Birthday Cake

Recommended for Chapter(s): 5

Demo #018

Materials NOT in box

1. Safety goggles.
2. Document camera (the document camera is on the bottom shelf of the shelving on your right as you come into the demonstration room next to demo # 049).

Procedure

1. (Prep) Fill the pie plate with water.
    a. A few drops of blue food coloring can be added to make the water look more like a birthday cake and easier for the students to see.
2. Place the two pennies at the bottom of the pie plate. This is what the Erlenmeyer flask is going to sit on.
3. Put a candle in the cork and float it on top of the water
4. Light the candle.
5. Put the Erlenmeyer flask over the candle/cork making sure that it is sitting on top of the pennies.
6. Initially bubbles will be seen coming out from under the flask. Then the level of the water will rise inside the flask and the candle will go out as the water continues to rise.

Safety

1. Wear safety goggles.

Clean Up

1. Return the materials to the cart in the demonstration library room.

Stockroom Notes

1. Pour all colored water down the drain.
2. Replace glassware with clean glassware.
3. If needed refill any materials that have been used up.
4. Return items to demonstration tub.
5. Return tub to the demonstration library.
    a. The goggles go in the goggle box.
    b. The document camera goes on the bottom shelf of the shelving on your right as you come into the demonstration room next to demo # 049.

Discussion

The big question in this demonstration is what causes the water level to go up. One typical answer given by students is that the candle uses up the oxygen and because there is less oxygen in the container the water level rises. Let's examine the validity of this claim. First, is the oxygen in the container used up? Yes. We know the oxygen is used up because the candle goes out due to lack of oxygen. Now let's look at the second part of the statement does the level of the water go up because there is less oxygen. In order to determine this we need examine the chemical reaction in which the oxygen is used up. The chemical reaction for a burning candle is given below, with n values typically being between 22 and 27.

$$C_nH_{2n+2}(s) + \frac{3n+1}{2}O_2(g) \rightarrow nCO_2(g) + (n+1)H_2O(?)$$

Therefore, even though the oxygen gas is used up CO_2 gas is formed along with H_2O (which we will discuss the state of in a moment). If the water were all in the gas phase then you would have more moles of gas after the reaction than before the reaction which would cause the volume of the gas to expand. However, if the H_2O is all in the liquid phase then you will have more moles of gas in the reactants than in the products which would cause the volume of the gas to contract. Therefore, we need to determine the phase of water in this equation. The temperature of the flame in a candle is ~1800K, therefore, when the wax is combusted the water is in the gas phase. However, as the water vapor moves away from the candle and come into contact with the sides of the Erlenmeyer flask, which are approximately 25˚C, the water condenses and turns into a liquid. This condensation of water can be observed as water droplets that form on the inside of the Erlenmeyer flask during the demonstration. Therefore, the overall effect of the combustion reaction is to reduce the number of moles of gas in the flask. However, this number is less than one might expect due to the formation of $CO_2(g)$; for example if n=25 and all of the H_2O goes into the liquid phase then the number of moles of gas in the reactants are 38 and the number of moles of gas in the products are 25 causing a net change of 13 moles of gas.

Another factor plays a critical role in why the water is drawn up the flaks. The candle heats up the air inside of the flask. This results in the air expanding and gas particles escaping via bubbles under the lip of the flask. Therefore, the net number of gas molecules in the flask is decreased. When the candle goes out and the temperature returns to room temperature, there are fewer gas particles, causing the system to contract.

Materials for demo 018

1. 500 ml Erlenmeyer flask
2. Pie plate
3. Cork with hole and quarter/penny glued on bottom
4. Blue food coloring in dropper bottle
5. 2 Pennies
6. 2 Packs of matches
7. Birthday candles
8. Bottle with tap water