

2007 AP® ENVIRONMENTAL SCIENCE FREE-RESPONSE QUESTIONS

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.
 - (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.

STOP

END OF EXAM

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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<ul style="list-style-type: none">-subsidize• Laws/regulations<ul style="list-style-type: none">-CAFE standards, zoning, limits/bans, fines• Direct action<ul style="list-style-type: none">- build mass transit, build bike paths, HOV lanes, plant vegetation, convert to less-polluting practice• Education<ul style="list-style-type: none">- 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>