2022

AP CollegeBoard

AP® Environmental Science

Sample Student Responses and Scoring Commentary Set 2

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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) **Identify** one negative human health effect linked to the exposure to pollutants resulting from the combustion of coal. **1 point**

Accept one of the following:

- Lung disease/respiratory diseases (asthma, COPD, bronchitis, lung cancer)
- Neurological damage
- Birth defects
- Heart disease
- Eye irritation/respiratory irritation/headaches

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

(b) (i) **Describe** an environmental problem associated with coal ash waste disposal. **1 point**

Accept one of the following:

- Leaching from landfills/clay-lined pits
- Overflowing of coal ash into bodies of water
- Leaking and contamination of groundwater, soil, or nearby bodies of water
- Coal ash washing into bodies of water as a result of severe weather events
- Dry ash carrying into nearby bodies of water, increasing turbidity/decreasing photosynthesis

(ii) A proposed solution is to dispose North Carolina's coal ash in clay-lined pits. **Justify** this solution by providing one advantage of using clay soil. **1 point**

- Clay is less permeable than unlined pits and can prevent the leaching of coal ash into soil/groundwater.

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

(c) (i) **Calculate** the percent change in Charlotte's population from 2013 to 2019. **Show** your work. **1 point**

One point for the correct setup to calculate the percent change:

- $\frac{857{,}425 \text{ people} - 757{,}278 \text{ people}}{757{,}278 \text{ people}} \times 100$
- $\left(\frac{857{,}425 \text{ people}}{757{,}278 \text{ people}} - 1\right) \times 100$

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

Accept one of the following:

- 13%
- 13.22%
- 13.224602%

(ii) Based on Charlotte's 2019 growth rate of 1.88%, **calculate** the year when the population of Charlotte will double, assuming the growth rate stays the same. **Show** your work. **1 point**

One point for the correct setup to calculate the year the population of Charlotte will double:

- Doubling time $= \frac{70}{1.88} = 37$ years + 2019

One point for the correct calculation year the population of Charlotte will double: **1 point**

- 2056

(iii) The average Charlotte resident uses 90 gallons of water per day. **Calculate** the gallons of water used by the population of Charlotte in the year 2018. **Show** your work. **1 point**

One point for the correct setup to calculate the gallons of water used in 2018:

- $\frac{90 \text{ gallons of water}}{\text{person per day}} \times 841{,}611 \text{ people} \times 365 \text{ days}$

One point for the correct calculation of the gallons of water used in 2018: **1 point**

Accept one of the following:

- 27,646,921,350 gallons
- 2.76×10^{10} gallons
- 2.8×10^{10} gallons
- 3×10^{10} gallons

Total for part (c) 6 points

(d) Drought periods are becoming more frequent in North Carolina, causing water resources to become more scarce. **Describe** one realistic action that citizens could take to reduce domestic outdoor water use. **1 point**

Accept one of the following:

- Plant drought resistant plant species/use artificial landscaping/use xeriscaping to reduce the need for irrigation.
- Eliminate/reduce nonessential usage of water, such as washing of cars, power washing.
- Reduce the use of sprinklers/irrigation by monitoring soil conditions, weather conditions or reducing frequency.
- Collect rainwater or gray water for irrigation.
- Water plants/lawn before sunrise/after sunset to limit evaporation.
- Switch to drip irrigation to limit evaporation.

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) Asthma

(b) i) Coal ash can contain traces of toxic metals. When it is disposed of in large, unlined pits, these metals can seep into soils / water sinks ~~and~~ – entering ecosystems and harming organisms.

ii) Clay soil has ~~a~~ extremely low permeability. By disposing of coal ash in clay-lined pits, toxins ~~can~~ will remain contained and not be able to leach out of their containment areas.

(c) i) $\frac{857,425 \text{ ppl} - 757,278 \text{ ppl}}{757,278 \text{ ppl}} \cdot 100 = 13.2\%$ change in pop

ii) ~~70 / 1.88%~~ $\frac{70}{1.88\%} + 2019 = 2056$

iii) ~~Assuming~~ $\frac{90 \text{ gallons/person}}{1 \text{ day}} \cdot \frac{365 \text{ days}}{1 \text{ yr}} = \frac{32850 \text{ g/person}}{1 \text{ yr}} \cdot \frac{841,611 \text{ ppl}}{1 \text{ yr}}$

$= 2.76 \cdot 10^{10}$ gallons used in 2018

(d) ~~Plant gardens/yards with~~ Landscape with native plants / plants that require less water to grow.

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. One negative human health effect linked to the combustion of coal is asthma. When humans inhale the combustion, ~~their~~ lungs will clog, making it hard to breathe.

b. i. Depositing coal ash into dry ash landfills, gives ~~the air the~~ ash the opportunity to enter the air, if picked up by the wind. This can be a human health hazard, as people would be breathing in thick, ashy air, and would be an enviornmental problem because it is increasing the amount of VOC's in the air.

ii. Clay soil will densely pack the coal ash, so that it is not loose and can travel anwhere.

c. i. $859{,}425 - 757{,}278 = 100{,}147$

$100{,}147 / 757278 = 0.132246018 \approx 13\%$ increase

ii $70/1.88 \approx 37$

$2019 + 37 = 2056$

iii. 90 gallons/day
841,611/pop
} 75,744,990 gallons/day $\times 365 =$

$2.764692135 \times 10^{10}$ $\approx 2.76 \times 10^{10}$

~~d) Citizens can take shorter showers, and save many gallons of water per day.~~

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) Citizens can limit how often their sprinklers are activated, or water their plants on their own with a hose of watering pot of some sort.

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)
(i) Respitory illnesses like lung cancer and asthma.

(b)
(i) Toxic, hazardous waste can lead to respiratory problems. Also harm ecosystems and animals. Also air and water pollution.

(ii)
clay soil - very little permeation and doesn't break down easily. Also Earth has lots of it.

(c)
(i) 2019 - 2013 = 6 857,425 - 757,278 = 100147/6 = 16691.16667%

(ii) 70/1.88% = 37.234 = 2019 + 37 = 2056

(iii) 8 26,060 · 90 gallons = 747545400 · 365 days = $2.714 \cdot 10^{10}$

(d)
(i) Low flow faucets and showerheads, drip irrigation, less ~~shower~~ waste of water, use "express" cycle on dishwasher and washing machine - or "green" option-program on machine.

Question 3

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

Overview

This question focused on the broad categories of coal combustion and human population dynamics. In parts (a) and (b) students were expected to demonstrate understanding of the negative human health effects and environmental impacts of the products and byproducts of coal combustion. Students were asked to identify a human health impact related to pollutants from coal combustion. Students were then asked to describe a problem with the disposal of coal ash waste and to justify why using clay-lined pits might be a solution to some of these problems [Topic 7.1 Introduction to Air Pollution, Topic 8.2 Human Impacts on Ecosystems, Topic 9.3 Solid Waste Disposals]. Students applied Science Practice 1 Concept Explanation and Science Practice 7 Environmental Solutions to answer this section of the question.

In part (c) students were first asked to calculate a percent change in the population of Charlotte, North Carolina over a period of time. Students were also asked to calculate the doubling time of the population based on a constant growth rate. Lastly, students were asked to calculate the amount of water the city would use in a particular year using the data provided and dimensional analysis [Topic 3.8 Human Population Dynamics]. Students applied Science Practice 6 Mathematical Routines, to complete this section of the question.

Part (d) asked students to describe a realistic action that could be taken to reduce domestic outdoor water use [Science Practice 7 Environmental Solutions and Topic 5.12 Introduction to Sustainability].

Sample: 3A
Score: 10

One point was earned in part (a) for identifying “asthma” as a negative human health effect. One point was earned in part (b)(i) for describing “metals can seep into soils.” One point was earned in part (b)(ii) for describing, “Clay soil has extremely low permeability” and “toxins will … not be able to leach out of their containment areas.” Two points were earned in part (c)(i). One point was earned for the correct setup, and 1 point was earned for the correct calculation of percent change. Two points were earned in part (c)(ii). One point was earned for the correct setup, and 1 point was earned for the correct calculation of doubling time. Two points were earned in part (c)(iii). One point was earned for the correct setup, and 1 point was earned for the correct calculation of gallons of water used. One point was earned in part (d) for describing “Landscape with native plants/plants that require less water to grow.”

Question 3 (continued)

Sample: 3B
Score: 6

One point was earned in part (a) for identifying "asthma" as a negative human health effect. No points were earned in part (b)(i). The response states a human health hazard and not an environmental problem. No points were earned in part (b)(ii). One point was earned in part (c)(i). No point was earned for the correct setup as the response did not multiply by 100 in the setup. One point was earned for the correct calculation of percent change. Two points were earned in part (c)(ii). One point was earned for the correct setup, and 1 point was earned for the correct calculation of doubling time. One point was earned in part (c)(iii). No point was earned for the setup, and 1 point was earned for the correct calculation of gallons of water used. One point was earned in part (d) for describing, "Citizens can limit how often their sprinklers are activated."

Sample: 3C
Score: 3

One point was earned in part (a) for identifying "lung cancer" as a negative human health effect. No points were earned in part (b)(i). No points were earned in part (b)(ii). No points were earned in part (c)(i). Two points were earned in part (c)(ii). One point was earned for the correct setup, and 1 point was earned for the correct calculation of doubling time. No points were earned in part (c)(iii). No points were earned in part (d). The response provides examples of ways to reduce indoor water use rather than outdoor water use.