Name: ________________________________

**Answer Key: Observing a Candle**

**Background**

You will observe a burning candle in this experiment. When you light a candle, you initiate a chemical reaction called combustion. This reaction is expressed as follows:

\[
\text{hydrocarbons} + \text{oxygen} \rightarrow \text{carbon dioxide} + \text{water} + \text{heat/light}
\]

or

\[
C_nH_{2n+2} + O_2 \rightarrow CO_2 + H_2O + \text{energy}
\]

You can tell that a chemical reaction occurs because heat and light are released. Combustion reactions require three things to take place: fuel (hydrocarbons), oxygen, and ignition. Hydrocarbons are molecules made up of hydrogen and carbon and substances such as gasoline, fuel oil, and propane are examples of hydrocarbons.

In this experiment you will use a candle, which is also a hydrocarbon. You will use oxygen in the atmosphere, and you will supply ignition with a match.

It may seem odd to think that burning the candle produces water. It is hard to see the water that results from burning the candle because it is a gas. Carbon dioxide is also a gas and it is more dense than air, so it “sinks” and can be separated from air easily.

When CO₂ is added to a calcium hydroxide, Ca(OH)₂, solution (limewater), it reacts to form insoluble calcium carbonate, CaCO₃. This substance is white and when the reaction occurs, it makes the solution turn cloudy because of the insoluble CaCO₃.

**Prelab Questions**  *See sample answers at the end of the document*

Answer the following questions on a separate sheet of paper and turn in before lab day:

1. What happens to a candle when you light it?
2. How can you prove that a candle needs oxygen to burn?
3. How can you prove that a candle produces carbon dioxide when it burns?
4. How can you prove that a candle produces water when it burns?
5. What happens when you hold a piece of glass in different parts of the flame? What do these results say about the process of burning wax in a candle?
6. Is it possible to light a candle without directly touching the flame and the wick? Why or why not?

**Purpose**

You will make a series of observations to hone your observation skills for future experiments. You will learn something new about an object you assume is familiar.

**Materials**

- Candle
- Matches
- Safety goggles
- Ruler
- Balance
- Watch glass
- 400-mL beaker
- CO₂ indicator solution in a beaker
Safety
- Always wear safety goggles when working in a chemistry lab.
- Tie back loose hair and clothing.

Procedure
Before proceeding with any procedure steps your group has designed, get approval from your teacher. Once you have made observations, if you feel you don’t quite understand what you’ve observed, check in with your teacher to discuss before moving on to the next part. *Observations will vary, but the experimental designs should be similar in principle.*

PART I: Observations of the Candle
1. Record some quantitative observations about the candle before you light it. Record things such as length, mass, diameter, length of wick, or anything else that occurs to you. Try getting the mass of the candle at specific time intervals while burning: does its mass change over time? *Observations will vary depending on the candle, but students should notice the quantities described in the prompt and that the mass decreases as the candle burns.*

2. Record some qualitative observations about the candle before you light it. Record such things as wax color, color of wick, smell, new/old/damaged, or anything else that occurs to you. *Observations will vary depending on the candle, but students should notice the qualities described in the prompt and that the candle is solid (but somewhat moldable) with a string in the center for the wick.*

3. Record the sequence of events that occurs as you light the candle. Try to be as detailed as possible. These observations will be qualitative and should be as organized as possible. *Observations will vary, but students should notice that the wick catches fire first, the wax begins to melt, and the flame grows and stabilizes. They should note the colors of the different parts of the flame (blue at the base, orange at the top) and its teardrop shape.*
PART II: Candles Use Oxygen as They Burn

1. When the chemical change called combustion happens, oxygen must be present. Oxygen is a gas that makes up about 20% of Earth’s atmosphere (by volume). Can you prove that oxygen from the air is required for the candle to burn? As a group, suggest a procedure. Have your teacher approve the procedure before carrying it out.

   Students should identify that cutting off oxygen supply from the air will extinguish the flame. One way they could accomplish this is by putting the candle in the beaker and covering the beaker’s opening with a watch glass. When the flame burns all the oxygen in the beaker, the flame should go out.

2. Write down what you observe in your experiment, whether it seems relevant or not. Observations will vary, should see what is described above in #1.

PART III: Candles Produce Carbon Dioxide as They Burn

1. Combustion produces carbon dioxide (CO₂). Recall from the background a way to detect CO₂ using a solution. Devise and carry out an experiment to test whether a candle releases CO₂.

   The background information describes how CO₂ reacts with limewater to form insoluble calcium carbonate. Students might suggest capturing CO₂ by burning the candle inside a beaker. Since the CO₂ is heavier than the rest of the air, it will sink to the bottom. If they then cover the opening with a watch glass to trap CO₂ in the beaker, they could submerge the beaker in another beaker containing limewater, remove the watch glass, and see if calcium carbonate forms.

2. Write down what you observe in your experiment, whether it seems relevant or not. Observations will vary, but students should see white solid calcium carbonate settle to the bottom of the limewater solution when the CO₂ is released in the limewater.

PART IV: Candles Produce Water as They Burn

1. Combustion reactions also produce water (H₂O). Because the candle also releases heat, if water is present you will have to provide a way to cool it down to see it. Can you prove that candles do release H₂O? Devise and carry out an experiment.

   Students should identify that water condenses on cool surfaces. They might suggest taking a room temperature (or colder, if they have access to ice cubes) watch glass or other glass surface and holding it above the flame to see if liquid water droplets form.

2. Write down what you observe in your experiment, whether it seems relevant or not. Observations will vary, but students should notice water droplets form on cooler surface held above the flame.
PART V: Flames Have Parts
1. There are at least three distinct regions in a candle flame. One: the blue-rimmed clear region very close to the wick. Two: the dim-orange-fading-to-bright-yellow region that produces light. Three: the clear region just above the visible flame. Observe these flame regions. Devise and carry out an experiment to observe what is in these regions. Write down the steps of your experiment below and show them to your teacher before proceeding.

   Students will need to put something (that won’t burn/melt) into the different regions of the flame to see what is there. They will likely come to the conclusion that something made of metal (like a spoon) or glass (like a stir rod or watch glass) will be best suited for this. They should find unburned wax condensing on the metal/glass in zone 1 right next to the wick, soot in the yellow luminous region in zone 2, and water vapor condensing in zone 3 just above the flame.

2. Write down what you observe in your experiment, whether it seems relevant or not. Observations will vary, but students should notice the three things described above in #1.

PART VI: Flames Can Be Surprising
Your teacher will show you the “jumping flame trick”.

Analysis
Part II-V:
1. Write a short story about what happens to the solid wax as it melts, enters the flame, burns, and leaves the flame. Answers will vary, but it should start with lighting the wick, which melts the wax, which then vaporizes and burns (reacts with oxygen) in the heat of the flame, which produces light and heat as well as soot, water vapor, and carbon dioxide, which are released from the flame.

Part VI:
1. Describe how to perform the jumping flame trick in your own words. Light two candles. Blow one of them out. Bring the second lit candle near the trail of smoke left by the first extinguished candle, but not touching the wicks. The flame will burn the vaporized wax in the candle smoke and work its way back to the wick of the first candle to relight it.

2. What makes the trick possible? This is caused by the vapor trail of wax that hangs over the candle in the smoke trail left behind when the candle is blown out.

3. What burns in a candle: the wick, the solid wax, the melted wax, or vaporized wax? Justify your answer. The vaporized wax is what burns. The wax in its vaporized state is what makes the flame travel through the air back to the first candle. If it was the melted or solid wax or the wick that were burning, the flame would have to be touching that material and the jumping flame trick wouldn’t work.
Prelab Questions:

1. What happens to a candle when you light it?
The wax melts, then is drawn up through the wick, vaporizes, and burns, producing CO$_2$ and water vapor.

2. How can you prove that a candle needs oxygen to burn?
Cut off the candle’s oxygen supply and the flame will go out.

3. How can you prove that a candle produces carbon dioxide when it burns?
Burn the candle in a small container. The CO$_2$ produced will settle to the bottom because it is more dense than air and eventually there will be enough of it that it will displace the normal atmosphere, which will put out the candle as it won’t have access to oxygen anymore. Alternatively, you could capture the gases produced by the burning candle and bubble them through limewater to see if solid calcium carbonate is produced from the reaction of the lime water with the CO$_2$.

4. How can you prove that a candle produces water when it burns?
Putting a cool surface above the flame will allow the water vapor produced by burning the candle to condense on that surface and form water droplets.

5. What happens when you hold a piece of glass in different parts of the flame? What do these results say about the process of burning wax in a candle?
The glass is cooler than the flame and allows hot substances to condense on it. Just above the flame, water vapor produced from the combustion reaction will condense. In the yellow part of the flame, soot will collect on the glass. Very close to the wick, some unburned vaporized wax will condense. The condensation of water vapor shows that water is a product of the reaction. The soot indicates that the reaction hasn’t burned entirely cleanly, so some of the carbon from the candle wax has not reacted to form CO$_2$ but has formed some other carbon by product. The wax re-solidifying indicates that it is in a vapor form surrounding the wick, which is what burns, rather than the solid or liquid phase.

6. Is it possible to light a candle without directly touching the flame and the wick? Why or why not?
Since the vaporized wax is what is burning, not the solid or liquid form of the wax, the candle can be light without directly touching the flame and the wick. Using the trail of vapor left behind with the smoke just after the candle is blown out, another flame can “jump” back along that trail of vapor to the candle wick and relight the recently extinguished flame.