Candle Lab: Physical & Chemical Changes

Summary Michael Faraday, 19th century chemist, found much to observe as a candle burns. He wrote a book and gave talks on the subject. You have seen candles burn perhaps on a birthday cake. But you probably have never considered the burning candle from a chemist's point of view. From these observations and some simple chemical tests, you will try to determine what must be present in order for a candle to burn and what the products of combustion are.

Learning Goals
1. Carefully observe and describe the characteristics of a candle flame.
2. Determine what part of the candle is burning.
3. Infer the reactants & products of the combustion

Materials: (pair of students)
- Wax candles 2
- Matches 1 book
- Shallow plastic or metal 1
- limewater solution 25 ml
- 250 ml beaker 1
- 250 ml Erlenmeyer flasks 1
- Rubber stopper to fit the flask 1
- Wire gauze square 1
- Tongs 1

Safety:
Keep all flammable materials away from matches and burning candles.
Wear safety goggles.

Procedure
1. **Light the candle.** To make it stand, place it in a small ball of clay fixed to the center of the pan. Carefully observe the flame. List at least 8 observations of the flame. Look at the colors and the shape of the flame. Where does the burning take place? What is burning?

   Observations
   1   3   5   7
   2   4   6   8

2. When a chemical change takes place, a different substance is formed. When a physical change takes place, the substance changes shape or phase, but the substance remains the same. Classify each of the observations in step #1 as a chemical or physical change by writing a P or a C next to it.

3. **2nd Lit candle held near recently-lit candle.** Light a second candle and hold the flame 2-4 cm from the flame of the first candle. Gently blow out the first candle flame and then move the other flame in to the smoke from the first flame. Do you have to touch the wick in order to get the candle to relight? Write at least 2 observations below. What does this tell you about the part of the candle that is burning?

Observations

4. **Wire gauze lowered onto flame.** Relight the standing candle and blow out the second candle. Using a tongs, hold the wire gauze over the flame, perpendicular to the flame. Slowly lower the gauze on to the flame. Do not touch the wax. If the flame appears to go out, quickly move the wire gauze to the side. Record your observations. What do you think is
happening? What does this say about the part of the candle that is burning?

Observations

5. **Beaker of ice water over flame**. Place approximately 150 ml of ice water in a 250 ml beaker. Dry the outside of the beaker. Hold the beaker about 4-5 cm above the flame. Look for the formation of a new compound on the bottom of the beaker. (Note: you may see the formation of black soot on the bottom of the beaker. That is not the compound that we are looking for. If you see soot, you are probably holding the candle too close to the flame). Record your observations. What do you think the compound is? Where do you think that the compound came from?

Observations

6. **Erlenmeyer Flask lowered over candle in a dish of water**. Pour water in to the pan that the candle is in to a depth of 1 cm. Quickly lower the mouth of the Erlenmeyer flask over the candle so that the mouth of the candle is below the surface of the water. Hold the flask in place for approximately one minute. After 1-2 minutes, lift the flask out of water and quickly place the rubber stopper in the mouth of the flask. Record your observations below.

Observations

7. **Reaction between limewater and products of combustion**. (Information: Calcium hydroxide is in lime water. When it is exposed to a carbon-containing compound, calcium carbonate (chalk) may form.) Add 25 ml of limewater to the flask in which you have trapped the gas products of combustion. Stopper the flask and swirl the solution for about 1 minute. Record your observations below. What does this tell you about the gas that was formed?

Observations

**Analyze and Conclude**: Please answer the following questions in complete sentences that restate the question.

**Good Answer**: I think the candle burns as a solid. This is because the match flame had to touch the actual candle before the wick would light, and the candle is a solid. It would not light when the liquid wax was touched by flame.

**Poor Answer**: burns as a solid. Because candles are solid.

1. Do your results indicate that the candle burns as a solid, liquid or a vapor?
2. Provide an observation that helped you determine this and explain how it helped you decide this.
3. What two products do you think were produced from the combustion of a candle?
4. Provide justification for each product you identified in question #3.
5. List at least two observations that helped you determine this and explain how it helped you decide this.
6. What gas in our atmosphere is needed for combustion?
7. Some fire extinguishers have a compressed gas in them. Do you think that gas would be oxygen, hydrogen or carbon dioxide?
8. What did you observe that helped you decide this?
9. What changes occurred in the water level when you put the Erlenmeyer over the flask.
10. Propose an explanation for why this occurred.
Teaching Notes and Tips

The students should observe that the flame is not touching the solid candle or the melted wax. It appears to be only touching the wick. I ask them if they think that the candle would burn as long if it were only the wick that was burning. What is the purpose of the wax? When the students place the first flame into the smoke of the second candle, they should see the second candle relight. It is not necessary to touch the wick in order for it to relight. This should lead them to conclude that it is the wax vapor that is burning.

When the students place the beaker containing the ice water above the candle, they should see condensation on the bottom of the beaker. If they hold it too close, they will not see the condensation and will see soot form. Students will usually recognize that the condensation is made of water, but they have difficulty recognizing that it comes from the combustion of the candle.

When the Erlenmeyer flask is placed over the top of the candle in the water, student should observe that the water candle goes out and the water rises. The students test the gas that was collected with phenol red solution (an acid-base indicator). They should observe that a white substance forms in the limewater solution. When students are asked to propose why the water rises in the flask, they come up with a variety of different ideas. Some of these include ideas such as, "all the oxygen was used up and so it created an empty space" or it 'gets sucked into the flask". You can remind them that carbon dioxide was created and it also takes up space. The new part of this is the extension to the lab. In this inquiry activity, I ask students to try to determine what factors affect how high the water rises and then revise their hypothesis. An explanation as to why this occurs is that the air inside the flask is heated by candle. This causes the air inside the flask to expand and some of it escapes when the flask is placed over it. When the candle goes out and the air cools, it contracts. Since the pressure outside the flask is greater than inside the flask, the water is pushed up into the flask. The collapsing can demo would be a good follow-up activity to this lab.

Assessment

Assessment of this activity will be based on the lab report that they hand in. Key concepts that I want them to understand is the importance of making and recording good observations, the difference between chemical and physical change, and making inferences from their observations.

Discussion Questions to ask

1. Is combustion of a candle (or anything) physical or chemical change?

2. Formula for our fuel, candle wax, is $C_{25}H_{52}$. What else besides a fuel, and a spark, must be present for combustion to occur?

$$C_{25}H_{52} + O_2 \rightarrow H_2O + CO_2$$

3. Looking at the reactants (left side), consider the parts like Legos. You have a lot of C atoms, H atoms, and O atoms. They will rearrange to make products.

4. In step 5 of the lab, what substance formed on the outside of the beaker, indicating a possible product of combustion? Condensation = water = $H_2O$. 

5. IN step 7 of the lab, what happened in the flask? Remember, we trapped the gases from combustion in the flask, then put lime water in the flask. If you saw white particles form, this is chalk (CaCO₃), indicating that some C-containing gas was trapped from combustion.

SHOW: \[ \text{Ca(OH)}_2 + ___ \rightarrow \text{CaCO}_3 + \text{H}_2\text{O} \]

Using the Lego analogy, what “Legos” in the chalk did you get from limewater? Answer: Ca & O. So we must have got the C from the unknown gas. What gas do you know that contains carbon? Carbon dioxide.