

2021

AP[®]

CollegeBoard

AP[®] Environmental Science

Sample Student Responses and Scoring Commentary Set 1

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Free Response Question 1

- Scoring Guideline**
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Question 1: Design an Investigation**10 points**

(a) (i) Identify the independent variable in the experiment. **1 point**

- Direction the panels face

(ii) Identify the dependent variable in the experiment. **1 point**

- Amount of electrical energy produced

(iii) Identify a reasonable hypothesis for the experiment. **1 point**

Accept one of the following:

- If the photovoltaic panels face north/south/east/west, then the maximum amount of electricity will be produced.
- The position (compass direction) of solar panels will affect how much energy is produced.
- Solar panels positioned with greatest access to the sun will generate more energy.
- The compass direction the panels face will not have an effect on the amount of electricity produced.

(iv) Describe one variable that was not discussed that could affect the results of the study. **1 point**

Accept one of the following:

- Panels tilted to an improper angle that does not match the position of the sun will decrease energy/kWh production.
- Shade or shadows from trees, dust, clouds or snow on the panels would prevent absorption of sunlight, decreasing energy/kWh production.
- Seasonal or daily variations in solar intensity will lead to an increase or decrease in energy/kWh production.
- Cooler temperatures produce more kWh because heat decreases the efficiency of solar panels.

Total for part (a) 4 points

(b) (i) Identify the location shown in the diagram where the kinetic energy of the water is transformed into mechanical energy. **1 point**

- Turbine
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- (ii) Explain** why the water in the storage reservoir has potential energy that is useful in hydroelectric power generation. **1 point**

Accept one of the following:

- The dam holds water at a higher elevation than the turbine and is allowed to flow downhill toward the turbine.
- Water has potential energy due to gravity allowing water to flow down toward the turbine when released.
- The greater the difference between the dam height (head) and position of the turbine, the more hydrostatic pressure is built up.

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- (iii) Explain** how coupling hydroelectric power with solar or wind power is an advantage to providing a constant source of electricity to a community. **1 point**

Accept one of the following:

- Solar and wind power are both intermittent as result of weather changing from day to day (or day to night) so hydroelectric power could be used to provide electricity when the solar or wind power is unavailable/not sufficient for electricity demand.
- Solar or wind power could be used to pump water into a reservoir increasing the amount of water behind the dam to increase hydroelectric power generation.

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- (iv) Explain** how a hydroelectric power system, like the one depicted, may be negatively affected by climate change. **1 point**

Accept one of the following:

- Decrease in water storage due to drought, evaporation or reduced rain fall decreases the amount of electricity generated.
- Increased need for irrigation due to drought or reduced rainfall leads to reduction of the amount of water stored in reservoirs, decreasing the amount of electricity generated.
- Increased frequency of extreme precipitation events such as floods or droughts as a result of climate change cause a larger amount of sediments to fill the reservoir, reducing storage capacity and decreasing the amount of electricity generated.
- In the short-term, run-off may increase from loss of glaciers, leading to increased water available for power production, increasing the amount of electricity generated.
- In the long-term, after glaciers melt, there will be decreased run-off, decreasing water storage, decreasing the amount of electricity generated.

Total for part (b) 4 points

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- (c) (i) Identify** one advantage, other than the generation of hydroelectric power, of the formation of a reservoir behind a hydroelectric dam. **1 point**

Accept one of the following:

- Increase in aquatic habitat behind the dam/increase in lake species in reservoir
- Provision of recreational facilities
- Increased flood control
- Water storage/drinking water source
- Water for irrigation

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- (ii) Explain** the effect of increased silt in the reservoir on the hydroelectric power system. **1 point**

Accept one of the following:

- Silt in reservoirs decreases water storage capacity and can lead to reduced power generation or reduced potential energy.
- Silt in reservoirs decreases water storage capacity and can lead to the release of water over a spillway, rather than using it to generate electricity.
- Silt can damage the turbine and other mechanical equipment by abrasion of blades. Damaged equipment decreases efficiency and/or requires expensive repairs.

Total for part (c) 2 points

Total for question 1 10 points



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

- 1 a) i) the compass direction of where the solar panel is facing.
- ii) the amount of electricity produced in kWh.
- iii) If the PV panels are installed on a roof in the northern hemisphere, the greatest amount of electricity produced will be when facing south.
- iv) If the area has a lot of precipitation, resulting in blockage from the sun, this will decrease the amount of sunlight therefore decreasing the amount of electricity produced, no matter which direction the PV panels are facing.
- b) i) The turbine is the location of the hydro-electric dam where water's kinetic energy turns into mechanical energy.
- ii) The water in the storage reservoir contains a lot of water being contained at a higher altitude than where the turbine is. As gravity pulls down the water from ~~the~~ ~~to~~ ~~me~~ potential to kinetic energy, this increases the rate at which electricity is generated.
- iii) Even if there is a lack of sun due to clouds or a lack of wind in the troposphere, the water located in the storage reservoir is

Question 1 Question 2 Question 3



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

constant therefore the community is able to rely on many renewable energy sources to provide electricity.

iv) Climate change may increase surface temperatures, leading to evaporation of water in the storage reservoir. The hydro-electric power system no longer has the potential energy it needs to produce electricity.

c) i) Recreational facilities may be used for activities, allowing for social entertainment in a community.

ii) The increase in silt has lead to ~~the turbines malfunctioning as it is~~ an increase of mechanical weathering of the dam itself, slowly breaking off small pieces that may damage the dam's structure.

Question 1

Question 2

Question 3

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

- a) The independent variable is the compass direction the PV panels are facing. The dependent variable is the ~~amount~~ ~~of electricity~~ amount of electricity (in kWh) the panel can produce. If the PV panels face either east or west then the amount of electricity generated will increase because the sun rises and sets in those directions. One variable that isn't discussed is the amount of condensation and precipitation in the ~~area~~ area. This can affect the results because clouds block sun light so areas with more clouds ~~will~~ would generate less electricity.
- b) Kinetic energy turns to mechanical energy at the ~~turbine~~ generator. It has potential energy because the water from there creates kinetic energy ~~and then that~~ and then that kinetic energy is turned to mechanical energy. By coupling it with wind and solar you can keep constant energy because there isn't always wind and sun to make electricity, so the hydroelectric power and make energy when solar or wind can't. Hydroelectric power ~~power~~ will be negatively affected by climate change if the water gets too cold and freezes.
- c) The reservoir is where water is cleaned and filtered to be put back into the environment. Silt can either get ~~stuck~~ stuck in the turbine and stop it from functioning or it can block the dam gate.



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

- 1.(a)(i) The independent variable of the experiment will be the sun or amount of light that is being measured.
- (ii) The dependent variable is the position or direction of the panels that will change.
- (iii) A reasonable hypothesis for this experiment would be that the panels will be able to produce the most amount of electricity when facing the direction the sun rises from which would be the east.
- (iv) One variable that could change the results of the study that was not discussed was the weather and how it can affect the amount of exposure the solar panels have to light.
- (b)(i) Kinetic energy turns into mechanical energy in the turbine section of the generator.
- (ii) ~~the~~ The stored water is important to power generation because it not only will later ~~be~~ be used and changed to kinetic energy ~~but~~ but it pushes the function/use of the generator.
- (iii) Hydroelectric power combined with wind power benefits a community by ensuring constant usable energy production in the case of one resource becoming scarce.
- (iv) These power systems can be negatively affected by climate change through the depletion of water in areas with dams due to increased temperatures and therefore more precipitation.
- (c)(i) The development of a reservoir behind a dam could be beneficial as it will protect the dam from possible environment

Question 1 Question 2 Question 3



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

tal dangers such as strong winds, debris, and pollution.

(ii) Increased silt in the reservoir could lead to challenges as silt erodes easily ~~to~~ and could be caught in the turbines needed to produce energy as well as increase pollution.

Question 1

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 identify components of a scientific experiment and to explain the process of hydroelectric power generation. Students were expected to explain why the power may be combined with other renewable sources of energy and how climate change and the runoff of silt may impact hydroelectric power generation.

In part (a) students were expected to demonstrate their ability to identify the components of a hypothesis and to generate a reasonable hypothesis when given a research question [Practice 4-Scientific Experiments]. In part (b) students were expected to explain the conversions of energy as water moved through a hydroelectric dam [Topic 6.9-Hydroelectric Power]. The stimulus provided a diagram of a hydroelectric power plant, and students were expected to identify steps of power production within the plant and explain concepts tied to hydroelectric power generation [Practice 1-Concept Explanation and Practice 2-Visual Representation]. Students were asked to explain why it is beneficial to pair hydroelectric power with solar or wind power [Topics 6.8-Solar Energy and 6.12-Wind Energy]. They were also asked to describe the impact of climate change on the use of hydroelectric power [Topic 9.5-Global Climate Change]. In part (c) students were asked to identify the benefits of the reservoirs created behind dams [Topic 6.9-Hydroelectric Power] and to explain the impact of increased silt on the ability of the dam to create power.

Sample: 1A

Score: 9

One point was earned in part (a)(i) for identifying “compass direction of where the solar panel is facing” as the independent variable. One point was earned in part (a)(ii) for identifying “The amount of electricity produced in kWh” as the dependent variable. One point was earned in part (a)(iii) for identifying “If the PV panels are installed ... The greatest amount of electricity produced will be when facing south” as the hypothesis. One point was earned in part (a)(iv) for describing, “If the area has a lot of precipitation, resulting in blockage from the sun, this will decrease the amount of sunlight therefore decreasing the amount of electricity produced.” One point was earned in part (b)(i) for identifying “turbine” as the location. One point was earned in part (b)(ii) for explaining the water is “contained at a higher altitude than where the turbine is” and “gravity pulls down the water.” One point was earned in part (b)(iii) for explaining, “Even if there is a lack of sun due to clouds or a lack of wind in the troposphere, the water ... is constant.” One point was earned in part (b)(iv) for explaining, “evaporation of water in the storage reservoir” would have the result that “The hydro-electric power system no longer has the potential energy it needs to produce electricity.” One point was earned in part (c)(i) for identifying “Recreational facilities” as the advantage. No point was earned in part (c)(ii).

Sample: 1B

Score: 5

One point was earned in part (a)(i) for identifying “compass direction the PV panels are facing” as the independent variable. One point was earned in part (a)(ii) for identifying the “amount of electricity (in kWh)” as the dependent variable. One point was earned in part (a)(iii) for identifying “If the PV panels face either east or west then the amount of electricity generated will increase” as the hypothesis. One point was earned in part (a)(iv) for describing that “areas with more clouds would generate less electricity.” No point was earned in part (b)(i). No point was earned in part (b)(ii). One point was earned in part (b)(iii) for explaining “there isn’t always wind and sun to make electricity, so the hydroelectric power ... make energy when solar or wind can’t.” No point was earned in part (b)(iv). No point was earned in part (c)(i). No point was earned in part (c)(ii).

Question 1 (continued)

Sample: 1C

Score: 2

No point was earned in part (a)(i). No point was earned in part (a)(ii). One point was earned in part (a)(iii) for identifying “panels will be able to produce the most amount of electricity when facing ... east” as the hypothesis. No point was earned in part (a)(vi). One point was earned in part (b)(i) for identifying “turbine” as the location. No point was earned in part (b)(ii). No point was earned in part (b)(iii). No point was earned in part (b)(iv). No point was earned in part (c)(i). No point was earned in part (c)(ii).