

2024



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# AP<sup>®</sup> Environmental Science

## Sample Student Responses and Scoring Commentary Set 1

### **Inside:**

#### **Free-Response Question 3**

- Scoring Guidelines**
- Student Samples**
- Scoring Commentary**

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

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**(a)** **Identify** a fuel used in a nuclear power plant. **1 point**

Accept one of the following:

- Uranium
- U-235
- Plutonium

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**(b)** **Describe** a negative environmental impact on nearby bodies of water that is caused by using water for cooling in nuclear power plants. **1 point**

Accept one of the following:

- Thermal pollution raises water temperature outside range of tolerance of organisms.
- Thermal pollution decreases dissolved oxygen.
- Water temperature increases, which decreases dissolved oxygen.
- Organisms can be wounded or killed at water intake.
- Water loss through evaporation can decrease stream flow/volume of water.

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**(c)** In 2021,  $4.1 \times 10^{12}$  kilowatt hours (kWh) of commercial electricity was generated in the United States. Nuclear power accounted for 18.9% of the total commercial electricity. **Calculate** the amount of electricity in kWh generated by nuclear power in the United States in 2021. **Show** your work. **1 point**

One point for the correct setup to calculate the amount of electricity generated by nuclear power in 2021:

Accept one of the following:

- $(4.1 \times 10^{12} \text{ kWh}) \times 18.9\%$
- $(4.1 \times 10^{12}) \times 0.189$
- $\frac{4.1 \times 10^{12}}{100} = \frac{x}{18.9}$

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One point for the correct calculation of the total amount of electricity generated by nuclear power in 2021: **1 point**

Accept one of the following:

- 774,900,000,000
- $7.749 \times 10^{11}$
- $7.75 \times 10^{11}$
- $7.7 \times 10^{11}$

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

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(d) In addition to reducing greenhouse gas emissions, **describe** how switching from coal-burning power plants to natural gas power plants will improve air quality. **1 point**

- There is less NO<sub>x</sub>/SO<sub>x</sub>/ash/particulates/toxic metals/smog formed from the burning of natural gas compared to coal.

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(e) **Justify** the proposed solution by explaining an additional advantage, other than the reduction of atmospheric greenhouse gases. **1 point**

Accept one of the following:

- Trees can provide forest habitat/increase biodiversity/diversify niches in the area.
- Creates jobs for planting trees/recreational industries/harvesting wood.
- Trees create a more aesthetically pleasing environment/enhance cultural ecosystem services.
- Planting trees can decrease soil loss/erosion/sedimentation in waterways.
- Trees can provide shade/decrease ambient temperature.
- Planting trees slows water runoff/reduces flooding.

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(f)  $7.4 \times 10^7$  cubic meters of natural gas were extracted from a large deposit in 2020. An average of 4.76 kWh of electricity can be generated from each cubic meter of natural gas combusted. In 2020, an average home consumed 10,715 kWh of electricity. **Calculate** how many homes could have been provided with electricity by natural gas extracted from the large deposit in 2020. **Show** your work. **1 point**

One point for the correct setup to calculate how many homes could have been provided with electricity by natural gas:

Accept one of the following:

- $(7.4 \times 10^7 \text{ m}^3) \times \frac{4.76 \text{ kWh}}{1 \text{ m}^3} \times \frac{1 \text{ home}}{10,715 \text{ kWh}}$
- $(7.4 \times 10^7 \text{ m}^3) \times \frac{4.76 \text{ kWh}}{10,715 \text{ kWh}}$
- $(7.4 \times 10^7) \times \frac{4.76}{10,715}$

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One point for the correct calculation of how many homes could have been provided with electricity by natural gas: **1 point**

Accept one of the following:

- 32,874
- 32,873
- 33,000

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

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- (g)** In 2021,  $8.99 \times 10^{11}$  kWh of electricity was generated through the combustion of coal. **1 point**  
 One kilogram of carbon dioxide is produced per kWh of electricity generated by combusting coal, while 0.42 kilograms of carbon dioxide is produced by combusting natural gas. **Calculate** how much less carbon dioxide would have been produced in 2021 if all coal-burning power plants were replaced with natural gas-burning power plants.  
**Show your work.**

One point for the correct setup to calculate how much less carbon dioxide would have been produced in 2021:

Accept one of the following:

- $\frac{(1.0 \text{ kg} - 0.42 \text{ kg})}{1 \text{ kWh}} \times (8.99 \times 10^{11} \text{ kWh})$
- $(1.0 \text{ kg} - 0.42 \text{ kg}) \times (8.99 \times 10^{11} \text{ kWh})$
- $(1.0 - 0.42) \times (8.99 \times 10^{11})$
- $\left( \frac{8.99 \times 10^{11} \text{ kWh}}{1} \times \frac{1 \text{ kg}}{\text{kWh}} \right) - \left( \frac{8.99 \times 10^{11} \text{ kWh}}{1} \times \frac{0.42 \text{ kg CO}_2}{\text{kWh}} \right)$ , THEN  
 $8.99 \times 10^{11} \text{ kg CO}_2 - 3.776 \times 10^{11} \text{ kg CO}_2$

One point for the correct calculation of how much less carbon dioxide would have been produced in 2021: **1 point**

Accept one of the following:

- 521 billion kg
- 521,420,000,000 kg
- $5.2142 \times 10^{11}$  kg
- $5.21 \times 10^{11}$  kg
- $5.2 \times 10^{11}$  kg

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

**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.) Uranium rods
- B.) The water that is returned will make the stream/body of water it was returned to, hotter. Therefore decreasing the dissolved oxygen levels which will kill organisms that cannot tolerate low dissolved oxygen levels.
- C.)  $(4.1 \times 10^{12}) \times 0.189 = 7.749 \times 10^{11} \text{ kWh}$
- D.) Switching to Natural Gas from Coal will improve our air quality because Natural Gas when burned, releases little to no ash or soot, so we won't have as many respiratory issues when burning natural gas.
- E.) Besides from the reduction of greenhouse gas emissions, large scale tree planting will also improve water quality of local streams, by reducing the amount of runoff into the stream by preventing soil erosion.
- F.)  $(7.4 \times 10^7) \times 4.76 \text{ kWh}$   
 $= 352240000 \text{ kWh}$   
 $\frac{352240000 \text{ kWh}}{10,715} = 32873.542 \text{ homes}$
- G.)  $(8.99 \times 10^{11}) \text{ kWh} \times 1 \text{ kg} = 8.99 \times 10^{11} \text{ kg CO}_2 \text{ from coal}$   
 $(8.99 \times 10^{11}) \text{ kWh} \times 0.42 \text{ kg} = 3.7758 \times 10^{11} \text{ kg CO}_2 \text{ from NG}$   
 $(8.99 \times 10^{11}) \text{ kWh} - (3.7758 \times 10^{11}) \text{ kWh}$   
 $= 5.214 \times 10^{11} \text{ less kg of carbon}$

Use a pen with black or dark blue ink only. Do NOT write your name. Do NOT write outside the box.

**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) A fuel used in a nuclear power plant is methane. This fuel is an important source to the plant.

(b) A negative environmental impact on water is that it harms the water quality causing oxygen to be depleted and killing many aquatic organisms.

$$(c) 4.1 \times 10^{12} \text{ (kwh)} \times 0.189 = 7.749 \times 10^{11} \text{ kwh}$$

Answer:  $7.749 \times 10^{11}$  kwh

(d) Switching from coal-burning power plants to natural gas power plants will improve air quality by reducing amount of human sickness. Many humans have airborne diseases such as asthma caused by air quality and the transition will improve health.

(e) An additional advantage is spreading more biodiversity in large-scale tree planting. By implenting more trees, more oxygen will be produced and there is room for more biodiversity including birds who will use trees as their habitat. This will improve the environment.

$$(f) \frac{7.4 \times 10^7 \text{ cubic meters}}{1 \text{ cubic meter}} \times \frac{4.76 \text{ kwh}}{10,715 \text{ kwh}} = \frac{32873.5416}{\text{homes}}$$

Answer: ~~32873.5416~~ 32,874 homes

Use a pen with black or dark blue ink only. Do NOT write your name. Do NOT write outside the box.

- **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.

$$(g) \frac{8.99 \times 10^{11} \text{ kWh}}{1 \text{ kWh}} \times \frac{1 \text{ kg CO}_2}{0.42 \text{ kg CO}_2} = 2.14047619 \times 10^{12} \text{ kg of CO}_2$$

Answer:  $2.14047619 \times 10^{12} \text{ kg of CO}_2$

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Use a pen with black or dark blue ink only. Do NOT write your name. Do NOT write outside the box.



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.) Methane.

(b.) Organisms can be harmed in the collection of water through the machines catching and killing them.

$$(c.) 4.1 \times 10^{12} = 4.1 \times 10^{12} \times 0.189 = 7.749$$

(d.) This would improve air quality by cutting down the harmful gases coal lets into the atmosphere and replacing it with a gas the atmosphere can process correctly.

(e.) Cheaper way of fueling power plants. ~~4.76~~

$$(f.) 10,715 \div 4.76 = 2251.05$$

$$(g.) 8.99 \times 10'' = 8.99 \times 0.42 = 3.78 \quad | \quad 8.99 - 3.78 = 5.21 \text{ kg}$$

Use a pen with black or dark blue ink only. Do NOT write your name. Do NOT write outside the box.



### 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 concepts related to electricity generation [Topic 6.3 Fuel Types and Uses], math skills related to energy [Science Practice 6 Mathematical Routines and Topic 6 Energy Resources and Consumption], and advantages of forests [Topic 5 Land and Water Use].

In part (a) students were expected to demonstrate understanding of how electricity is generated in nuclear power plants [Science Practice 1 Concept Explanation and Topic 6.6 Nuclear Power].

In part (b) students were required to describe how using water in cooling towers of a nuclear power plant can have negative impacts on nearby bodies of water [Science Practice 7 Environmental Solutions and Topics 6.6 Nuclear Power and 8.6 Thermal Pollution].

In part (c) students were asked to calculate the amount of electricity that was generated at nuclear power plants from a given total electrical energy production and a given percent that was generated at nuclear power plants [Science Practice 6 Mathematical Routines and Topic 6.6 Nuclear Power].

In part (d) students were expected to demonstrate understanding of the impacts on air quality by switching from coal power plants to natural gas power plants [Science Practice 7 Environmental Solutions and Topics 6.3 Fuel Types and Uses, 7.4 Atmospheric CO<sub>2</sub> and Particulates, and 7.7 Acid Rain].

In part (e) students were asked to justify the advantages of planting large areas with trees, excluding the reduction of atmospheric greenhouse gasses [Science Practice 7 Environmental Solutions and Topics 5.17 Sustainable Forestry, 4.2 Soil Formation and Erosion, and 2.2 Ecosystem Services].

In parts (f) and (g) students were expected to calculate answers associated with energy consumption and production. In part (f) students were asked to calculate how many homes could be provided with electricity from a given amount of natural gas that had been extracted [Science Practice 6 Mathematical Routines and Topic 6.2 Global Energy Consumption]. In part (g) students were required to calculate how much less CO<sub>2</sub> would be produced if all coal power plants were converted to natural gas [Science Practice 6 Mathematical Routines and Topics 6.3 Fuel Types and Uses and 6.5 Fossil Fuels].

#### Sample: 3A

#### Score: 10

1 point was earned in part (a) for identifying “uranium rods.” 1 point was earned in part (b) for describing “the water then is returned will make the stream/body of water it was returned to hotter ... decreasing the dissolved oxygen levels.” 2 points were earned in part (c). 1 point was earned for the correct setup, and 1 point was earned for the correct answer. 1 point was earned in part (d) for describing “Switching to Natural Gas from coal ... when burned, releases little to no ash.” 1 point was earned in part (e) for justifying “by preventing soil erosion.” 2 points were earned in part (f).

### Question 3 (continued)

1 point was earned for the correct setup, and 1 point was earned for the correct answer. 2 points were earned in part (g). 1 point was earned for the correct setup, and 1 point was earned for the correct answer.

**Sample: 3B**

**Score: 5**

No point was earned in part (a). No point was earned in part (b). 2 points were earned in part (c). 1 point was earned for the correct setup, and 1 point was earned for the correct answer. No point was earned in part (d). 1 point was earned in part (e) for justifying “more biodiversity in large-scale tree planting.” 2 points were earned in part (f). 1 point was earned for the correct setup, and 1 point was earned for the correct answer. No points were earned in part (g).

**Sample: 3C**

**Score: 2**

No point was earned in part (a). 1 point was earned in part (b) for describing “Organisms can be harmed in the collection of water through the machines catching and killing them.” 1 point was earned in part (c). 1 point was earned for the correct setup, but no point was earned for the answer. No point was earned in part (d). No point was earned in part (e). No points were earned in part (f). No points were earned in part (g).