**Experimenting with a Candle**

**Purpose**

The purpose of this experiment is to use the scientific method to identify the reactants and products in the chemical reaction of burning a candle. To accomplish this goal, you will need to practice the art of observation, ask questions, and develop of a good understanding of the scientific process.

**Introduction**

How does a candle burn? You may think the answer is simple, but closer observation and experimentation reveal that the burning of a candle is rather complex. To really explain what is happening on the molecular level when a candle burns, we will need to employ the scientific method.

**The Scientific Method**

The scientific method is a systematic way of attempting to explain natural phenomena, and careful observation is the first step in this process. An observation is a fact obtained with the senses without judgment. For example, given a piece of ice in water, one would observe that the ice floats. This is an example of an observation. Recording that the ice is less dense than the water is not an example of an observation, since the density (mass/volume) of ice and water is not sensed directly. The comparison of the densities of the liquid vs. solid water is an interpretation, rather than an observation. An interpretation is an explanation. Observations, not interpretations, are the direct input that should be recorded while performing every experiment.

During this activity you will observe the burning of a candle, formulate questions about the process, and conduct experiments to gain insight into what is happening. What you find may surprise you!

**The Candle**

A candle is made of paraffin (also known as paraffin wax), and a wick. Paraffin is purified from crude oil, and is thus a petroleum product. Petroleum is formed in the Earth in a natural process over millions of years. Paraffin is a mixture of molecules made of carbon and hydrogen, or hydrocarbons. Although paraffin is comprised of a variety of different hydrocarbon molecules, a typical molecule contains 25 carbon atoms, and 52 hydrogen atoms; we can use this to give us C25H52 as a rough chemical formula for paraffin. The wick in a candle is typically a braided cotton string. Cotton consists largely of cellulose, which is the most abundant biomolecule on Earth. It is composed of carbon, hydrogen, and oxygen.

**Combustion Reaction**

Now that you know what a candle is made of, your task is to determine which part of the candle provides the fuel for the flame, or the combustion reaction. You will also perform and design experiments to determine what other substances are required and produced as the result of burning a candle. To give you a hint, combustion reactions always produce carbon dioxide gas, along with one other product that you will identify. At the end of your experiments, you will use your data to write an equation for the combustion reaction you have witnessed. Don’t worry about using chemical formulas – your equation should follow the format shown below:

Paraffin or cellulose (you choose) + reactant (you identify) 🡪 product (you identify) + carbon dioxide (g)

A complete chemical equation includes not only the identity of each substance, but also its phase (i.e. solid, liquid or gas), so be sure to include this information in your final equation.

**Pre-activity Questions**

These pre-activity questions are to be completed *before* starting the in-class activity. They may be collected and graded, or there may be a short quiz over these questions given at the start of the in-class activity.

1. Given an example of an observation unrelated to this lab.
2. What are the two components of a candle, and of what is each component made?
3. What is always one product of a combustion reaction?
4. What are the three pieces of information you are trying to obtain from your experiments?
5. Where should used matches be disposed?
6. What do the instructions say to do immediately after reading the directions for each experiment?

**Materials**

You will be given the following materials to use for your experiments. Make sure you are familiar with every item on the list. Verify that you have all items before starting the experiment.

* candle
* note card
* matches or butane lighter
* aluminum foil
* 1L beaker
* balance

**Safety and Waste Management**

1. The largest risk in this experiment is the danger of hair or clothing catching on fire. Long hair should be tied back, and loose clothing attended to. Reacquaint yourself with the locations of the fire safety equipment.
2. If matches are used, be sparing with their use to keep the air in the classroom cleaner. Extinguish any matches in a 250 mL beaker with about 50 mL of water.

All materials should be returned to their places of origin. Candles may be left attached to note cards for the next class. Used matches should be retrieved from the waste beaker and placed in the trash can.

**Procedure**

The procedure for this activity is separated into a number of individual experiments, each of which focuses attention on one aspect of a burning candle. After you have performed the required experiments, you will design additional experiments to complete your understanding of the candle burning process.

**I. Candle Observation**

1. Observe the candle as carefully as you can, using your senses: sight, sound, feel, smell (but not taste!). Record as many observations as you can on your report form under the title "OBSERVATIONS, BEFORE BURNING."
2. If the candle is not already attached to a note card, use melted wax to attach it, as shown by your instructor.
3. Light the candle. Observe the candle and flame as carefully as you can. Record as many observations as possible on the report form under "OBSERVATIONS, DURING BURNING." Include a sketch. Observe the candle burning ***for at least three (3) minutes***.
4. Blow the candle out. Observe the candle until no more changes are taking place. Record your observations under "OBSERVATIONS, AFTER EXTINGUISHING."
5. Keeping in mind that your task is to discover the identity of the reactants and products of the combustion reaction, write three questions that arise from your observations on your report form. Only write questions for which you do not know the answer! If you find formulating these questions difficult, you may not have observed the candle carefully enough. Relight, and observe again.
6. In addition, propose one experiment that may help you reach your goal. (Keep in mind that if you and your lab partners all propose the same experiment, you’re not going to get very far!)

**II. Identifying the Fuel: Wax or Wick?**

For each experiment below, do the following (record your responses on your [report form](http://www.nshs-science.net/chemistry/common/pdf/candle_report_form.pdf%22%20%5Ct%20%22resource%20window) or in your laboratory notebook, as instructed by your teacher):

1. Read the experiment.
2. Predict what will happen when you do the experiment. Record your prediction(s).
3. Perform the experiment.
4. Write your observations.
5. Indicate how your observations may help you answer the question at hand.

**Experiment 1**

Will the gas released from the wick when a candle is extinguished burn?

1. Light the candle.
2. Allow the candle to burn for about a minute.
3. Light a match. (The flame from another lit candle may substitute for a burning match.)
4. Gently blow the candle out.
5. Immediately place the lit match about one inch above the wick in the path of the gas ("smoke"), which is being released by the extinguished candle. If nothing happens, try it again, placing the lit match a little closer to the wick. If something does, see if the same thing happens if the lit match is held higher above the wick.

**Experiment 2**

Will the candle still burn if a piece of aluminum foil is placed over the wick before the candle is lit?

1. Cut a piece of aluminum foil into a square with 3 cm sides.
2. Use your pen or pencil tip to punch a hole through the center of the foil. Make the hole about the same diameter as the diameter of the wick.
3. Place the aluminum foil tightly over the wick, covering the wax at the top of the candle. Only the wick should be exposed above the aluminum foil.
4. Light the wick and observe for several minutes.

**Experiment 3**

What happens to the mass of a candle as it burns?

1. Determine the mass of a candle and base and record.
2. Burn for 4 minutes.
3. Determine the mass of the candle and base again and record.

**III. Identifying the Additional Product**

The combustion reaction of burning a candle produces carbon dioxide, along with one other product that you must identify using the following experiment.

**Experiment 4**

What other product, in addition to carbon dioxide gas, is produced by burning a candle?

1. Light the candle.
2. Lift a clean, dry 1 liter beaker with both hands, and place it inverted over the candle as shown by your instructor. *The rim of the beaker should be roughly level with the base of the wick of the candle*. Observe for 1-2 minutes. Make sure you observe the beaker as well as the flame carefully!
3. Lift the beaker off of the candle and place upright (right side up) on the lab bench. ***Be careful — the beaker will be hot!***
4. Observe the beaker carefully, and record your observations. If you would like to repeat the experiment, allow the beaker to cool first.

**IV. Identifying the Additional Reactant**

It’s your turn to design one or more experiments using the materials at hand to determine the identity of the remaining reactant needed for burning a candle. Remember that you are working with a burning candle, so **lab equipment near the flame may become hot – use caution!**

As you design and carry out your experiments, be sure to write down your protocol and observations in the space provided. Use enough detail so that you could hand your paper to some one else and they could perform the experiment exactly the way you did without asking you any questions. Make notes about how your observations help you identify the reactant in this combustion reaction or inspire another experiment.

**Post-activity Questions**

Answer the post-activity questions in your laboratory notebook, or on the [answer sheet](http://www.nshs-science.net/chemistry/common/pdf/candle_post_questions.pdf%22%20%5Ct%20%22resource%20window) as instructed by your teacher.

1. What substance (the wick or the wax) is the primary fuel for a burning candle?
What evidence from the experiments supports this?
2. What is the identity of the "smoke" that is released when a candle is extinguished?
What evidence from the experiments supports this?
3. What phase changes take place in the wax when a candle burns?
What evidence from the experiments supports this?
4. What is the role of the wick in a burning candle?
What evidence from the experiments supports this?
5. The primary elements in a candle are carbon and hydrogen.
	* 1. What happens to the carbon when the candle burns?
		2. What happens to the hydrogen when the candle burns?
6. Write a balanced chemical equation using chemical formulas and phases for the combustion (burning) of a candle. (You will receive help on this in class!)
7. Write **two** questions about the burning of a candle that were *unanswered* in this activity.