**Figure 11.1.3**

**Measuring How Much Gas Matter You Have**

Gas and liquid volumes are measured using the same units, but it is a little trickier (and a lot more fun), to measure the volume of gas. It is common to measure the volume of gas produced by chemical reactions, the set up for which is shown below. In our example, we are measuring the gas produced from an acid-base reaction. The acid is acetic acid (vinegar) and the base is sodium bicarbonate (baking soda). When the two are mixed, they react vigorously in an acid-base neutralization reaction and, as we learned in the last chapter, form water and carbon dioxide (a gas). Using the Erlenmeyer flask with a stopper, we can set up a system to collect and measure the volume of gas produced by this chemical reaction. The stopper has a hole just large enough to push the collection tube through and is stuck into the top of the flask. The collection tube connects the inside of the Erlenmeyer flask to the inside of the inverted graduated cylinder. When the gas is released from the reaction occurring in the Erlenmeyer flask, it bubbles out of the vinegar and into the inside of the flask. When it does that, the gas starts taking up space in the flask, which the flask cannot accommodate (because it is already filled with gas matter from the atmospheric air), but the chemical reaction continues to produce gas, which keeps bubbling up out of the vinegar and into the flask. As the gas from the reaction fills more space in the flask, it pushes air from the inside of the flask into the tube, and then goes through the tube into the graduated cylinder, which had been filled with water to the top and then carefully turned upside down and put into a tray containing water. In so doing, the top of the cylinder is placed under water and none of the water will flow out of the cylinder (unless something pushes it out). The tube coming out of the flask is run through the water tray and into the cylinder. So, when the gas starts flowing out of the flask and into the tube, and then from the tube into the cylinder, the gas starts pushing water out of the graduated cylinder into the tray of water. This is a phenomenon known as **displacement**. Displacement occurs when matter starts taking up space that another body of matter occupies, pushing it aside. The displacement started in the Erlenmeyer flask when the gas produced by the chemical reaction displaced the air inside of the flask and into the tube. The displacement continued as the air in the tube was displaced by the air coming into the tube from the flask and then from the inside of the tube into the graduated cylinder. As the gas is displaced into the graduated cylinder from the flask, the gas that accumulates in the cylinder displaces the water out of the cylinder. The more space—or volume—the gas takes up in the cylinder, the more water is displaced out of the cylinder and into the water tray. The longer the reaction runs, the more gas is produced, the more displacement occurs as the gas moves from the flask and into the graduated cylinder. The more gas that flows into the graduated cylinder, the more water is displaced out of the cylinder. After a few minutes, the reaction is complete, no more gas is produced, and the displacement stops. Then you can measure how much gas was produced by the reaction, because it is equal to the amount of water displaced from the cylinder, which is measured in units of cubic centimeters ($cm^3$) and often abbreviated "cc" (but I will stick with $cm^3$). In our example below, about 46 $cm^3$ of gas was produced.

New Graphic