

Relating Combustion with Emissions

Combustion is one type of chemical change, in which chemical substances are burned (oxidized) to produce energy. Fuels that we burn to warm our homes, generate electricity, or do other useful work are made primarily of carbon, hydrogen, nitrogen, and oxygen. When they combust, or burn, these chemicals combine with oxygen and are transformed into new substances. Although some of the products of combustion are invisible to us, their presence in the air contributes to global warming and air pollution. Other combustion products, such as soot, may visibly contribute to the pollution problem.

Imagine that you are the engineer for a “smokestack” energy-producing facility (an energy plant that burns hydrocarbons for fuel). You have three problems to solve today.

1. Find out why the smoke coming from your stack is blacker than usual. Why is this a concern? Black smoke is tiny particles suspended in the air called particulates. Particulates are one form of air pollution that increases the cost of keeping our clothes and furniture clean. More significantly, particulates can also cause health problems.
2. Determine if carbon dioxide is being given off by your smokestack. Why is this a concern? Although carbon dioxide is colorless and odorless, it is not a completely harmless gas in the atmosphere. It is strongly suspected that carbon dioxide in the atmosphere contributes to global warming by preventing solar heat from reradiating into space.
3. Find out if your smokestack could be partly responsible for the heavy rainfall in the community surrounding the plant compared to other parts of the region.

In this laboratory activity, you will use a candle to construct a model of a smokestack in order to study the products of combustion and the effects of combustion on emissions.

OBJECTIVES

Construct a model of a combustion power plant with a smokestack.

Deduce cause-and-effect relationships between combustion and the resulting emissions.

Solve some emission problems for a combustion power plant.

MATERIALS

- candle, 4–6 in. long
- matches
- clay
- reference books
- glass jar, 1 gal., with screw-on lid
- spatula, metal, with insulated handle
- limewater

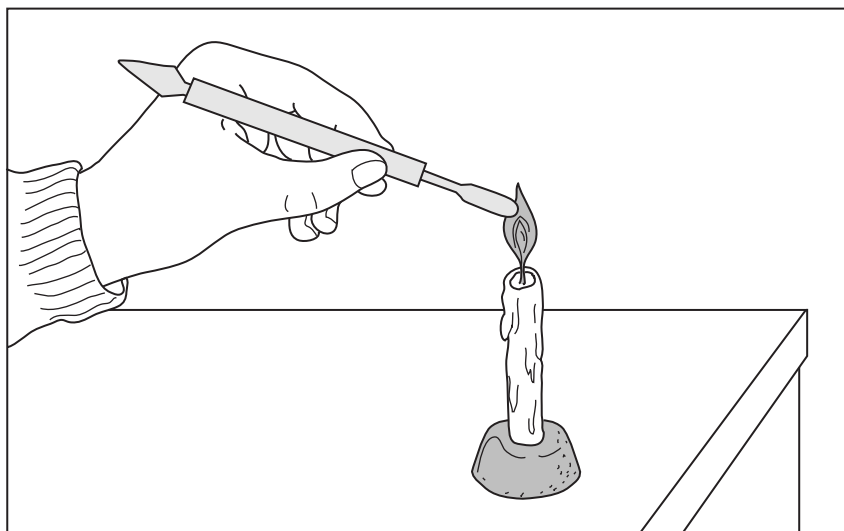


Relating Combustion with Emissions *continued*

Procedure

PART I—MODELING BLACK SMOKE

1. With a small ball of clay, make a holder for your candle. Insert the candle in the holder and secure it to your work area so that it will not topple over. Then, light the candle.
2. Slowly bring the spatula into the orange portion of the candle flame, as shown below.



3. Observe what collects on the metal surface and record your observation.

4. Observe the flame. Does the flame become “smoky” when you interfere with the incoming air around the flame by placing the spatula in its path? Record your observation.

5. Blow out the candle.

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PART II—MODELING GAS EMISSION TESTING

6. Secure your unlit candle in the bottom of the jar.
7. Light the candle, and cover the jar with the lid. Allow the candle to burn until it goes out.
8. Unscrew the lid, and remove the candle as quickly as possible. Use caution with the metal lid, which may be hot. Keep the jar upright while removing the candle. Pour limewater into the bottle to a depth of about 1 cm. Replace the lid, and shake the contents. What changes do you observe in the limewater? Record your observations below.

9. Dispose of the mixture in the jar as your teacher directs. Carefully dry the inside of the jar.

PART III—MODELING HEAVY RAIN

10. Secure your unlit candle in the bottom of the jar.
11. Light the candle, and screw on the lid. Carefully observe whether any moisture forms on the inside of the bottle. Record your observations below.

Analysis

1. **Analyzing Results** Identify the cause-and-effect relationship associated with the particulate you observed in Part I of the Procedure. Where did the particulate material come from? Hint: What elements do all fuels contain?

2. **Analyzing Results** Identify the cause-and-effect relationship associated with the production of carbon dioxide in Part II of the Procedure. What is the source of the carbon dioxide?

3. **Analyzing Results** Identify the cause-and-effect relationship associated with the production of water in Part III of the Procedure. Where could this moisture have come from? Hint: Think about the elements involved in combustion.

Relating Combustion with Emissions *continued***Conclusions**

- 4. Applying Conclusions** Develop a solution to reduce particulate emissions.
Hint: Black smoke arises from the incomplete combustion that occurs due to an inadequate supply of oxygen.

- 5. Applying Conclusions** Develop a solution to reduce carbon dioxide emissions.
Hint: How did your model remove carbon dioxide from the air?

- 6. Applying Conclusions** Develop a solution to remove airborne water from emissions. Hint: How did your model remove moisture from the air?

Extension

- 1. Research and Communication** Analyze the following problem: Another part of your job as engineer is to order new supplies of fuel. You learn about a supplier who can provide fuel at lower cost. However, this fuel is not as pure and contains more nitrogen and sulfur than the fuel you have been using. These elements will react with oxygen in air, giving rise to nitrogen oxides and sulfur oxides. Do some research and answer the following questions. What effect do nitrogen oxides and sulfur oxides have on the atmosphere and the environment? What factors must you consider in deciding whether or not to use the nitrogen- and sulfur-rich fuels?
