

**AP[®] ENVIRONMENTAL SCIENCE
2007 SCORING GUIDELINES**

Question 4

Some scientists estimate that by 2025 over 60 percent of the global human population will live in urban areas. Urban residents experience a variety of problems related to the physical environment.

(a) Describe how the temperature of urban areas like Atlanta, Philadelphia, and Chicago differs from that of surrounding rural areas. (1 point)

Temperatures in urban areas tend to be **higher** than those in rural areas. (This temperature difference, called the “urban heat island effect,” is typically larger during the nighttime hours.)

(b) Identify and describe TWO differences between urban and surrounding rural areas that contribute to the temperature difference between them. (4 points)

1 point each for stating two possible differences. 1 point for describing each stated difference. The description must match the given difference.

Possible Differences	Possible Descriptions
More: <ul style="list-style-type: none"> • asphalt • concrete • buildings, etc. Fewer/less: <ul style="list-style-type: none"> • trees • vegetation* 	<ul style="list-style-type: none"> • Change in surface composition causes overall urban albedo (reflectivity) to decrease. The resulting increase in energy emission causes the temperature to rise. • The absorption of additional solar radiation by surfaces causes the temperature to increase due to increased energy emission by the surfaces. • Reduces the natural cooling effects of shading and evaporation of water from soil and leaves (may be regional) • Buildings may intercept outgoing infrared radiation emitted by the earth’s surface. The absorption and scattering of this radiation reduces the rate of energy loss and leads to elevated urban temperatures.
More: <ul style="list-style-type: none"> • cars • factories/industry • machinery that use combustion 	<ul style="list-style-type: none"> • Heat is a by-product of combustion.
Tall buildings/narrow streets	<ul style="list-style-type: none"> • Trap warm air between them or may reduce airflow • May reduce cooling by convection
More people	<ul style="list-style-type: none"> • Require housing, air conditioning, factories that all produce heat as a by-product

*In the Southwest increased vegetation leads to increased urban temperatures. The transpiration introduces more water vapor that may trap heat.

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Question 4 (continued)

- (c) Urban areas typically have levels of air pollution that are significantly higher than those found in surrounding rural areas. Identify a characteristic of the urban microclimate that leads to higher levels of air pollution and describe how that characteristic contributes to the increase. (2 points)**

1 point is awarded for identifying the characteristic, and 1 point is awarded for describing how it contributes to increased air pollution.

Possible Characteristic	Possible Description (must be specific)
(Increased combustion) due to large numbers of: <ul style="list-style-type: none"> • automobiles • burning garbage • factories • airplanes • or other urban machinery 	<ul style="list-style-type: none"> • Increased temperature along with ozone precursors (e.g., NO_x, VOCs) increase ground level ozone • Increase in particulates (ash or soot) from incomplete combustion • Nitrogen oxides react with oxygen to form nitrogen dioxide (a foul-smelling brown gas). Also may combine with water vapor and other pollutants to produce smog • Other pollutants include sulfur oxides, lead, CO, and NO_x
Industrial processes	<ul style="list-style-type: none"> • Petroleum refineries produce hydrocarbon and particulates. • The volatile fumes from dry cleaners contribute to photochemical smog. • Bakeries and dry cleaners release hydrocarbons, which are converted with sunlight and other gasses to form ozone.
Urban development	<ul style="list-style-type: none"> • Increase in particulates from exposed soil
Tall buildings	<ul style="list-style-type: none"> • Trap pollutions or limit airflow, which will limit diffusion of pollutions
Less vegetation	<ul style="list-style-type: none"> • Less filtering/absorption of particulates, or pollutants such as CO, SO_x, NO_x, and ozone
Urban heat island effect	<ul style="list-style-type: none"> • Ozone formation due to photochemical reactions from precursors

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Question 4 (continued)

(d) Identify and describe TWO actions that local governments in urban areas could take to reduce outdoor air pollution. (2 points)

1 point is awarded for each acceptable action with an outcome attached that reduces outdoor air pollution.

Possible Action	Possible Outcome (Valid description that supports the action)
<ul style="list-style-type: none"> • Incentives/taxes -subsidize • Laws/regulations -CAFE standards, zoning, limits/bans, fines • Direct action - build mass transit, build bike paths, HOV lanes, plant vegetation, convert to less-polluting practice • Education - promote, suggest, encourage 	<ul style="list-style-type: none"> • Reduced number/use of motor vehicles • Reduced emissions (tailpipe/industrial, etc.) • Improved fuel efficiency • Reduced particulates or other specific pollutants • Reduced fossil fuel use

(e) Identify and describe TWO ways in which the local hydrologic cycle of urban areas differs from that of nearby rural areas. (2 points)

1 point is awarded for each acceptable way with a complete thought attached.

Possible Ways
<p>Manmade urban surfaces (e.g., asphalt, concrete, rooftops) absorb little water when compared with rural areas with more vegetation. This can result in:</p> <ul style="list-style-type: none"> • Greater runoff in urban areas/decreased infiltration • Increased flooding during heavy rainfall events • Rapid discharge of water from storm drains directly into bodies of water • Reduced water evaporation from the soil into the atmosphere • Increased stream flow (peak flow, etc.) • Alteration of evapotranspiration rates <p>Urban heat island effect causes daytime convection/rainfall to be more vigorous over urban areas.</p>

4. Some scientists estimate that by 2025 over 60 percent of the global human population will live in urban areas. Urban residents experience a variety of problems related to the physical environment.
- Describe how the temperature of urban areas like Atlanta, Philadelphia, and Chicago differs from that of surrounding rural areas.
 - Identify and describe TWO differences between urban and surrounding rural areas that contribute to the temperature difference between them.
 - Urban areas typically have levels of air pollution that are significantly higher than those found in surrounding rural areas. Identify a characteristic of the urban microclimate that leads to higher levels of air pollution and describe how that characteristic contributes to the increase.
 - Identify and describe TWO actions that local governments in urban areas could take to reduce outdoor air pollution.
 - Identify and describe TWO ways in which the local hydrologic cycle of urban areas differs from that of nearby rural areas.

(a) Urban areas like Atlanta, Philadelphia, and Chicago have temperatures that are slightly higher than that of surrounding rural areas. This difference is often several degrees Celsius.

(b) Among the many differences between urban and rural areas, there are two that particularly affect their temperatures: pavement and skyscrapers. An urban area is guaranteed to have much more pavement than rural areas. From streets to parking lots, there is simply much more black pavement in urban areas than there is in rural areas. The darkness of the pavement absorbs more light from the sun, thus generating more heat. The amount of tall buildings and skyscrapers only adds to the problem. Where a rural area may have a few homes and barns, an urban area will have blocks of ten blocks of multi-story buildings. These tall buildings block the winds that would otherwise reach all areas of the city, which prevents the circulation of the heat produced from the pavement. Therefore, urban areas are hotter than rural areas.

(c) One very significant aspect of the microclimate of urban areas that causes air pollution is the huge number of automobiles in such a small area. This density magnifies the effect of auto emissions. Thus, the ^{small} CO_2 , CO , and SO_2 that are produced from a single car quickly become large amounts when there are thousands of cars stuck in a

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city during rush hour.

(d) Local gov'ts could reduce outdoor emissions in a number of ways. One would deal with the problem discussed in part (c). The local gov't could ~~provide tax incentives for anyone who~~ adopt and advertise an effective and cheap mass transit system. If fewer people drove their cars to work everyday, there would be fewer cars emitting exhaust every morning, and the cars that remained on the road would have to spend less time there, as traffic would be reduced. Another possibility involves another source of pollution. The city gov't could require stricter emission controls from factories, which produce concentrated sources of pollution. If all factories are forced to use such methods as scrubbing or coal gasification, then they will produce fewer pollutants.

(e) Not only does the temperature differ in urban areas, but the hydrologic cycle does as well. Again because of pavement, the water hitting the ground has a much higher velocity, when hitting the ground. The lack of tree cover and roots that would normally slow the rain down causes it to maintain its speed when it reaches the ground. Then, the impervious pavement does not allow it to ~~percolate~~ percolate into the ground. This has the effect of reducing the amount of water that reaches the groundwater.

Another way the hydrological cycle is different in urban areas is the relative lack of evapotranspiration. With few trees compared to rural areas, there ~~are~~ is less water being absorbed from the ground. This means that less water can ~~re~~ re-enter the hydrologic cycle by transpiring from tree leaves and then evaporating.

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4. Some scientists estimate that by 2025 over 60 percent of the global human population will live in urban areas. Urban residents experience a variety of problems related to the physical environment.
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 - (b) Identify and describe TWO differences between urban and surrounding rural areas that contribute to the temperature difference between them.
 - (c) Urban areas typically have levels of air pollution that are significantly higher than those found in surrounding rural areas. Identify a characteristic of the urban microclimate that leads to higher levels of air pollution and describe how that characteristic contributes to the increase.
 - (d) Identify and describe TWO actions that local governments in urban areas could take to reduce outdoor air pollution.
 - (e) Identify and describe TWO ways in which the local hydrologic cycle of urban areas differs from that of nearby rural areas.

a) Large cities generally have higher average temperatures than surrounding areas. ~~because a lack of vegetation~~

b) The temperatures in the cities is higher because concrete and asphalt (which covers lots of land in cities) have low specific heats. These surfaces heat up quickly and warm the air around them. Also, there are not many trees in urban areas, which lower average temperatures by providing shade.

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- ~~d) Urban ~~emissions~~ heat islands, when hot air masses remain trapped over an urban area, ~~there is little rainfall because the cold fronts~~~~
- c) Urban areas have more residents, which requires more cars, factories, and buildings. Car exhaust emits carbon and sulfur dioxides and particulate matter into the air. Carbon dioxide is a greenhouse gas which traps the sun's energy in the atmosphere. The combination of these pollutants and the sunlight can create smog, which is only intensified by ^{automobile} ~~car~~ exhaust and factory emissions.
- d) Local governments could require stricter standards for auto emissions tests. This would force car owners and manufacturers to make sure their cars were operating as cleanly as possible. Governments could also phase in more alternative energy sources, like solar or wind power, which don't give off air pollutants when burned, like coal or fossil fuels.
- e) Urban areas sometimes form a heat island, where the combination of the heat from the asphalt and concrete and the tall buildings, which can

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block the movement of clouds create an area of little rainfall. hot air masses get trapped over the city and prevent cold fronts from creating rain.

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 - (e) Identify and describe TWO ways in which the local hydrologic cycle of urban areas differs from that of nearby rural areas.

A. Urban areas are often a heat island. The temperature of the urban area, including urban sprawl, is significantly higher than the temperature of surrounding rural areas that have not been developed.

B. Urban areas have less trees and other vegetation than rural areas. Trees provide shade and help air flow. Urban areas use more energy, such as having more lights, than rural areas. When energy is burned/used, heat is given off as a by-product. For example, lightbulbs give off heat when in use.

C. Urban areas sometimes suffer from a temperature inversion, especially if the area is surrounded by mountains. Due to concrete, asphalt, etc. the air near the ground ~~is~~ cools slower than the air around it. ~~when~~ A layer of cold air then resides over the warm air and traps the

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warm air beneath it. Pollution created in urban areas, such as the gases and particulate matter emitted when driving cars, become trapped. The pollutants are unable to disperse. This creates an extremely high level of air pollution. The urban area is surrounded by warm air and air pollutants trapped by a layer of cooler air on ~~top~~ top due to this.

D. The government can set up a public transportation system, such as buses or subway, to reduce the amount of air pollution from the burning of fossil fuel when people drive cars. individual

~~The government can also give tax rebates or make tax deductible to buy fuel efficient or electric.~~

The government can set up bike lanes and sell bicycles at a subsidized price to promote alternative means of transportation that doesn't require fossil fuels.

E. Due to the high amounts of asphalt parking lots, concrete sidewalks, etc. precipitation does not permeate the ~~soil~~ ground. The soil cannot absorb and hold as much water in urban areas as in rural areas. In rural areas, the soil is exposed to precipitation and can absorb the water. ~~There is more runoff in urban areas than in rural areas.~~ The soil holds more water in rural ~~the~~ areas than in urban areas.

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There is also more run off in urban areas than rural areas. In rural areas, ~~the~~ ~~precipitation~~ precipitation can be absorbed by the soil. In urban areas, concrete prevent the absorption of precipitation, so it follows the flow of gravity and creates run off.

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AP[®] ENVIRONMENTAL SCIENCE

2007 SCORING COMMENTARY

Question 4

Overview

The aim of this question was to assess knowledge of contemporary environmental issues related to urban and rural areas. Students were asked to describe differences in temperature, pollution, and the hydrologic cycle between the two areas. Additionally, they were asked to name actions that local governments could take to reduce urban outdoor air pollution.

Sample: 4A

Score: 10

Part (a): One point was earned for describing urban areas as having “temperatures that are slightly higher than that of surrounding rural areas.”

Part (b): Four points were earned: 1 point for identifying that urban areas have “much more black pavement,” 1 point for describing how these surfaces absorb and reradiate [“generating”] the heat, 1 point for identifying that urban areas have “tall buildings,” and 1 point for describing how these buildings block the wind and decrease air circulation.

Part (c): Two points were earned: 1 point for giving “the huge number of automobiles” as an aspect of urban areas that causes air pollution, and 1 point for stating that the automobiles emit CO.

Part (d): Two points were earned: 1 point for describing how local governments could adopt a “cheap mass transit system” that would result in fewer people driving cars, and 1 point for describing how local governments “could require stricter emission controls from factories,” resulting in fewer pollutants in the air.

Part (e): One point was earned for explaining that urban areas have paved surfaces that result in less storm water absorption and infiltration into the ground. A second point could have been earned for the mention of less evapotranspiration, but the maximum of 10 points had already been reached.

Sample: 4B

Score: 9

Part (a): One point was earned for noting that urban areas have “higher average temperatures.”

Part (b): Four points were earned: 1 point for stating that urban areas have asphalt that “covers lots of land in cities,” 1 point for noting that urban areas have large areas covered with concrete, and 2 points for describing how both of these surfaces reradiate heat and “warm the air around them.”

Part (c): Two points were earned: 1 point for noting that urban areas have more cars (required by more residents), and 1 point for stating that these cars have sulfur dioxide (and particulates) in their exhaust.

Part (d): Two points were earned: 1 point for describing how “[l]ocal governments could require stricter standards for auto emissions [*sic*] tests” resulting in cars that run “as cleanly as possible,” and 1 point for describing how local governments “phase in [convert to] more alternative energy sources” that do not give off air pollutants, thus reducing the need for fossil fuels.

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Question 4 (continued)

Part (e): No points were earned in part (e).

Sample: 4C

Score: 6

Part (a): One point was earned for stating that cities have “significantly higher” temperatures.

Part (b): Two points were earned: 1 point for stating that urban areas have fewer trees, and 1 point for explaining that “[t]rees provide shade” that can cool the rural areas as opposed to urban areas. No point was awarded for “more lights,” as these are not significant contributors to the heat island effect.

Part (c): No points were awarded. Inversions are geographical occurrences and not a result of the urban environment.

Part (d): Two points were earned: 1 point for describing how local governments could “set up a public transportation system ... to reduce the amount of air pollution from the burning of fossil fuel” from cars, and 1 point for describing how local governments could “set up bike lanes ... to promote alternative means of transportation” that do not burn fossil fuels.

Part (e): One point was earned for describing how “high amounts of asphalt parking lots” block precipitation so that it “does not permeate the ground” and hence more runoff occurs in urban areas. No additional point was gained by describing the contrasting situation in rural areas.