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

## Sample Student Responses and Scoring Commentary Set 2

### **Inside:**

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

- Scoring Guideline**
- Student Samples**
- Scoring Commentary**

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

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**(a) Describe** why coal is considered a nonrenewable energy source. **1 point**

Accept one of the following:

- Nonrenewable energy sources like coal exist in a fixed/finite/limited amount.
- The formation rate of coal is less than the consumption/combustion rate of coal.

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**(b) Describe** one potential environmental advantage of replacing a coal-fired power plant with a natural-gas power plant. **1 point**

Accept one of the following:

- Natural gas combustion emits fewer greenhouse gases/less CO<sub>2</sub>.
- Natural gas combustion does not emit mercury/lead/cadmium/uranium.
- Natural gas combustion emits less NO<sub>x</sub>/SO<sub>x</sub>/reduces acid precipitation.
- Natural gas combustion produces less/no particulate matter/soot/smog.
- Transport of natural gas destroys/fragments less habitat or requires less fossil fuel use than transport of coal.
- Habitat destruction due to the impoundment of coal ash or coal slurry is negated.
- Coal extraction destroys habitat by strip mining or mountaintop removal.

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**(c) Describe** one economic advantage of using natural gas, rather than coal, in producing electricity. **1 point**

Accept one of the following:

- Transport of natural gas (in pipelines) costs less than transport of coal (by rail).
- Natural gas (methane) harvested from a decomposition reaction (landfills, wastewater treatment plants, biodigesters) costs less than coal.
- There are fewer health-related issues linked to the burning of natural gas than are linked to burning coal, leading to lower health care costs for individuals or society as a whole.
- There are fewer pollution controls needed for a natural gas powerplant, decreasing the cost of operation/construction/permitting.
- There are lower combustion-residue disposal costs from the operation of natural gas burning powerplants than from coal-burning power plants.
- Natural-gas-burning power plants are much more efficient (more electricity output from the same energy input) than coal-burning power plants leading to lower fuel costs.

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- (d) When natural gas is used to heat homes, it can produce carbon monoxide gas, which can lead to carbon monoxide poisoning in humans. **Propose** a solution to reduce the incidence of carbon monoxide poisoning in humans. **1 point**

Accept one of the following:

- Install/use/replace/update carbon monoxide detectors/alarms/sensors or replace the batteries within these devices.
- Perform regular maintenance on natural gas furnaces to ensure that minimal carbon monoxide is created or that the combustion products are properly vented/exhausted to the building exterior.
- Create laws or regulations that mandate that carbon monoxide detectors must be installed in all homes of any type.
- Use PSA's, billboards, or other methods to inform/educate the public about carbon monoxide poisoning.
- Change the home heating system to a method that does not include the combustion of a fuel that may produce carbon monoxide.

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- (e) **Calculate** the percent change in the average annual PM<sub>2.5</sub> concentration in the air from 1990 to 2016. **Show** your work. **1 point**

One point for the correct setup (must include units and multiplication by 100 to yield a true percentage) to calculate the percent change:

- $$\frac{(188 \mu\text{g}/\text{m}^3 - 85 \mu\text{g}/\text{m}^3)}{85 \mu\text{g}/\text{m}^3} \times 100$$

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

- 121%
- 120%
- 121.2%

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

- (f) Trees can remove PM<sub>2.5</sub> from the atmosphere when particulates settle on the leaves and are subsequently washed onto soil by rain. The average annual removal of PM<sub>2.5</sub> is 2.3 kilograms per hectare. **Calculate** the decrease in PM<sub>2.5</sub> removal in kilograms if logging reduced a forested area from 50,000 hectares to 43,000 hectares. **Show** your work. **1 point**

One point for the correct setup (must include units) to calculate the number of kilograms of PM<sub>2.5</sub>:

- $$(50,000 \text{ ha} - 43,000 \text{ ha}) \times \frac{2.3 \text{ kg}}{\text{hectare}}$$
- $$50,000 \text{ ha} \times 2.3 \text{ kg/ha} = 115,000 \text{ kg}; 43,000 \text{ ha} \times 2.3 \text{ kg/ha} = 98,900 \text{ kg}$$
$$115,000 \text{ kg} - 98,900 \text{ kg}$$

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One point for the correct calculation of the number of kilograms of PM<sub>2.5</sub>: **1 point**

- 16,100 kilograms of PM<sub>2.5</sub>
- 16,000 kilograms of PM<sub>2.5</sub>

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

**(g)** Research has shown that hospital admissions for cardiovascular problems increase 1% with every 10% increase in PM<sub>2.5</sub> concentration. A city experienced a 23% increase in PM<sub>2.5</sub> concentration and had 7,390 hospital admissions for cardiovascular issues over a one-year period. **Calculate** the anticipated increase in the number of hospital admissions for cardiovascular issues during the next year if the PM<sub>2.5</sub> concentration continues to rise at an identical rate. **Show** your work. **1 point**

One point for the correct setup to calculate the increase in hospital admissions:

- $\frac{0.23}{0.10} \times 0.01 \times 7,390$  admissions
- $\frac{0.23}{0.10} \times \frac{1}{100} \times 7,390$  admissions
- $\frac{23\%}{10\%} \times 1\% \times 7,390$  admissions

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One point for the correct calculation of the increase in hospital admissions. **1 point**

Accept one of the following:

- 169 more admissions
- 170 more admissions

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

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**Total for question 3 10 points**



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

3)

- a) Coal is a non-renewable energy source because the resource is being used faster than it can replenish.
- b) Natural gas burns more efficiently and completely, meaning there will be less ~~particulate matter~~ and greenhouse gases in the air that contribute to global warming.
- c) Natural gas burns more efficiently meaning that more energy can be harvested from it.
- d) A way to reduce CO poisoning in humans is to install viable carbon monoxide detectors and make sure to change the batteries periodically.
- e)  $\frac{188 - 85}{85} \times 100 = \boxed{121.176\%}$  change in annual  $PM_{2.5}$  from 1990 to 2016.

$$f) (50,000 \text{ hectares} \times 2.3 \text{ kg/hectare}) - (43,000 \text{ hectares} \times 2.3 \text{ kg/hectare}) = 16,100 \text{ kg}$$

There was a decrease of 16,100 kg in  $PM_{2.5}$  removal.

$$g) \frac{23\%}{10\%} = 2.3 \quad 1\% \times 2.3 = 2.3\% \quad 7390 \times .023 = 169.97$$

The ~~ati~~ anticipated increase in hospital admissions in the next year is ~~169.97~~ or 170 people.

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) Coal is a nonrenewable energy source because there is not an infinite amount of it, eventually it will run out.

3(b) Less pollutants like carbon dioxide are produced with natural gas power plants.

3(c) It is cheaper to use natural gas in producing electricity than coal.

3(d) Homes could be required to have so many carbon monoxide alarms. This would alert humans more often if carbon monoxide is present, reducing poisoning.

$$3(e) \frac{188-85}{85} \times 100 = 121.18\%$$

$$3(f) \begin{array}{l} 2.3 \times 50,000 = 115,000 \quad 2.3 \times 43,000 = 98,900 \\ 115,000 - 98,900 = 16,100 \text{ kilograms} \end{array}$$

$$3(g) \begin{array}{l} 23\% - 10\% = 13\% \text{ increase} \quad 23\% + 13\% = 26\% + 3\% = \\ 29\% \quad 29\% / 23\% = 1.26 \end{array}$$

~~$$7390 \times 1.26 = 9317$$~~

$$7390 \times 1.26 = 9312$$

$$9312 - 7390 = 1922 \text{ increases}$$

1922 increase in hospital admissions

Question 1

Question 2

Question 3



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

a) Coal is considered a non-renewable resource because it is located on Earth in finite supply. Coal mines are not infinitely supplied on ~~Earth~~ Earth.

b) One environmental advantage is that a natural gas power plant won't produce as much air pollution as a coal-fired power plant, because natural gas is the cleanest source of non-renewable energy.

c) One economic advantage is that natural gas is much easier and cost effective to obtain than mining for coal. Mining for coal requires machinery and equipment to be ~~done~~<sup>used</sup>, while natural gas can be obtained by easier means.

d) In order to reduce carbon monoxide poisoning, certain filters can be placed on top of smoke stacks to decrease the extent at which carbon monoxide is emitted into the atmosphere.

$$e) \frac{188 - 85}{85} = 1.212 \times 100 = 121.176\%$$

$$f) \frac{50,000}{2.5} - \frac{43,000}{2.5} = 3043.479 \text{ ~~kg~~ Kilograms}$$

$$g) \frac{.01}{.1} = \frac{x}{.23} \quad x = 0.023$$

$$1.023 \times 7390 = 7559.97 \text{ hospital admissions}$$

### Question 3

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

#### Overview

The intent of this question was for students to demonstrate their ability to describe nonrenewable energy sources and compare coal and natural gas electricity generation. Students were expected to show their work and complete calculations related to air pollution/particulate pollution.

In part (a) students were expected to demonstrate an understanding of nonrenewable energy sources [Practice 1-Concept Explanation, Topic 6.1 is Renewable and Nonrenewable Energy]. In parts (b) and (c) students were asked to describe an environmental and an economic advantage of replacing a coal-fired powerplant with a natural-gas power plant [Practice 7-Environmental Solutions, Topic 6.3 Fuel Types and Uses]. In part (d) students were asked to propose a solution to reduce the incidence of carbon monoxide poisoning in humans. In parts (e), (f), and (g), students were asked to calculate the percent change of an air pollutant over a particular time period, the amount of particulate pollution reduction by leaf deposition, and the increase in the number of hospital admissions due to an increase in particulate pollution. The calculation portions of the question evaluated understanding and application of Science Practice 6 Mathematical Routines [Topic 7.1-Introduction to Air Pollution].

#### Sample: 3A

##### Score: 8

One point was earned in part (a) for describing “coal ... is being used faster than it can replenish.” One point was earned in part (b) for describing an environmental advantage as “there will be less greenhouse gases in the air.” No point was earned in part (c). One point was earned in part (d) for proposing the solution of “install ... carbon monoxide detectors.” One point was earned in part (e) for calculating the correct percent change of 121.176%. No point was earned for the setup as units were not included. Two points were earned in part (f). One point was earned for calculating the correct answer of 16,100 kg, and one point was earned for the correct setup, including units. Two points were earned in part (g). One point was earned for calculating the correct answer of 170. One point was earned for the correct setup.

#### Sample: 3B

##### Score: 5

One point was earned in part (a) for describing coal as nonrenewable because there “is not an infinite amount of it.” One point was earned in part (b) for describing an environmental advantage as “less pollutants like carbon dioxide are produced with natural gas power plants.” No point was earned in part (c). One point was earned in part (d) for proposing the solution to carbon monoxide poisoning as “Homes could be required to have so many carbon monoxide alarms.” One point was earned in part (e) for calculating the correct percent increase of 121.18%. No point was earned for the setup as no units are included. One point was earned in part (f) for calculating the correct decrease of  $PM_{2.5}$  as 16,100 kg. No point was earned for the setup as no units are included, and the “98,900” is converted to “989,000” in the subtraction pair. No points were earned in part (g).

#### Sample: 3C

##### Score: 2

One point was earned in part (a) for describing coal as “located on Earth in finite supply.” No point was earned in part (b). No point was earned in part (c). No point was earned in part (d). One point was earned in part (e) for calculating the correct answer of 121.176% increase. No point was earned for the setup as units are not included. No points were earned in part (f). No points were earned in part (g).