2022

AP CollegeBoard

AP® Environmental Science

Sample Student Responses and Scoring Commentary Set 1

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Free-Response Question 2

- ☑ **Scoring Guidelines**
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Question 2: Analyze an Environmental Problem and Propose a Solution

10 points

(a) (i) Based on the data in the graph, **identify** the highest methane concentration found in well water in Pennsylvania. **1 point**

- 64 mg/L

(ii) Based on the data in the graph, **describe** the relationship between the concentration of methane in well water and the distance to a fracking well. **1 point**

Accept one of the following:

- Methane concentration decreases as distance from the fracking well increases.
- Methane concentration increases as distance from the fracking well decreases.
- There is an inverse/nonlinear relationship/negative correlation between the two variables.

(iii) Based on the data in the graph, **identify** the minimum safe distance that a new water well should be located from an existing fracking well. **1 point**

Accept any value between:

- 1,800 – 2,200 meters

(iv) **Explain** how fracking fluid is used to access oil and natural gas in sedimentary rock, such as shale, during the fracking process. **1 point**

Accept one of the following:

- Fracking fluid is injected/pumped into the well under high pressure, opening rock fissures, releasing oil and natural gas.
- Sand grains in the fracking fluid hold the newly formed cracks/fractures open to allow the oil and natural gas to flow up the well.

(v) **Identify** one negative geologic effect in an area where hydraulic fracturing (fracking) occurs. **1 point**

Accept one of the following:

- Earthquakes/seismic activity
- Ground subsidence/sinkholes

Total for part (a) **5 points**

(b) (i) The use of groundwater for fracking is an example of individuals using a shared resource for their own self-interest. **Identify** the environmental concept illustrated by this example of overuse of a shared resource. **1 point**

- Tragedy of the Commons

(ii) **Describe** one environmental problem that may result from increased use of groundwater for fracking in arid or semiarid regions. **1 point**

Accept one of the following:

- Loss of habitat/productivity in spring-fed ecosystems as springs dry up
- Loss of habitat/productivity/degraded water quality in streams and estuaries fed by groundwater discharge
- Soil erosion as vegetation dies as a result of lowered water table and roots no longer hold soil
- Desertification as a result of lowered water table

(iii) **Describe** how overuse of coastal groundwater supplies can result in water that is unsuitable for human consumption. **1 point**

- The ocean water flows into aquifers (saltwater intrusion), contaminating the aquifer with saltwater.

Total for part (b) **3 points**

(c) (i) **Make a claim** for a realistic governmental action to improve air quality by reducing consumption of oil. **1 point**

Accept one of the following:

- Increase fuel economy standards for motor vehicles.
- Invest in renewable energy resources.
- Use tax incentives to encourage sales of hybrid/electric vehicles.
- Subsidize projects that increase the use of public transportation/walking/cycling.
- Create tax incentives for companies offering work-from-home options.
- Increase gasoline tax/reduce oil subsidies.

(ii) **Justify** the action proposed in part (c)(i) by stating a potential environmental advantage of that action, other than slowing global climate change. **1 point**

Accept one of the following:

Governmental action proposed in (c)(i)	Justification of the action proposed by stating a potential environmental advantage
Increase fuel economy standards for motor vehicles	• Decreased oil/fuel consumption, which leads to reduced particulates, surface ozone/photochemical smog or acid rain • Decreased oil consumption, which leads to fewer oil spills/decreased groundwater depletion/contamination from fracking/drilling operations

	• Decreased oil consumption, which leads to decreased disruption to wildlife/habitats (habitat fragmentation, noise pollution) from drilling operations
Invest in renewable energy resources	• Decreased oil/fuel consumption, which leads to reduced particulates, surface ozone/photochemical smog or acid rain • Decreased oil consumption, which leads to fewer oil spills/decreased groundwater depletion/contamination from fracking/drilling operations • Decreased oil consumption, which leads to decreased disruption to wildlife/habitats (habitat fragmentation, noise pollution) from drilling operations
Use tax incentives to encourage sales of hybrid/electric vehicles	• Decreased oil/fuel consumption, which leads to reduced particulates, surface ozone/photochemical smog or acid rain • Decreased oil consumption, which leads to fewer oil spills/decreased groundwater depletion/contamination from fracking/drilling operations • Decreased oil consumption, which leads to decreased disruption to wildlife/habitats (habitat fragmentation, noise pollution) from drilling operations
Subsidize projects that increase the use of public transportation/walking/cycling	• Decreased oil/fuel consumption, which leads to reduced particulates, surface ozone/photochemical smog or acid rain • Decreased oil consumption, which leads to fewer oil spills/decreased groundwater depletion/contamination from fracking/drilling operations • Decreased oil consumption, which leads to decreased disruption to wildlife/habitats (habitat fragmentation, noise pollution) from drilling operations
Create tax incentives for companies offering work-from-home options	• Decreased oil/fuel consumption, which leads to reduced particulates, surface ozone/photochemical smog or acid rain • Decreased oil consumption, which leads to fewer oil spills/decreased groundwater

	depletion/contamination from fracking/drilling operations • Decreased oil consumption which leads to decreased disruption to wildlife/habitats (habitat fragmentation, noise pollution) from drilling operations	
Increase gasoline tax/reduce oil subsidies	• Decreased oil/fuel consumption, which leads to reduced particulates, surface ozone/photochemical smog or acid rain • Decreased oil consumption, which leads to fewer oil spills/decreased groundwater depletion/contamination from fracking/drilling operations • Decreased oil consumption, which leads to decreased disruption to wildlife/habitats (habitat fragmentation, noise pollution) from drilling operations	
	Total for part (c)	**2 points**
	Total for question 2	**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.

ai) 64 mg/L

aii) The concentration of methane and the distance to the fracking well have an inverse relationship. As distance to the nearest fracking well increases, the methane concentration in well water decreases

aiii) 2,200 m

aiv) Fracking fluid is used by cracking sedimentary rock underground in order to access more natural gas. The fracking fluid is transported underground to this rock in order to access natural gas, and oil as oil is found under natural gas reserves, allowing the natural gas to be exported back to the surface and thus expand access to a fossil fuel resurve.

av) Increased seismic activity

bi) Tragedy of the commons

bii) One environmental problem is moisture loss. As this water is being used up for fracking, the groundwater is depleted, making these arid regions more arid with a loss of water moisture, that can lead to desertification and soil erosion.

biii) This overuse can lead to saltwater intrusion. As this fresh water is being used up, this non fresh water with salt will rise and replace the fresh water's

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posinon, resulting in saltwater to be used for human consumption, which is unsuitable.

c(i) one government action is to provide tax incentives to those who built cleaner, or renewable power plants. By providing an a motive to building renewable power plants, more individuals will switch to cleaner sources of energy compared to oil.

c(ii) An advantage to this action is increased reliance of renewable sources, which do not release pollutants such as NOx or SOx. These pollutants are released through the combustion of oil and natural gas and can lead to respiratory issues such as bronchitis or irritating the lung, which is preventable through more tax incentives to build more renewable energy power plants.

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) The highest methane concentration is 64 mg/L.

a)ii) As the distance to a fracking well increases, the concentration of methan in well water decreases.

a)iii) The minimum safe distance should be 700 m.

a)iv) First, they drill deep into the ground. We'll first reach natural gas and then oil. As we drill into the sedimentary rock, such as shale, we use fracking fluid to "pipe out" the oil underneath the natural gas.

a)v) Groundwater contamination can occur during fracking.

b)i) Tradgedy of the Commons is this environmental concept.

b)ii) Depletion of aquifers may occur from increased use of groundwater for fracking. This will occur when people no longer can use/depend on the groundwater for agricultural practices and will need to get their water from someplace else. This will lead to them drawing more and more water from aquifers.

b)iii) Overuse of coastal groundwater supplies can result in an intrusion of salt, creating more salt water. We cannot use this salt water and it is unsuitable for human consumption.

c)i) Governments can provide free public transportation to reduce the amount of oil we consume when we fill our individual cars.

c)ii) ~~the will decrease the rate of~~ FC We will reduce photochemical smog in cities by reducing the amount of cars on the road. This will cause less NO_x emissions, reducing smog.

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.

ai) 64 mg/L is the highest.

aii) The farther the distance to nearest fracking well, the less methane is in well water. When well water methane concentration goes up, distance from the nearest fracking well goes down.

aiii) 2,000 m is the minimum safe distance.

aiv) Fracking fluid is used in a fracking well, and breaks down sedimentary rock, so the natural gas and oil inside escape.

av) ~~Depletion of natural gas and oil;~~ Contamination of natural underground watersheds, and destruction of sedimentary rock.

bi) ~~Unsustainable~~ Carrying Capacity is being illustrated here, by the overuse of a resource negatively affecting a environment.

bii) Water used by habitats and organisms will be used up or depleted too quickly for organisms to properly obtain or use it.

biii) Fracking and other ~~practices~~ overusing groundwater can cause sediment to build up, contaminating the water source.

ci) Use solar energy ~~to power machines that~~ would instead of combusting fossil fuels.

● **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.

C ii) Solar energy can ~~powerbe~~ provide energy even when the sun isn't out by powering a battery of energy cell.

Question 2

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

Overview

The intent of this question was for students to demonstrate their ability to interpret a graph and to provide an environmental solution to a given environmental problem. Students were expected to convey an understanding of resource use and air quality improvements.

In part (a) students were asked to analyze a graph of methane concentrations in drinking water wells in Pennsylvania, and to derive quantitative data from the graph [Practice 5 Data Analysis, Topic 6.5 Fossil Fuels]. Students were then asked to identify one negative geologic effect in an area where hydraulic fracturing (fracking) occurs.

In part (b) students were asked to identify the environmental concept illustrated by an example of overuse of a shared resource [Topic 5.6 Tragedy of the Commons] and then describe the effect of increased groundwater use in applied contexts [Topic 1.7 The Hydrologic Cycle, Topic 8.2 Human Impacts on Ecosystems, Topic 5.10 Impacts of Urbanization]. The task required students to apply Practice 1 Concept Explanation and Practice 7 Environmental Solutions.

In part (c) students were asked to make a claim and justify a realistic governmental action to improve air quality by reducing oil consumption. This part required students to apply content from Topic 7.1 Introduction to Air Pollution, Topic 8.2 Human Impacts on Ecosystems, and Topic 6.3 Energy Conservation and skills from Practice 7 Environmental Solutions to appropriately respond to the prompt.

Sample: 2A
Score: 8

One point was earned in part (a)(i) for identifying “64 mg/L” as the highest methane concentration found in well water. One point was earned in part (a)(ii) for describing the relationship as “an inverse relationship. As distance to the nearest fracking well increases, the methane concentration in well water decreases.” One point was earned in part (a)(iii) for identifying “2,200 m” as the minimum safe distance. No point was earned in part (a)(iv). The response explanation is incomplete. One point was earned in part (a)(v) for identifying “Increased seismic activity.” One point was earned in part (b)(i) for identifying “Tragedy of the Commons.” No point was earned in part (b)(ii). One point was earned in part (b)(iii) for describing that “non fresh water with salt will rise and replace the fresh water’s position, resulting in saltwater to be used for human consumption.” One point was earned in part (c)(i) for making the claim “to provide tax incentives to those who built cleaner, or renewable power plants. By providing a motive to building renewable power plants.” One point was earned in part (c)(ii) for justifying the claim in (c)(i) by stating a potential environmental advantage as “not release pollutants such as NO_X or SO_X.”

Question 2 (continued)

Sample: 2B
Score: 5

One point was earned in part (a)(i) for identifying "64 mg/L" as the highest methane concentration found in well water. One point was earned in part (a)(ii) for describing the relationship "As the distance to a fracking well increases, the concentration of methan in well water decreases." No point was earned in part (a)(iii). No point was earned in part (a)(iv). No point was earned in part (a)(v). One point was earned in part (b)(i) for identifying "Tragedy of the Commons." No point was earned in part (b)(ii). The response does not describe an environmental problem. No point was earned in part (b)(iii). The response states the "intrusion of salt," not saltwater. One point was earned in part (c)(i) for making the claim, "Governments can provide free public transportation" to reduce oil consumption. One point was earned in part (c)(ii) for justifying the claim in (c)(i) by stating a potential environmental advantage as "reduce photochemical smog."

Sample: 2C
Score: 3

One point was earned in part (a)(i) for identifying "64 mg/L" as the highest methane concentration found in well water. One point was earned in part (a)(ii) for describing the relationship as "The farther the distance to the nearest fracking well, the less methane is in the well water." One point was earned in part (a)(iii) for identifying "2,000 m" as the minimum safe distance. No point was earned in part (a)(iv). No point was earned in part (a)(v). No point was earned in part (b)(i). No point was earned in part (b)(ii). No point was earned in part (b)(iii). No point was earned in part (c)(i). The response does not include a governmental action. No point was earned in part (c)(ii).