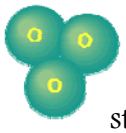
Name: Date:

Background



Ozone (O_3) is a gas that is naturally present in our atmosphere. Each ozone molecule contains three atoms of oxygen (the third oxygen makes this molecule highly reactive). Ozone is found primarily in two regions of the atmosphere. About 90% of atmospheric ozone is in the stratosphere and the remaining 10% is found the troposphere, the region closest to Earth.

Stratospheric ozone is considered to be "good" ozone because it absorbs some of the sun's biologically harmful ultraviolet radiation. With the thinning of the ozone layer, harmful UV rays reach the Earth's surface. Excess exposure to UV rays is associated with skin cancer in humans. Ground level ozone (troposphere ozone), formed from pollutants released into the atmosphere. is considered "bad" ozone. Excessive ground level ozone exposure reduces crop yields and forest growth and has harmful effects on respiratory systems of animals and plants.

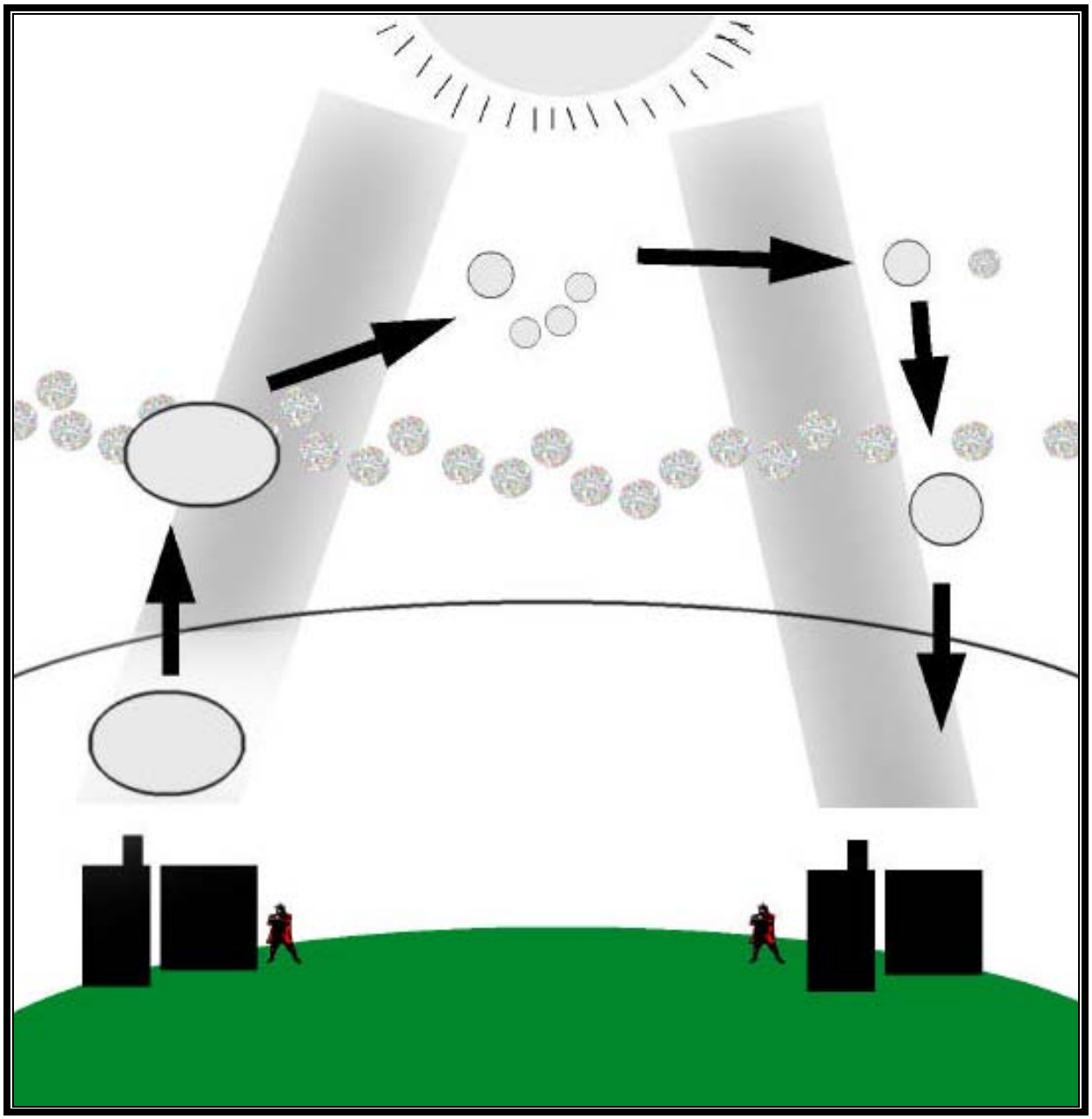
In the early 1970s, scientists discovered that chlorofluorocarbons (CFCs), used as refrigerants in air conditioners, refrigerators, and freezers, and as propellants in cleaners, room deodorizers, furniture polishes, hair spray, and perfumes, were damaging the ozone layer. CFCs are very stable molecules and when released into the air, can remain in the atmosphere for a long time, eventually being pushed by atmospheric air currents into the stratosphere, where they are broken down by UV rays from the sun, releasing free chlorine. The chlorine becomes actively involved in breaking down ozone, so that two molecules of ozone are replaced by three molecules of molecular oxygen, leaving chlorine to repeat the process up to 100,000 times. The result is the thinning of the ozone layer. Other chemicals that damage the ozone layer include methyl bromide (used as a pesticide) and halons (used in fire extinguishers). As methyl bromide and halons are broken apart, they release bromine atoms, which are 40 times more destructive to ozone molecules than chlorine atoms.

Part I:

Using the word bank below, label the illustration that depicts the steps involved in ozone depletion (words are not in any particular order). Note: All words must be used as labels in the illustration.

Chlorine & Oxygen Bond	Stratosphere
CFCs take years to reach stratosphere	
CFCs	CFCS
UV light	UV light breaks down CFCs
Chlorine is split from CFC molecule	Ozone layer
Less Oxygen is available to form ozone	UV light
Thinning Ozone Layer	Cl-O bond

The Process of Ozone Depletion



Part II:

Hole in the Ozone Layer?

In the early 1980s the first evidence of ozone depletion was found above Antarctica. The severe depletion of the Antarctic ozone layer is called the "ozone hole". Antarctic ozone depletion is seasonal, occurring primarily in late winter and early spring (August-November) and is due to unique weather conditions that exist nowhere else on the globe. The very low temperatures of the Antarctic stratosphere during the winter months create ice clouds called polar stratospheric clouds (PSCs). Special chemical reactions that occur on the surface of these clouds release chlorine and bromine molecules that, with sunlight, cause the severe depletion of ozone in the Antarctic springtime. This depletion appears as a "hole" in images of the Antarctic taken from space.

Answer the following questions:

1. Is the "ozone hole" really a hole in the ozone layer? Explain your answer.
2. Read the cartoon below. Do you think this is a feasible solution to reducing greenhouse gases? Explain your answer.

Part III.

Motor vehicle exhaust, industrial emissions, gasoline vapors, and chemical solvents, as well as natural sources, emit nitrogen oxide gases (Nox) and volatile organic compounds (VOC) that help form ozone. Ground-level ozone is the primary constituent of smog. Sunlight and hot weather cause ground-level ozone to form in harmful concentrations in the air. Many urban areas tend to have high levels of "bad" ozone, but even rural areas are also subject to increased ozone levels because wind carries ozone and pollutants hundreds of miles away from their original sources.

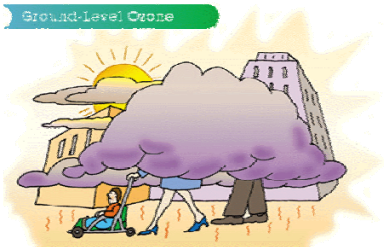
As a result of the 1990 Clean Air Act Amendments, the EPA requires extensive monitoring of ozone and its precursors in areas with persistently high ozone levels (mostly large metropolitan areas). In these areas, many States like New York have established ambient air monitoring sites which collect and report detailed data for volatile organic compounds, nitrogen oxides, ozone and meteorological parameters. Ground level ozone is at its highest level during the summer, with hot and dry weather. On Long Island, there is an air monitoring station in Babylon. The chart below summarizes the highest concentrations of ground ozone recorded at the Babylon Monitoring Station during July, 2008.

Using the data from the Babylon Ozone Monitoring Station, graph the "Highest Conc. O3" versus "Date" on your graph paper. Use a pencil and be sure to plot all points and connect them from left to right.

Babylon Ozone Monitoring Station*	
Date (Day-Month-Year)	**Highest Conc. O_3** (ppb)
01-Jul-2008	75.7
02-Jul-2008	65.0
03-Jul-2008	77.5
04-Jul-2008	73.6
05-Jul-2008	57.3
06-Jul-2008	54.9
07-Jul-2008	48.6
08-Jul-2008	68.9
09-Jul-2008	57.1
10-Jul-2008	53.4
11-Jul-2008	65.6
12-Jul-2008	52.7
13-Jul-2008	45.4
14-Jul-2008	53.5
15-Jul-2008	85.9
16-Jul-2008	95.9
17-Jul-2008	113.5
18-Jul-2008	110.3
19-Jul-2008	91.5
20-Jul-2008	41.5
21-Jul-2008	84.2
22-Jul-2008	55.4
23-Jul-2008	52.9
24-Jul-2008	57.3
25-Jul-2008	71.5
26-Jul-2008	69.9
27-Jul-2008	51.6
28-Jul-2008	74.4
29-Jul-2008	89.2
30-Jul-2008	92.8
31-Jul-2008	85.5

http://www.dec.ny.gov/airmon/stationStatus.php?stationNo=46

Part IV:



Studying the effects of ground level ozone is often done with plants, since the leaves are replaced each year and it is much easier to evaluate the sources of damage in leaves than it is to assess such effects in lungs of animals and humans. Typically, plants will begin to exhibit damage when the ozone level reaches 40 ppb (parts per billion). This means that for every one billion molecules of air, there are 40 molecules of ozone. At this level, plants begin to show signs of biological change. If the level reaches greater than 80 ppb, susceptible species evidence a 10% decrease in growth.

1. On your graph, using a light colored pencil, lightly shade in the range of values where plants would have chronic exposure 40 to 80 ppb.
2. Using a darker pencil, lightly shade on your graph where the plants would get acute exposure > 80 ppb.
3. Based upon your data for July 2008, determine the number of days that local plants on Long Island may have been damaged from **chronic exposure (40 to 80 ppb)**.
4. Based upon your data for July 2008, determine the number of days that local plants on Long Island may have suffered from **acute exposure (> 80 ppb).**
5. Sweet-Gum, Tulip Tree, Black Locust, Winged Sumac, Milkweed, Black Cherry, and Northern fox grape are some of the local Long Island plants affected by ground level ozone. Ground level ozone will damage the photosynthetic cells on the top of the leaves, causing a black stippling effect on the upper leaf surface. The veins of ozone of such damaged leaves are not affected. Below are images of four milkweed leaves. Leaf A is from a healthy milkweed plant. The other three leaves have been damaged by three different sources. Pick the leaf you believe was damaged as a result of ground level ozone exposure. Provide an explanation of your choice.

Leaf A

Leaf B

Leaf C

Leaf D

6. Based on your reading above, if a normal milkweed plant has a mass of 2500 grams, predict the mass of an ozone damaged milkweed plant.

Part V:

Ground level ozone can be a serious problem, particularly for senior citizens, children, and people with heart and lung conditions such as emphysema, bronchitis, and asthma. Such individuals often have a difficult time breathing during high ozone days. When ground ozone is high, even a short exposure can inflame breathing passages, decreasing the lungs' working capacity, causing shortness of breath, wheezing, and coughing among susceptible persons.

The table below summarizes the precautions the general public should take at varying index values of ground level ozone. Using the data from your graph, determine the number of days in July 2008 that corresponded to each index value range.

EPA Air Quality Index for Ozone

Index Values (ppb)	Levels	Cautionary Statements	Number of Days in July
0-50	Good	None	
51-100	Moderate	Unusually sensitive people should consider reducing prolonged or heavy exertion outdoors.	
101-150	Unhealthy for Sensitive Groups	Active children and adults, and people with lung disease, such as asthma, should reduce prolonged or heavy exertion outdoors.	
151-200	Unhealthy	Active children and adults, and people with lung disease, such as asthma, should avoid prolonged or heavy exertion outdoors. Everyone else, especially children, should reduce prolonged or heavy exertion outdoors.	
201-300	Very Unhealthy	Active children and adults, and people with lung disease, such as asthma, should avoid all outdoor exertion. Everyone else, especially children, should avoid prolonged or heavy exertion outdoors	

1. How many days in July 2008 was the ozone index high enough for persons sensitive to ground level ozone to limit their outdoor behaviors?
2. Predict the behaviors wild animals sensitive to ground level ozone might exhibit during the days you indicated in question 1.

Part VI. Please read the following scenario:

Anjulie, a senior in high school, has worked as a life guard at a local outdoor pool for the last three summers. On her off days, Anjulie spends most of time outdoors, mostly at the beach, swimming, sunbathing and playing volleyball. Although Anjulie is very fair and has had several bad sunburns in the last few years, she often forgets to apply sunscreen and believes that since she is in the water so much, it washes off and doesn't really protect her skin. One day, after showering after a day working at the pool, Arianna, a fellow lifeguard and Anjulie's best friend notices that a mole on Anjulie's back appears to have changed color and is raised. Arianna also thinks the mole may have changed shape. Anjulie tells her friend that lately, the mole has been quite itchy. Arianna tells Anjulie that her mom has warned her to be aware of any moles that may change in shape or color. Anjulie is not very

concerned, but Arianna pesters Anjulie to show her mother the mole. When Anjulie's mother see her mole, she immediately calls the dermatologist and makes an appointment for the next day.

Anjulie's Mole

Before   **After**

1. Describe the changes that you observe in the before and after pictures of Anjulie's mole.

The next day, Anjulie and her mother go to the dermatologist. After showing Dr. Sunwise her mole, he explains that he will need to biopsy the mole to determine the exact problem. Anjulie's mother discusses with Dr. Sunwise the possibility that the mole may be cancerous. Anjulie thinks her mom is overreacting; how could she be at risk for skin cancer when she was only 18 years old. A week later, Anjulie's mole is still itching. She is not too concerned since she is believes that cancer is an 'old person's disease'. Later that day, Anjulie and her mom return to Dr. Sunwise's office, where he gently informs her that she has skin cancer. He explains the options for treatment, but Anjuli is not listening; she is too upset and does not understand why and how she could have skin cancer.

2. Describe the function of a biopsy.
3. Hypothesize as to what factors may have contributed to Anjulie's skin cancer.
4. If you were in Anjulie's position, would you have done anything differently to protect yourself from getting skin cancer (be honest!). Why or why not?
5. Do you feel that peer pressure may prevent someone from using sunscreens? Explain your answer.

Analysis and Conclusions:

1. Briefly describe the thinning of the ozone layer in the stratosphere.
2. In your own words, describe how ground level ozone is formed.
3. Why is it necessary for the world population to commit to stopping ozone depletion?
4. What is a bioindicator?
5. How can using milkweed and other plants as bioindicators help us keep the air clean?
6. How damaging was ground level ozone to plants and humans during July 2008. Use specific evidence from your graph and air quality index chart to justify your answer.
7. Do you think that the actions of individual people, like you, can help to stop the harm human activities have on the environment? Explain your answer.

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