Michael Faraday's
The Chemical History of a Candle

with Guides to Lectures, Teaching Guides & Student Activities

Articulate Noise Books

Urbana, Illinois

First Edition: May 2016

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Michael Faraday's The Chemical History of a Candle: with Guides to Lectures, Teaching Guides & Student Activities / Bill Hammack - 1st edition (version 1.1)

ISBN 978-1-945441-00-4 (pbk)

ISBN 978-0-9839661-9-7 (electronic)

ISBN 978-0-9839661-8-0 (hbk)

1. Chemistry—Popular works. 2. Combustion—Popular works.

3. Candles. 4. Faraday, Michael, 1791–1867 I. Title.

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OBSERVATIONS OF A CANDLE

Science is one way we have to try to better understand the world around us. We sometimes start by asking questions, such as, “I wonder what clouds are made of?”, or “I wonder why the sky is blue?” To answer these questions we make careful observations. Observing is not just “seeing” but paying careful attention to details. It is important to write down these observations because it is easy to overlook or forget them. We can use these observations to develop theories or explanations of *why* something is the way that it is. With incorrect or missing observations, our theories are more likely to be incorrect.

Today, you will observe some candles. Your goals are to:

- Write as much detail as you can about what a candle looks like before it is lit, while it is lit, and after you blow out the flame.
- Ask questions and try to design and carry out experiments to answer these questions.
- Try to better understand how a candle works.

Part one: The unlit candle

Describe the candle as completely as you can. Make sure to answer the following questions:

- What color is the candle?
- How big is the candle?
- What shape is the candle?
- What does the wick look like?

Part two: The lit candle

Light the wick of the candle or have your teacher do it for you and then answer the following questions about the flame of the candle. Pictures would help your answers.

- How big is the flame?
- What is the shape of the flame?
- What color(s) do you notice in the flame?
- Is the flame brighter in some areas more than others?

Also, provide answers for each of the following:

- Do you see any smoke coming from the candle?
- Describe what is happening to the wax of the candle.
- Describe what is happening to the wick of the candle.

Part three: The blown-out candle

Carefully blow out the flame. Describe what you see. Pay attention to any smoke, the wick, and the wax of the candle. Answer the following questions:

- How does the candle and wick differ from before the candle was lit?
- How are they the same?

Part four: Developing questions to experiment with the candle

Work with a partner and come up with questions and experiments you can do with the candle. For example, "what happens if you cover the lit candle with a glass?" Once you have some questions, talk them over with your teacher and classmates and develop a list of questions for the class to answer.

Part five: Experimenting with the candle

With the permission of your teacher, carry out your experiments and make sure to take detailed notes about what you observe. Share your results with the class.

CONVECTION CURRENTS & DENSITY

Use scissors to cut the design on the next page by cutting all of the lines. You will be able to hold what is the middle of the circle and the cut paper will form a spiral. Poke a small hole in the top of the spiral and connect a length of thread so that you can hold the thread and let the spiral hang freely. Does the spiral spin if you dangle it in the air?

Next, light a candle and hold the center of the spiral above the flame of the candle. Be careful that the paper does not touch the flame. What happens now? Does the spiral spin?

Move the spiral from the candle or blow out the candle. What happens? Can you explain your observations?

CAPILLARY ACTION

In the candle the molten wax rise up the wick by capillary action, which is demonstrated in the activities described here.

Moving water from one beaker to another

1. Get two drinking glasses, a stirring rod, a piece of paper towel, and blue and yellow food coloring.
2. Fill one of the drinking glasses with almost a cup of water, add 10 drops of blue food coloring to the water, and stir. Add a cup of water and ten drops of yellow food coloring to the other glass.
3. Take the piece of paper towel and twist it to make something that resembles a rope.
4. Place one end of the paper towel rope into the beaker with the blue water. Watch what happens to the water. Bend the rope and place the other end into the other glass (with the yellow food coloring).
5. Watch this for a couple of minutes and observe what is happening. Over the course of an hour continue with other activities, and return to this from time to time.

Moving water up celery

1. Get a drinking glass, a stalk of celery, a knife, and food coloring.
2. Put about a ¼ cup of water into the glass, add 10 drops of red or blue food coloring in the water, and stir.
3. Cut off a bit of each end of the celery stalk.
4. Place a freshly cut end of the celery stalk into the colored water.
5. Let this sit while you do the other activities and return to this from time to time.

Blooming flowers

1. Color and cut out a paper flower on the next page and then fold the petals. Work with someone else and fold the petals differently. Perhaps one person can fold them one by one in order, and another in a different order.
2. Use the dropper to add a little water to the center of a flat dish.
3. Drop the flower with the folded petals into the middle of the water. Watch what happens.
4. What happens?
5. Why does this happen?

Part one: How many drops of H_2O can fit on a penny?

You are going to see how many drops of water you can add to a penny before the water runs off of the penny.

First of all, make a guess: how many drops of water do you think will fit on the penny?

My guess is ______________________________

Water drops on a penny

1. Rinse a penny in tap water and dry completely.
2. Place the penny on a paper towel.
3. Use a dropper to place drops of water on the penny (one at a time) until *any* amount of water runs over the edge of the penny.
4. Record the number of drops for that trial in the table on the next page.
5. Repeat Steps 1–4 once more and calculate the average. Record this in the table on the next page.

NUMBER OF WATER DROPS ON A PENNY

trial #1	trial #2	average

Part two: Hanging drops of water

How big is your drop?

1. Get a glass, a dropper, and wax paper that has been taped to a piece of cardboard. Fill the cup with water.
2. Squeeze the bulb of the pipet and place the tip under water. Allow the bulb to expand to fill the pipet with water.
3. Over the plastic sheet, see how large of a water drop you can make without letting the water drop fall from the pipet. Compare your drop to those of the others in the class. Make a sketch of the water drop coming out of the pipet.

Touching water

1. Place a drop of water on a piece of wax paper taped to cardboard.

2. Gently touch the tip of the pipet to the top of the drop of water. What happens?
3. Gently squeeze the pipet so a water drop hangs from the pipet (like in Part One above) and touch this drop to the top of the water drop on the wax paper. What happens?

Part three: Moving water

Moving water by pulling

1. Place several drops of water on the wax paper.
2. Gently touch the tip of the pipet to the side of one of the drops and pull the water drop until it touches another drop. What happens?
3. Use the pipet to drag all of the drops of water together. When you have a large water drop, try to pull it with the pipet. What happens? If you can still pull the water drop, keep adding water until you can no longer pull the drop. What happens when you try to pull it?

Moving water by tilting

1. Get the large drop of water in the middle of the wax paper on the cardboard.

2. Tilt the cardboard so that the water drop moves. Try to get the drop as close to the edge as possible without falling off, and then back to the middle. Practice until you feel comfortable that you can control the drop.

Part four: Water vs. alcohol: which is "stickier"?

Alcohol drops on a penny

1. Rinse a penny in tap water and dry completely.
2. Place the penny on a paper towel.
3. Use a dropper to place drops of alcohol on the penny (one at a time) until *any* amount of alcohol runs over the edge of the penny.
4. Record the number of drops for that trial in the table on the next page.
5. Repeat Steps 1–4 once more and calculate the average. Record this in the table on the next page.

NUMBER OF ALCOHOL DROPS ON A PENNY

trial #	trial #2	average

Comparing drops

1. Make as tall a drop of water as possible on the piece of wax paper (keep adding drops and look at it from the side until it is not getting taller).
2. Make as tall a drop of alcohol as possible on the piece of wax paper (keep adding drops and look at it from the side until it is not getting taller).
3. Draw a picture below of each from the side showing which is taller. Label the drops.

(wax paper)

Questions

Which molecules are "stickier": water molecules or alcohol molecules? How do you know?

MOLECULES ARE "STICKY"

Teacher's Guide

Part one: How many drops of H_2O can fit on a penny

The guess and actual number of water drops on a penny will vary. Students generally guess a number smaller than the actual and are quite surprised by how many drops of water they can fit on a penny. The average value is the sum of the two values divided by 2.

Part two: How big is your drop?

Students are generally surprised as well how big of a drop of water can hang from a dropper—the surface tension of water is greater than they imagine.

Touching water

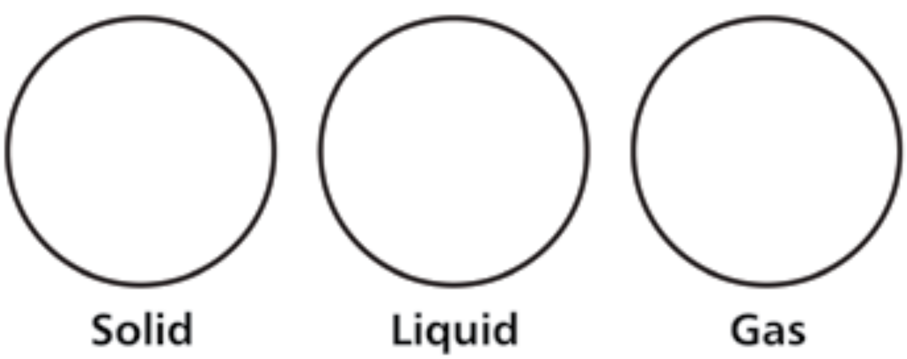
The water drop will "bead up" on the wax paper, that is, it will not lie flat. It will form what looks like a ball. When the pipet touches the water, the plastic of the pipet will attract the water and "tug" at the drop (students will pull the water drops in the next section). When a drop of water from the pipet is touched to the drop of water on the wax paper, the water from the pipet will generally be pulled into the water drop to form a larger drop (aided by gravity).

PHYSICAL CHANGES: CHANGES OF STATE

Matter generally exists in three states or phases: solid, liquid, or gas. We can change the state in a variety of ways and this usually, but not always, involves heat in some way. When a substance undergoes a change of state or a phase change, we consider it a physical change because the molecules that make up that substance are not changed (which is different from a chemical change).

Solids have their own shape, while liquids and gases take the shape of their container. Solids and liquids have definite volumes, but a gas expands to fill the volume of its container. It is important to consider the molecules making up the solid, liquid, or gas when considering the difference among these states.

Before we begin the lab, show the differences among a solid, liquid, and gas using circles to represent molecules and then explain your sketches.



Changes between any two states in any direction are possible. Name as many of these processes as you can and place your answers in the table below. We will discuss ones you do not know.

Process	**Name of Phase Change**
solid to liquid	
liquid to solid	
liquid to gas	
gas to liquid	
solid to gas	
gas to solid	

In chemistry, we also write these changes in the form of an equation. For example, suppose solid "A" is heated until it turns into a liquid. We say that solid A melted to form liquid A, and we can represent this as:

$$A(s) \rightarrow A(l)$$

The arrow shows that a transformation has occurred. We use (*s*) to designate a solid, (*l*) for liquid, and (*g*) for gas.

In order for a change of state to occur, energy is either required or released. Let's look at two samples of H_2O, one liquid and one solid.

Add about 200–250 mL of $H_2O(l)$ to one 400-mL beaker, and about 200–250 mL of $H_2O(s)$ to another 400-mL beaker.

Place each on a hotplate and use a thermometer to determine the temperature of each. Make sure to take the temperature in the middle of each of the samples. Record these temperatures in the table on the next page.

Turn the hotplate to the highest setting and start the timer. Record the temperatures at every 1 minute interval, making sure to take the temperature in the middles of the samples, and making sure to carefully stir the samples. Record the temperatures in the table on the next page.

	Temperature of $H_2O(l)$	Temperature of $H_2O(s)$
initial		
1 minute		
2 minutes		
3 minutes		
4 minutes		
5 minutes		
6 minutes		
7 minutes		
8 minutes		
9 minutes		
10 minutes		

Explain your results for both $H_2O(l)$ and $H_2O(s)$.

Water as liquid & vapor

Add 150 mL water to a 400-mL beaker. Put the beaker on a hot plate and bring the water to a boil. Take the beaker off of the hotplate. Place a watch glass over the beaker. Make observations inside and outside of the beaker, along with on the top and bottom of the watch glass. Remove and add the watch glass to the beaker a few times. Write down any observations.

1. What change(s) occurs in the beaker? Describe, name, and write an equation for the change or changes.
2. What change(s) occurs on the top of the watch glass? Describe, name, and write an equation for the change or changes.

Water as solid, liquid, & vapor

1. Add some ice to the top of the watch glass when it is on the beaker. Record observations.
2. What change(s) occurs on the bottom of the watch glass? Describe, name, and write an equation for the change or changes.
3. Add a few drops of food coloring to the water and bring the water to boiling. Take the beaker off of the hot plate, place a watch glass over the beaker, and some ice on the watch glass. Record observations, specifically at the bottom of the watch glass.

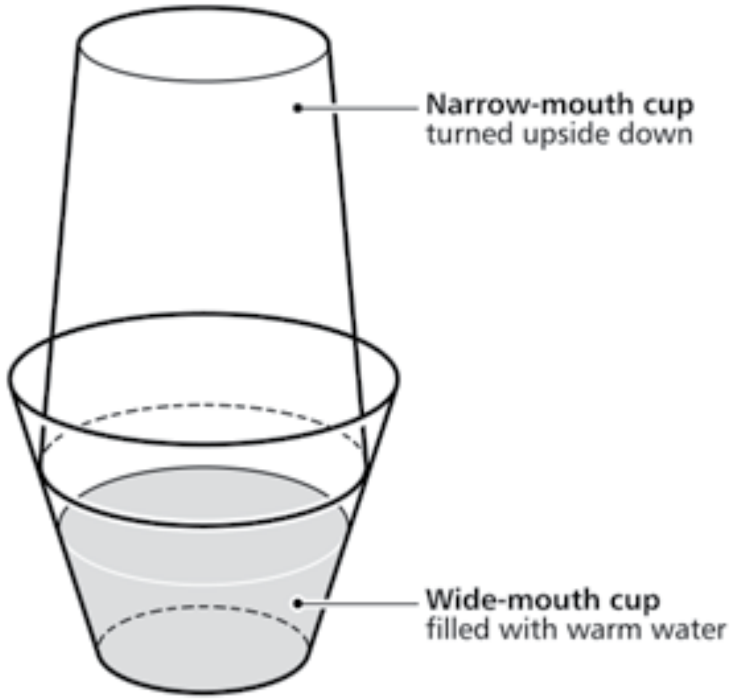
Variation: Water as a liquid & vapor

You will need:

- Two clear plastic cups—one with a wide mouth, and one with a smaller mouth. The small-mouth cup should fit upside down in the wide-mouth as in the figure on the next page.
- Hot water

Procedure

1. Fill a wide-mouth cup about ½ full of hot water.
2. Place the small-mouth cup upside down inside the other cup as shown below.
3. Observe the cups. Pay attention to the inside of the cups. Do you see anything?
4. After about 2–3 minutes, remove the top cup and feel the inside. What do you notice?


Narrow-mouth cup
turned upside down
Wide-mouth cup
filled with warm water

Physical change or chemical change?

1. You will need two plastic cups, two ¼-cup measuring cups, and a spoon.
2. Add a spoonful of baking soda to each beaker (add the same amount to each beaker—as close as you can make it).
3. Measure ¼ cup of water and ¼ cup of vinegar.
4. Add the water to one cup and the vinegar to the other cup.
5. Record your observations.

Question 1: In one of these cups there was a physical change and in the other there was a chemical change. Which was which? How can you tell?

Question 2: In general, what are four clues that a chemical reaction has occurred?

Baking soda & vinegar

Part one: Collecting the gas

1. You will need a small water bottle, one ¼-cup measuring cup, a balloon, a funnel, and a spoon.

2. Add a spoonful of baking soda to the balloon using the funnel.
3. Pour ¼ cup of vinegar into the bottle.
4. Fix the balloon to the mouth of the bottle.
5. Lift the balloon and allow the baking soda to go into the bottle.
6. Record your observations. Draw a picture before, during, and after the reaction.

Part two: Testing the gas

1. Add a spoonful of baking soda to a plastic cup.
2. Pour ¼ cup of vinegar into the beaker.
3. Place a flaming splint into the beaker. What happens?
4. How can you tell that carbon dioxide gas was a product of the reaction?

Baking soda & vinegar

1. Measure ¼ cup of vinegar into a plastic cup. Measure the temperature of the vinegar.
2. Add a teaspoon of baking soda to vinegar.
3. Write down your observations. Record the temperature of the solution.
4. Was this a chemical reaction? How can you tell? What clues were there?