SCIENCE FRIXION STEM LESSON PLANS

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Grades 6–8

CONVECTION CURRENTS

Through a teacher demonstration using a candle, clear tubing and a cardstock partition, students observe a strange phenomena wherein a lit candle extinguishes itself when a section of clear tubing is placed over the candle. However, when the tubing contains a cardstock partition, the candle remains lit until the partition is removed. Students followup this demonstration by using Pilot FriXion pens to investigate the role of convection currents to explain how the partition allows the candle to continue to burn.

LEARNING OBJECTIVES

After this activity, students should be able to:

- Define combustion and the components necessary for combustion to occur.
- Differentiate between conduction, convection and radiation as the three modes of heat transfer.
- Explain why FriXion ink is a useful tool for understanding convection of gases and the candle phenomena.

Developed by

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MATERIALS

For teacher demonstration:

- Aluminum foil
- Cardstock
- Paraffin wax candle (camping style works best)
- 60cm length of acrylic tubing, approximately 4.5cm inner diameter
- T-shaped partition, approximately 20cm x 4.5cm
- Clay

To share with the entire class (per student group of 2):

- FriXion pens
- Aluminum foil
- Cardstock
- Birthday candle
- 12” plastic tubing, approximately 1” in diameter and minimum of 1/16” thick
- Water
- Clay
- Weigh boat or dish

INTRODUCTION/MOTIVATION

Combustion is a chemical reaction where a fuel combines with oxygen in the air, typically forming carbon dioxide and water, and releasing energy in the form of heat and light. We use combustion to heat our homes and power our vehicles. The energy released by combustion is carried by the hot gases formed as fuel burns, in this case by the gases produced by the burning candle wax.

The heat carried by these hot gases can move in several different ways: convection, conduction and radiation. Conduction works by direct contact of two materials, such as when your hand grasps a cup filled with hot chocolate. In this case, heat is transferred by conduction to your hand, which is in direct contact with the hot mug. Convection works through the interaction of fluid molecules such as gases or liquids. Convection typically occurs when a hot fluid or gas moves upward. If you’ve ever held your hand above a candle, you’ve felt heat transfer via convection as the hot rising air hits your hand. Radiation works through the movement of heat waves. This is similar to light and radio waves.

For this lesson, we will focus on heat transfer via convection as we observe a lit candle. As the candle burns, the heat produced will cause the air in the tubing to expand and create a convection current upwards. We will use the thermo-sensitive ink of Pilot FriXion pens to help us better understand how convection of gases work as well as to explain why a candle will burn out when an open tube is placed over it but will remain lit if the tubing contains a partition.

PROCEDURE

Before the Activity

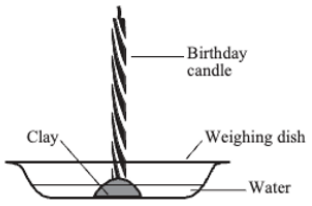
- Gather materials for the teacher demonstration.
- Fashion a t-shaped partition for the teacher demonstration. The approximate dimensions should be 20cm x 4.5cm and should fit snugly inside the acrylic tube. Cover the length of the partition with aluminum foil.
- Both the demonstration and student experiment involve lit candles. Students should wear protective goggles and a fire extinguisher should be nearby. **If no safety equipment is available for students, this lesson should be done only as a teacher demonstration.**

Teacher Demonstration

1. Use a small ball of clay to firmly fix the candle onto a table-top so it is unlikely to fall over.
2. Ask students to predict what will happen when you light the candle and then place a clear section of tubing over the candle.
3. Make sure all students can see the demonstration and that, for safety, no student is too close to the flame.
4. Light the candle, then place the acrylic tube over the candle. The candle should go out in twenty or thirty seconds.
5. Repeat the experiment, this time first inserting a t-shaped partition covered with aluminum foil (see illustration) in the top of the acrylic tubing before placing it over the lit candle. The candle will continue to burn.
6. Remove the partition carefully while the candle burns. The candle will extinguish itself in twenty to thirty seconds.

With the Students

1. Explain to students the three different modes of heat transfer (radiation, conduction and convection).
2. Have students write their heat transfer definitions in their science notebook, with an example of each that they have experienced or seen in their own lives.
3. Pass out materials to students. Have them construct the following setup using the materials:
   a. Ensure that the candle is pushed fully into the clay and that the tube will fit over the clay.
   b. Add enough water to reach the top of the clay. Water prevents air from entering from the bottom of the apparatus.



4. Have students construct the T-shaped divider as shown in the figures at right. It is important that the partition fits snugly in the tubing and is covered with aluminum foil.

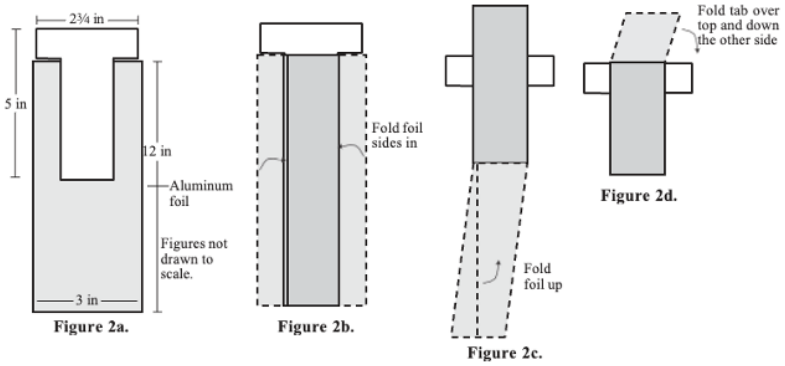


Figure 2a. Figure 2b. Figure 2c. Figure 2d.

5. Tell students you will share FriXion pens. Explain that heat is needed to break the covalent bonds in the ink. When the bonds are broken, the colored pigment separates, and the ink becomes clear. Students will be using FriXion ink specifically to make inferences about heat transfer via convection.
6. Have students use the FriXion pens to draw a tight grid of lines or scribbles over the aluminum foil on the T-shaped partition. Ensure that both sides of the partition are covered with a grid of FriXion ink.
7. Instruct students to place the T-shaped partition into the clear plastic tube.
8. Before lighting the candles, instruct students to look for changes in the color of the FriXion ink once the candle is lit, and record their observations.
9. Light the candles, and have the students carefully place the tubing with T-shaped partition over the burning candle.
   a. While the candle is burning, have students place a finger from each hand over each side of the T-shaped divider for a few seconds. Have them record any temperature differences they observe.
   b. Have students carefully remove the T-shaped divider from the tubing. Students should record their observations.
   c. Do not allow the candles to burn for more than 60 seconds. This can cause the plastic tubing to soften and distort.
10. Once the candle is extinguished, have students compare the ink on both sides of the T-shaped divider and record their observations.

DISCUSSION QUESTIONS

- Was there any temperature difference on either side of the T-shaped divider? How can you explain this?
- How could you prove that there was a temperature difference on the sides of the T-shaped divider using the results of your experiment?
- How does the convection current that forms with the divider in place differ from when the tubing has no divider?
- Explain why combustion stops when there is no divider in the tube but continues when the T-shaped divider is installed in the tube.