduated cylinder. Measure and record the volume. This is the initial volume of the entire air sample.

Calculations

1. Determine the volume of oxygen that was lost. This is done by subtracting the volume of air remaining after the reaction from the initial volume of the entire air sample before the reaction.
2. Calculate the percent oxygen by volume in the air sample:

$$\text{Percent oxygen in air} = \frac{\text{volume of oxygen}}{\text{volume of air}} \times 100$$

Questions

1. If the iron did not react completely with the oxygen, how would it affect the results that you calculate for the percent oxygen in air? (First, decide how it would affect the volume of water that entered the tube. Then, determine how it would affect your result.) Explain your reasoning clearly.
2. Why do we wet the inside of the test tube before putting the iron into it?
3. In a similar experiment done by another student, the total volume of the test tube was 35.9 mL. The volume of air remaining in the test tube after it was allowed to react with the iron was 29.1 mL. Calculate the percent oxygen by volume in this air sample, according to this data. Show your work.