Air quality unit

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Program Outcomes

Students will use the conventional language/vocabulary, instrumentation, and operations of science.

Students will construct, use and interpret graphs, tables, and charts.

Students will consider different points of view. They will debate issues, support their point of view with evidence and will draw conclusions based on presented facts and strength of argument.

Course-Unit Outcomes

The students will examine the effects of air, water, and soil pollution on human and environmental health/quality.

The students will summarize efforts and economic costs involved with pollution clean-up.

Overview:

I. Air as a natural resource-- features and functions
    A. Pie graph of atmosphere composition
    B. Atmosphere strata
II. Pollution types, sources, effects
    A. Graphic Organizer of pollutants
    B. Primary Air Pollutants (pie graph) and sources (bar graph)
    C. Pollutant Feature Analysis
III. Measuring and reducing pollution
    A. Particulates lab
    B. Car emissions lab (lab book page 43)
    C. Carbon Dioxide Emissions (MEECs lab)
    D. Ozone measurement (Globe protocols)
    E. Sulfur dioxide emissions lab (lab book page 49)
IV. Economic costs of clean-up and health-related care
    A. Scrubbers
    B. Catalytic Converters (and emissions testing) Debate
    C. Health effects brochure creation
V. Impact of human practices on environmental health (ie air pollution)
    A. Individual contributions
    B. Society contributions
    C. Legislation and regulation

Appendices:

1. Pie graph and bar graphs[1] regarding pollution sources & related questions
2. Atmosphere diagram[1] and related questions
3. Pollutant graphic organizer
4. Pollutant characteristics feature analysis
5. What if? Cause-effect relationships

6. Air Quality Index worksheet/webquest
7. Lab handouts/data tables
6. Brochure Evaluation Rubric
7. Unit exam
8. Resources

[1]Pie graph was recreated for the purpose of this unit, but text book provides bar graph (figure 6-3) and atmosphere diagram (figure 7-4). They can also be found online or in other resources.

I. Lesson Outcomes: Air as a natural resource-- features and functions

The students will be able to

define the atmosphere as a thin layer of gases surrounding planet Earth that allow live to exist.
interpret a pie graph to determine the percentage of nitrogen, oxygen and other gasses.
interpret a figure to describe characteristics of our atmospheric layers
conclude that without the atmosphere and/or with major disruptions to the atmosphere, life would be disrupted and potentially would cease to exist.

A. Have students read text section on air for previous evening's homework. Draw students' attention to the pie graph showing atmosphere composition. Briefly show students air molecule models of N_2, O_2, and CO_2. Give students white boards and markers. Ask the following questions one at a time and have students respond on their boards, showing them when all students have had a chance to respond:

1) What percentage of the atmosphere is Oxygen? [identifying]
2) Which element makes up most of the atmosphere? [ranking]
3) Approximately what FRACTION of the atmosphere is Nitrogen? [generalizing]
4) We breathe in/inhale Oxygen, what chemical do we breathe out/exhale? [recall]
   If students are uncertain, review respiration-photosynthesis connections (use figure 7-2 in text)
5) What percentage of the atmosphere is CO_2? [identifying]

B. Draw students' attention to the atmosphere-layer illustration. Ask the following questions and have students respond on their boards, showing them when all students have had a chance to respond:

1) Which layer is closest to the Earth's surface? [identifying]
2) Which layer is the largest [interpreting]
3) At what height above the Earth (sea level) does the stratosphere start? . . . end? [interpreting]
4) How large (width) is the Mesosphere? [calculating]
5) In which layer does weather occur? . . . In which layer is the ozone [using figure captions]
6) In which layer do we live? [synthesizing]

Notes: Have students add the above information to their science logs/journals. For time and/or accuracy sake, you may want to provide blank graphs and diagrams then have students fill in the information.

II. Lesson Outcomes: Pollution types, sources, effects

The students will be able to

Create a graphic organizer to show pollutant types
Interpret a table and graphs describing various pollutants
Fill in a feature analysis table to describe different pollutants' effects
Recognize that pollutants affect the chemical composition of the atmosphere and hinder its functioning.

A. Have students read text on air pollution. Provide graphic organizer outline (see appendix). Have students fill in. For advanced students, have them illustrate each pollutant with a colored illustration of the molecule.
B. Direct student attention to pie graph on primary air pollutants and bar graph of pollutant sources. Handout worksheet and have students complete using provided information.
C. Use text, lecture, or table, to provide information students need in order to fill in feature analysis table.
D. Discuss the sources and effects of pollutants.

III Lesson Outcomes: Measuring and reducing pollution

The students will be able to

- Describe particulates as airborne solids that reduce visibility
- Compare particulate samples
- Rank cars contribution to particulate pollution
- Deduce that carbon dioxide contributes to global warming
- Distinguish between good and bad ozone
- Respond to AQI warnings
- Observe and describe effects of sulfur dioxide on plants
- Control variables in 3 different experiments

A. Particulates lab: (See appendix for lab handout.) As a class, examine a campus map. Decide where to place particulate collection cards in order to collect data. Create particulate collection cards. Collect cards and examine them with a hand lens or microscope. Count the particulates collected. As a class, create a bar graph comparing the densities: particulates/cm^2 and/or rates particulates/hour. As a challenge (or for homework) have students calculate the number of particulates that would be collected over a greater area or longer time.

B. Car emissions lab (lab book page 43, see appendix for more information). Recruit volunteers to show/share their cars. Depending on accessibility, you may need to collect some data prior to class. Have students record various information about each car including make/model, age, mileage, emission scores, and motor specifications. For each car, place a clean white tube sock over tail pipe. Have owner start car and run for one minute. Compare socks to illustrate the particulate emissions. Discuss the additional pollutants emitted that are not visible or that were vaporized, hence not trapped in sock.

SAFETY ALERT: Have students stand at least 10 meters away from cars and make sure the car is in park/braked. Remove sock with heat-resistant mitt.

C. Carbon Dioxide Emissions lab (MEECS lab, see appendix for lab handout, or have students record in their lab journals). Discuss the scientific method and the need to have a control and/or keep variables controlled. Review lab safety rules. Demonstrate how CO_2 can be detected using limewater-- have a student exhale into limewater until it changes color. Set up experiment in sun or bright light and in view of a clock (or provide students with stop watches). Assemble two atmosphere kits per demonstration (either model for the whole class, or have students perform experiment in small groups): inside a ziplock bag place a thermometer (or temperature probe), a small cup of with 5 ml of vinegar and a larger cup with 5ml of baking soda. Record each bag's temperature on data sheet. Have students pour vinegar into baking soda in one bag, seal both bags and take temperature measurements then record on data sheets. Show students that the gas produced in the experimental bag was indeed CO_2. Have students make a time vs temperature graph illustrating the difference between the two ziplock bags. Have students draw conclusions about the affect of CO_2 on temperature.

Have students:
-deduce the relationship between world wide temperatures and atmospheric CO_2.
-predict what would happen to temperatures if CO_2 increased in our atmosphere.
-interpret line graph showing CO_2 and world temperatures to confirm/refute their prediction (use long-term graph comparing CO_2 and Worldwide temperatures-- textbook figure 7-2).
-draw conclusions about the impact of human activity on CO_2 using the Mauna Loa research station data (figure7-13 in textbook).
-predict what will happen if. . . . (see increase/decrease worksheet in appendix.)

Using their reading, students should pictorially illustrate the green house effect and using the mixed up letters identify the five major green house gasses.

D. Ozone measurement (Globe protocols). Discuss the chemical make up of Ozone, how it is formed (see text book figure 7-18) and the fact that one CFC can create 100,000 ozone molecules. Compare the effect of Ozone in the stratosphere and in the troposphere. Take ozone readings. Submit to Globe on-line. Compare Ozone readings in your area, your region and nation wide.

Have students visit http://www.airnow.gov. Explore and complete worksheet/webquest (see appendix)

E. Sulfur dioxide emissions lab (lab book page 49; see appendix for more information). This experiment exposes one plant to sulfur dioxide and encourages a week-long period of observation for students to note effects SO_2 has on plant health. Have students carefully draw two plants noting any signs of illness or injury and predict what effects acid-forming SO_2 might have on an exposed plant. Place each plant in a leak-free bag and mist with a spray bottle 5 times[2]. In a chemical hood or outdoors, place a beaker containing 2g of sodium nitrate inside one bag, pour 2ml of 1M sulfuric acid into the beaker, close and secure bag. Simply close and secure the other bag[2]. Wait 10 minutes. Open the bags and set plants in conducive growing environment. Observe over the next few days, making notes and/or drawing illustrations to show plant health.

SAFETY CONCERN: Be certain that Sulfur Dioxide is not released into the classroom-- perform outdoors or within chemical hood. When opening the bags, have students stay at least 5 meters away while the gas dissipates.

[2] misting is optional, but discuss with students the need to keep all but the independent variable the same.

IV. Lesson Outcomes Economic costs of clean-up and health-related care

The students will be able to

- Use a pro/con table to argue for/against the use of industrial Scrubbers.
- Present two or more arguments for/against the use of catalytic converts in cars.
- Evaluate presented arguments and compose a short essay supporting their perspective on the use of catalytic converters in cars.
- Create a brochure illustrating the relationship between pollution and health

A. Scrubbers. Explain how scrubbers work and their purpose. Create a pros/cons table to show the economic and environmental issues.

B. Catalytic Converters (and emissions testing) Debate: If possible, invite a guest speaker from the Department of Transportation, an emissions center, or a mechanics shop-- see if they can bring actual catalytic converters and/or publications related to their use. As a class, make a list of the pros and cons of buying and using equipment to reduce auto emissions. Divide into two teams to debate the issue by assigning characters to each student (ie a biologist, a car owner, a government official, a car dealer). Have each student present two reasons for their side, allow for teams to meet to make a unified argument, open the debate for discussion, have closing remarks, then as judge(s) make their verdict, have students write short paragraph explaining their own (not assigned character's) opinion of the issue and assessing their performance in the debate.

C. Health effects brochure creation: Have students choose a health concern[3] and create a brochure indicating the relationship between the pollution and the effect, describing how to reduce/prevent the impact, and listing at least two places where people can go to get more information.

[3]alternatively, students can select a pollutant and create a brochure showing the negative effects that pollutant has on health (see appendix for rubric)

V. Lesson Outcomes: Impact of human practices on environmental health (ie air pollution)
The students will be able to

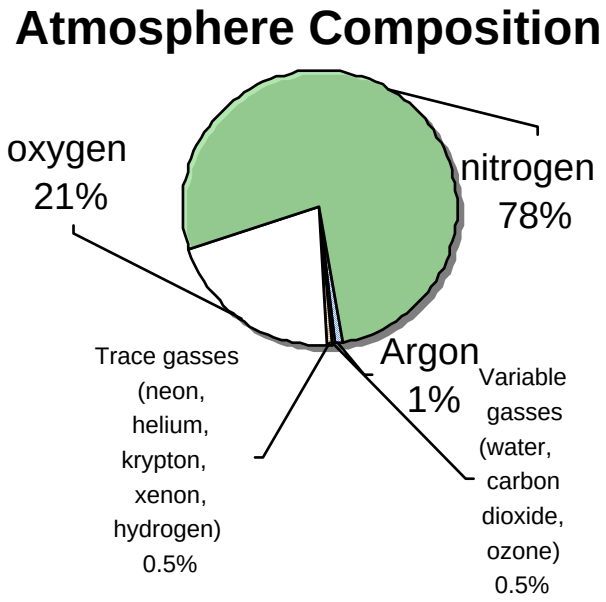
Illustrate 2 or more ways individuals can reduce their negative impact on air quality
Recognize the societal impact of emission regulation
Identify the Clean Air Act as a federal piece of legislation aimed at reducing air pollution

A. Individual contributions: discuss how people contribute to air pollution. Make a poster to show what we can do to reduce our impact.
B. Society contributions: discuss how society contributes to air pollution. Consider the trade-offs or compromises people make when considering how much pollution is acceptable.
C. Legislation and regulation: discuss the major pieces of legislation (clean air act, etc.) that have been put into place. Research their effectiveness.

Appendix

Using the Atmosphere Pie Graph[1], answer the following questions on your whiteboard.

1) Which element makes up most of the atmosphere's composition?



2) What percentage of the atmosphere is N_2?

3) Approximately what fraction of the atmosphere is N_2

4) Which chemical do we need for respiration (to breathe)?

5) What percentage of the atmosphere composition is Oxygen?

6) We breathe out CO_2 and plants use this Carbon Dioxide for Photosynthesis. How much of the atmosphere's composition is CO_2?_____ notice that it shares a pie piece with water and ozone-- CO_2 is actually LESS than half a percent!!! Is it still an important gas?

Use an Atmosphere diagram[1], answer the following questions:

1) Which -sphere is closest to the surface of the Earth?
2) Which layer starts 45 km above the Earth?
3) At what height does the Mesosphere stop?
4) Which layer is more than 400km wide?
5) In which layer do we find the helpful ozone layer?

Pollutants and Sources

Interpret: *Using the pie and bar graphs[1] showing pollutants and pollution sources to answer the following questions*

1) Which pollutant is the most common?

_____

2) What percentage of pollutants are particulates?

_____

3) VOC is an abbreviation for

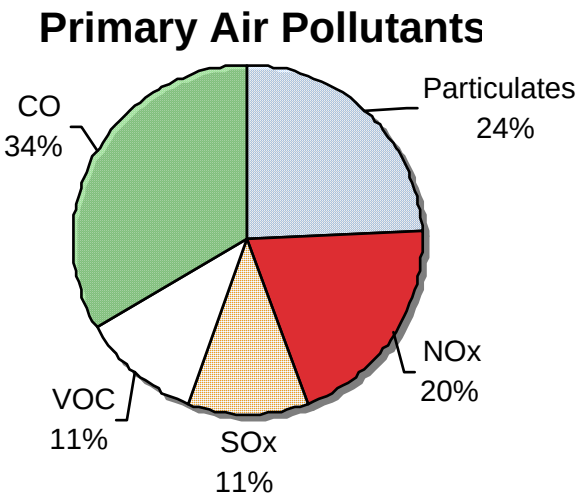
_____ _____ _____

4) Which pollutant is made by transportation?

_____.

5) What is the source of most sulfur oxides (SO_x)?

_____

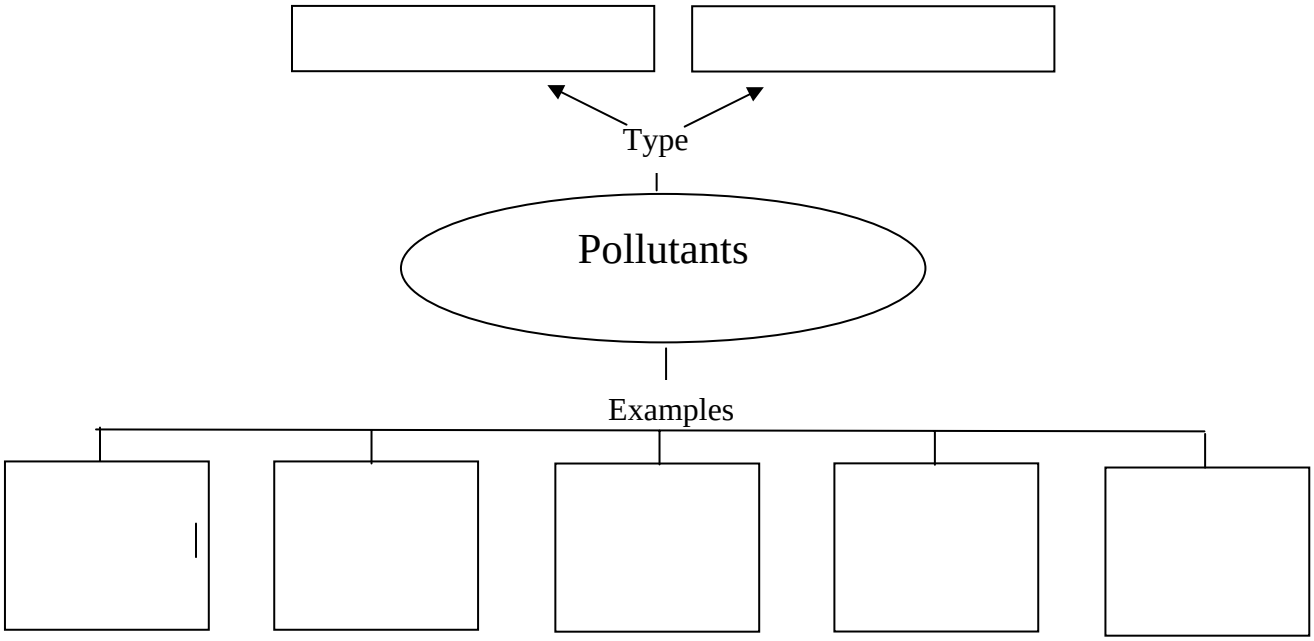


6) A city notices a lot of particulates in their air. Should they
   a) reduce transportation
   b) reduce burning fuels (other than in vehicles)
   c) reduce industry
   d) all of the above

[1]Pie graphs were recreated for the purpose of this unit, but text book provides bar graph (figure 6-3) and atmosphere diagram (figure 7-4). They can also be found online or in other resources.

Pollutant Graphic Organizer

Fill in the boxes to show the relationship between concepts and terms in this unit.



Feature analysis

Read the possible characteristics for each pollutant. Place a check in a pollutant's column if it has the indicated characteristic. The first one has been done for you.

	CO	NO_x	SO_x	VOCs	Particulates
In the gas phase @ STP	✓	✓	✓	✓	
Problems with respiration -- breathing/using O_2					
Associated with cancer					
Harms plants					
Damages objects					
Acid rain					
Smog and dirty air (low visibility)					

What if . . . increase ↑&↓ decrease relationships

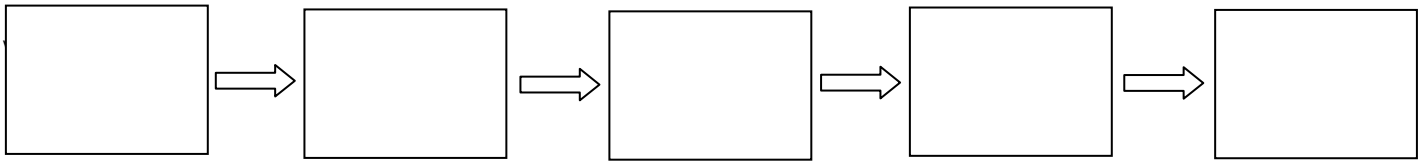
Read the first phrase in each sentence. Consider its affect on the following variable. In the blank, write the word increase or decrease to show the result.

IF carbon dioxide increases ↑, Temperature _____
IF carbon dioxide decreases ↓, Temperature _____

If temperature increases ↑, ice melt _____
If ice melt increases ↑, sea levels _____
If sea levels increase ↑, land surface _____

If temperature decreases ↓, ice melt _____
If ice melt decreases ↓, sea levels _____
If sea levels decrease ↓, land surface _____

Choose one global change. Complete this flow chart to show all the changes that could result.



Rearrange the letters to discover the 5 major greenhouse gasses

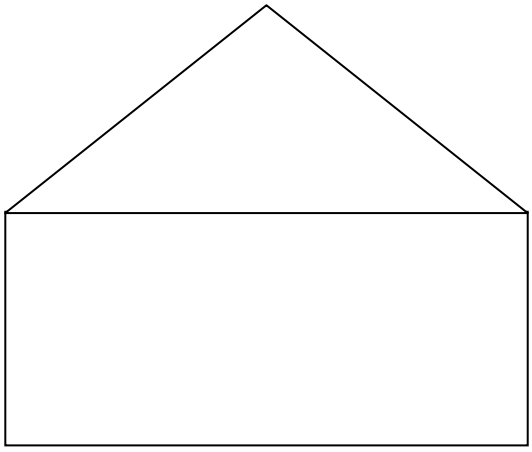
t a w r e *p o r a v*
_ _ _ _ _ _ _ _ _ _ _ _

r a b c n o *i o i d d x e*
_ _ _ _ _ _ _ _ _ _ _ _ _ _ _

C C s F
_ _ _ _

e t a h n e m
_ _ _ _ _ _ _ _

t i n o r s u *x i o e d*
_ _ _ _ _ _ _ _ _ _ _ _



Air Quality Index WEBQUEST

The Air Quality Index describes how clean or polluted outdoor air is. It helps to identify when pollution can be dangerous to your health. Colors indicate air quality. Green is good, other colors indicate pollution that may be harmful to different people.

Visit http://www.airnow.gov/. *There is a map in the middle of the page with tabs above it. If you look at the bottom of the map there are more links-- these make the map bigger, but take time to load.*

Under the National Outlook tab:
Describe the area where you live (what color, any interesting weather etc.) :

_____

_____

Change the tab to Today's Forecast.
What color/shape is marked near your home area?_____
What does this mean about the AIQ where you live? _____
Where is the AIQ most dangerous? _____
(where are Ozone Action! Days?)

Change the tab to Ozone Now
What color is your home area? _____
What does this mean about the ozone where you live? _____

Change the tab to Particulates Now
What color is your home area? _____
What does this mean about the ozone where you live? _____

On the left is a column with links. Click on "Local Forecasts & Conditions" then find your home area using the map or drop down box and clicking on your city's link.

What is the current AQI for Ozone? _____ _Color:_____
What is the current AQU for PM 2.5? _____ _Color:_____

Should people in your home area take precautions when going outside today?_____

On the right is a column listing Action Days and Highest QQI Forecasts.
Where is the PM2.5 t predicted to be the highest? _____

Where is the ozone predicted to be the highest? _____

Visit: http://lungaction.org/reports/sota06_cities.html *and discover how your city ranks.*

Pittsburgh is the _____Metropolitan Area Most Polluted by Short-Term Particle Pollution

Pittsburgh is the _____Metropolitan Area Most Polluted by Year-Round Pollution

Pittsburgh is the _____Most Ozone-Polluted City

Visit http://lungaction.org/reports/stateoftheair2006.html *Place zip code 15218—Pittsburgh in the box and fill in this table. Choose another town, enter it, and write down the data.*

	Pittsburgh	_____ Town of your choice
Ozone Grade		
Orange ozone days		
Red ozone days		
Purple ozone days		
Particle pollution		
Pediatric asthma		
Adult Asthma		
Chronic Bronchitis		
Emphysema		
Cardiovascular Disease		
Diabetes		
Total population		

Create a bar graph to compare the number of orange, red and purple ozone days in each city.

Particulates Lab Handout

Question: Where on campus will we collect the most particulates?

Hypothesis: We will collect the most particulates _____

Procedure: (fill out on your own): _____

_____

_____

Data:

Location				
Draw a picture of your card				
Count the number of particulates				

Conclusion: _____ had the most particulates. I know this because:_____

_____

_____

Car Emissions Lab Handout:

Question: Which vehicle has the most visible emissions?

Hypothesis: _____ will make the sock the dirtiest-- it will have the most visible emissions.

Procedure: (fill out on your own): _____

_____

_____

Data:

Vehicle				
Make/Model				

Year built (age)				
Milage				
Emission Scores				
Motor specs.				
Observations of Sock				

Conclusion: _____ had the worst visible emissions. I know this because:_____

_____

_____

Carbon Dioxide Emissions Lab

Question: How will the temperature inside our small model green house change when we increase the carbon dioxide?

Hypothesis: The temperature in the high CO_2 environment will _____

_____

Procedure: (fill out on your own): _____

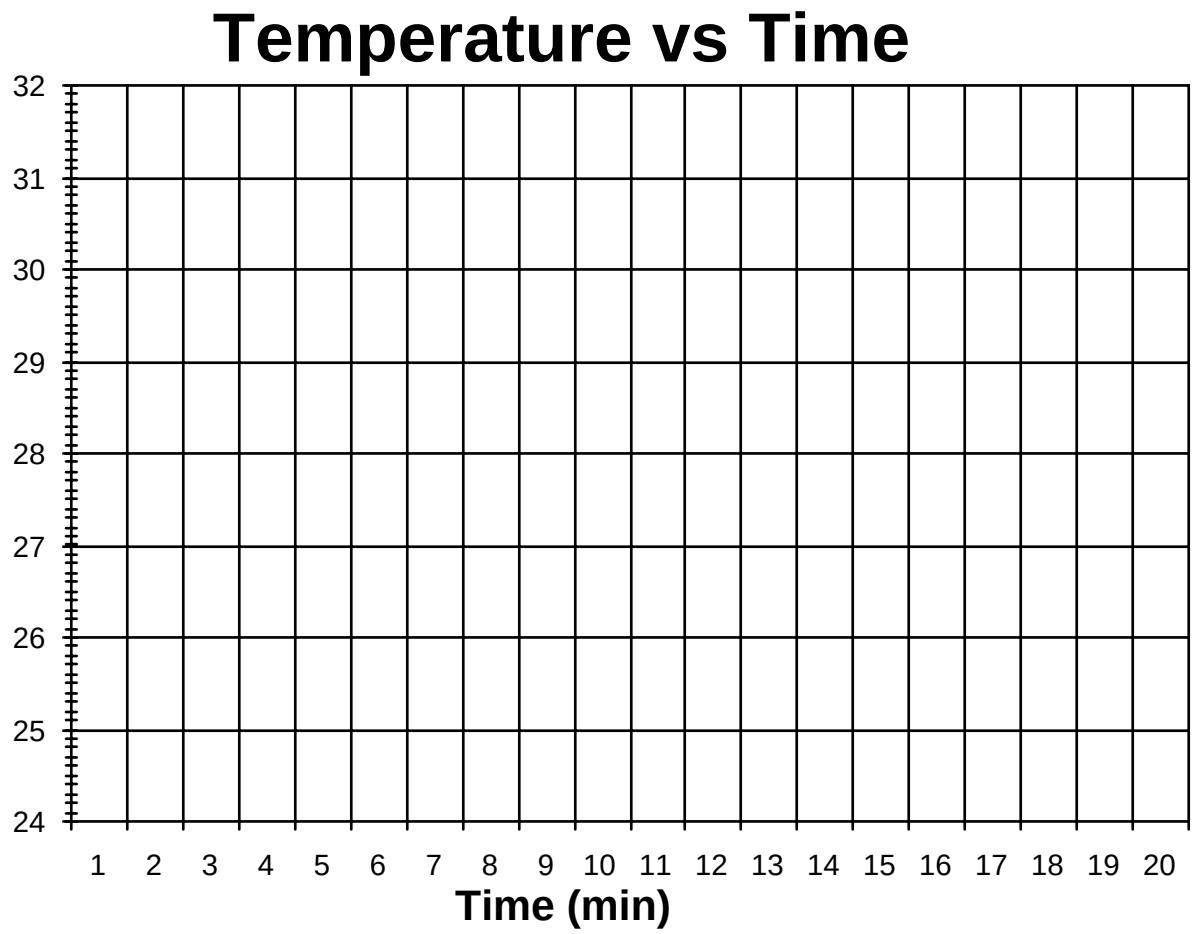
_____

_____

Data:

	Exposed to Sulfur Dioxide	Control Plant
BEFORE chemical reaction		
30sec		
60 sec		
90 sec		
120 sec		
150 sec		
180sec		
210 sec		
240 sec		
270 sec		

300 sec		
6 min		
7 min		
8 min		
9 min		
10 min		
15 min		
20 min		



Note: Graph scale and range can be changed or eliminated.

Conclusion: _____

_____

_____

Sulfur Dioxide Emissions Lab

Question: What will happen to a plant exposed to Sulfur Dioxide and Acid Rain?

Hypothesis: The plant exposed to Sulfur Dioxide and Acid Rain will _____

_____

Procedure: (fill out on your own): _____

_____

_____

Data:

Draw Plant and/or make notes	Exposed to Sulfur Dioxide	Control Plant
BEFORE exposure		
Immediately AFTER Exposure		
Day 1 After exposure		
Day 2 After exposure		
Day 3 After exposure		

Conclusion: _____

_____

_____

Health Brochure Rubric

	NO CREDIT	PARTIAL CREDIT	FULL CREDIT	Student grade	Teacher grade
A	Title absent (0)	Title not clear, too small or too big	(2) Title clear, centered, ~1/3 of front panel.		
B	No illustration (0)	Front panel picture has weak connection with topic	(3) Front panel picture clearly illustrates topic		
C	No symptoms (0)	Less than 2 or inaccurate symptoms	(2) Lists 2 or more symptoms of health problem		
D	No causes (0)	Less than 2 or inaccurate causes	(2) Lists 2 or more causes of health problem		
E	No relationship shown (0)	Relationship is implied	(3) Uses visuals and/or text to show relationship between air quality and health		
F	No table or chart OR plagiarized without giving credit. (0)	Table or chart related to topic from book or other source (with credit given)	(5) Student- created or modified table or chart related to topic is clear and informative		
G	No photo or illustration (0)	Photo shows body part or effect without a clear explanation	(5) Photograph or illustration clearly shows and explains the health problem in the body		
H	No contact information (0)	Contact information incomplete or inaccurate	(2) Back panel has information on at least 2 contacts (books, websites, organizations) where people can get more information.		
I	Brochure is messy or has more than 2 errors (0)	Brochure is nice, but may need more color, better layout or some proofing (has 1-2 errors)	(10) Brochure is appealing and error free.		

Name _____

Air Quality Exam

Read each statement. If the statement is true, circle T. If it is false, circle F.

T/F Burning Fossil Fuels pollutes the air

T/F Industrial scrubbers and catalytic converters are used because they are inexpensive ($cheep)

T/F The ozone layer in the stratosphere protects the earth from harmful UV rays

T/F You must have your car tested for emissions.

Read each question or statement. Choose the letter of the answer that best answers each question or completes each statement.

What is the name of the thin layer of gas that surrounds the Earth?

a) atmosphere
b) biosphere
c) lithosphere
d) gasosphere

Earth's atmosphere is mostly made of:

a) Carbon
b) Hydrogen
c) Nitrogen
d) Oxygen

If Carbon Dioxide increases in the atmosphere, what can we expect?

a) temperature will stay the same
b) temperature will increase
c) Temperature will decrease

Use this figure to answer the following question:

Where is the stratosphere?

a) between the Earth's surface and 10 km
b) between 10 km and 45 km above the earth
c) between 45 km and 80 km above the earth
d) between 80 km and 500 km above the earth

Today has been called an Ozone Alert! Day. The local news is predicting your area will have an Orange AIQ. You should:

a) stay inside all day
b) go outside if you want, but only for limited time
c) stay outside all day

Which is related to air pollution?

a) asthma
b) the flu
c) ear infections
d) lice

The clean air act is a _____ law

a) local (Edgewood)
b) state (PA)
c) federal (USA)

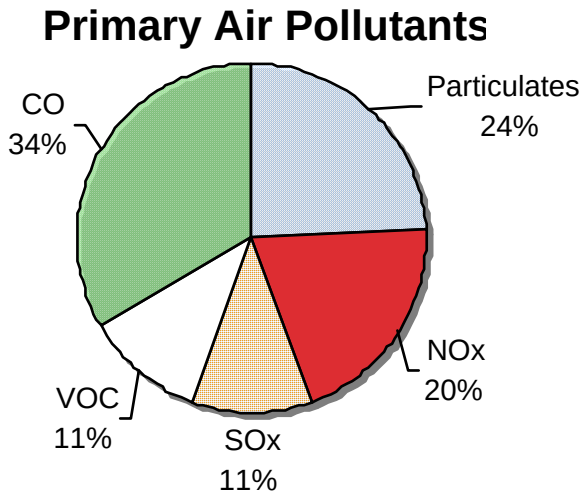
Which of these people might NOT support a law that requires factories to reduce pollution emissions

a) a mother who lives near a factory
b) a legislator who writes environmental bills
b) an employee who works with dangerous factory chemicals
c) a factory owner who would have to pay money to reduce emissions

Sally wanted to test the effect of carbon monoxide on plants. She found a daisy and a rose plant. She placed the daisy plant in one bag with carbon monoxide. She placed the rose plant in a bag without carbon monoxide. She made observations to see what carbon monoxide would have on the plants. Her science teacher said that she did not follow the scientific method. What was wrong with the way she set up her experiment?

a) she did not weigh the plants
b) she did not use enough carbon monoxide
c) she did not spray the bags with water
d) she did not use the same plants in her control and experiment bags

Use the graph below to answer the next question



Which is the most common (highest %) pollutant?

a) SO_x
b) NO_x
c) VOC
d) none of the above

Use the table below to answer the next question.

	CarA	Car B	Car C	Car D
Cost	$7,000	$8,500	$10,000	$10,000
Year	1998	2002	2002	2004
Fuel efficiency	15 mpg	22mpg	28mpg	12 mpg
Odometer reading	87,000mi	34,000mi	31,000mi	28,000mi
Particulate emissions	Heavy	Moderate	Light	Light
NO_x emissions	Pass	Pass	Pass	Fail
VOC emissions	Pass	Pass	Pass	Pass
CO emissions	Fail	Pass	Pass	Fail

You have 10,000 to buy a used car. You want a car that will pollute the least. Which car would be the best choice for your new car?
a) Car A
b) Car B
c) Car C
d) Car D

Jim set four particulate collectors out. He collected them four days later.
Rank the areas from least (1) to most (4) particulates.

Loccation	Near garbage	Near garden	On roof	Under tree
Particulate collector				
Rank				

LaToya, Mark and Suki looked at his data and noticed that there were many particulates under the tree. Which conclusions could be supported by this data? Check all that apply
_____ it is very polluted under the tree
_____ the tree protects the collector from particulates
_____ birds and animals in the tree cause particulates to fall
_____ there is not much air under the tree

Short answer:
What would happen to people if the atmosphere disappeared overnight?
(must be written in a paragraph and give three or more results)

What are two things you can do to reduce air pollution?

Resources

Arms, K. (1996). Environmental Science. New York: Holt, Rinehart and Winston.

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