

**AP[®] ENVIRONMENTAL SCIENCE
2008 SCORING GUIDELINES**

Question 1

(a) Calculate the number of acres required to produce 1,000 gallons of oil in one year from

(i) microalgae

(One point is earned for the correct answer.)

$$\frac{10,000 \text{ gal}}{1 \text{ acre}} = \frac{1,000 \text{ gal}}{x \text{ acres}} \quad x = \mathbf{0.1 \text{ acre}}$$

OR

$$1 \text{ acre} = 10,000 \text{ gal}; \quad 1,000 \text{ gal} \times \frac{1 \text{ acre}}{10,000 \text{ gal}} = \mathbf{0.1 \text{ acre}}$$

(ii) soybeans

(One point is earned for the correct answer.)

$$\frac{50 \text{ gal}}{1 \text{ acre}} = \frac{1,000 \text{ gal}}{x \text{ acres}} \Rightarrow x = \mathbf{20 \text{ acres}}$$

OR

$$1 \text{ acre} = 50 \text{ gal}; \quad 1,000 \text{ gal} \times \frac{1 \text{ acre}}{50 \text{ gal}} = \mathbf{20 \text{ acres}}$$

(A third point is earned in part (a) for a correct setup of both the microalgae and soybean calculations.)

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Question 1 (continued)

(b) Describe TWO environmental advantages that biodiesel production from microalgae offers over biodiesel production from the other crops listed in the table.

(One point is earned for each correct advantage; accept only the first two advantages given. Each advantage listed must include a corresponding description.)

Advantage	Description
Less land use	<ul style="list-style-type: none"> • Less habitat destruction and/or less loss of biodiversity • Protection of watersheds from agricultural runoff
Decreased tilling of soil	<ul style="list-style-type: none"> • Less soil erosion
Decreased pesticide and/or fertilizer use	<ul style="list-style-type: none"> • Less runoff of pesticides and/or fertilizers
Decreased fossil fuel consumption for tilling soil, harvesting crops, and/or manufacturing and applying fertilizers and pesticides	<ul style="list-style-type: none"> • Less mining and drilling for fossil fuels, resulting in less habitat destruction and less loss of biodiversity • Less air pollution (e.g., NO_x, O₃)
Decreased energy consumption for extracting oils from microalgae	<ul style="list-style-type: none"> • Less mining and drilling for fossil fuels, resulting in less habitat destruction and less loss of biodiversity • Less air pollution (e.g., NO_x, O₃)
Decreased irrigation of land	<ul style="list-style-type: none"> • Less soil salinization and/or less desertification • Less aquifer depletion
Less nutrient depletion of soil	<ul style="list-style-type: none"> • Less land under cultivation
Microalgae may be grown in wastewater	<ul style="list-style-type: none"> • Less runoff and less infiltration of wastewater

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Question 1 (continued)

- (c) Explain why burning biodiesel fuel has a different impact on atmospheric CO₂ concentrations than does burning fossil fuels.**

(One point is earned for a correct explanation.)

Biodiesel contains carbon that was recently present in the atmosphere rather than fossil-fuel carbon that was in the atmosphere long ago and has been sequestered beneath Earth's surface. Hence the burning of biodiesel does not contribute to a net increase in the amount of carbon dioxide currently circulating in the atmosphere, whereas the burning of fossil fuel does contribute to a net increase in the concentration of carbon dioxide in the atmosphere.

- (d) Discuss TWO benefits, other than those related to atmospheric impacts, of increased reliance on biodiesel fuels over the next 50 years.**

(A total of 3 points can be earned according to the following guidelines.)

- No point is earned for one correct benefit with no appropriate discussion.
- One point is earned for one correct benefit with an appropriate discussion.
- One point is earned for two correct benefits with no appropriate discussion.
- Two points are earned for two correct benefits with one appropriate discussion.
- Three points are earned for two correct benefits with two appropriate discussions.
- Only the first two benefits mentioned in the response can earn points.
- Benefits based on speculation about future energy prices do not earn points.

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Question 1 (continued)

Benefit	Sample Discussion
Biofuels are renewable resources	<ul style="list-style-type: none"> • Fossil fuels are nonrenewable • Renewable resources are less likely to be exhausted
Increased jobs	<ul style="list-style-type: none"> • More labor needed in the agricultural sector
Increased profits for companies	<ul style="list-style-type: none"> • Industries in the agricultural sector will increase sales
Decreased reliance on imported fossil fuels	<ul style="list-style-type: none"> • Decreases political instability • Results in a self-sufficient supply of energy
Increased global political stability	<ul style="list-style-type: none"> • Reliance on imported fossil fuels decreases • Disputes over oil are frequently the cause of disagreements among nations
Reduced transportation costs	<ul style="list-style-type: none"> • Fewer oil spills during transport • Fossil fuels must be transported over greater distances
Reduced land disturbance	<ul style="list-style-type: none"> • Result of less fossil fuel extraction
Preservation of petroleum	<ul style="list-style-type: none"> • For nonenergy uses (e.g., plastics, petrochemicals, medical purposes)
Reduced insecurity as fossil fuel reserves decrease	<ul style="list-style-type: none"> • Enhances a shift to alternate energy sources
Reduced petroleum use	<ul style="list-style-type: none"> • Petroleum reserves will dwindle over the next 50 years
Increased nutrient capture from wastewater	<ul style="list-style-type: none"> • Less escapes into the environment • Reduced eutrophication of waterways
Increased availability of waste products	<ul style="list-style-type: none"> • Increased availability for use as animal feed or soil amendment
Decreased disposal of used cooking oil	<ul style="list-style-type: none"> • Results in less waste disposal

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Question 1 (continued)

(e) Describe TWO economic or societal problems associated with producing fuel from corn.

(One point is earned for each correct response that includes a corresponding description; only the first two responses can earn points.)

Problem	Description
Increase (or decrease) in corn prices	<ul style="list-style-type: none"> • As corn is used for energy production, the demand for corn will become greater • Increased corn growing may flood market
Increased prices for food (e.g., beef, chicken, anything made with corn syrup)	<ul style="list-style-type: none"> • Result of increased corn prices • Increased demand for corn
Increased prices for commodities other than corn	<ul style="list-style-type: none"> • Increased corn production reduces land area for other crops, reducing supply of commodities
Shortages of food for human consumption	<ul style="list-style-type: none"> • Decreased supply of corn • Decreased availability of crops displaced by corn production
Cultural extinction	<ul style="list-style-type: none"> • Rainforest destruction for the production of crops displaced by corn production displaces indigenous cultures
Decreased aesthetic value of land	<ul style="list-style-type: none"> • Natural areas converted to farmland have less aesthetic value
Loss of jobs	<ul style="list-style-type: none"> • Lower demand for energy production jobs not associated with corn (e.g., coal mining, petroleum engineering)
Energy shortages	<ul style="list-style-type: none"> • Poor crop yields resulting from drought, pestilence, etc., result in less corn to produce energy
Increased land costs	<ul style="list-style-type: none"> • Due to increased demand for agricultural lands
Decreased availability of land for nonagricultural use leading to less land for cities	<ul style="list-style-type: none"> • Due to increased demand for agricultural lands

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Question 1 (continued)

Problem	Description
Decreased availability of land for nonagricultural use leading to public opposition	<ul style="list-style-type: none"> • Due to increased demand for agricultural lands
Reduced water supply for cities	<ul style="list-style-type: none"> • Due to increased agricultural water consumption
Increased societal risks associated with exposure to agricultural chemicals	<ul style="list-style-type: none"> • Increased pesticide and fertilizer use
Higher costs to cultivate and maintain agricultural land	<ul style="list-style-type: none"> • Increased use of marginal lands to grow more corn
Overuse of agricultural land	<ul style="list-style-type: none"> • Loss of productive land
Increased taxes or unavailable public money	<ul style="list-style-type: none"> • Subsidies that divert public money to pay for corn production.
The need to convert combustion engines to burn ethanol or biodiesel	<ul style="list-style-type: none"> • Using corn for fuel will result in fuel that is not compatible with current engines
More expensive than alternatives	<ul style="list-style-type: none"> • Higher cost for resources (e.g., fertilizer, pesticides, land, water) needed to produce fuel from corn as compared with producing other fuels

- (c) Explain why burning biodiesel fuel has a different impact on atmospheric CO₂ concentrations than does burning fossil fuels.
- (d) Discuss TWO benefits, other than those related to atmospheric impacts, of increased reliance on biodiesel fuels over the next 50 years.
- (e) Describe TWO economic or societal problems associated with producing fuel from corn.

$$a) i \text{ microalgae } \frac{10,000 \text{ gal}}{1 \text{ acre}} = \frac{10,000 \text{ gal}}{1 \text{ acre}} \quad \frac{1 \text{ acre}}{10,000 \text{ gal}} = \frac{X \text{ acre}}{1000 \text{ gal}}$$

$$1 \text{ acre} \times 1000 \text{ gal} = 1 \text{ acre}$$

$$\frac{10,000 \text{ gal}}{10,000 \text{ gal}}$$

$$ii \text{ Soybeans } \frac{1 \text{ acre}}{50 \text{ gal}} = \frac{X \text{ acre}}{1000 \text{ gal}} \quad \frac{1 \text{ acre} \times 1000 \text{ gal}}{50 \text{ gal}} = 20 \text{ Acres}$$

b) Microalgae biodiesel production uses far less land than other crops. Therefore less wilderness and forest areas need to be destroyed and replaced with farmland. Also microalgae does not need as many fertilizers and pesticides to ensure substantial growth. Less chemicals and nutrients will runoff into water ecosystem, poison plants and animals and not as much cultural eutrophication will occur.

c) Biodiesel fuel still creates CO₂ when burned just as fossil fuels do. However, biodiesel fuels only release as much CO₂ as extracted from the atmosphere during photosynthesis. Fossil fuels on the other hand release CO₂ that has been stored underground for millions of years. Biodiesel does not lead to a net increase in ^{atmospheric} CO₂ levels and these levels remain constant in the atmosphere unlike when ~~burning~~ burning fossil fuels.

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ADDITIONAL PAGE FOR ANSWERING QUESTION 1

d) Increased benefits from biodiesel include less reliance on foreign countries providing essential fuel and using a renewable resource. In the current world, oil is ~~for~~ ~~or~~ extremely expensive and oil money supports instability ~~in~~ ~~and~~ in foreign countries such as Iraq or Nigeria. ~~Increased~~ Increased use of biofuels would result in less dependence on these countries. Also biofuels are renewable and society does not have to fear ~~the~~ ~~depletion~~ depletion of biofuels and an impending crisis.

e) Using biofuels can raise the prices of food due to increased demand. The poor in the world may not be able to afford the increased food prices and may resort to violence and rioting. Also biofuels can displace jobs related to fossil fuel extraction and refinement causing unemployment and economic downturn in areas such as Texas or the Middle East.

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- (c) Explain why burning biodiesel fuel has a different impact on atmospheric CO₂ concentrations than does burning fossil fuels.
- (d) Discuss TWO benefits, other than those related to atmospheric impacts, of increased reliance on biodiesel fuels over the next 50 years.
- (e) Describe TWO economic or societal problems associated with producing fuel from corn.

- a) (i) $\frac{1000}{100000} = \frac{1}{100}$ of an acre for microalgae, and
 (ii) $\frac{1000}{50} = 20$ acres for soybeans.
- (b) Microalgae requires the least amount of land, thus the least amount of land disruption, and it removes CO₂ from coal-burning power plants.
- (c) Burned biodiesel fuel release CO₂ that will be absorbed by the plant grown to make it. Fossil fuel never recapture the CO₂ once released.
- (d) ~~Almost~~ Almost all of ~~of~~ the microalgae is used up when grown for ~~of~~ biodiesel, such as: the oil is used for heating, electricity generation, and various fuels, and ~~the~~ remaining can be used for feed or fertilizer. Reliance on biodiesel would also decrease use of fossil fuels.
- (e) Fuel from corn has lead to an increase in Corn crops, decreasing other crops. This has lead to a price increase on foods other than corn and in cotton goods. Also we are becoming dependant on corn, and it is dangerous because disease could strike and kill most corn crops.

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- (c) Explain why burning biodiesel fuel has a different impact on atmospheric CO₂ concentrations than does burning fossil fuels.
- (d) Discuss TWO benefits, other than those related to atmospheric impacts, of increased reliance on biodiesel fuels over the next 50 years.
- (e) Describe TWO economic or societal problems associated with producing fuel from corn.

(a) i - microalgae - ~~microalgae~~

10,000

- 1,000

1.1 acres per year

ii - soybeans

1,000

= 50

200 acres per year

(b) Biodiesel production can be used to produce electricity. Biodiesel can also be ~~be~~ used to heat places.

(c) Burning biodiesel has a different impact on atmospheric CO₂ than does burning fossil fuels because it is more energy efficient, it does not give off emissions that destroy the ozone layer.

(d) Biodiesel is produced by microalgae which produces more gallons of oil per acre per year out of any other. Biodiesel is ~~more~~ easier to get because there is more of it.

(e) Producing fuel from corn provides less corn for people to actually harvest to eat. ~~more~~ Producing fuel from corn is also very

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expensive compared to other ways to produce fuel.

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AP[®] ENVIRONMENTAL SCIENCE

2008 SCORING COMMENTARY

Question 1

Overview

This was the document-based question. After reading a newspaper article, students were asked a series of questions related to the subject of the article, biodiesel fuel. The questions required students to demonstrate knowledge of alternative energy sources, the carbon cycle, and the issues surrounding the use of food products to produce energy.

Sample: I-1A

Score: 10

Part (a): 3 points were earned. The student earned 1 point in part (a)(i) and 1 point in part (a)(ii) for correctly answering that .1 acre and 20 acres of land would be required to produce 1,000 gallons of oil in one year from microalgae and soybeans, respectively. The student earned 1 point for correctly showing how to arrive at the answers to both parts (a)(i) and (a)(ii).

Part (b): 2 points were earned. The student describes two environmental advantages of using microalgae over the other crops listed in the document. The first correct description is “uses far less land,” resulting in “less wilderness and forest areas . . . destroyed.” The second correct description is that using “microalgae does not need as many fertilizers,” resulting in less “runoff.”

Part (c): The student earned 1 point for correctly explaining that biodiesel fuel releases the CO₂ that it “extracted . . . during photosynthesis,” while fossil fuels “release CO₂ that has been stored underground for millions of years.”

Part (d): 2 points were earned. The student earned 1 point for discussing one nonatmospheric benefit of increased use of biodiesel fuels over the next 50 years: “less reliance on foreign countries” for fuel, linked with “instability in foreign countries.” The second correct benefit the student identifies but does not discuss is that “biofuels are renewable.”

Part (e): 2 points were earned. The student describes two economic or social problems associated with producing fuel from corn. The first correct description is that “increased demand” can “raise the prices of food.” The second correct description is that using “biofuels can displace jobs related to fossil fuel extraction and refinement.”

Sample: I-1B

Score: 5

Part (a): 3 points were earned. The student earned 1 point in part (a)(i) and 1 point in part (a)(ii) for correctly answering that 1/10 acre and 20 acres of land would be required to produce 1,000 gallons of oil in one year from microalgae and soybeans, respectively. The student earned 1 point for correctly showing how to arrive at the answers to both parts (a)(i) and (a)(ii).

Part (b): No points were earned. The student does not describe an environmental advantage of using microalgae over the other crops listed in the document. The description of the first advantage, less land use, is too vague as “the least amount of land disruption” may not be an environmental advantage. The second advantage, removal of “CO₂ from coal-burning power plants,” is not described.

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Question 1 (continued)

Part (c): The student earned 1 point for the correct explanation that “the plant grown to make” biodiesel fuel “absorbed” the CO₂ that is released when it is burned, while CO₂ released by fossil fuels is not “recapture[d].”

Part (d): No points were earned. The student does not discuss a nonatmospheric benefit of increased use of biodiesel fuels over the next 50 years. The first of the two proposed benefits is not adequate, and the second benefit is not discussed.

Part (e): The student earned 1 point for the correct description of one economic or social problem associated with producing fuel from corn: “an increase in corn crops, decreasing other crops,” leads to “a price increase on foods other than corn and in cotton.”

Sample: I-1C

Score: 2

Part (a): 2 points were earned. The student earned 1 point in part (a)(i) for correctly answering that .1 acre of land would be required to produce 1,000 gallons of oil in one year from microalgae. The student did not earn any points in part (a)(ii) because the answer—that 200 acres of land would be required to produce 1,000 gallons of oil in one year from soybeans—is incorrect. The student earned 1 point in part (a) for showing how to correctly arrive at the answers to both parts (a)(i) and (a)(ii).

Part (b): No points were earned.

Part (c): No points were earned.

Part (d): No points were earned.

Part (e): No points were earned. The student mentions that “[p]roducing fuel from corn provides less corn . . . to eat” but does not describe an associated societal problem (such as hunger, malnutrition, or social unrest).