



The Chemistry of Air Pollution

In this second lesson of the Clean Air Campaign's "Elements of Air Pollution" unit, students will explore elements and compounds which form the major types of air pollution resulting from auto and power plant emissions, by playing an interactive computer game, undertaking Internet-based research, playing Ozone Tag simulation games, and conducting a hands-on investigation of acid rain. (Environmental Education)

<i>Education Committee</i>	<i>The Clean Air Campaign®</i>	<i>Fulton</i>	<i>EEinGEORGIA.org</i>
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Primary Learning Outcomes

What is the difference between an atom and a molecule? How do gas molecules move? What can I learn about an element from the periodic table? Which elements or compounds form pollutants? How is air pollution formed? How does the law of conservation of matter govern reactions, which result in air pollution? How can air pollution be mitigated or reduced?

Additional Learning Outcomes

What are the differences among elements, compounds and mixtures? Is air pollution natural or man-made? What are the chemical formulas for the types of pollutants, which result from auto and power plant emissions? What are the effects of air pollution on people and the environment?

Assessed QCC Standards:

Grade: 6

Science

Physical Science

5

Topic: Structure of Matter

Standard: Explains the properties and phases of matter, using as an example the composition and properties of water. 5.1 Distinguishes between atoms and molecules and among elements, mixtures and compounds. 5.2 Describes the structure of elements. 5.3 Describes the periodic table of elements and uses it to find information about an element. 5.4 Uses the periodic table to classify an element as a metal, nonmetal or metalloid. 5.4 Describes atomic number and atomic mass. 5.6

Distinguishes physical and chemical properties and physical and chemical changes. 5.7 Recognizes and writes common chemical symbols, chemical formulas and chemical equations.

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Topic: Structure of Matter

Standard: Defines acid and base. 7.1 Describes the characteristic properties of acids and bases. 7.2 Lists the names, formulas and uses of some common acids and bases. 7.3 Explain what a salt is and how salts form.

Procedures/Activities

Step: 1 Duration: Teacher Preparation

To prepare for this lesson, the teacher will need to request one "Save Planet Polluto" CD Rom from The Clean Air Campaign, free to teachers in the metro Atlanta area, and load this software on the hard drive of each computer to be used by students (one computer per student or per pair of students is recommended). If it is a policy of the school district to have software approved before it is installed, this should also be done in advance of the lesson. Minimum hardware requirements: Windows 95/ 98/ 2000/ ME/ NT/ XP; 32 MB free RAM; 114MB free hard drive space OR Macintosh Power PC System 7.5 or later; 32 MB free RAM; 125 MB free hard drive space. For purposes of obtaining a free copy of Planet Polluto from The Clean Air Campaign, the metro Atlanta area includes the following counties: Barrow, Bartow, Carroll, Cherokee, Clayton, Cobb, Coweta, Dekalb, Douglas, Fayette, Forsyth, Fulton, Gwinnett, Hall, Henry, Newton, Paulding, Rockdale, Spalding and Walton. The Clean Air Campaign may be contacted at mail@cleanaircampaign.com or call toll free: 1-877-CLEANAIR or direct: 404-817-7762.

Print and copy the Ozone Tag player directions attached at Step 6. Gather construction paper, scissors and fasteners for students to use in making atomic headbands, OR pre-cut 5cm wide strips of construction paper, OR purchase fabric squares or bandanas in the these quantities and colors, some of which will be re-used from round to round: Blue – one for each student in class; Green – ten; Purple - three; Yellow – three; Red – one; Black – one; Orange – four; and Brown – two.

Print and copy the Lab Report (attached below) for each student. Gather materials needed for hands-on investigation, as indicated in Materials list.

Web Resources for Step 1

Title: The Clean Air Campaign Web site

URL: <http://www.cleanaircampaign.com/>

Annotation: Teacher background information on smog, ozone and the air quality index.

Attachments for Step 1

Title: Lab Report for Chemistry of Air Pollution **FileName:**

[Chemistry of Air Pollution Lab Report.doc](#)

Description: The Lab Report provides a student worksheet for each major activity in the lesson. Graphics from Microsoft Design Gallery and The Clean Air Campaign, with permission.

Step: 2 Duration: 20 minutes

Introduction

Distribute a Lab Report to each student (attached at Step 1). Provide each student (or pair of students) with a computer on which the Planet Polluto software has been pre-loaded. Tell the class that they are going to begin to learn about the chemistry of air pollution by using an interactive computer game. Direct students to do the following:

- 1) log in as "New Recruits" by typing a name and creating a password;
- 2) click on the green transporter button to enter the "Air Academy"; and
- 3) select "Chemistry Lab."

Once in the Chemistry Lab, students should read the background information on the opening page, click on "Continue" to do the experiments, and return to the Lab to "Play Again," as many times as necessary for each student to correctly identify the chemical components of ozone and two types of particulate pollution. Students should record the names of these components on their Lab Reports, before hitting the "Escape" button on upper left corner of keyboard and then clicking "Save and Quit" so the game may be continued later.

Step: 3 Duration: 30 -40 minutes

Research

Confirm that students have exited the Planet Polluto game. While still at the computers, students should be directed to the Web resources linked below. After reading the information on each Web page, students should answer related questions on their Lab Reports.

Web Resources for Step 3

Title: Clean Air Campaign: Sources of Smog

URL:

http://www.cleanaircampaign.com/index.php/cac/air_quality_and_health/sources_of_smog

Annotation: This Web page contains information on how smog is formed. Students should refer to this Web page when completing the Lab Report.

Title: Acid Rain Students' Site

URL: http://www.epa.gov/acidrain/site_students/index.html

Annotation: Information about the effects and origins of acid rain, from EPA. Students should be sure to click on all links including the one for more information about the pH scale. Record characteristics of acids and bases on the Lab Report in the Acid Rain section.

Title: Interactive Periodic Table

URL:

<http://www.webelements.com/webelements/scholar/index.html>

Annotation: The Web Elements Periodic Table allows students to click on each element for detailed information and photo. Referring back to the Planet Polluto Chemistry Lab activity and The Clean Air Campaign's Smog Sources Web page by looking at their worksheets, students should identify each individual element, which is part of the listed air pollution compounds. They should then refer to the periodic table, click on each of these elements and record the symbol, atomic number, atomic mass and at least one property or characteristic. In addition, students should read information about each element and the compounds of which it is a part, to find information about its role in forming air pollution. Be sure to direct students to click the Physical Data and Biology links, if available, on the left side of each element's Web page.

Step: 4 Duration: 20 minutes

Acid Rain Investigation

Explain that acid rain is a form of pollution caused by sulfur emissions from cars and coal-burning power plants, which are oxidized and then dissolved before falling to Earth as acidic precipitation. [Specifically, sulfuric acid is formed when sulfur dioxide (SO₂) is oxidized (combines with oxygen in the atmosphere) to produce sulfur trioxide (SO₃), and then dissolved in water vapor in the atmosphere: SO₃ + H₂O = H₂SO₄]. In the classroom or science lab, students will simulate the effects of acid rain by dropping diluted vinegar-water on various building materials. Start by assigning lab partners so that students work in pairs (or a group of three, if necessary because of odd number). Provide each lab partner with safety goggles and a hand lens (magnifying glass). Each set of partners should also receive a test surface (reaction plate, Petri dish, or bowl), vinegar, distilled water, a beaker, graduated cylinder, dropper bottle or pipette, pH paper and a color chart and chips of various types of building materials. The building materials should include a combination of those which are carbonate and will react with vinegar, e.g. limestone, marble or chalk; and those which will not, e.g. wood, brick or granite. (See Materials list). Direct students to follow the procedures in their Lab Reports.

Step: 5 Duration: 15 minutes

Chemistry 'Light': Molecules in Motion

Take the class outside to a flat, grassy area for an introduction to chemistry. Because

Ozone Tag will be played immediately afterwards, take all of the supplies, materials and directions needed for Step 6 at this time. (See Materials list). In addition, every student will need a clipboard, pencil and Lab Report to answer questions in Part 4. (Note: A copy of the next paragraph is included with the Ozone Tag teacher notes attached at the next step, for convenience).

Ask if anyone knows in which state of matter particles are most active? (Gas) In which state they are least active? (Solid) Assemble the class in a block, standing shoulder to shoulder. Tell everyone to vibrate in place (without moving their feet) to represent the movement of molecules in a solid. Next, line students up along the “bottom” of an imaginary container and tell them they may walk around and bump into one another as long as they remain within an arms-length of another molecule (student) at all times. Ask the class what movement they are simulating? (the movement of particles in a liquid). Finally, tell students to run and gently bounce off one another within the entire space of a larger designated area, to represent the movement of molecules in a gas.

Step: 6 Duration: 25 - 45 minutes

Ozone Tag Simulation Games

Now the class is ready to play the Ozone Tag games. Follow the Teacher Notes (attached) to set up the activities. The directions call for students to be divided into four groups. Be prepared to provide a copy of the group directions to each student in a group. Each player will fashion a headband with the materials provided to indicate the type of atom he or she represents. Blue = oxygen, red = fluorine, gold = chlorine, black = carbon, and orange = sun (ultraviolet radiation), green = nitrogen, purple = volatile organic compounds (VOCs). Allow time for the groups to prepare their headbands and practice their demonstrations. Then invite each group, in numerical order, to explain, demonstrate concepts and lead a game related to the chemistry of ozone pollution. Rounds One and Two focus on processes involving “good” stratospheric ozone; Rounds Three and Four focus on “bad” tropospheric (ground-level) ozone. Remember to debrief the ozone tag games, using the tips at the end of the Teacher Introduction page (attached). The Web resource linked below provides a brief animation of stratospheric ozone depletion, which may be useful in the debriefing once students are back in the classroom.

Web Resources for Step 6

Title: Ozone Animation

URL:

http://www.bom.gov.au/lam/Students_Teachers/ozanim/ozoanim.shtml

Annotation: Teacher background information on stratospheric ozone formation and depletion. The animation on this Web site is limited but very helpful. The teacher may want to use an Internet connected computer, scan converter and television monitor to

display the animation on this Web page for the class before or after the tag games.

Attachments for Step 6

Title: Ozone Tag Directions, including Teacher Notes **FileName:**
[Ozone Tag Directions.doc](#)

Description: Make copies of directions to distribute to students. Six copies of Group 1 directions will be needed; 9 copies of Group 2 directions; 8 copies of Group 3 directions; and 7 copies of Group 4 directions. (For classes with fewer than 30 students, any group may be reduced by the number of its oxygen atoms. In turn, oxygen atoms may be played by volunteers from the class, when that group does its demonstration. The number of students needed for each group, without oxygen atoms, is: Group 1- 1 student; Group 2- 6 students; Group 3- 4 students; and Group 4- 5 students).

Step: 7 Duration: 10 - 30 minutes

Planet Polluto and Clean Air Campaign Revisited

The teacher will direct students to The Clean Air Campaign Web site for ideas on how to reduce air pollution, which should be recorded in the last section of the Lab Report. Remind students to click the links on the Web page for more information. After listing at least five strategies, students may return to the "Save Planet Polluto" game and continue to play, watching specifically for air pollution solutions and recording these in their Lab Reports. For best results, each student should use the same computer as before and work through as many levels of the game as time allows, paying particular attention to NOxVILLE. Finally, each student should choose one strategy for reducing air pollution, which she or he feels, would be most effective and write about it in detail on the Lab Report.

Web Resources for Step 7

Title: Clean Air Campaign: Clean Air Lifestyle

URL:

http://www.cleanaircampaign.com/index.php/cac/your_commute/clean_air_lifestyle

Annotation: This Web page provides strategies for reducing air pollution.

Step: 8 Duration: 15 minutes

Debriefing

Place a piece of chart paper on the wall for each of the five elements researched in this unit (oxygen, nitrogen, carbon, sulfur and hydrogen) and ask each student to write one fact.

Ask students to identify the lesson's Big Ideas about elements, molecules, compounds and air pollution. Responses may include any of the following:

- * Every atom of a particular element is identical to others of that element.
- * A molecule can be made of atoms of the same element (e.g. O₃) or of a compound (containing atoms of different elements, such as H₂O).
- * A compound always has the same formula (therefore the same exact proportion of atoms).
- * Chemical reactions form totally new substances which are unlike the component elements.
- * The characteristics of an element are completely different from the characteristics of a compound, which contains that same element. [Example: Oxygen is totally different from ozone (O₃), sulfuric acid (H₂SO₄), or water (H₂O)].
- * Atoms of elements, which are involved in a chemical reaction, come out of the reaction in the same proportion, although differently aligned or arranged. No atoms are lost in the process.
- * The atmosphere contains many types of gases, which are always moving, colliding and chemically reacting with each other.
- * Ozone is a pollutant, which is formed by chemical reactions, not emitted directly from a car or truck tailpipe or from a power plant smokestack.
- * Ozone is constantly being created and destroyed by natural processes.
- * In addition, auto and power plant emissions undergo chemical reactions in the presence of sunlight, which cause ozone to be formed.
- * Volatile organic compounds (VOCs) are emitted by trees and also contained in vapors and fumes of paints, gasoline and cleaning solvents. VOCs alone are not considered pollutants but VOCs, which chemically react with nitrogen oxides, are pollutants.
- * Movement of atmospheric gases can cause pollution to be found far from where it formed.

Step: 9 Duration: Teacher Feedback

The Clean Air Campaign is pleased to provide standards-based air quality lesson plans for 4th through 8th grades. Please offer your feedback after implementing this lesson plan, because there is no substitute for real classroom experience. Send teacher name, school name and address, grade level, lesson name, comments or suggestions and the number of students who completed the lesson to: mail@cleanaircampaign.com. Each teacher who responds will receive a Clean Air Campaign goody bag as a 'thank you.'

Materials and Equipment

1. "Save Planet Polluto" CD Rom (one copy), to pre-load game on each student computer. (See Step 1 for details).
2. Internet-connected computer (for each student or pair)

For each student:

3. Copy of Lab Report at Step 1
4. Clipboard and pencil

For each pair of students:

5. Vinegar (15-30 ml)
6. Distilled water (approx. 100+ ml)
7. Dropper bottle or pipette
8. Marble, wood, granite, plastic, brick, limestone and chalk chips
9. Hand lens
10. 200 ml Beaker
11. Graduated cylinder to measure 15 ml
12. pH paper with color chart
13. Stirring rod

For ozone tag:

14. Large box
15. Bandanas or construction paper and tape for atomic headbands (1 blue for each student, plus the following: 4 orange, 3 yellow, 1 red, 2 brown, 3 purple, 1 black, 10 green)
16. 4-6 soccer cones for boundaries

For the teacher:

17. Timer, whistle
18. Scoring rubrics, answer key attached at Assessment

Standards (Local and/or National)

Georgia Performance Standards

S8P1. Students will examine the scientific view of the nature of matter.

- a. Distinguish between atoms and molecules.
- b. Describe the difference between pure substances (elements and compounds) and mixtures.
- c. Describe the movement of particles in solids, liquids, gases and plasmas states.
- d. Distinguish between physical and chemical properties of matter as physical (i.e., density, melting point, boiling point) or chemical (i.e., reactivity, combustibility).
- e. Distinguish between changes in matter as physical (i.e., physical change) or chemical (development of a gas, formation of precipitate and change in color).
- f. Recognize that there are more than 100 elements and some have similar properties as shown on the Periodic Table of Elements.
- g. Identify and demonstrate the Law of Conservation of Matter.

Total Duration

2 hours, 35 minutes to 3 hours, 20 minutes

Technology Connection

Students will use Internet-connected computers and special software to play an interactive game. Computers will also be used by students to conduct research online and by the teacher to obtain background information.

Assessment

Student performance will be evaluated based on the completed Lab Report and participation in lesson activities.

Attachments

Title: Lab Report Answer Key **FileName:** [Chemistry of Air Pollution Lab Report Answer Key.doc](#)

Description: Answers are provided for all portions of the student Lab Report. Graphics from Microsoft Design Gallery and the Clean Air Campaign, with permission.

Title: Chemistry of Air Pollution Scoring Rubric **FileName:** [Scoring Rubric for Chemistry of Air Pollution.doc](#)

Description: This scoring rubric provides a way to assess all of the lesson work products. Graphics from Microsoft Design Gallery and the Clean Air Campaign, with permission.

Extension

Students may reinforce information from the Planet Polluto computer game with a coloring book (intended for younger children). Also available is an interactive quiz on the differences in elements, mixtures and compounds. For student research on air pollution in Georgia, there is a useful Web site, which provides links to information for each type of pollutant.

Web Resources

Title: Georgia's Air Quality

URL:

<http://eeingeorgia.org/net/content/item.aspx?s=5454.0.68.4863>

Annotation: EEInGeorgia's Web page about the state of air pollution in Georgia, with links to relevant reports and activities. Useful for a student research project.

Title: Elements, Compounds and Mixtures

URL: <http://www.funtrivia.com/playquiz.cfm?qid=148865&origin=>

Annotation: This Web page contains an interactive quiz about the differences in elements, compounds and mixtures, which provides

helpful background information for students. After submitting their responses, students will be able to view correct answers with explanations.

Title: Planet Polluto Coloring Book

URL: http://www.planetpolluto.com/coloring_book.pdf

Annotation: Sixteen page coloring book which corresponds to Planet Polluto game.

Remediation

Accommodation

For students with exceptional needs, what changes can be made in instruction and teaching delivery to enhance student participation and learning? Each area below is a direct link to general classroom accommodations.

[Non-readers](#) [Physical Impairments](#) [Sensory Impairments](#) [Attention/Behavior Gifted](#)

Each disability below is a direct link to general classroom accommodations specific for that disability.

[Autism](#)

[Deaf - Blind](#)

[Deaf/Hard of Hearing](#)

[Emotional and Behavioral Disorder](#)

[Mild Intellectual Disability](#)

[Orthopedic Impairment](#)

Other Health Impairments:

[Attention Deficit Disorder/Attention Deficit Hyperactivity Disorder](#)

[Tourette Syndrome](#)

[Significant Development Delay](#)

[Specific Learning Disability](#)

[Speech - Language Impairment](#)

[Traumatic Brain Injury](#)

[Visual Impairment](#)

Modification

For students with significant disabilities, what changes can be made in instruction and teaching delivery to allow students to participate in classroom instruction while working on IEP objectives and off grade level QCC standards. Below are suggested modifications correlated to the procedures of this lesson plan.