Air Quality & Chemistry Teaching Unit

By Rebecca Heckman

Target*:* Freshman Chemistry

How to use this unit:

This Air Quality Unit is broken up into several parts.

1. First read the unit overview for a brief description of the unit and activities.
2. The Daily Lesson plans list objectives, activities, materials, and a teacher's guide as to what to do and how long to spend on each section, during every day of the Unit. The "T" stands for Topic for the day, the "A" stands for Agenda for the day, the second "A" stands for Assignment. All students are required to record these items into a Science notebook, in order to prepare them for class. Daily Questions occur school-wide for all classes and are recorded in the science notebook.
3. The Appendices lists by day, the worksheets, readings, powerpoints, etc. used (Appendix1 is for day 1; Appendix 2 is day 2). Tthe MEECS info and toolkits must be obtained directly from the original source.
4. Resources section lists all the sources used.
5. The Assessment section lists the ways that I plan to assess learning throughout the unit.

Unit Overview

This unit is designed to introduce the concept of air quality to Freshman Chemistry students. Students will learn what the air is composed of and how that composition is altered due to human influence. This unit will begin to introduce the possible effects of human impact on the globe. This unit connects to my curriculum by addressing my assigned benchmarks, along with a school wide focus on interpretation of graphs and applications of chemistry in the "real world". I teach basic chemistry (periodic table, structures of atoms, etc.). Since this may be the only chemistry class that some students take, my goal is for students to internalize some chemical principles, but mostly that they will become more globally consciences voters and consumers.

Michigan Benchmarks High School

Social studies:

- ◊ VI.1.HS.1
  Generate possible alternative resolutions to public issues and evaluate them using criteria that have been identified.

Science:

- ◊ **SCI.IV.2.HS.2**
  Explain why mass is conserved in physical and chemical changes.
- ◊ **SCI.IV.2.HS.1**
  Explain chemical changes in terms of the breaking of bonds and the rearrangement of atoms to form new substances.
- ◊ **SCI.IV.1.HS.1**
  Analyze properties of common household and agricultural materials in terms of risk/benefit balance.
- ◊ **SCI.V.3.HS.4**
  Explain the impact of human activities on the atmosphere and explain ways that individuals and society can reduce pollution.

Math:

- ◊ **MAT.III.1.HS.1** Collect and explore data through observation, measurement, surveys, sampling techniques and simulations.
- ◊ **MAT.III.1.HS.4**
  Identify what data are needed to answer a particular question or solve a given problem and design and implement strategies to obtain, organize and present those data.

◊ **MAT.I.1.HS.2**
Analyze, interpret and translate among representations of patterns including tables, charts, graphs, matrices and vectors.

Day 1

Objectives
1. Students will identify reactants and products
2. Students will describe physical and chemical changes associated with a reaction.
3. Students will identify a some ways that humans are altering Michigan's air quality

T: Michigan's Air
A: lab activity, discuss lab, break in to groups, read, and turn in outlines
A: Work on presentations
Daily Question: What part of the chemical equation ($CO_2 + Ca(OH) \rightarrow CaCO_3 + H_2O$ is provided by your breath?

Materials
Student copies of Michigan's Environment 2005 (3rd) Biennial Report intro (pages 1-3) plus p. 35-43 and 63-67.
Blank transparencies for student use
pH paper
Student thinking journals
Prepared Limewater and sample containers
Straws
Chemical Equation written on lab board

Teacher notes:
Opening Activity (10 min):
Before and After Observation lab
Have 15 samples of limewater containers all set-up in the lab plus 30 straws
Students will work in pairs and make observations of water prior to beginning lab (including pH strip)
Student will take turns blowing air into water sample and record results.
Students will do a journal with this prompt:
"If the chemical equation is this, ($CO_2 + Ca(OH) \rightarrow CaCO_3 + H_2O$, explain what is going on…"
Teacher explanation (5 min): go over reactants and products plus Limewater at saturation point with intro of a reactant, the CO_2 reacts to form Calcium Carbonate and H_2O: Main Idea: Even small things added to the air can change the natural state of things. Michigan's environment is the same way: It can be altered by things that we do.

(10 min)Break Students into groups of 2-3 to jigsaw information below. A-F can be doubled up if necessary.
Outline of student presentations as follows:
1. Introduction
2. Air pollutants
    a. CO
    b. Pb
    c. NO_2
    d. O_3
    e. VOC's
    f. SO_2
3. Air Quality Index
4. Greenhouse Gases
5. Air Radiation Monitoring (if necessary to keep groups small)

(30 min) Students must read assigned section and give a presentation to class explaining important facts from that section to rest of class. Any graph in section should be discussed. These will be provided as a transparency to each group to use. Each group must turn in by end of class a neat outline of their presentation to aide classmates

in note-taking. These should be short presentations (no more than 4 minutes apiece) that provide good facts. There will be a quiz will be over information presented. Groups should have about ½ hour to work together during class

Collect note taking outlines: answer questions, etc.

Day 2
Objectives

1. Students will categorize pollution sources as point, mobile on road, mobile off road, area, or natural
2. Students will demonstrate an understanding of the relative contributions of each type of pollution and relate it to Michigan air quality.
3. Students will be able to list the common air pollutants in Michigan and cite their major sources.

T: Michigan's Air
A: cut out models, present, classwork
A: Complete concept map
Daily Question: Name 3 things that are added to Michigan's air

Materials
Color Transparency of graphs for each groups presentation
Student copies of outlines for note taking
Student copies of concept map (MEECS page 68)
Student copies of Models of Atoms and molecules (MEECS)
Scissors
Small envelopes
Colored pencils

Teacher's Notes
(5 min) Student should grab scissors and work on cutting out models of atoms/ molecules while discussing presentations: place pieces in envelope when done.
(30 min) Handout note outlines and have student give presentations in order listed on Day 1.
(10 min) Summary by myself reiterating important statements
(10 min)Pass out concept map: Based on information learned today finish the concept map by adding colors/pictures/words to show this same information in a new way. This can be finished as homework if necessary.

Day 3
Objectives

1. Students will explain how combustion is related to air quality.
2. Students will identify reactants and products
3. Students will identify physical and chemical changes associated with combustion.

T: Changes in Air Quality
A: Candle observations, air pollution and burning lecture, journals
A: Burning Questions at home
Daily Question: Name a source that is a major contributor to the quality of Michigan's Air

Materials
Clear 2 L pop bottle
Spray bottle with water
Dust/ talcum powder
Vanilla extract, onion
Air freshener
6-7 tea candles
1 pillar candle

Matches
6-7 large beakers
6-7 bottlecaps of limewater (pre-prepared and settled)
Student copies of Danger in a cave
Student copies of Models of Atoms and molecules (Meecs): pre-cut
Student copies of Burning Questions at Home activity
Cobalt Chloride paper

Teacher's notes
(5 min)Spot Check Homework
(35 min) Follow Page 4 MEECS Lesson 1
Add to Step 1 more information on the layers of the atmosphere surrounding the Earth: Stratosphere and troposphere's: distance from Earth, thicknesses, compositions, purpose
**Switch Step 3 and 4 (making step 4 only 5-10 minutes long with focus on combustion)
Continue with Step 5 as indicated.

(10 in) Take 10 point quiz from information presented in yesterday's presentations
(5 min) Work on Vocab Wall (This is a large scale Vocab and Definition Matching game on my wall that students create) and hand out homework

Day 4
Objectives
1. Students will list the common pollutants nationally and cite their major sources.
2. Students will describe the health and ecosystem effects of polluted air.
3. Students will prepare ozone paper (Schoenbein Paper) for next days use

T: Monitoring Air Quality
A: readings and activity, Lab prep, group assignment
A: Handout page 72-75
Daily Question: What is the Chemical Formula for Ozone?

Materials
Each student lab group needs:
Safety goggles for each
250 ml beaker
1 ¼ tsp cornstarch
100 ml Distilled water
Hot plate
Oven mitt
¼ tsp Potassium Iodide
Glass Stirring rod
3 filter paper (or 1 more than the number of people on group)

Drying racks
Dark room
Student Copies of play MEECS Page 40-46
Copy of MEECS pages 47-48-49 cut into strips, laminated
Way to stick laminated strips to the wall
Separate headings of 10 air pollutants (listed MEECS page 47, top)
Student copies of directions for Schoenbein Paper (appendix)
Student Copies of MEECS graphs pages 72, 73, 74 and activity page 75.

Teacher's notes
(15 min)Have someone collect Homework and Pass out playbooks and assign roles. Read through together.

(10 min) [You will have the 10 air pollutants from page 47 written as headings on construction paper. These are then spread out throughout the room/hall. There should be some double sided sticky tape underneath for them to post their strip.] Break students into group of three with 1 person acting as a recorder. Hand out one of the laminated strips to each group. They should walk around room and determine where their strip belongs. Recorder should make a note of the 10 types of air pollutant for the group to keep as notes. Students will then tell teacher where they placed their strip to obtain entry to lab.
(10 min) Students groups should directions to prepare ozone paper for ozone monitoring. Remind them to coat evenly but not too heavily or it won't dry out properly. Safety precautions: Potassium Iodide is a skin irritant After placing ozone paper on drying racks, students should move out of lab and hand them their homework packets. (20 min) They can work as a group until class is over. Also, they should do a short journal free-write to process the day's information.

Day 5
Objectives

1. Students will recognize the importance of air pollution stations
2. Students will be able to explain how a particle collector and ozone paper can be used to monitor pollution
3. Students will be able to define a greenhouse gas and identify several by chemical structure.

T: Air Quality
A: lab, individual work, Lecture
A: particle collector assignment, finish up "what's in air", review vocab
Daily Question: What makes good ozone "good"?

Materials
4x6 index cards (enough for each student)
Ruler with cm
Quarter size circle templates
Double sided sticky tape (6 inch strips)
Plastic bags for each student
Ozone gas
Student copies of procedure for making particle collector/ozone monitor (MEECS page 97-98)
Answer from MEECS page 50 to yesterdays activity.
Student copies of MEECS page 91 and 92 "What's in the air?"
Student particle counting grids (MEECS page 101)

Teacher's notes
(10 min) Students should check into lab and <u>each</u> work on making a particle collector, with an ozone strip attached to it. They should place the extra ozone strip, labeled, into observation fume hood so teacher can expose to ozone gas. Students should record any observations in journal.
(10 min) Students should return to seats with article "What's in the Air" and accompanying Questions- students should work on these while you finish up with other groups.
(10 min) Teacher should ask students to get information from yesterday's group recorder. Go through correct results and discuss that ozone is not the only thing in the air. These other things contribute to the formation of the ozone though. So the ozone becomes the way to measure how much of those other air pollutants are present.
(15 min) Pass out lecture notes and present power point slideshow from "Climate Change, Wildlife and Wildlands" going from Slide 4 – slide 11
(10 min) Handout homework page 98 and go through ?1 and 2 in class: Give some background information on the Ozone paper: found on page 83 MEECS. Explain to student ts what is expected with table1 (# 3) and #4. Explain they must bring back collector and homework sheet for full credit. Might need to point out that the particle monitor and the ozone strip are actually 2 different tools.

Extra Credit:
Students could read an article from ChemMatters and Answer questions (see Appendix)

Day 6
Objectives

1. Students will compare the particle and ozone levels in different locations
2. Students will infer possible sources of the particle and ozone pollution
3. Students will explain the impact of human actions on the environment

T: Monitoring Air Quality
A: finish homework, class discussion, packets 72-75, journal
A: review vocab/ notes
Daily Question: Should we be concerned about the general level of ozone for our area? Why or why not?

Materials
Large map of local area
Colored push pins
Transparency Master of Table 2 with column added for nearest city
Student copies of page 99 MEECS
Strips of particle counting grid for each student

Teacher's Notes
(20 min) Have students work on page 99 MEECS. Tell them that the information they get from Table 2 will also be entered into a spreadsheet so that each student will have access to this information. [I would probably have this as an overhead projector.] For #7, have a local area map and use push pins to indicate ozone levels for all to see. (push pin colors: White- low ozone, green- medium ozone, Blue- high ozone) Teacher should allow students to discuss their findings in order to prepare for classroom discussion.
(10 min) Collect homework and class work. Then have a classroom discussion/conclusion of experiment: Talk about findings, problems with experiments, how to do it differently, etc.
(15 min) Hand back homework packet 72-75. Discuss answers and relate to student experiments' (dirt road, more dust? Wood burning stove, lots of particles? Etc.)
(10 min)Have students write in journal, based on prompt "What could I do to reduce air pollutants"

Day 7
Objectives

1. Students will apply knowledge of Michigan's air quality to develop a strategy to mitigate a real problem
2. Students will recognize that different people have different perspectives on the same air quality issues

T: air quality
A: review, test, turn in journals and daily questions
A: KWL a fact sheet on climate change
Daily Question: What concerns you more, high ozone or particle pollution? Why?

Materials
Student copies of test rubrics
A toolkit for Teachers and Interpreters "Climate Change, Wildlife, Wildlands," CD-rom from U.S. EPA
Student copies of fact sheet on climate change (from cd above)
Blank paper or poster boards

Teacher's notes
(10 min) Teacher should prompt classroom with random questions and answers (go through the unit's Daily Questions) to get minds engaged. Have a question and answer time, (45 min) As a test students can either develop a small poster that summarizes the chemical and ethical pros and cons of burning gas or wood or write a paragraph that suggests a regulation that could be enforced in our hometown related to air quality and why that regulation is important. As you collect test, give student fact sheet to look over and do KWL on.

Overall Assessment

The overall assessment occurs on the 7th day of the unit. It will show what the student knows about the environment and what they feel is important.

Other assessments that should be considered is the completion of the daily work, especially the answers for the Daily Questions.

Journals are another mode of assessment and should be graded with the needs of each individual student in mind.

The Quiz on day three would serve to assess interpretation of student presentations and how much they know about their state.

Grading rubrics are under the Appendix for the appropriate day.

References

MEECS- Michigan Environmental Education Curriculum Support "Air Quality Lesson Plans" from the Michigan Dept of Environmental Quality

State of Michigan's environment 2005 third biennial Report

A toolkit for Teachers and Interpreters "Climate Change, Wildlife, Wildlands," CD-Rom from U.S. EPA, National park Service, and US fish and Wildlife Service containing fact sheets, slideshows, video and other goodies

Americal Chemical Society Website for Chemmatters Teacher's Guide index http://acswebcontent.acs.org/education/chemmatters/tg/2005_9_tg.doc

Appendix 1
*Whatever outlines the student gives you, consolidate and make copies for the class to aide in note-taking.

Example outline

- ◊ what is CH4
- ◊ How it is made
- ◊ How often it is found
- ◊ This is changing
- ◊ What it does in the air
- ◊ some pros and cons of CH4 in the environment

The outline should provide the basic idea of what your presentation will be about, but leave out facts so classmates can take notes.

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The outline should provide the basic idea of what your presentation will be about, but leave out facts so classmates can take notes

Appendix 2
* Should have copies of note outlines from yesterday to handout

*Models of Atoms and molecules C, O, H, N, CH4, CO2, H20 provided by MEECS: can be found in notebook (lesson 1 pages 13, 14, 15)or color transparency ones can be found on CD Rom in Lesson 2 "pictures of atoms and molecules" (This one has a lot more molecules to choose from and many are being presented that day. It will be important to have them pre-cut are ready to look at.

*Transparency Master on page 68 MEECS notebook. This should be used as a concept map to reorganize thoughts after presentations.

Appendix 3

*MEECS page 4 starts Lesson 1 *
*MEECS provides the Burning Questions at Home to copy as homework

Teacher's Answer KEY

1. Local and states regulations began to move away from a strict approach into a non-regulatory approach during the

   A. 1960-1970
   B. 1970-1980
   C. 1980-1990
   D. 1990-2000

2. What is a challenge facing Michigan in the 21st century?
   A. To keep gas prices down.
   B. To accurately identify and track changes in the environment.
   C. To stop people from wasting energy.
   D. To find and stop all forms of pollution.

3. Why should caution be used when reading and interpreting graphs in this reportt?
   A. This is a 2 year report and may not be enough time to accurately see changes in the environment.
   B. This report is biased because it is created under direction of Jennifer Granholm.
   C. The graphs

4. The overall air quality in Michigan, in the last 35 years has
   A. Shown improvement
   B. Shown no change
   C. Gotten worse

5. Which items below are considered "criteria pollutants"?
   A. Carbon dioxide, carbon monoxide, nitrous oxide, sulfur oxide
   B. Carbon monoxide, Nitrogen dioxide, lead, particulate matter
   C. Ozone, carbon dioxide, Iron, nuclear waste

6. Lead in the air has decreased since 1980's primarily due to what factor?
   A. Removing lead from pencils.
   B. Removing lead in building materials.
   C. Removing lead from gasoline.
   D. Controlling smelting operations

7. Nitrogen dioxide is formed from
   A. Burning of car tires
   B. Power plants burning fuels
   C. Reactions caused by acid rain

8. Ozone is NOT
   A. Responsible for many respiratory problems
   B. A normal part of the earth's atmosphere
   C. Higher is sunny weather
   D. Formed from burning coal

9. Particulate matter is
   - ***A. A term referring to small solid or liquid particles or droplets found in the air***
   - B. A term referring to a solid piece of matter that is composed of several combined pieces
   - C. A term referring to road dust.

10. Nationwide the largest source of sulfur dioxide is…
   - A. Cars burning gasoline
   - B. Nuclear power plants
   - C. Industrial space heating
   - ***D. Coal-burning power plants***

11. Greenhouse gases are
   - A. Not found naturally in the atmosphere
   - B. Of concern due to dramatic decrease in quantity over the last 35 years.
   - ***C. Of concern due to dramatic increase in quantity over the last 35 years.***
   - D. Dependant of the amount of sunlight making it through the cloud cover.

12. The most common greenhouse gas is

A. Methane	***B. Carbon dioxide***	C. CFC's	D. Nitrous oxide

13. AQI stand for
   - A. Aquamarine Quality Information
   - B. Ambient Qualitative Index
   - ***C. Air Quality Index***
   - D. Air Quantity Information

14. AQI information should be checked

A. Every season	B. Yearly	C. Monthly	***D. Daily***

15. Radioactive fallout
   - A. Has been increasing with the increase in nuclear power plants
   - B. Has been Decreasing with the increase in nuclear power plants
   - C. From nuclear weapons testing has been increasing
   - ***D. From nuclear weapons testing has been decreasing***

Michigan's Air Quality Quiz

Name_____ Hour_____ Date_____

1. Local and states regulations began to move away from a strict approach into a non-regulatory approach during the

A. 1960-1970
B. 1970-1980
C. 1980-1990
D. 1990-2000

2. What is a challenge facing Michigan in the 21st century?
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D. Carbon dioxide, carbon monoxide, nitrous oxide, sulfur oxide
E. Carbon monoxide, Nitrogen dioxide, lead, particulate matter
F. Ozone, carbon dioxide, Iron, nuclear waste

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    C. From nuclear weapons testing has been increasing
    D. From nuclear weapons testing has been decreasing

Appendix 4
*MEECS provides play on page 40-46
*MEECS provides pages 47-48-49 to copy and laminate
*MEECS provides graphs and homework activity pages 72-75

Directions for Schoenbein paper groups of 2 ** adapted from MEECS page 82

This is to make an ozone test strip. The paper should change color when exposed to ozone because the ozone reacts with the Potassium Iodide to from a new product called potassium hydroxide which leaves the iodine atoms free to react with the starch. This was developed by Christian Fredrich Schoenbein in1839.
The reaction:
$2KI + O_3 + H_2O \rightarrow 2KOH + O_2 + I_2$
Then
I_2 + starch → blue color

Materials:
250 ml beaker
2 small Glass plates
1 ¼ tsp cornstarch
100 ml distilled water
¼ tsp potassium iodide
3 filter paper (1 for each person plus 1 control)
Glass stirring rod
2 small Paintbrushes
Hot plate to share to another group
Hot Hands protectors to share

Procedure
1. Make sure all member of group are wearing appropriate safety goggles and aprons.
2. Take a 250 ml beaker and add 100 ml of distilled water. Then add 1 ¼ tsp of cornstarch
3. GENTLY heat mixture until it gels and then remove at once with "hot hands" for safety.
4. Add ¼ tsp of Potassium Iodide and STIR well. Let mixture cool for about 5 minutes
5. Filter paper should be placed on glass plate and carefully "painted" with the paste. Be sure to coat evenly and not make it to thick/thin.
6. Turn paper over and paint over side the same way.
7. Take paper to designated drying rack in back room.
8. WASH HANDS THROUGHLY!

Tomorrow we will cut the filters in halve and place on an air quality monitor.

Appendix…5
*MEECS page 50 answers ready to discuss correct answers
* MEECS provides particle collector procedure and accompanying activity (pages 97-99)
*MEECS provides article and questions about "whats in the air" page 91-92
*EPA provides a powerpoint on their CD-Rom to use to discuss greenhouse gases. (under interactive materials: slideshow:) Have notes to accompany slides.

Extra credit stuff
Sample issue free pdf file in my original folder or online at http://www.chemistry.org/portal/a/c/s/1/acsdisplay.html?DOC=education%5ccurriculum%5cchemmatters%5cissue_arch.html start at page 14

Anticipation Guides*provided by Chemmatters- chemistry.org

Anticipation guides help engage students by activating prior knowledge and stimulating student interest before reading. If class time permits, discuss their responses to each statement before reading each article. As they read, students should look for evidence supporting or refuting their initial responses.

Reading Strategies*provided by Chemmatters- chemistry.org

These content frames, matrices, and organizers help students locate and analyze information from the articles. Student understanding will be enhanced when they explore and evaluate the information themselves, with input from the teacher if students are struggling. If you use these reading strategies to evaluate student performance, you may want to develop a grading rubric such as the one below.

Score	Description	Evidence
4	Excellent	Complete; details provided; demonstrates deep understanding.
3	Good	Complete; few details provided; demonstrates some understanding.
2	Fair	Incomplete; few details provided; some misconceptions evident.
1	Poor	Very incomplete; no details provided; many misconceptions evident.
0	Not acceptable	So incomplete that no judgment can be made about student understanding

Extra information and extra credit activities below:

- **For Sample issue from Chemmatters please see .pdf file in original folder. It should be entitled "2005_9_smpissue". Page 14 begins the article that this guide accompanies.**

Directions for all Anticipation Guides: In the first column, write "A" or "D" indicating your agreement or disagreement with each statement. As you read, compare your opinions with information from the article. In the space under each statement, cite information from the article that supports or refutes your original ideas.

Clearing the Air—Treaties to Treatments

Me	Text	Statement
		1. London smog and Los Angeles smog are formed by similar processes.
		2. The 1992 Montreal Protocol, signed by more than 180 countries including the U. S., set a timetable to phase out ozone depleting chemicals.
		3. The 1997 Kyoto Protocol aims to cut greenhouse gas emissions.
		4. There is only one significant greenhouse gas, and that is CO_2.
		5. "Brown clouds" usually remain over the high population areas where they are formed.
		6. Greenhouse gas emissions are tied to our energy use.

Clearing the Air—Treaties to Treatments

Compare and contrast the Montreal Protocol and the Kyoto Protocol in the chart below.

	Montreal Protocol	Kyoto Protocol
Year signed		
Countries that signed		
Purpose		
How the goal is to be met		
Problems in implementing the pact		

Clearing the Air—Treaties to Treatments **from ChemMatters*

Background

International treaties for solving global environmental crises present political challenges unparalleled in other categories of human interaction. The central question of this article is: Why are these treaties so difficult?

You and your students might want to prepare for reading this article by thinking about other instances and situations in which action is called for before outcomes can be predicted with certainty. In daily life, we are urged to adopt healthy lifestyles without the guarantee they will insure long life. Adults invest money in stocks based on certain hunches and performance patterns with no guarantee that they will increase in value. Our government ordered pre-emptive military action be taken based on uncertain intelligence reports with no guarantee that the action would improve national security. In short, it is not unusual for individuals and nations to take action even when outcomes are uncertain. As the article points out—deciding to take NO action is also a decision.

What makes global environmental agreements even more difficult is the uneven distribution of sacrifice and risk they require. Is it fair to ask a developing country to make the same economic sacrifice that a prosperous industrial power makes? On the other hand, is it fair to expect disproportionate cutbacks on the part of industrial nations while neighboring countries continue to pollute the atmosphere with environmentally destructive industrial practices?

And all of this decision making takes place while the global climate changes in a slow, often uneven manner. Some locales even report cooler than average temperatures as weather patterns slowly shift with changing ocean and air currents.

Excellent additional background for this article may be found on the NASA Goddard Spaceflight website called Earth Observatory. The site map is at http://earthobservatory.nasa.gov/masthead.html. The "Features" option is especially rich with articles on evidence of global climate change.

For a look at serious policy issues facing global decision making efforts, see the Pew Center on Global Climate Change. The web page describes the current status of policy making, both national and international: http://www.pewclimate.org/

Connection to Chemical Concepts

More about the release of CO_2 into the atmosphere from human activities

The technical term that is applied to materials released into the atmosphere because of human activities is *anthropogenic*. For example, there is a "natural" greenhouse effect that is the result of the normal concentration of carbon dioxide, water vapor and other gases that would be in Earth's atmosphere even if humans did not exist. Then there are the additional gases, especially carbon dioxide, that enter the atmosphere as a result of human activities, particularly the burning of fossil fuels. This results in what is called the *enhanced greenhouse effect.*

The amount of carbon dioxide released into the atmosphere is astounding. A table containing a vast amount of data from a large number of countries can be found at: http://www.emep.int/emis_tables/tab7.html

If you access any of this data, one thing should probably be kept in mind. Anthropogenic emissions are typically expressed in terms of metric tons of carbon. This means that if you are looking at anthropogenic emissions of carbon dioxide, for example, you need to convert the values to an equivalent amount of carbon. This is accomplished simply by using the relative molecular weight of the molecule in question compared to the atomic weight of carbon. For example, an anthropogenic emission of 5500 million metric tons of carbon dioxide is equivalent to:

(5550)(12/44) = 1514 million metric tons of carbon

Because the molar mass of carbon dioxide is 44, while the atomic weight of carbon is 12.

An interesting table of conversion factors relating to different carbon containing compounds can be found at: http://www.eia.doe.gov/oiaf/1605/gg00rpt/appendixf.htm

Some interesting statistics

Population and energy consumption statistics will vary, depending upon the source of the information, so the data below should not be taken to represent definitive values, but rather as reasonable estimates.

The total population of the World is about 6,400,000,000, and is growing at about 150 people per minute.

The population of the United States is about 277,000,000, and is growing at the rate of about 5-6 people per minute.

So the U.S. represents about 4.5% of the total population of the world.

We account for about 35% of the world's energy consumption.

Less than 8% of our energy consumption is comes from renewable resources.

About 85% of our energy consumption comes from fossil fuels, almost half of which is imported.

Possible Student Misconceptions

There is a lot of misunderstanding about what the "greenhouse effect" really is. Perhaps one of the most common is that the only reason a greenhouse becomes warm is that light energy enters, but cannot escape. While that may basically be true, the major reason the greenhouse becomes hot is due to the fact that it is more or less sealed up and cannot exchange its inside air with outside air. There is an interesting discussion of this at: http://www.ems.psu.edu/~fraser/Bad/BadGreenhouse.html

You may also need to consider the common misconception about the term "proof" in science. Scientists gather information and conduct experiments to support and, in some cases, reject theories. And a theory is simply the best statement that can be made based upon all available verifiable information. Scientists understand uncertainties, and they easily accept that knowledge and understanding advances without achieving 100% certainty. For the general public, this acceptance does not come as easily. The moment a theory is questioned and revised with new information, many voices rise to say, "Again, a major theory is disproved!"

For people deliberating treaties for controlling global climate change, the prospect of taking action, often expensive action, in the context of uncertainties makes progress especially difficult.

Demonstrations and Lessons

The article suggests that finding a solution to the world's energy crises will loom large in decades to come. *ChemMatters* April 2003 featured an activity titled "Green Energy—It's Your Decision". The activity challenged students to select the most efficient method in terms of energy and cost for heating 200 mL of water to a required temperature. They were to consider a laboratory hot plate, a bunsen burner, and a microwave oven. The activity was adapted from *Introduction to Green Chemistry: Instructional Activities for Introductory Chemistry*, published by the American Chemical Society, 2002. The activity is included on the 20-year CD Rom of *ChemMatters* articles available for purchase on this *ChemMatters* website.

Suggestion For Student Projects

There are many environmental regulations and public policies under scrutiny and debate at the national and intermantional level. Students could work in groups to research the underlying science and the various positions taken by opposing groups. Some of these regulations involve emissions of specific chemicals like arsenic, mercury, and various organic species.

Regulations ofter refer to industry standards for pollutants and emissions. Students will find that these standards translate into the thresholds below which the presence of these substances are legal. Sometimes the decisions made about setting standards revolve around the limits of affordable testing equipment. An amount that can be detected using expensive analytical tests in laboratories might go undetected with the day to day equipment used in the field. Students might interview water-quality or air-quality experts for more information on the subject of regulations and standards.

Anticipating Student Questions

What would the climate be like if we got rid of ALL greenhouse gases?

The complete answer involves some complex thinking. Basically, we know how much energy reaches the Earth from the Sun. We know how much of this energy is absorbed by the Earth and how much is reflected. The energy that is absorbed warms the Earth. The Earth, like all objects, emits energy, and if it became warmer, it would emit even more energy. Of course the energy arriving on the Earth and the energy leaving the Earth must be equal. Otherwise the Earth would either be getting hotter or colder. So from this "energy balance," scientists can calculate how warm the Earth would be in order to emit the same amount of energy it receives every day. That comes out to be –18 ^{o}C. Brrrrr.

Is there anything that can be done about the smog problem short of giving up our use of internal combustion automobiles?

Yes, and much has been done already. One of the major technological advances has been the installation of catalytic converters on automobiles. The name suggests what they do. A catalytic converter contains catalysts, often transition metals such as palladium, Pd, or platinum, Pt. These catalysts transform unburned hydrocarbons and carbon monoxide into carbon dioxide while at the same time converting NO_x back into the elements nitrogen and oxygen.

Websites For Additional Information

Several excellent Websites have been cited in this Teacher's Guide entry. Use these cites to find additional links to information about greenhouse gases, ozone, and policy making.

Appendix 6

Ozone paper color	Ozone level	Average particles /square	Description of particles	location

*MEECs provides page 99
*MEECS provides particle counting grids page 101; 4 per page
*MEECS provides answers to homework packet on page 76

In grading journal: look for students to have made a connection between what happens at their house and the ozone or particles collected their.

Appendix 7
*Fact sheet on Climate change provided by EPA on CD-Rom in Toolkit for interpreters

Answers to Daily Questions
Day 1: CO2 or the reactant
Day 2: any of these 3: CO2, CO, NO2, NO, lead, SO2, Particulate matter,
Day 3: coal fired power plants or incinerators
Day 4: 03
Day 5: high up in atmosphere and keeps earth's temperature regulated
Day 6: yes; ozone causes damage and has health effects
Day 7: variable: look for a distinct choice and support

Rubrics below:

Choice 1 poster series

Your test is to design A poster that summarize all environmental and ethical concerns (pros and cons) of using EITHER wood or gas to heat your home in the winter. It will be graded using the rubric below. There is a possible 20 points.

presentation	1	2	3	4
Organization and Quality	Has no organization **and** is sloppy in appearance	Has either little to no organization or is sloppy; other is medium	Has average organization **and** is not sloppy in appearance	Has either high organization and is very neat
Positives	Lists 0-1 positives to the fuel source	Lists 2 positives to the fuel source	Lists 3 positives to the fuel source	Lists 4 or more positives to the fuel source
Negatives	Lists 0-1 negatives to the fuel source	Lists 2 negatives to the fuel source	Lists 3 negatives to the fuel source	Lists 4 or more negatives to the fuel source
Facts (other than + or – information)	Lists 0-1 extra facts about the fuel source	Lists 2-3 facts about the fuel source	Lists 4-5 facts about the fuel source	Lists 6 or more facts about the fuel source
Global trends impact	Lists 0 impacts/trends	Lists 1 impact/ trend	Lists 2 impacts/trend	Lists 3 impact/trend

Choice 2 paragraph

Your test is to write a paragraph explaining a regulation or law that should go into effect and why it is important to the environment. It must be supported by more than just ethical concerns (i.e. you NEED DATA in it!!) It must be organized into proper paragraph structure. It will be graded with the rubric below for a possible 20 points.

presentation	1	2	3	4
Organization and Quality	Has no organization **and** is sloppy	Has either little to no organization **or** is sloppy; other is medium	Has average organization **and** is not sloppy in appearance	Has either high organization **and** is very neat
The law or regulation	Is very vaque and does not convey intended message	Is somewhat vaque or does not convey intended message	Is mostly clear, and conveys intended message	Is very clear, and conveys intended message
Ethical concerns	Lists 0	Lists 1	Lists 2	Lists 3 or more
Facts (data to support ethical concerns)	Lists 0-1 extra facts about the fuel source	Lists 2-3 facts about the fuel source	Lists 4-5 facts about the fuel source	Lists 6 or more facts about the fuel source
Global trends/ impact	Lists 0 impacts/trends	Lists 1 impact/ trend	Lists 2 impacts/trend	Lists 3 impact/trends