2019

AP CollegeBoard

AP® Environmental Science

Sample Student Responses and Scoring Commentary

Inside:

Free Response Question 2

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

AP® ENVIRONMENTAL SCIENCE
2019 SCORING GUIDELINES

Question 2

As conventional sources of crude oil are depleted, unconventional sources such as oil sands (also known as tar sands) are being utilized. Oil sands contain bitumen, which can be processed into a synthetic crude oil. A region of boreal forest in Alberta, Canada, that covers a deposit of oil sands will be cut and removed during the process of bitumen extraction. It is estimated that the deposit contains 73 billion barrels of recoverable bitumen. The rate of extraction from the deposit will be approximately 1 million barrels of bitumen per day.

(a) **Identify** one ecological benefit, other than providing habitat, that is provided by forests.

(1 point for the correct identification of an ecological benefit provided by forests)

- Absorb carbon dioxide/produces oxygen (gas exchange)
- Maintain ecological and/or species diversity
- Provide food for organisms
- Moderate/regulate (local) climate
- Purify/filter water or air
- Reduce soil erosion
- Absorb/store/regulate water
- Help maintain stream temperature/stream flow
- Aid in nutrient cycling
- Aid in soil formation

(b) **Identify** one economic benefit that is provided by forests.

(1 point for the correct identification of an economic benefit provided by forests)

- Source of forest products (timber, medicine, nuts, crops such as shade-grown coffee, etc.)
- Tourism
- Jobs in recreation/tourism/forestry
- Reduction in air pollutants, which can
  - reduce health care costs
  - improve crop yields

(c) **Describe** TWO environmental consequences, other than those related to the loss of boreal forest habitat, that result from the extraction of bitumen or the transportation of synthetic oil to customers.

(2 points; 1 point for each correct description of an environmental consequence that results from the extraction of bitumen or the transport of synthetic oil to customers)

- Release of greenhouse gases/air pollutants such as NO_X from fossil fuel combustion that powers equipment/transportation/oil processing
- Release of air pollutants (NO_X, SO_X, or particulates) during mining operations or oil processing
- Storage and disposal of large amounts of solid/liquid mining waste, which can be toxic to organisms
- Pollution of surface water and/or groundwater from oil spills/leaks during transport
- Sediment pollution in surface water and/or groundwater from strip mining
- Disturbance from pipelines, such as habitat fragmentation, disruption of migratory routes, etc.
- Noise pollution from use of machinery during processing or transport
- Diversion/use of water from surface water and/or groundwater for processing oil

Question 2 (continued)

(d) Assuming the above extraction rate, **calculate** how many days will be needed to extract the recoverable volume of bitumen from the oil sands.

(2 points; 1 point for the correct setup and 1 point for the correct answer)

$$7.3 \times 10^{10} \text{ barrels of bitumen} \times \frac{1 \text{ day}}{1.0 \times 10^{6} \text{ barrels of bitumen}}$$

$$= 7.3 \times 10^{4} \text{ days}$$

$$= 73{,}000 \text{ days}$$

(Note: Units are not required in the answer)

(e) **Calculate** how many years will be needed to fully extract the recoverable volume of bitumen from the oil sands.

(2 points; 1 point for the correct setup and 1 point for the correct answer; incorrect answer from (d), used correctly, can still earn points in part (e)

$$7.3 \times 10^{4} \text{ days} \times \frac{1 \text{ year}}{365 \text{ days}}$$

$$= 2 \times 10^{2} \text{ years}$$

$$= 200 \text{ years}$$

(Note: Units are not required in the answer.)

(f) Monthly production of synthetic crude oil is 30 million barrels. Producing one barrel of synthetic crude oil uses two barrels of heated freshwater. **Calculate** the number of barrels of freshwater needed each year to supply this demand.

(2 points; 1 point for the correct setup and 1 point for the correct answer)

$$\frac{3 \times 10^{7} \text{ barrels of synthetic oil}}{1 \text{ month}} \times \frac{2 \text{ barrels of fresh water}}{1 \text{ barrel of synthetic oil}} \times \frac{12 \text{ months}}{1 \text{ year}}$$

$$= 7.2 \times 10^{8} \text{ barrels of fresh water}$$

$$= 720{,}000{,}000 \text{ barrels of fresh water}$$

(Note: Units are not required in the answer)

2. As conventional sources of crude oil are depleted, unconventional sources such as oil sands (also known as tar sands) are being utilized. Oils sands contain bitumen, which can be processed into a synthetic crude oil. A region of boreal forest in Alberta, Canada, that covers a deposit of oil sands will be cut and removed during the process of bitumen extraction. It is estimated that the deposit contains 73 billion barrels of recoverable bitumen. The rate of extraction from the deposit will be approximately 1 million barrels of bitumen per day.

   (a) **Identify** one ecological benefit, other than providing habitat, that is provided by forests.

   (b) **Identify** one economic benefit that is provided by forests.

   (c) **Describe** TWO environmental consequences, other than those related to the loss of boreal forest habitat, that result from the extraction of bitumen or the transportation of synthetic oil to customers.

   GHG released

   (d) Assuming the above extraction rate, **calculate** how many days will be needed to extract the recoverable volume of bitumen from the oil sands.

   (e) **Calculate** how many years will be needed to fully extract the recoverable volume of bitumen from the oil sands.

   (f) Monthly production of synthetic crude oil is 30 million barrels. Producing one barrel of synthetic crude oil uses two barrels of heated freshwater. **Calculate** the number of barrels of freshwater needed each year to supply this demand.

a) Forests act as a carbon sink & provide carbon sequestration.

b) Forests can draw tourists to and encourage eco-tourism, which can stimulate the local economy.

c) Machinery needed for the extraction of bitumen may use oil and fuel, which can produce greenhouse gases like carbon dioxide or carbon monoxide when used/combusted. Carbon dioxide is a greenhouse gas and traps heat; increased emissions of carbon dioxide from machinery used to extract bitumen can contribute to atmospheric warming and long-run climate change. Another environmental consequence could potentially be groundwater pollution. If

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

the synthetic
pipelines are used to transport oil, the pipelines could leak or rupture, leading to the synthetic oil contaminating valuable stores of groundwater or aquifers.

d) 73×10^9 barrels $\cdot \frac{\text{day}}{1 \times 10^6 \text{ barrels}} = 73 \times 10^3$ days
$= 7.3 \times 10^4$ days
= 73000 days needed to extract the recoverable bitumen

e) 73×10^9 barrels $\cdot \frac{1 \text{ day}}{1 \times 10^6 \text{ barrels}} \cdot \frac{1 \text{ year}}{365 \text{ days}}$

$= \frac{73 \times 10^3}{365} = \frac{7.3 \times 10^4}{365} = \frac{73000}{365}$

200
365 | 73000
730
000

$\times \frac{365}{2}$
730

= 200 years needed

f) 30×10^6 barrels of synthetic oil $\cdot \frac{12 \text{ months}}{1 \text{ year}} \cdot \frac{2 \text{ barrels freshwater}}{1 \text{ barrel oil}}$

$(30 \times 10^6)(24)$ $\quad \times \frac{24}{30}$ $\quad = 720 \times 10^6$
720

$= 7.20 \times 10^8$ barrels of heated freshwater per year

GO ON TO THE NEXT PAGE.

2. As conventional sources of crude oil are depleted, unconventional sources such as oil sands (also known as tar sands) are being utilized. Oils sands contain bitumen, which can be processed into a synthetic crude oil. A region of boreal forest in Alberta, Canada, that covers a deposit of oil sands will be cut and removed during the process of bitumen extraction. It is estimated that the deposit contains 73 billion barrels of recoverable bitumen. The rate of extraction from the deposit will be approximately 1 million barrels of bitumen per day.

   (a) **Identify** one ecological benefit, other than providing habitat, that is provided by forests.

   (b) **Identify** one economic benefit that is provided by forests.

   (c) **Describe** TWO environmental consequences, other than those related to the loss of boreal forest habitat, that result from the extraction of bitumen or the transportation of synthetic oil to customers.

   (d) Assuming the above extraction rate, **calculate** how many days will be needed to extract the recoverable volume of bitumen from the oil sands.

   (e) **Calculate** how many years will be needed to fully extract the recoverable volume of bitumen from the oil sands.

   (f) Monthly production of synthetic crude oil is 30 million barrels. Producing one barrel of synthetic crude oil uses two barrels of heated freshwater. **Calculate** the number of barrels of freshwater needed each year to supply this demand.

a) Forests are a very useful carbon sink, absorbing carbon from the atmosphere for photosynthesis to produce oxygen. Thus, they are important in preventing greenhouse gases from building up.

b) Forests provide valuable economic resources such as lumber and paper, and ~~sustaining~~ sustaining forests long term keeps these economic resources around long term as well.

c) The extraction of bitumen will result in increased soil erosion as more of the soil is exposed to water and wind. This leads to much less biodiversity and fertility in the

GO ON TO THE NEXT PAGE.

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

long term.

Additionally, the transportation of this synthetic oil will release CO_2 into the atmosphere as it likely travels very long distances to the customer. These increased emmissions further worsen the greenhouse effect and contribute to climate change.

~~c)~~ ~~73×10^9 barrels $\times$ 1×10^6~~

d) 73×10^9 barrels $\times \frac{1 \text{ day}}{1 \times 10^6 \text{ barrels}} = 73 \times 10^3$ days

$= 73{,}000$ days to extract the bitumen.

e) $\frac{73{,}000 \text{ days}}{365 \text{ days/yr}} = 200$ years

f) $\frac{30 \text{ million barrels oil}}{1 \text{ month}} \times \frac{12 \text{ months}}{1 \text{ yr}} \times \frac{2 \text{ barrels water}}{1 \text{ barrel oil}} = 720$ million barrels water.

$\Rightarrow$ 720 million barrels of freshwater are needed each year to supply this demand.

2. As conventional sources of crude oil are depleted, unconventional sources such as oil sands (also known as tar sands) are being utilized. Oils sands contain bitumen, which can be processed into a synthetic crude oil. A region of boreal forest in Alberta, Canada, that covers a deposit of oil sands will be cut and removed during the process of bitumen extraction. It is estimated that the deposit contains 73 billion barrels of recoverable bitumen. The rate of extraction from the deposit will be approximately 1 million barrels of bitumen per day.

   (a) **Identify** one ecological benefit, other than providing habitat, that is provided by forests.

   (b) **Identify** one economic benefit that is provided by forests.

   (c) **Describe** TWO environmental consequences, other than those related to the loss of boreal forest habitat, that result from the extraction of bitumen or the transportation of synthetic oil to customers.

   (d) Assuming the above extraction rate, **calculate** how many days will be needed to extract the recoverable volume of bitumen ~~from the oil sands.~~

   (e) **Calculate** how many years will be needed to fully extract the recoverable volume of bitumen from the oil sands.

   (f) Monthly production of synthetic crude oil is 30 million barrels. Producing one barrel of synthetic crude oil uses two barrels of heated freshwater. **Calculate** the number of barrels of freshwater needed each year to supply this demand.

(a) forests are a big oxygen supply / CO_2 regulator for the environment due to plants performing photosynthesis.

(b) Wood from trees has a very large economic value when it is sold at a large scale like from a forest. Forests can provide money through tourism like hiking and ropes courses.

(c) This extraction will greatly disturb the forests' habitats. The animals living in the forest will no longer have a safe home during extraction, as trees are cut down and humans and machinary are disturbing the ecosystem. ~~Transportation~~ transportation of the synthetic oil is also horrible for the environment as the transportation trucks will contribute to air pollution.

GO ON TO THE NEXT PAGE.

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

(d) $73 \text{ billion barrels} \cdot \frac{1 \text{ day}}{1 \text{ million barrels}} \cdot \frac{10 \text{ million}}{1 \text{ billion}} = 730 \text{ days}$

It will take 730 days to extract the recoverable volume of bitumen (73 billion barrels) from the oil sands.

(e) $730 \text{ days} \cdot \frac{1 \text{ yr}}{365 \text{ days}} = 2 \text{ years}$

It will take 2 years to fully extract the recoverable volume of bitumen from the oil sands.

(f) $\frac{30 \text{ million barrels}^{CO}}{1 \text{ month}} \cdot \frac{1{,}000{,}000 \text{ barrels}^{CO}}{1 \text{ million barrel}^{CO}} \cdot \frac{2 \text{ barrels heated FW}}{1 \text{ barrel CO}} \cdot \frac{12 \text{ mo}}{1 \text{ yr}}$

$= 720{,}000{,}000$ barrels of heated freshwater

It will take 720,000,000 barrels of freshwater each year to supply the stated demand.

GO ON TO THE NEXT PAGE.

AP® ENVIRONMENTAL SCIENCE
2019 SCORING COMMENTARY

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 evaluate the benefits of forests, the consequences of extraction of bitumen and to complete several calculations relating to the extraction of bitumen and production of synthetic crude oil. Students were asked to identify an ecological benefit and an economic benefit provided by forests. These concepts were drawn from the following section of the topic outline: II. The Living World, A. Ecosystem Structure. Students were then asked to describe two environmental consequences that result from the extraction of bitumen or the transport of synthetic oil. These concepts were drawn from the following sections of the topic outline: IV. Land and Water Use, B. Forestry and VI. Pollution, A. Pollution Types.

In the second part of the question, students were asked to calculate the number of days needed to extract the recoverable volume of bitumen from oil sands based on a given extraction rate. Students were then asked to calculate how many years would be needed to fully extract the recoverable volume of bitumen from the oil sands. Finally, students were asked to calculate the number of barrels of freshwater needed to produce 30 million barrels of synthetic crude oil in a year. These concepts were drawn from the following sections of the topic outline: I. Earth Systems and Resources, C. Global Water Resources and Use and IV. Land and Water Use, E. Mining.

Sample: 2A
Score: 10

The response earned 1 point in part (a) for identifying “carbon sink” as an ecological benefit of forests. The response earned 1 point in part (b) for identifying “draw tourists” as an economic benefit of forests. The response earned 2 points in part (c): 1 point for describing that fossil fuel combustion by machinery used in extraction results in greenhouse gas production and 1 point for describing pipeline leaks that lead to contamination of groundwater as environmental consequences that result from the extraction of bitumen or the transportation of synthetic oil. The response earned 2 points in part (d): 1 point for the correct setup with units and 1 point for the correct answer. The response earned 2 points in part (e): 1 point for the correct setup with units and 1 point for the correct answer. The response earned 2 points in part (f): 1 point for the correct setup with units and 1 point for the correct answer.

Sample: 2B
Score: 8

The response earned 1 point in part (a) for identifying “carbon sink” as an ecological benefit of forests. The response earned 1 point in part (b) for identifying “resources such as lumber” as an economic benefit of forests. No points were earned in part (c). The student identifies two environmental consequences, but one is related to the loss of boreal forest habitat and one is not specific to the extraction of bitumen or the transport of synthetic oil. The response earned 2 points in part (d): 1 point for the correct setup with units and 1 point for the correct answer. The response earned 2 points in part (e): 1 point for the correct setup with units and 1 point for the correct answer. The response earned 2 points in part (f): 1 point for the correct setup with units and 1 point for the correct answer.

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2019 SCORING COMMENTARY

Question 2 (continued)

Sample: 2C
Score: 6

The response earned 1 point in part (a) for identifying "oxygen supply" as an ecological benefit of forests. The response earned 1 point in part (b) for identifying "wood … is sold" as an economic benefit of forests. No points were earned in part (c). The student identifies two environmental consequences, but one is related to the loss of boreal forest habitat and one is not specific to the extraction of bitumen or the transport of synthetic oil. No points were earned in part (d) because the student has an invalid conversion factor in the calculation setup and an incorrect answer. The response earned 2 points in part (e): 1 point for a correct setup with units using the incorrect answer from part (d) and 1 point for a correct answer from the setup the student provides. The response earned 2 points in part (f): 1 point for the correct setup with units and 1 point for the correct answer.