

**AP<sup>®</sup> ENVIRONMENTAL SCIENCE  
2014 SCORING GUIDELINES**

**Question 4**

**(a) The atmosphere is one important carbon reservoir.**

**(i) Describe a biological process by which carbon is removed from the atmosphere and converted to organic molecules.**

*(1 point for a correct description, with or without an equation: A student can earn the point even without explicitly identifying the process as photosynthesis if an accurate description is provided. No point is earned for naming photosynthesis without a description)*

*Example:*

Photosynthesis: the process by which plants/autotrophs take in carbon dioxide from the atmosphere and convert it into food/glucose/sugar/complex carbohydrates; plants/autotrophs fix carbon into food/glucose/sugar/complex carbohydrates.

**(ii) Describe a biological process by which carbon is converted from organic molecules to a gas and returned to the atmosphere.**

*(1 point for a correct description: A student can earn the point even without explicitly identifying the process if an accurate description is provided. No point is earned for listing a word as an answer; the answer must identify the form of carbon being released into the atmosphere as part of the description)*

- Respiration breaks down food/glucose/sugar/complex carbohydrates and releases CO<sub>2</sub> into the atmosphere
- Animals digest food and produce gases such as methane that can be emitted either through belching or flatulence
- Decomposition of organic material by bacteria or fungi converts organic carbon into gases such as methane

**(b) Oceans and terrestrial systems are also important carbon reservoirs.**

**(i) Explain how atmospheric carbon is incorporated into two oceanic sinks.**

*(2 points: 1 point for each correct description of carbon incorporation into an oceanic sink. Only the first two descriptions can earn points)*

- Carbon (CO<sub>2</sub>) can be taken up by organisms like phytoplankton for photosynthesis
- Carbon can be taken up by marine organisms and used for shells, skeletons, coral, etc.
- Biological pump (organisms in the upper ocean sink to the bottom of the ocean)
- Atmospheric CO<sub>2</sub> can dissolve directly into ocean water **OR** atmospheric CO<sub>2</sub> can dissolve into precipitation and ultimately reach the ocean
- Carbon can react with other elements/compounds and form carbonates/limestone/sedimentary rocks (just “rocks” is too vague to earn a point)

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**Question 4 (continued)**

**(ii) Identify one terrestrial sink, other than fossil fuels, that stores carbon for thousands to millions of years.**

*(1 point for the correct identification of a long-term terrestrial sink of carbon)*

- Old growth forests/trees that live for thousands of years (just “forests” does not earn credit)
- Trapped/incorporated into ice caps/glaciers
- Limestone or sedimentary rocks
- Incorporation into soil
- Freshwater wetlands/bogs
- Peat formation/burial of plant material under anaerobic conditions
- Dissolved in aquifers

**(c) The burning of fossil fuels has been shown to increase the concentration of carbon in the atmosphere. Discuss TWO other human activities that increase the concentration of carbon in the atmosphere.**

*(2 points: 1 point for each accurate discussion of a human activity that increases atmospheric carbon compounds NOT related to burning fossil fuels)*

- Deforestation—cutting down trees reduces the reservoirs for carbon **OR** cutting down trees can result in carbon being released back into the atmosphere through the process of decay/decomposition
- Biomass burning releases carbon (CO, CO<sub>2</sub>, carbon particulates)
- Trash/waste incineration can release carbon (CO<sub>2</sub>, CO, carbon particulates)
- Slash and burn agricultural practices—burning organic matter releases carbon (CO<sub>2</sub>, CO, carbon particulates)
- Deep plowing or strip mining disrupts soil and releases carbon (CO<sub>2</sub>)
- Humans make landfills that can produce carbon-containing carbon-based gases (mainly methane)
- Raising cows and/or other ruminant animals releases carbon-containing gases (methane)
- Manufacture and use of CFCs/HFCs/other carbon-containing compounds releases carbon
- Destruction of wetlands (releases CO<sub>2</sub>/removes sink for CO<sub>2</sub>)
- Production of cement releases CO<sub>2</sub>

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**Question 4 (continued)**

**(d) Identify an environmental problem that results from elevated atmospheric carbon concentrations. Discuss one consequence of the problem you identified.**

*(2 points: 1 point for identification of a specific environmental problem associated with elevated atmospheric carbon and 1 point for discussion of a consequence of the identified problem)*

(Note: The discussion of a consequence must be connected to the stated environmental problem and must be connected to the environment. Examples of environmental problems and consequences are shown in the table below.)

Environmental problem	Environmental Consequence
Global climate change/global warming/increased global temperatures	<ul style="list-style-type: none"> <li>• some species of plants and/or animals will not be able to survive temperature changes</li> <li>• climate zones will shift so some species may not be able to adapt</li> <li>• sea level rise which will flood habitats</li> </ul>
Sea level rise	<ul style="list-style-type: none"> <li>• coastal habitats will be flooded</li> </ul>
Ice caps/glaciers melting	<ul style="list-style-type: none"> <li>• flooding and habitat loss</li> </ul>
Ocean acidification	<ul style="list-style-type: none"> <li>• shells of marine organisms may dissolve</li> <li>• lower pH may be below the tolerance level of some species</li> </ul>
Reduction in air quality due to (for example) increased CO in the atmosphere	<ul style="list-style-type: none"> <li>• hazardous to animals breathing it in</li> </ul>

**(e) Phosphorus is another element important to all organisms.**

**(i) Describe one major way in which the phosphorus cycle differs from the carbon cycle.**

*(1 point for a correct description of a difference between the phosphorus and carbon cycles)*

- Phosphorus cycle does not typically have a gas/atmospheric phase
- It is more difficult for living organisms to access phosphorus since it has to be weathered from rocks and minerals (phosphorus cycle is much “slower” than the carbon cycle; phosphorus has fewer sinks than carbon)

**(ii) Identify one reason that phosphorus is necessary for organisms.**

*(1 point for a correct reason that phosphorus is necessary for organisms)*

- Phosphorus is a component of nucleotides/ATP in cells
- It is necessary for the formation of DNA and RNA
- Phospholipids are a major component of all cell membranes
- Phosphorus is found in/gives strength to the bones and/or enamel of teeth in mammals

4. Biogeochemical cycles describe the movement of certain elements (typically bound with other elements in compounds) through Earth's atmosphere, hydrosphere, biosphere, and lithosphere. These elements and their compounds are necessary components of all life, and because they cycle, they can be used repeatedly by new generations of organisms. Each biogeochemical cycle has different pathways with various reservoirs (sources and sinks) where elements may reside for days or millions of years.
- (a) The atmosphere is one important carbon reservoir.
- Describe** a biological process by which carbon is removed from the atmosphere and converted to organic molecules.
  - Describe** a biological process by which carbon is converted from organic molecules to a gas and returned to the atmosphere.
- (b) Oceans and terrestrial systems are also important carbon reservoirs.
- Explain** how atmospheric carbon is incorporated into two oceanic sinks.
  - Identify** one terrestrial sink, other than fossil fuels, that stores carbon for thousands to millions of years.
- (c) The burning of fossil fuels has been shown to increase the concentration of carbon in the atmosphere. **Discuss** TWO other human activities that increase the concentration of carbon in the atmosphere.
- (d) **Identify** an environmental problem that results from elevated atmospheric carbon concentrations. **Discuss** one consequence of the problem you identified.
- (e) Phosphorus is another element important to all organisms.
- Describe** one major way in which the phosphorus cycle differs from the carbon cycle.
  - Identify** one reason that phosphorus is necessary for organisms.

a.) • During photosynthesis plants remove atmospheric carbon in the form of  $\text{CO}_2$  and convert it to sugar releasing  $\text{O}_2$ . During cellular respiration sugar is converted back into  $\text{CO}_2$  and released into the atmosphere.

b.) Some organic molecules containing carbon sink deep to the ocean floor and can sit there for many years. Also,  $\text{CO}_2$  can dissolve in water and stay in the depths of the ocean for many years. Swamps with a lot of decaying organic material can store carbon for many years.

c.) Burning forests releases stored carbon into the atmosphere and also prevents them from storing more carbon in the future.

Also, destroying swamps and marshes releases a lot of stored carbon into the atmosphere.

d.) Extra atmospheric carbon creates carbonic acid which forms from mixing  $CO_2$  with water. Extra carbonic acid makes rain more acidic which can cause oceans to become more acidic. Ocean acidification is very harmful to coral reefs which are important areas of species diversity.

e.) The phosphorous cycle is different from the carbon cycle because phosphorous does not have a gas form so it doesn't enter the atmosphere. Phosphorous is necessary in building bones and muscles.

4. Biogeochemical cycles describe the movement of certain elements (typically bound with other elements in compounds) through Earth's atmosphere, hydrosphere, biosphere, and lithosphere. These elements and their compounds are necessary components of all life, and because they cycle, they can be used repeatedly by new generations of organisms. Each biogeochemical cycle has different pathways with various reservoirs (sources and sinks) where elements may reside for days or millions of years.

(a) The atmosphere is one important carbon reservoir.  
(i) Describe a biological process by which carbon is removed from the atmosphere and converted to organic molecules.

(ii) Describe a biological process by which carbon is converted from organic molecules to a gas and returned to the atmosphere. *sulfur cycle*

(b) Oceans and terrestrial systems are also important carbon reservoirs.

(i) Explain how atmospheric carbon is incorporated into two oceanic sinks.

*dissolved CO<sub>2</sub> absorbed by ocean.*

(ii) Identify one terrestrial sink, other than fossil fuels, that stores carbon for thousands to millions of years.

*ocean, or forests; plants.*

(c) The burning of fossil fuels has been shown to increase the concentration of carbon in the atmosphere.

Discuss TWO other human activities that increase the concentration of carbon in the atmosphere. *Deforestation!*

(d) Identify an environmental problem that results from elevated atmospheric carbon concentrations.

Discuss one consequence of the problem you identified. *Global warming rising sea levels due to melting cont. ice.*

(e) Phosphorus is another element important to all organisms.

(i) Describe one major way in which the phosphorus cycle differs from the carbon cycle.

(ii) Identify one reason that phosphorus is necessary for organisms. *No atmospheric component. Necessary for plant growth.*

a) i) photosynthesis is when plants absorb carbon dioxide from the atmosphere and, with sunlight and water, convert it to the organic molecule of glucose along with oxygen.

ii) Respiration is a process, especially in animals, which takes the oxygen and glucose <sup>organic compound</sup> from plants and converts it into carbon dioxide, which, through exhalation, is released into the atmosphere.

b) i) Oceanic carbon is stored in the ocean either through decayed organisms turned into fossil fuels <sup>with time</sup> and buried under the ocean floor, or it is absorbed in the form of <sup>dissolved</sup> CO<sub>2</sub> by the ocean itself.

ii) plants can store carbon <sup>as</sup> biomass; for instance,

## ADDITIONAL PAGE FOR ANSWERING QUESTION 4

trees, which can survive for thousands of years, store carbon through the process of photosynthesis, and in the form of carbon dioxide ( $\text{CO}_2$ ).

d) Increased atmospheric carbon concentrations can lead to global warming through the greenhouse effect; this problem could have consequences such as a rise in sea level. Global warming and increased carbon ~~levels~~ would lead to a rise in global temperature, which ~~will~~ would lead to a melting of continental ice and a rise in sea level.

e) i) The phosphorus cycle has no atmospheric component like the carbon cycle does. It isn't stored in the atmosphere.

ii) Phosphorus is necessary for organisms as it is vital for plant growth. Along with nitrogen in the form of nitrates, phosphorus is needed as phosphates for plants in order to grow and survive. The plants depend on the phosphorus as do any organisms that consume plants.

c) Deforestation leads to an increase of carbon ~~in~~ in the atmosphere, as there are less trees to convert the and absorb the carbon dioxide, so more is left in the atmosphere. ~~With the growth in human population, more humans~~ ~~living~~ also releases carbon into the atmosphere, especially when

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In tundra and permafrost, where carbons often stored, when exposed, it is released to the atmosphere.

As the human population grows, so does the amount of carbon dioxide released into the atmosphere through respiration, a process which converts the oxygen humans breath into carbon dioxide.

STOP

END OF EXAM

THE FOLLOWING INSTRUCTIONS APPLY TO THE COVERS OF THE SECTION II BOOKLET.

- MAKE SURE YOU HAVE COMPLETED THE IDENTIFICATION INFORMATION AS REQUESTED ON THE FRONT AND BACK COVERS OF THE SECTION II BOOKLET.
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- a) A biological process in which carbon is removed from the atmosphere and converted to organic molecules would be ~~the~~ photosynthesis. When plants undergo photosynthesis it takes Carbon Dioxide from the air and releases oxygen back into the air. The formula for photosynthesis is  $6\text{CO}_2 + 6\text{H}_2\text{O} \xrightarrow{\text{light}} \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$ . This formula shows the input of water and  $\text{CO}_2$  & the output of glucose &  $\text{O}_2$ . glucose being the organic molecule
- a) A biological process in which carbon is converted from organic molecules to a gas is cellular respiration. Mammals such as humans undergo cellular respiration, we breath in oxygen in the air and release Carbon Dioxide as the waste product back into the air. The formula for cellular respiration is  $\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O}$ . This formula shows the organic molecule Glucose and oxygen as the input and Carbon Dioxide and water as the output.
- b) Oceans can store atmospheric gases like carbon deep in the ocean because the ocean ~~is~~ becomes colder ~~as~~ the further down you go. This makes the water molecules more tightly packed trapping the carbon molecules in it.
- b) A terrestrial sink would be burying the carbon deep underground and trapping it there.
- c) ~~The ~~is~~ burning of forest increases the amount of carbon in the atmosphere and ~~the~~ deforestation ~~increases~~ increases the ~~amount~~ amount of atmospheric carbon by decreasing the amount of plants~~

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available to take carbon dioxide from the air. The second human activity is industrial plants adding more greenhouse gases to the air because it is causing the ocean to warm which releases the trapped  $\text{CO}_2$  into the air.

d) The increase in  $\text{CO}_2$  heats up the earth and melts the frozen land ice. This causes the sea level to rise. The rise in sea level causes a heat island effect that will melt more ice and destroy habitats of the organisms that live there.

e) The major way the phosphorus cycle differs from the carbon cycle is the phosphorus cycle never goes into the atmosphere.

f) Phosphorus is necessary for organisms because phosphorus is used in ATP and in the phospholipid bilayer of our cells and the sugar-phosphate backbone of DNA.

STOP

END OF EXAM

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# AP<sup>®</sup> ENVIRONMENTAL SCIENCE 2014 SCORING COMMENTARY

## Question 4

### Overview

This question was intended to determine students' understanding of biogeochemical cycles. In particular, the question focused on the carbon cycle and students' ability to identify terrestrial and oceanic sources, sinks, and reservoirs of carbon, as well as the form of carbon in these reservoirs and the processes that move carbon from one reservoir to another. The last part of the question focused on the phosphorus cycle.

### Sample: 4A

**Score: 10**

Two points were earned in part (a): 1 point in (a)(i) for "plants remove ... and convert it to sugar" and 1 point in (a)(ii) for "during respiration sugar is converted back into CO<sub>2</sub> and released into the atmosphere." Three points were earned in part (b): 2 points in (b)(i) for "organic molecules containing carbon sink deep to the ocean floor and can sit there for many years" and for "CO<sub>2</sub> can dissolve in water"; and 1 point in (b)(ii) for "swamps with decaying organic material can store carbon for many years." Two points were earned in part (c): 1 point for "burning forests releases stored carbon into the atmosphere" and 1 point for "also prevents them from storing more carbon in the future." Two points were earned in part (d): 1 point for the problem of "extra carbonic acid makes rain more acidic which can cause oceans to become more acidic" and 1 point for "ocean acidification is very harmful to coral reefs." One point was earned in (e)(i) for "phosphorus does not have a gas form." A point could have been earned in (e)(ii) for "phosphorus is necessary in building bones" but the maximum score on the question is 10.

### Sample: 4B

**Score: 8**

Two points were earned in part (a): 1 point in (a)(i) for "plants absorb carbon dioxide from the atmosphere ... convert it to the organic molecule of glucose" and 1 point in (a)(ii) for "animals which takes oxygen and glucose ... and converts it into carbon dioxide." Three points were earned in part (b): 2 points in (b)(i) for "decayed organisms ... buried under the ocean floor" and for "absorbed in the form of dissolved CO<sub>2</sub> by the ocean itself"; and 1 point in (b)(ii) for "trees which can survive for thousands of years." One point was earned in (c) for "deforestation ... there are less trees to ... absorb the carbon dioxide so more is left in the atmosphere." One point was earned in (d) for "increased atmospheric carbon concentrations can lead to global warming." One point was earned in (e)(i) for "no atmospheric component"; no point was earned in (e)(ii).

### Sample: 4C

**Score: 6**

Two points were earned in part (a): 1 point in (a)(i) for an equation showing the chemical process of photosynthesis and 1 point in (a)(ii) for "cellular respiration ... the organic molecule glucose as the input and carbon dioxide as the output." No points were earned in (b)(i); no point was earned in (b)(ii) because "burying the carbon" is too general. One point was earned in (c) for "deforestation ... decreasing the amount of plants available to take carbon dioxide from the air." One point was earned in (d) for "heats up the earth." No point was earned for "destroy habitats of organisms that live there" because of the incorrect statement linking sea level rise with the heat island effect. Two points were earned in (e): 1 point in (e)(i) for "phosphorus cycle never goes into the atmosphere" and 1 point in (e)(ii) for "phosphorus is used in ATP."