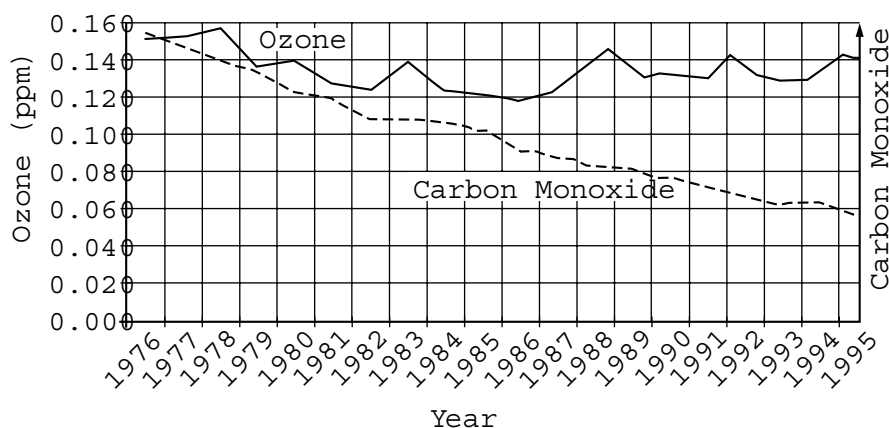
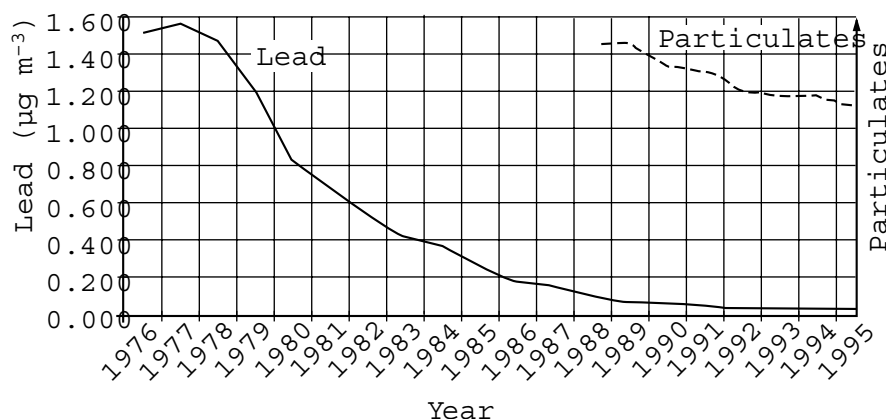


ATMOSPHERIC CONCENTRATIONS OF OZONE
AND CARBON MONOXIDE



ATMOSPHERIC CONCENTRATIONS OF LEAD
AND PARTICULATE MATTER



3. The six criteria pollutants used by the Environmental Protection Agency to assess air quality in the United States are NO_2 , SO_2 , carbon monoxide, lead, ozone, and particulates. The graphs above show trends in the concentration of four of these in a certain city in the United States.
- Describe and compare the concentration trends for ozone and lead. Calculate the percentage change in each from 1978 to 1988.
 - For either ozone or lead, identify the major source(s) of that pollutant and describe the main physiological effects in humans.
 - For either particulates or carbon monoxide, identify the major source(s) of that pollutant and describe the most effective method of reducing the concentration of the pollutant in the atmosphere.

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Question 3

- A. Describe and compare the concentration **trends** for ozone and lead. Calculate the percentage change in each from 1978 to 1988 (maximum of 4 points)

1 point:

Ozone - remains fairly high/constant OR **minimal** or **slight** decrease OR fluctuates around a mean. NO point for "fluctuates", "slight fluctuation", "no trend"

as compared to lead, which had the following trend:

1 point:

Lead - dramatically reduced OR falls consistently OR constant decline OR decreases OR drops

STUDENTS MUST SET UP THE PROBLEMS CORRECTLY AND AT LEAST SHOW CONCENTRATIONS USED FOR 1978 AND 1988 (OR A DIFFERENCE) AND HOW THEY CALCULATE THE PERCENTAGE

NO CREDIT FOR JUST A PERCENTAGE WITHOUT SHOWING WORK

1 point:

- Ozone - acceptable 1978 range between 0.155 to 0.145; (mid-point is about 0.157)
- Acceptable 1988 range between 0.135 to 0.142; mid-point is about 0.140
- Acceptable percentage range is about 1.5 - 13.5%

For example:

- i. ozone in 1978 was 0.155, in 1988 ozone was about 0.140
- ii. $0.155 - 0.140 = 0.015$
- iii. $0.015/0.155 \times 100 = 9.7\%$

1 point:

- Lead - acceptable 1978 range between 1.55 to 1.35; mid-point is about 1.5
- Acceptable 1988 range between 0.12 to 0.08; mid-point is about 0.1
- Acceptable percentage range of about 90 - 95%

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Question 3 (cont.)

For example:

- iv. lead in 1978 was 1.55; lead in 1988 was 0.12
- v. $1.55 - 0.12 = 1.43$
- vi. $1.43/1.55 \times 100 = 92.3\%$

In each case, either steps i and iii OR steps ii and iii must be shown for credit.

ALTERNATIVELY, THE PROBLEMS COULD BE SOLVED BY SETTING UP THE PROBLEM IN THE FOLLOWING WAY:

$$100 - [(1988 \text{ concentration}/1978 \text{ concentration}) \times 100] = \% \text{ change}$$

In this case, if it is clear that the student has taken a ratio of the '88/'78 concentrations AND that they understand that the % change is calculated by subtracting this from 100, they do not have to explicitly show the subtraction step. For example, some students set the problem up in the following way:

$$\begin{array}{rcl} 1988 \text{ concentration} & & x \\ & = & \frac{\quad}{100} \\ 1978 \text{ concentration} & & \end{array}$$

This equation by itself is NOT worth the point, as this would not give the correct CHANGE in the pollutant. Students must then also show (either explicitly or by a number) that they have subtracted x from 100

IF the problems are set up correctly, a maximum of 1 additional point can be given if the correct percentages are calculated for BOTH ozone AND lead

- B. For either ozone or lead, identify the major source(s) of that pollutant and describe the main physiological effects in humans (maximum of 3 points).

SOURCES (maximum of 2 points)

Ozone

Secondary pollutant - major source is from photochemical reactions (1 point)

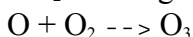
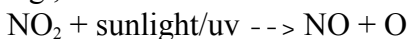
(1 elaboration point if significant details are given - e.g. sunlight/uv reacting with NO_x released by vehicles, causing O to react with O₂,

and in the presence of VOCs/hydrocarbons (HCs) allow O₃ to build up. Details can be given as a set of equations or extended description)

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Question 3 (cont.)

e.g.,



With VOCs/HCs



(VOCs/HCs limit the NO/O₃ reaction, causing O₃ to build up)

Reactions may also be written in a cyclic form

Lead

1 point for each major source, up to a maximum of 2 points

1. Major source was/is leaded gasoline
2. Mining/smelters
3. Municipal waste incineration (not just incineration)

If only 1 source is given, 1 elaboration point is possible for an expansion on a single source. For example, connecting the source to the reason for a drop in atmospheric concentration, discussing the connection of the source to the trend seen in the graph

PHYSIOLOGICAL EFFECTS (1 point for each example, with a maximum of 2 points)

Ozone

4. Chronic inhalation causes inflammation leading to fibrosis of the lungs (damages lung tissue; may also note that damage is irreparable)
5. An irritant; irritates eyes, nose, throat, lungs, and/or respiratory tract which can cause chest discomfort, shortness of breath, coughing (may also note that effects are irreparable)
6. Loss of lung capacity, loss of elasticity
7. Aggravates asthma, chronic bronchitis, emphysema, and heart disease
8. Suppresses immune system; lowers resistance to colds and pneumonia
9. Synergistic effect - smokers are at higher risk of ozone effects

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Question 3 (cont.)

Lead

10. Causes brain damage/mental retardation/impaired cognitive function
11. Learning disabilities
12. High blood pressure/hypertension
13. Death (even at relatively low concentrations)
14. Accumulates in the body and impairs tissues and organs, (inhibits synthesis of hemoglobin, causes enzymes to become inactive, can act as an endocrine disruptor)
15. Anemia
16. Miscarriage/premature birth

NO credit for just "birth defects" or "cancer"

NO credit for stratospheric ozone and linking UV light and skin cancer. Source and physiological effects must be consistent, i.e., sources **and** physiological effects of ozone, **or** sources **and** physiological effects of lead.

- C. For either particulates or carbon monoxide, identify the major source(s) of that pollutant **and** describe the most effective method of reducing the concentration of the pollutant in the atmosphere. (maximum of 3 points)

SOURCES (maximum of 2 points)

Particulates (max of 2)

1 point for each source, with a maximum of 2

1. Smokestacks, for example from coal-burning power plants
2. Industry such as stone & rock crushing, iron & steel
3. production, smelting, transportation and storage of grain, manufacture of cement, lime, pulp, and paper factories, mining, rock quarries (must give example)
4. Soil-eroded land disturbed by agriculture, desertification (by overgrazing, deforestation, etc), construction sites, unpaved roads

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Question 3 (cont.)

- 5. Refuse-burning incinerators, fireplaces, wood-burning stoves, leaf burning
- 6. Diesel fuel combustion
- 7. Natural sources - volcanoes, wind erosion, forest fires, pollen, salt spray, grass fires, etc
- 8. Incomplete combustion

NO credit for single terms such as "industry", "cars", "agriculture", etc.

OR

Carbon monoxide (max of 2)

1 point can be given for one of any of the following (max of 1 point):

- 9. Description of a source, such as exhaust from cars, other transportation or industry (must give an example of what kind of industry, i.e., Where is the CO coming from? No point for just a word like "cars", "industry", etc.)
- 10. Biomass burning (fireplaces, wood stoves, coal, etc)
- 11. Natural source - oxidation of methane; volcanoes

An additional (elaboration) point can be received for

- 12. Incomplete combustion

NO point for simply saying "CO comes from fossil fuels". However, "burning", "use", or "combustion of fossil fuels" would receive 1 pt

METHOD OF REDUCTION (1 point for a reduction method; 1

elaboration point if they then go on to discuss HOW this method will result in a reduction)

Particulates (max of 2)

- 13. Reduce smokestack emissions by filtering (bag house); cyclone precipitators, or electrostatic precipitators; scrubbers
- 14. Conserve electricity - which reduces demand on coal burning
- 15. More use of alternation energy sources such as solar, wind, or even nuclear power, which would reduce reliance on "dirty" fuels

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Question 3 (cont.)

16. Reduce or recycle materials which reduce refuse incineration and reduces industrial demand
17. Introduction of soil conservation practices, use ground cover, BMPs, limit deforestation and/or grazing
18. Watering down or spraying of tailing piles, unpaved roads
19. Ban outdoor burning, fireplace burning, wood-burning stoves
20. Fines for excess pollution; economic incentives to encourage less pollution
21. Limit population growth, which will limit demand for energy

OR

Carbon monoxide (max of 2)

22. Catalytic converters - convert CO to CO₂
23. Mandating emission standards; requiring inspections; fees or fines
24. More efficient fuel/engine technology
25. More public transportation/less private vehicle use/
carpooling/walking/biking etc. OR overall reduction in fossil fuel use
26. Oxygenation of fuels
27. Control of population growth would result in fewer cars, thus less CO

Sources and method of reduction must be consistent, i.e., sources **and** method of reduction for particulates, **or** sources **and** method of reduction for carbon monoxide