Name _____ Class _____ Date _____

Exploration Lab Environmental Engineering

Relating Ozone and Weather

Teacher Notes

TIME REQUIRED One 45-minute period to prepare indicator strips; 15–30 minutes a day thereafter to set up new strips and record weather data; two 45-minute periods at the end of the study to explore data and interpret results

SKILLS ACQUIRED

Collecting data
Communicating
Experimenting
Interpreting
Organizing and analyzing data

RATING

Teacher Prep–3
Student Set-Up–3
Concept Level–2
Clean Up–2

THE SCIENTIFIC METHOD

Analyze the Results Analysis, questions 1 and 2

Draw Conclusions Conclusions, question 4

Communicate the Results Extension, question 1

SAFETY CAUTIONS

If possible, substitute plastic for glassware to prevent cuts from broken glass. The hot plate should have a hot and/or an on/off indicator light to avoid burns.

MISCONCEPTION ALERT

Ensure that students fully understand the differences between ozone in the stratosphere and ozone in the troposphere, the latter of which includes ground-level ozone.

TIPS AND TRICKS

For regions with climates that vary by season, this study should be conducted either during late spring or late summer in order to observe measurable ozone. Encourage students to contact your regional environmental protection agency to obtain daily ozone data.

To request a Schoenbein Color Scale and a Relative Humidity Schoenbein Number Chart Scale, contact the National Center for Atmospheric Research, Boulder, Colorado. These scales may enable your students to analyze their results more quantitatively.

Name _____ Class _____ Date _____

TEACHER RESOURCE PAGE

Relating Ozone and Weather

Ozone forms a shield in Earth's stratosphere that protects Earth's surface by absorbing harmful UV radiation emitted by the sun. It is composed of three oxygen atoms, denoted O_3. Ozone is so important to life on Earth that laws have been passed to ban the use of ozone-depleting chemicals, some of which had been used in older refrigeration devices and aerosol cans. Scientists who were involved in the discovery of how ozone is depleted received the Nobel Prize in Chemistry in 1995. How then, if ozone is so important, can it be harmful?

The answer lies in the location of the ozone. Unlike helpful ozone, which resides high in the atmosphere between 15–50 kilometers above Earth's surface, harmful ozone is present near Earth's surface. Ground-level ozone forms when nitrogen oxides and hydrocarbons react with sunlight. These oxides come primarily from vehicle and industrial emissions.

You may have heard of ozone warnings in radio or television weather reports that suggested that people stay indoors. During days like that, the levels of ozone become so high that they jeopardize the health of those people who work and play outdoors. In this exploration lab, you will measure ground-level ozone levels at your school. You also will record weather data at the time of each ozone measurement and decipher any relationship among weather conditions and ozone concentrations in the air.

OBJECTIVES

Observe and **describe** daily weather conditions and ground-level ozone for one month.

Graph weather and ozone level data collected.

Relate weather conditions to ground-level ozone levels in your area.

MATERIALS

- beaker, 250 mL
- clothes pins
- corn starch, 1 $\frac{1}{4}$ teaspoons
- distilled water, 100 mL
- filter paper
- glass stirring rod
- gloves, thermal
- graph paper
- hot plate
- paint brush, small
- plate, oven-safe
- potassium iodide
- ring stands
- spray bottle for distilled water
- weather data (daily for one month)

Procedure

PART I—PREPARING SCHOENBEIN PAPER

In the nineteenth century, scientist Christian Friedrich Schoenbein developed the method that you will use in this lab to collect qualitative ground-level ozone data. He used the fact that ozone is highly oxidizing, and described the following chemical reaction to test for the presence of ozone:

$$2KI + O_3 + H_2O \quad 2KOH + O_2\ I_2$$

This reaction shows how ozone reacts with potassium iodide, KI, in the presence of water to form iodine, I_2. A color change occurs when iodine reacts with starch. You can use this information to prepare test strips to test for ozone.

1. Put on safety goggles and an apron.
2. Pour 100 mL of distilled water into the 250 mL beaker.
3. Add 1 $\frac{1}{4}$ teaspoon of cornstarch to the beaker of water.
4. Place the beaker on a hot plate and heat gently while stirring with the stirring rod. The mixture will become gelatinous.
5. Use thermal mitts to remove the beaker from the hot plate.
6. Add $\frac{1}{4}$ teaspoon of potassium iodide and stir well. Allow this mixture to cool.
7. Place a piece of filter paper on the thermal-safe glass plate. Apply the cooled, pasty mixture of potassium iodide and cornstarch to both sides of the filter paper with the paintbrush. Hang the filter paper to dry using clothes pins and ring stands with rings. Allow the filter paper to dry in a dark cabinet or low-temperature drying oven. Do not place the paper in direct sunlight.
8. Wash your hands thoroughly.
9. When the paper dries, cut it into strips approximately 1 cm wide. Store those strips that won't be used in an airtight container away from sunlight.

PART II—TESTING FOR OZONE

10. Spray the test strips with distilled water and hang them freely in the air at several locations on your school grounds. Be sure that the strips are not in direct sunlight. Develop a method for hanging your strips with a string. Try hanging strips in various locations around the school property. Number the strips and record their locations in a lab notebook.
11. For ideal results, the test strips should hang freely outside for 8 hours. Because most school days are shorter than 8 hours, develop a class plan for collection of the strips after school. The person collecting the strips must label them and place them in an airtight container and keep them out of sunlight until the class observes them the following day.
12. Take turns collecting and recording weather data each day. If weather instruments are available to the classroom, measure as much data as you can as a class. If not, use the radio, television, or Internet to obtain as up-to-date

weather information as possible. Record the following: relative humidity, temperature, and wind direction.

13. Contact a local air-quality monitoring agency for quantitative ozone concentration data. These data usually are reported in parts per billion (ppb). If available, record the ozone concentration in your area.

PART III—RECORD THE RESULTS

14. The next morning, spray the collected strips one at a time with distilled water. If ozone is present, it will react with the potassium iodide on the paper. The iodine will react with starch to produce a blue or purplish color. What color is the first strip? How can you relate a color change to ground-level ozone concentration?

Answers may vary. The color change is a qualitative indicator, but in general, the intensity of the color should increase with increasing ground-level ozone concentrations.

15. Describe and record the color of each wetted strip. Be careful to include the number of each strip to retain location information. Indicate the color change as having low intensity, moderate intensity, or strong intensity. Compare the colors with a Schoenbein color chart, if one is available.

16. Repeat all the steps in parts II and III each day for one month.

Analysis

1. **Describing Events** Did you note any variations in relative ozone concentration among the various sites on the school property?

   Answers may vary. Students may note more intense color changes for strips located closer to streets or parking lots. Also, if one area is damper than another, the damper region could show a stronger color change.

2. **Organizing Data** Prepare a data table for your month-long observations. Include the following column headings: Date; Color change intensity (low, moderate, or strong); Relative humidity; Temperature; and Wind direction. What, if any, correlations do you note among these variables?

   Answers may vary but should show the following trends: more ground-level ozone is present on hot and humid days as compared with dry, cooler days. Warm days with stagnant air are the more likely conditions for the production of high concentrations of ground-level ozone.

Relating Ozone and Weather *continued*

3. **Constructing Graphs** Plot graphs on a sheet of graph paper showing relationships among weather data and ozone concentrations. Use the ozone concentrations obtained from a local air-quality monitoring agency. For example, plot ozone concentration data (in ppb) on the *y*-axis of the graph, and temperature data, in degrees C, on the *x*-axis. You might need to adjust the horizontal and vertical scales of your graphs to be able to interpret results.

   Graphs will vary. Encourage students to be creative as they explore their data.

Conclusions

4. **Drawing Conclusions** What did your study indicate about any relationship among weather conditions and ozone concentrations?

   Students may have observed that warm temperatures and high relative humidity correlate with high ground-level ozone concentrations.

5. **Evaluating Data** Comment on the quality of your ozone detection method. Did it supply you with what you needed to adequately interpret results? Explain.

   Answers may vary. Students may mention that the color change indicator is only qualitative and that more sensitive instruments would be necessary to quantify the results. Others may say that the color indicator was enough to illustrate the influence of weather conditions on local ozone levels.

Extension

1. **Research and Communications** Research average ozone concentrations for three major metropolitan areas in the world that are located in different climates. Should any of these areas be avoided by people with respiratory distress? Write a paragraph summarizing the results of your research. Present your findings orally to your class.

   Students should note that large cities with long, warm, humid seasons are more susceptible to ground-level ozone alerts. Those with respiratory ailments should probably avoid these regions.

Name _____ Class _____ Date _____

Exploration Lab Environmental Engineering

Relating Ozone and Weather

Ozone forms a shield in Earth's stratosphere that protects Earth's surface by absorbing harmful UV radiation emitted by the sun. It is composed of three oxygen atoms, denoted O_3. Ozone is so important to life on Earth that laws have been passed to ban the use of ozone-depleting chemicals, some of which had been used in older refrigeration devices and aerosol cans. Scientists who were involved in the discovery of how ozone is depleted received the Nobel Prize in Chemistry in 1995. How then, if ozone is so important, can it be harmful?

The answer lies in the location of the ozone. Unlike helpful ozone, which resides high in the atmosphere between 15–50 kilometers above Earth's surface, harmful ozone is present near Earth's surface. Ground-level ozone forms when nitrogen oxides and hydrocarbons react with sunlight. These oxides come primarily from vehicle and industrial emissions.

You may have heard of ozone warnings in radio or television weather reports that suggested that people stay indoors. During days like that, the levels of ozone become so high that they jeopardize the health of those people who work and play outdoors. In this exploration lab, you will measure ground-level ozone levels at your school. You also will record weather data at the time of each ozone measurement and decipher any relationship among weather conditions and ozone concentrations in the air.

OBJECTIVES

Observe and **describe** daily weather conditions and ground-level ozone for one month.

Graph weather and ozone level data collected.

Relate weather conditions to ground-level ozone levels in your area.

MATERIALS

- beaker, 250 mL
- clothes pins
- corn starch, 1 $\frac{1}{4}$ teaspoons
- distilled water, 100 mL
- filter paper
- glass stirring rod
- gloves, thermal
- graph paper
- hot plate
- paint brush, small
- plate, oven-safe
- potassium iodide
- ring stands
- spray bottle for distilled water
- weather data (daily for one month)

Procedure

PART I—PREPARING SCHOENBEIN PAPER

In the nineteenth century, scientist Christian Friedrich Schoenbein developed the method that you will use in this lab to collect qualitative ground-level ozone data. He used the fact that ozone is highly oxidizing, and described the following chemical reaction to test for the presence of ozone:

$$2KI + O_3 + H_2O \quad 2KOH + O_2 + I_2$$

This reaction shows how ozone reacts with potassium iodide, KI, in the presence of water to form iodine, I_2. A color change occurs when iodine reacts with starch. You can use this information to prepare test strips to test for ozone.

1. Put on safety goggles and an apron.
2. Pour 100 mL of distilled water into the 250 mL beaker.
3. Add $1\frac{1}{4}$ teaspoon of cornstarch to the beaker of water.
4. Place the beaker on a hot plate and heat gently while stirring with the stirring rod. The mixture will become gelatinous.
5. Use thermal mitts to remove the beaker from the hot plate.
6. Add $\frac{1}{4}$ teaspoon of potassium iodide and stir well. Allow this mixture to cool.
7. Place a piece of filter paper on the thermal-safe glass plate. Apply the cooled, pasty mixture of potassium iodide and cornstarch to both sides of the filter paper with the paintbrush. Hang the filter paper to dry using clothes pins and ring stands with rings. Allow the filter paper to dry in a dark cabinet or low-temperature drying oven. Do not place the paper in direct sunlight.
8. Wash your hands thoroughly.
9. When the paper dries, cut it into strips approximately 1 cm wide. Store those strips that won't be used in an airtight container away from sunlight.

PART II—TESTING FOR OZONE

10. Spray the test strips with distilled water and hang them freely in the air at several locations on your school grounds. Be sure that the strips are not in direct sunlight. Develop a method for hanging your strips with a string. Try hanging strips in various locations around the school property. Number the strips and record their locations in a lab notebook.
11. For ideal results, the test strips should hang freely outside for 8 hours. Because most school days are shorter than 8 hours, develop a class plan for collection of the strips after school. The person collecting the strips must label them and place them in an airtight container and keep them out of sunlight until the class observes them the following day.
12. Take turns collecting and recording weather data each day. If weather instruments are available to the classroom, measure as much data as you can as a class. If not, use the radio, television, or Internet to obtain as up-to-date

weather information as possible. Record the following: relative humidity, temperature, and wind direction.

13. Contact a local air-quality monitoring agency for quantitative ozone concentration data. These data usually are reported in parts per billion (ppb). If available, record the ozone concentration in your area.

PART III—RECORD THE RESULTS

14. The next morning, spray the collected strips one at a time with distilled water. If ozone is present, it will react with the potassium iodide on the paper. The iodine will react with starch to produce a blue or purplish color. What color is the first strip? How can you relate a color change to ground-level ozone concentration?

15. Describe and record the color of each wetted strip. Be careful to include the number of each strip to retain location information. Indicate the color change as having low intensity, moderate intensity, or strong intensity. Compare the colors with a Schoenbein color chart, if one is available.

16. Repeat all the steps in parts II and III each day for one month.

Analysis

1. **Describing Events** Did you note any variations in relative ozone concentration among the various sites on the school property?

2. **Organizing Data** Prepare a data table for your month-long observations. Include the following column headings: Date; Color change intensity (low, moderate, or strong); Relative humidity; Temperature; and Wind direction. What, if any, correlations do you note among these variables?

3. **Constructing Graphs** Plot graphs on a sheet of graph paper showing relationships among weather data and ozone concentrations. Use the ozone concentrations obtained from a local air-quality monitoring agency. For example, plot ozone concentration data (in ppb) on the *y*-axis of the graph, and temperature data, in degrees C, on the *x*-axis. You might need to adjust the horizontal and vertical scales of your graphs to be able to interpret results.

Conclusions

4. **Drawing Conclusions** What did your study indicate about any relationship among weather conditions and ozone concentrations?

5. **Evaluating Data** Comment on the quality of your ozone detection method. Did it supply you with what you needed to adequately interpret results? Explain.

Extension

1. **Research and Communications** Research average ozone concentrations for three major metropolitan areas in the world that are located in different climates. Should any of these areas be avoided by people with respiratory distress? Write a paragraph summarizing the results of your research. Present your findings orally to your class.