2022

AP CollegeBoard

AP® Environmental Science

Sample Student Responses and Scoring Commentary Set 1

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Free-Response Question 3

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Question 3: Analyze an Environmental Problem and Propose a Solution Doing Calculations — 10 points

(a) **Describe** how urbanization leads to the formation of urban heat islands. **1 point**

Accept one of the following:

- Urban buildings can block wind currents, increasing local temperatures.
- Urban building materials/structures such as roads, sidewalks, and/or buildings hold in heat, causing the temperatures to increase.
- Urban areas have fewer trees, resulting in less shade/less transpiration, causing temperatures to increase.
- Urban areas have large numbers of vehicles/air conditioners/machinery that produce waste heat, causing temperatures to increase.

Total for part (a) **1 point**

(b) **(i)** **Propose** a reasonable solution that could help lower the temperature increases caused by urban heat islands. **1 point**

Accept one of the following:

- Plant green roofs on buildings/plant vegetation around buildings/increase green space.
- Use cool/reflective/lighter-colored surfaces on roofs/buildings/surfaces.
- Increase efficiency of a system that produces waste heat (vehicles, air conditioners).
- Decrease use of a system that produces waste heat (vehicles, air conditioners).

(ii) **Justify** the solution proposed in part (b)(i) by providing one additional benefit other than reducing temperatures in urban heat islands. **1 point**

Accept one of the following:

Solution proposed in (b)(i)	Justification solution with additional benefit
Plant green roofs on buildings/plant vegetation around buildings/increase green space	• Provides food crops • Creates habitat for biodiversity • Slows/captures runoff • Insulates buildings, which reduces heating/cooling costs • Provides aesthetic/cultural/recreational benefits • Reduces air pollution (particulates, O_3, SO_2, NO_2, CO) • Filters the air • Removes carbon from the atmosphere

Use cool/reflective/lighter-colored surfaces on roofs/buildings/surfaces	• Reflects solar energy, which reduces cooling costs • Reduces energy consumption, which reduces cooling costs
Increase efficiency of a system that produces waste heat (vehicles, air conditioners)	• Decreased production of CO_2, which reduces climate change • Reduces energy consumption, which reduces costs
Decrease use of a system that produces waste heat (vehicles, air conditioners)	• Decreased production of CO_2, which reduces climate change • Decreased use of vehicles, which reduces air pollution • Reduces energy consumption, which reduces costs

Total for part (b) **2 points**

(c) (i) As a result of improved technology, the efficiency of solar panels has changed over time. In 1992 a solar cell had a maximum efficiency of 15.9%. In 2017 a solar cell prototype capable of 44.5% efficiency was produced. **Calculate** the percent change in efficiency from the 1992 cell to the 2017 cell. **Show** your work. **1 point**

One point for the correct setup (must include multiplication by 100) to calculate the percent change:

- $\frac{44.5\% - 15.9\%}{15.9\%} \times 100$
- $\left(\frac{44.5\%}{15.9\%} - 1\right) \times 100$

One point for the correct calculation of the percent change: **1 point**

Accept one of the following:

- 179.9%
- 180%

(ii) The average home in the United States uses 12,900 kWh of electricity per year. The local power company is raising the cost of purchasing electricity from $0.11 per kWh to $0.13 per kWh. Assuming a home uses the average kWh of electricity in one year, **calculate** the change in electricity cost for one year for the homeowner. **Show** your work. **1 point**

One point for the correct setup (must include units) to calculate the change of electricity cost for one year:

- $12{,}900 \text{ kWh} \times \left(\frac{\$0.13 - \$0.11}{\text{kWh}}\right)$
- $12{,}900 \text{ kWh} \times \frac{\$0.13}{\text{kWh}} = \$1677$ **AND** $12{,}900 \text{ kWh} \times \frac{\$0.11}{\text{kWh}} = \$1419;\ \$1677 - \$1419$

One point for the correct calculation of the change of electricity cost for one year: **1 point**

- $258

(iii) The roof of a typical house in the United States receives a total of four hours of sunlight per day that can be converted by solar panels into electricity. A house has 30 solar panels on its roof, and each panel generates a maximum output of 300 watts. **Calculate** how many kWh can be produced by the system at maximum output in one calendar year. **Show** your work. **1 point**

One point for the correct setup to calculate the amount of kWh that can be produced at maximum output:

- $30 \text{ panels} \times \frac{300 \text{ watts}}{\text{panel}} \times \frac{1 \text{ kW}}{1{,}000 \text{ watts}} \times \frac{4 \text{ hours}}{\text{day}} \times \frac{365 \text{ days}}{1 \text{ year}}$

One point for the correct calculation of the amount of kWh that can be produced at maximum output: **1 point**

- 13,140 kWh per year

Total for part (c) **6 points**

(d) **Explain** why the Northern Hemisphere receives more solar energy from the Sun between June and August than the Southern Hemisphere receives between June and August. **1 point**

- During June through August, the Northern Hemisphere is tilted toward the Sun and receives more direct solar energy (per unit area) than the Southern Hemisphere.
- During June through August, the Northern Hemisphere is tilted toward the Sun and has more hours of sunlight.

Total for part (d) **1 point**

Total for question 3 **10 points**

Important: Completely fill in the circle that corresponds to the question you are answering on this page.

Question 1 ○ Question 2 ○ Question 3 ●

Begin your response to each question at the top of a new page. Do not skip lines.

a) Urbanization leads to the formation of heat islands through the dark color of ~~[illegible]~~ roads, parking lots, and roofs. The dark coloration of these features of cities have a tendency to absorb more sunlight with ~~[illegible]~~ less albedo, which cause them to heat up more, forming a heat island.

6i) A reasonable solution that could help lower temperature ~~[illegible]~~ increases would be the construction of green parks, which have lighter coloration and therefore less heat generation with sunlight.

6ii) One additional benefit of park construction would be the reduction of urban flooding. Roads, parking lots, and other ~~[illegible]~~ impermeable surfaces that dominate cities ~~[illegible]~~ cause high likelihoods of flooding, however, with grass and soil in parks to provide a place for runoff to infiltrate, flooding is ~~[illegible]~~ reduced.

c) $\frac{44.5\% - 15.9\%}{15.9} \times 100 = 179.874\%$

cii) $\frac{12900 \text{ kwh}}{1} \cdot \frac{\$.11}{1 \text{ kwh}} = \$1419$ $\frac{12900 \text{ kwh}}{1} \cdot \frac{\$.13}{1 \text{ kwh}} = 1677$

$\$1677 - \$1419 =$ **$258**

ciii) $30 \text{ ~~solar panels~~} \cdot \frac{300 \text{ w}}{1 \text{ ~~solar panel~~}} \cdot \frac{1 \text{ kw}}{1000 \text{ w}} \cdot \frac{4 \text{ hours}}{1 \text{ ~~day~~}} \cdot \frac{365 \text{ ~~days~~}}{1 \text{ year}}$

13140 kwh/year

Important: Completely fill in the circle that corresponds to the question you are answering on this page.

Question 1	Question 2	Question 3
○	○	●

Begin your response to each question at the top of a new page. Do not skip lines.

d) The Northern Hemisphere recieves more solar energy from the Sun between June and August due to the tilt of the Earth along its axis of rotation. During those months, the Northern hemisphere is tilted towards the sun because of its 23.5° tilt. This causes the sun's rays to be much more direct, inevitably leading to more sunlight and solar energy in the Northern hemisphere, as opposed to the southern hemisphere which recieves indirect rays from the sun at that time.

● **Important:** Completely fill in the circle that corresponds to the question you are answering on this page.

Question 1	Question 2	Question 3
○	○	●

Begin your response to each question at the top of a new page. Do not skip lines.

a) Urbanization leads to urban heat islands because we are using many products, like pavement and concreat, that trap heat. We need more roads, more buildings, more houses, etc., all of which trap heat and cause urban heat islands.

b i) Breaking up urban heat islands by adding more vegetation and parks will reduce the heat. ~~and being~~

b ii) More vegitation, trees, and parks will also lead to a reduction of CO_2, as ~~Plants~~ take in CO_2 for photosynthesis.

c i) 15.9% to 44.5% 44.5 - 15.9 = 28.6% change in efficency.

c ii) 12,900 kWh per ~~year~~ at $0.11 per kWh 12900 x 0.11 = $1419
$0.11 → $0.13 12900 x .13 = $1677 1677 - 1419 = ~~[redacted]~~258
It would be a $258 change in ~~a~~ cost for one year.

c iii) 4 hrs per day 30 panels 300 w per panel
30 x 300 = 9000 watts ~~x4 hrs = 36,000 watts x 365 days =~~
1 kWh = 1,000 watts 9000 x 365 days = 3,285,000 w ~~3,140,000~~
3285000 watts = 3285 kWh in 1 year.

d) The earth is on a tilt on it's axis. The Northern Hemisphere faces the sun sooner than the Southern Hemisphere, as the earth is rotation as well. So since the earth is tilted, the Northern half gets more sun before the Southern half, making their early summer months ~~trap~~ hotter than the South's Early Summer months.

● **Important:** Completely fill in the circle that corresponds to the question you are answering on this page.

Question 1 ○ **Question 2** ○ **Question 3** ●

Begin your response to each question at the top of a new page. Do not skip lines.

3(A) Urbanization leads to urban heat islands forming because of the great amount of people moving to cities. In order to make room for these people, more skyscrapres are built out of a certain material including up to all sides of the building such as the top where the sun beats down on it all day. Harmful gasses are then released into the environment all so there is more room for people to live in cities. (Bi) one solution that could be made is making the top of buildings into a garden. This way, the building on top could have grass and soil where new plants and other types of vegetation could be grown. (Bii) Other than reducing temperatures, more natural resources would be grown for animals such as birds to eat. (Ci) The percent change in efficiency is 24%. (Cii) The change in electricity cost is $4,008. (iii) About 840 kwh could be produced. (D) The northern hemisphere receives more solar energy from June through August because the Earth is tilted, and at the rate the Earth rotates, the Northern Hemispher is in months June -

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Question 1	Question 2	Question 3
○	○	●

Begin your response to each question at the top of a new page. Do not skip lines.

August. On the other hand, the Southern hemisphere is on a different part of the globe. So, the sun does not hit the Southern Hemisphere in June – August as much as it hits the Northern Hemisphere ~~there~~ at that time.

Question 3

Note: Student samples are quoted verbatim and may contain spelling and grammatical errors.

Overview

The intent of this question was for students to demonstrate an understanding of mathematical routines and to provide an environmental solution to a given problem. Students were expected to convey an understanding of urbanization and the use of solar panels in electricity generation.

In part (a) students were expected to demonstrate an understanding of the effects of urbanization on temperature [Practice 1 Concept Explanation and Topic 5.10 Impacts of Urbanization]. In part (b) students were tasked with proposing a solution to help lower the temperature caused by urban heat islands. The task aligns with Practice 7 Environmental Solutions. Finally, students were asked to justify the solution proposed by providing one additional benefit other than reducing temperatures in urban heat islands. This aligns with Practice 7 Environmental Solutions.

In part (c) students were asked to do calculations related to solar panels [Topic 6.8 Solar Energy and Practice 6 Mathematical Routines]. Students were tasked with calculating the percent change in efficiency of solar panels. Next students were tasked with calculating the change in electricity costs for one year based on changes in costs per kWh. Finally, the students were tasked with calculating how many kWh can be produced by a solar panel system in one year.

In part (d) students were asked to explain the seasonal relationship between solar energy and Earth's hemispheres. This task aligns with Topic 4.7 Solar Radiation and Earth's Seasons and Practice 1 Concept Explanation.

Sample: 3A
Score: 10

One point was earned in part (a) for describing "through the dark color of roads, parking lots and roofs … have a tendency to absorb more sunlight with less albedo, which cause them to heat up more." One point was earned in part (b)(i) for proposing the solution of "construction of green parks." One point was earned in part (b)(ii) for justifying the solution in part (b)(i) as "the reduction of urban flooding … grass and soil in parks to provide a place for runoff to infiltrate." Two points were earned in part (c)(i). One point was earned for the correct setup, and 1 point was earned for the correct answer. Two points were earned in part (c)(ii). One point was earned for the correct setup, and 1 point was earned for the correct answer. Two points were earned in part (c)(iii). One point was earned for the correct setup, and 1 point was earned for the correct answer. One point was earned in part (d) for explaining, "During those months, the Northern hemisphere is tilted towards the sun … This causes the sun's rays to be much more direct … more sunlight and solar energy."

Question 3 (continued)

Sample: 3B
Score: 4

One point was earned in part (a) for describing that "many products, like pavement and concreat, that trap heat." One point was earned in part (b)(i) for proposing the solution of "adding more vegetation and parks." One point was earned in part (b)(ii) for justifying the solution in part (b)(i) as "vegetation, trees, and parks will also lead to a reduction of CO_2." No points were earned in part (c)(i). One point was earned in part (c)(ii). No point was earned for the setup, and 1 point was earned for the correct answer. No points were earned in part (c)(iii). No point was earned in part (d).

Sample: 3C
Score: 2

No point was earned in part (a). One point was earned in part (b)(i) for proposing the solution of "making the top of buildings into a garden." One point was earned in part (b)(ii) for justifying the solution as "natural resources … grown for animals such as birds to eat." No points were earned in part (c)(i). No points were earned in part (c)(ii). No points were earned in part (c)(iii). No point was earned in part (d). The response does not provide an explanation.