

## Question 2: Analyze an Environmental Problem and Propose a Solution

10 points

|          |                                                                                                                                                                                                                                                                                                                                                                                       |                 |
|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| <b>A</b> | <b>Identify</b> the sea surface condition for the eastern equatorial area of the Pacific Ocean illustrated in Figure 1.                                                                                                                                                                                                                                                               | <b>Point 01</b> |
|          | Acceptable identification point: <ul style="list-style-type: none"> <li>(Ocean water) cooler than average</li> </ul>                                                                                                                                                                                                                                                                  |                 |
| <b>B</b> | Based on the information in Figure 1, <b>identify</b> the climate phenomenon associated with the sea surface conditions shown in the equatorial area of the Pacific Ocean.                                                                                                                                                                                                            | <b>Point 02</b> |
|          | Acceptable identification point: <ul style="list-style-type: none"> <li>La Niña</li> </ul>                                                                                                                                                                                                                                                                                            |                 |
| <b>C</b> | Based on the information in Figure 2, <b>describe</b> a difference in climate patterns between the regions A and B.                                                                                                                                                                                                                                                                   | <b>Point 03</b> |
|          | Examples of acceptable responses may include the following: <ul style="list-style-type: none"> <li>Region A has an increased chance of precipitation, while Region B has a decreased chance of precipitation.</li> <li>Region A will be wetter, while Region B will be drier.</li> </ul>                                                                                              |                 |
| <b>D</b> | <b>Describe</b> one reason why there is an increased risk of flooding in urban areas during extended periods of precipitation.                                                                                                                                                                                                                                                        | <b>Point 04</b> |
|          | Examples of acceptable responses may include the following: <ul style="list-style-type: none"> <li>Impervious/paved surfaces increase runoff/reduce infiltration/reduce absorption.</li> <li>Parking lots/roads/buildings/sidewalks increase runoff/reduce infiltration/reduce absorption.</li> <li>There is less vegetation and, therefore, less infiltration/absorption.</li> </ul> |                 |
| <b>E</b> | <b>Propose</b> a realistic solution a city could implement to decrease the risk of flooding in urban areas.                                                                                                                                                                                                                                                                           | <b>Point 05</b> |
|          | Examples of acceptable responses may include the following: <ul style="list-style-type: none"> <li>Use permeable pavement</li> <li>Plant vegetation/establish parks/create rain gardens/build green roofs</li> <li>Install retention ponds/stormwater basins</li> </ul>                                                                                                               |                 |

- F** **Justify** the solution proposed in part E by providing an additional advantage other than a reduction in the risk of flooding. **Point 06**

Examples of acceptable responses may include the following:

| Solution from part E                                                   | Justification of solution with additional advantages                                                                                                                                                                                                                                                                                                                                                               |
|------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Use permeable pavement                                                 | <ul style="list-style-type: none"> <li>Increased recharge of nearby aquifers/groundwater</li> <li>Decreased pollution in runoff</li> </ul>                                                                                                                                                                                                                                                                         |
| Plant vegetation/establish parks/create rain gardens/build green roofs | <ul style="list-style-type: none"> <li>Vegetation absorbs pollutants</li> <li>Vegetation stores carbon dioxide/produces oxygen</li> <li>Decreased erosion</li> <li>Increased/restored habitat for wildlife</li> <li>Increased biodiversity</li> <li>Helps reduce urban heat island effect</li> <li>Aesthetic enjoyment/improved quality of life</li> <li>Creates jobs (in landscaping/park maintenance)</li> </ul> |
| Install retention ponds/stormwater basins                              | <ul style="list-style-type: none"> <li>Decreased pollution in runoff</li> <li>Increased habitat/biodiversity</li> </ul>                                                                                                                                                                                                                                                                                            |

- G** **Describe** one difference between the climate of a temperate seasonal forest and that of a savanna. **Point 07**

Examples of acceptable responses may include the following:

- Temperate seasonal forests have a cooler climate than a savanna.
- Temperate seasonal forests have a stronger/colder winter than a savanna.
- Temperate seasonal forests have four distinct seasons while savannas do not.
- Temperate seasonal forests receive more annual precipitation than savannas.
- Temperate forests receive precipitation throughout the year while savannas have a rainy season/dry season.

- H** **Identify** the ecological process that occurs following a forest fire that leaves the soil intact. **Point 08**

Acceptable identification point:

- Secondary succession

**I** **Describe** one way burning forests contribute to atmospheric pollution. **Point 09**

Acceptable description point:

- Burning of trees releases CO<sub>2</sub>/CO/NO<sub>x</sub>/particulate matter/VOCs.

**J** **Describe** one sustainable forestry practice that could be used to reduce the occurrence or severity of forest fires. **Point 10**

Examples of acceptable responses may include the following:

- Prescribed burns can remove excess fuel/dead leaves/underbrush.
- Brush removal can remove excess fuel/dead leaves/underbrush.
- Selective cutting can create a fire break.
- In agroforestry, ground crops that might otherwise be fuel can be harvested/removed.

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

**10 points**

**(a)** **Identify** a typical type of plant that would be used in a desert-tolerant landscaping. **1 point**

Accept one of the following:

- Cactus/cacti
- Succulent plants
- Drought-tolerant plants

**(b)** **Justify** the removal of landscaping and lawns that use grasses not native to the local area by describing an additional advantage, other than reducing the amount of water needed for irrigation. **1 point**

Accept one of the following:

- Native desert plants support habitat/provide food for local/native wildlife.
- Less mowing leads to decreased yard maintenance time/costs.
- Desert tolerant plants need less fertilizer/pesticide.
- Creates jobs for landscapers to remove/replace turf.
- Decreased use of gas-powered yard tools reduces air pollution/noise pollution/gasoline consumption.

**(c)** **Describe** how a prescribed burn would reduce the severity and spread of forest fires. **1 point**

Accept one of the following:

- Prescribed burns/they remove undergrowth, decreasing fuel/flammable material.
- Prescribed burns/they thin forests/create a fire break, reducing the spread of fires.

**(d)** **Describe** a disadvantage of a prescribed burn in a forested ecosystem. **1 point**

Accept one of the following:

- Reduces habitat for wildlife/can harm or displace animals.
- Releases carbon dioxide, which contributes to climate change.
- Releases particulates/air pollutants, which worsens air quality.
- Runoff following a prescribed burn can degrade water quality.
- Reduces competition, which helps invasive species spread/expand.

|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                    |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|
| (e) | <p><b>Calculate</b> the number of million acre-feet (maf) of water currently in Lake Powell. <b>Show</b> your work.</p> <p>One point for the correct setup to calculate number of million acre-feet (maf) of water currently in the lake:</p> <p>Accept one of the following:</p> <ul style="list-style-type: none"> <li>• <math>25.16 \text{ maf} \times 36\%</math></li> <li>• <math>25.16 \times 0.36</math></li> </ul> <p>One point for the correct calculation of the number of million acre-feet (maf) of water currently in the lake:</p> <p>Accept one of the following:</p> <ul style="list-style-type: none"> <li>• 9.0576</li> <li>• 9.058</li> <li>• 9.06</li> <li>• 9.1</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>1 point</b>                     |
|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>Total for part (e) 2 points</b> |
|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                    |
| (f) | <p>The watershed of the Upper Colorado River contributes an average of 9.60 maf of water to Lake Powell annually. The melted mountain snow found in the watershed contributes 50% of the average river flow into Lake Powell. In 2021, the river flow was 36% of the annual average. Assuming that all resources to that flow contributed with the same proportions as in prior years, <b>calculate</b> the amount of water (in million acre-feet) that was contributed by the melted mountain snow in 2021. <b>Show</b> your work.</p> <p>One point for the correct setup to calculate amount of water in million acre-feet that was contributed by the melted mountain snow:</p> <p>Accept one of the following:</p> <ul style="list-style-type: none"> <li>• <math>9.60 \text{ maf} \times 36\% \times 50\%</math></li> <li>• <math>9.60 \text{ maf} \times 0.36 \times 0.5</math></li> <li>• <math>9.60 \times 0.36 \times 0.5</math></li> </ul> <p>One point for the correct calculation of the amount of water in million acre-feet:</p> <p>Accept one of the following:</p> <ul style="list-style-type: none"> <li>• 1.728</li> <li>• 1.73</li> <li>• 1.7</li> </ul> | <b>1 point</b>                     |
|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <b>Total for part (f) 2 points</b> |

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|-----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|
| (g) | <p>The average household in the United States consumes <math>5.0 \times 10^4</math> gallons of water in a year. <b>Calculate</b> the number of households that could be supported for one year by the average flow of 9.60 maf of water into Lake Powell. <b>Show</b> your work.</p> <p>One point for the correct setup to calculate the number of households that could be supported for one year by the average watershed flow:</p> <p>Accept one of the following:</p> <ul style="list-style-type: none"> <li>• <math>9.60 \text{ maf} \times \frac{3.26 \times 10^{11} \text{ gallons}}{1 \text{ maf}} \times \frac{1 \text{ household}}{5.0 \times 10^4 \text{ gallons}}</math></li> <li>• <math>9.60 \text{ maf} \times \frac{3.26 \times 10^{11} \text{ gallons}}{5.0 \times 10^4 \text{ gallons}}</math></li> <li>• <math>9.60 \times \frac{3.26 \times 10^{11}}{5.0 \times 10^4}</math></li> </ul> <p>One point for the correct calculation of the number of households:</p> <p>Accept one of the following:</p> <ul style="list-style-type: none"> <li>• 62,592,000</li> <li>• <math>6.2592 \times 10^7</math></li> </ul> | <b>1 point</b>                        |
|     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | <b>Total for part (g) 2 points</b>    |
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2019

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## Scoring Guidelines

## 2019 SCORING GUIDELINES

## Question 1

(a) Use the maps provided to answer the following questions.

(i) **Identify** the preferred nesting habitat for piping plovers.

(1 point for the correct identification of a preferred nesting habitat for piping plovers)

- Unvegetated sand
- Sandy areas/open sandy beaches
- Washovers

(ii) **Describe** the change in the number of piping plover nests in Assateague Island between 1999 and 2009.

(1 point for the correct description of the change in the number of piping plover nests)

- The number of nests decreased by almost half (43%).
- The number of nests decreased from 44 to 25.
- There were 19 more nests in 1999 than in 2009.

(iii) **Describe** one likely reason for the change in the number of piping plover nests between 1999 and 2009.

(1 point for the correct description of a likely reason for the change in the number of piping plover nests)

- The preferred habitat was reduced because of a decrease in unvegetated sandy areas.
- The preferred habitat was reduced because of an increase in the amount of vegetation/revegetation.

(b) Coastal species are affected by more than just natural events.

(i) Special beach restrictions can help piping plovers during nesting season. **Describe** one restriction that could reasonably be implemented to help prevent the destruction of plover nests by human actions.

(1 point for the correct description of a restriction that could reasonably be implemented to help prevent the destruction of plover nests by human activity)

- Post warning signs/fencing/barrier tape/boardwalks around the nesting area.
- Place wire enclosures/other barriers over active nests.
- Limit specified recreational activity on beaches with plover nests (prohibit kite flying, fireworks, etc.).
- Implement motor vehicle restrictions (limit times, size of vehicles, raking, etc.).
- Require pets to remain indoors or on leashes.

## 2019 SCORING GUIDELINES

## Question 1 (continued)

(ii) In addition to providing habitat for piping plovers, barrier islands (and closely related landforms) are important for other reasons. **Explain** one way that these features help to preserve and protect the environment in coastal regions.

(1 point for the correct explanation of one way that features of barrier islands help to preserve and protect the environment in coastal regions)

- They block/buffer the wind and/or waves, which mitigate beach erosion.
- They reduce storm surge, which protect the interior coastline from flooding.
- They block/buffer the waves and create wetland ecosystems/pools, which serve as habitat for a variety of species (fish, turtles, migratory birds, etc.).
- They trap sediments/pollutants in wetland habitats/marsh grasses, which filter the water.

(iii) **Identify** one human action that directly threatens coastal habitats and **describe** one impact on species, other than the piping plover, that use the habitat.

(2 points; 1 point for the correct identification of a human action that directly threatens coastal habitats and 1 point for the correct description of the impact of human activity on species that use the habitat)

| Identify one human action that directly threatens coastal habitats | Describe one impact on species that use the habitat                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|--------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Tourism/Recreation                                                 | <ul style="list-style-type: none"> <li>• Beachgoers accidentally step on or crush nests of species on the beach.</li> <li>• Unleashed pets on beaches may cause stress and/or disrupt nesting, survival, etc. of coastal species.</li> <li>• Vehicles on beach can disrupt nesting, survival, etc. of coastal species habitat.</li> <li>• Beachgoers leave food/garbage that attracts predators/harbors pathogens of coastal species.</li> <li>• Sunscreen washes off and can be toxic to coral or other coastal marine organisms.</li> </ul> |
| Coastal Development                                                | <ul style="list-style-type: none"> <li>• Development (commercial, residential, recreational) can lead to the loss of suitable habitats of coastal species.</li> <li>• Development near beach may increase noise pollution or light pollution, which disrupts nesting/migration/survival of coastal species.</li> <li>• Development near beach may provide food/garbage that attracts predators/harbors pathogens of coastal species.</li> </ul>                                                                                               |
| Littering/Solid Waste Disposal                                     | <ul style="list-style-type: none"> <li>• Coastal species get tangled up in trash (plastic) on the beach or in coastal water.</li> <li>• Coastal species ingest trash, which fills or blocks respiratory/digestive tract.</li> </ul>                                                                                                                                                                                                                                                                                                           |
| Offshore Oil Drilling                                              | <ul style="list-style-type: none"> <li>• Spilled oil coats coastal marine organisms, impacting survival.</li> <li>• Spilled oil can be toxic if ingested by coastal marine species.</li> </ul>                                                                                                                                                                                                                                                                                                                                                |
| Commercial Fishing                                                 | <ul style="list-style-type: none"> <li>• Dredging or trawling can destroy coral/habitat for bottom-dwelling organisms.</li> <li>• Overharvesting can dramatically decrease coastal populations of fish or shellfish.</li> <li>• Coastal species can unintentionally get trapped in fishing gear.</li> </ul>                                                                                                                                                                                                                                   |

## 2019 SCORING GUIDELINES

## Question 1 (continued)

(c) **Identify** one economic impact on coastal communities that has resulted from rising sea levels.

(1 point for the correct identification of one economic impact on coastal communities that has resulted from rising sea levels)

- Decrease of tourist revenue
- Decrease of property value
- Increase in damage to property, land, or infrastructure requiring repair or replacement
- Increase in insurance costs
- Loss of agricultural land or aquaculture operations resulting in financial loss
- Loss of fish nurseries in wetland areas leading to less revenue for commercial fisheries
- Increase in jobs in infrastructure/construction to repair damaged structures and properties
- Increase in costs associated with preventative measures (building sea walls, raising building, etc.)

(d) **Describe** TWO methods that may be used locally to protect coastal communities from rising sea levels.

(2 points; 1 point for each correct description and method that may be used locally to protect coastal communities from rising sea levels)

- Raise structures to reduce or prevent water damage.
- Move/build structures back from the beach (setbacks) to reduce or prevent water damage.
- Install pumps to reduce flooding.
- Build structures, such as sea walls, to protect area from wave action/storm surge/flooding/erosion.
- Plant vegetation along appropriate shoreline to decrease erosion.
- Replenish sand to address problems from erosion or to increase width of beach.
- Build jetties/groins to act as a barrier from waves.

## 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<sub>x</sub> from fossil fuel combustion that powers equipment/transportation/oil processing
- Release of air pollutants (NO<sub>x</sub>, SO<sub>x</sub>, 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

## 2019 SCORING GUIDELINES

## 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)

## 2019 SCORING GUIDELINES

## Question 3

The graph shows measurements of atmospheric levels of carbon dioxide (CO<sub>2</sub>) at Mauna Loa Observatory, Hawaii, and the measurements of pH levels in the ocean nearby at Station ALOHA. Measurements of pH began in 1992.

(a) Use the graph above to answer the following questions.

- (i) **Determine** the concentration of CO<sub>2</sub> (in ppm) recorded at Mauna Loa in 2005.

(1 point for identifying from the graph the correct value of concentration of CO<sub>2</sub> recorded at Mauna Loa in 2005)

380 ppm (+/- 5 ppm)

- (ii) **Determine** the pH recorded at Station ALOHA in 2005.

(1 point for identifying from the graph the correct value of pH recorded at Station ALOHA in 2005)

8.08 (+/- 0.02)

(b) Changes in atmospheric carbon dioxide affect Earth's oceans.

- (i) **Predict** the effect of increased concentration of atmospheric CO<sub>2</sub> on the concentration of CO<sub>2</sub> in the ocean.

(1 point for correctly predicting the effect of an increase in concentration of CO<sub>2</sub> in the ocean)

- Oceanic CO<sub>2</sub> will increase.
- Dissolved oceanic CO<sub>2</sub> will increase.

- (ii) Based on the data, **identify** the relationship in the concentration of atmospheric CO<sub>2</sub> and the pH of the ocean water.

(1 point for correctly identifying the relationship between the concentration of atmospheric CO<sub>2</sub> and the pH of ocean water based on data)

- As atmospheric CO<sub>2</sub> increases, pH decreases.
- As more CO<sub>2</sub> dissolves in the water, it becomes more acidic/less alkaline.
- As atmospheric CO<sub>2</sub> increases, H<sub>3</sub>O<sup>+</sup> or H<sup>+</sup> ions increase.

- (iii) **Provide** the complete chemical equation that represents the reaction between oceanic carbon dioxide (CO<sub>2</sub>) and water (H<sub>2</sub>O).

(1 point for the correct balanced chemical equation that represents the reaction between oceanic carbon dioxide and water)

- CO<sub>2</sub> + H<sub>2</sub>O → H<sub>2</sub>CO<sub>3</sub> (carbon dioxide plus water produces carbonic acid)
- CO<sub>2</sub> + H<sub>2</sub>O → H<sup>+</sup> + HCO<sub>3</sub><sup>-</sup> (carbon dioxide plus water produces one hydrogen ion and one bicarbonate ion)
- CO<sub>2</sub> + H<sub>2</sub>O → 2H<sup>+</sup> + CO<sub>3</sub><sup>2-</sup> (carbon dioxide plus water produces two hydrogen ions and one carbonate ion)

## 2019 SCORING GUIDELINES

## Question 3 (continued)

- (iv) **Identify** the specific environmental problem that directly results from the decrease in pH of Earth's oceans.

(1 point for correctly identifying the specific environmental problem that directly results from the decrease in pH of Earth's oceans)

Ocean Acidification

- (c) Changes in pH in the world's oceans pose a risk to many marine organisms.

- (i) **Explain** why certain organisms, in particular those with calcium carbonate shells or exoskeletons, are threatened by the decreasing pH levels measured in seawater.

(2 points; 1 point for correctly explaining the impact of a decrease in pH on shells or exoskeletons and 1 point for an impact on survival of organisms)

| Chemical impact on shell/coral formation                                                                                                                                                                                                  | Impact on survival of organism                                                                                                                                                                                                               |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A decrease in pH levels could <ul style="list-style-type: none"> <li>• Cause shells/exoskeletons to dissolve</li> <li>• Prevent the growth of new coral/shells</li> <li>• Prevent renewal/maintenance of existing coral/shells</li> </ul> | Organisms, such as mollusks and coral, would be threatened with <ul style="list-style-type: none"> <li>• Reduced fitness/decreased number of offspring</li> <li>• Increased predation risk</li> <li>• Increased threat of disease</li> </ul> |

## 2019 SCORING GUIDELINES

## Question 3 (continued)

- (ii) Other than threats posed by decreasing pH, **identify** an additional anthropogenic threat to the world's coral reef ecosystem and **describe** how the threat damages the coral reefs and coral reef ecosystems.

(2 points; 1 point for the correct identification of an additional anthropogenic threat to the world's coral reef ecosystem and 1 point for correctly linking a description of the identified threat to the damage to coral reefs and coral reef ecosystems)

| Identify one additional anthropogenic threat to the world's coral reef ecosystems       | Describe how the threat damages coral reefs and coral reef ecosystems                                                                                                                                                              |
|-----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Increased ocean temperature                                                             | <ul style="list-style-type: none"> <li>• Coral bleaching (loss of the algal symbiont)</li> <li>• Reduction of dissolved oxygen concentration</li> </ul>                                                                            |
| Recreational activities, such as watercraft, scuba, snorkeling, swimming, etc.          | <ul style="list-style-type: none"> <li>• Physical damage to/destruction of coral reefs</li> </ul>                                                                                                                                  |
| Fishing practices, such as bottom trawling, dynamite fishing, overfishing, etc.         | <ul style="list-style-type: none"> <li>• Physical damage to/destruction of coral reefs</li> <li>• Removal of key species disrupts the food web/causes a trophic cascade</li> </ul>                                                 |
| Nutrient pollution (from agricultural runoff, wastewater treatment plants, etc.)        | <ul style="list-style-type: none"> <li>• Cultural eutrophication and eventual decrease in dissolved oxygen levels</li> <li>• Excessive algal growth reduces light penetration</li> </ul>                                           |
| Sediment pollution (from logging operations, mining, etc.)                              | <ul style="list-style-type: none"> <li>• Increased turbidity/reduction in light penetration</li> <li>• Deposited sediments cover/smother coral reefs</li> </ul>                                                                    |
| Chemical pollution, such as oil spills, pesticide runoff, sunscreen, etc.               | <ul style="list-style-type: none"> <li>• Disruption of reproduction and growth cycles</li> <li>• Disruption of metabolic processes</li> <li>• Endocrine disruption/DNA damage</li> <li>• Reduction in light penetration</li> </ul> |
| Plastic/solid waste pollution                                                           | <ul style="list-style-type: none"> <li>• Physical damage to/destruction of members of the coral reef ecosystem</li> <li>• Reduction of light penetration</li> </ul>                                                                |
| Introduction of invasive species (lionfish/turkey fish, Philippine mantis shrimp, etc.) | <ul style="list-style-type: none"> <li>• Invasive species can outcompete native species</li> </ul>                                                                                                                                 |

## 2019 SCORING GUIDELINES

## Question 4

One reason that people visit national parks is to view the scenery. Visibility at the four parks in the graph has been reduced over time so that by 2015 the visibility was an average of 70 miles less than the historical visibility. Regional air pollutant sources are commonly located over 100 miles away from national parks.

- (a) Based on the data provided in the graph, **identify** the national park that had the greatest loss of visibility as of 2015 when compared with the historical natural visibility.

(1 point for the correct identification of the national park that has had the greatest loss of visibility)

Sequoia National Park

- (b) Visibility in national parks can be affected by many different air pollutants.

- (i) **Identify** a primary air pollutant.

(1 point for the correct identification of a primary air pollutant)

- Carbon dioxide (CO<sub>2</sub>)
- Carbon monoxide (CO)
- Nitrogen oxides (NO<sub>x</sub>)
- Nitrous oxide (N<sub>2</sub>O)
- Particulate Matter (PM)
- Sulfur dioxide (SO<sub>2</sub>)
- Methane (CH<sub>4</sub>)
- Volatile organic compounds (VOCs)

- (ii) **Describe** how a primary air pollutant becomes part of the atmosphere.

(1 point for the correct description of how a primary air pollutant becomes part of the atmosphere)

- Primary pollutants are released directly from a specific source, such as a smokestack, tailpipe, leaking pipelines, etc.
- Primary pollutants are released from the combustion of fossil fuels.
- Some pollutants (CO, PM) are a result of incomplete combustion of hydrocarbons.
- Some pollutants (methane, nitrous oxide, ammonia) are released directly from a biological source, such as cows, swamps, etc.

- (iii) **Identify** a secondary air pollutant.

(1 point for the correct identification of a secondary air pollutant)

- Ozone (O<sub>3</sub>)
- Sulfuric acid (H<sub>2</sub>SO<sub>4</sub>)
- Sulfur trioxide (SO<sub>3</sub>)
- Nitric acid (HNO<sub>3</sub>)
- Peroxyacyl nitrates (PANs)
- Nitrogen dioxide (NO<sub>2</sub>)
- Aldehydes

## 2019 SCORING GUIDELINES

## Question 4 (continued)

- (iv) **Describe** how a secondary air pollutant is formed within the atmosphere.

(1 point for the correct description of how a secondary air pollutant is formed within the atmosphere)

- Secondary air pollutants are formed when primary pollutants react with other compounds.
- Ozone (O<sub>3</sub>) forms when primary pollutants such as NO<sub>x</sub> and VOCs react with oxygen in the presence of sunlight.
- Sulfuric acid forms when SO<sub>x</sub> reacts with water.
- Nitric acid forms when NO<sub>x</sub> reacts with water.

- (c) In 1990 Great Smoky Mountains National Park had a visibility of 25 miles. Visibility data for 2015 can be determined from the graph above.

- (i) **Calculate** the percentage of increase in visibility from 1990 to 2015.

(1 point for the correct calculation of the percentage of increase in visibility from 1990 to 2015. Students are not required to show work.)

$$80\% \text{ increase in visibility } \left( \frac{45 \text{ miles} - 25 \text{ miles}}{25 \text{ miles}} \times 100 = 80\% \right)$$

- (ii) **Discuss** TWO specific actions that the state or federal government could take or encourage to further improve the visibility in Great Smoky Mountains National Park.

(2 points; 1 point for each correct and realistic discussion of a specific action the state or federal government could take or encourage to further improve the visibility in Great Smoky Mountains National Park)

- Require or offer incentives for utilities/corporations to reduce emissions by specific methods, such as cap-and-trade, pollution-prevention control devices, alternative energy sources, environmental standards on new equipment, etc.
- Limit vehicle traffic in the park through increased parking fees, free/required shuttles, HOV priority parking, etc.
- Enact stricter standards for emissions on motor vehicles.
- Offer incentives to switch from gasoline-powered vehicles to electric vehicles or natural-gas powered vehicles.
- Offer tax credits or subsidies to homeowners to increase the use of renewable energy sources.
- Limit incineration practices/prohibit campfires to reduce air pollutants.

**2019 SCORING GUIDELINES****Question 4 (continued)**

(d) Excluding air pollution, **discuss** TWO additional ways national park ecosystems are being degraded by high levels of visitor use.

(2 points; 1 point for each correct discussion of an additional way national park ecosystems are being degraded by high levels of visitor use)

- Littering or inappropriate disposal of trash can negatively impact the health of wildlife.
- Littering or inappropriate disposal of trash can negatively impact water quality.
- Infrastructure construction/maintenance can result in habitat fragmentation.
- Driving or walking off road/path damages vegetation, increases erosion, or increases soil compaction.
- Noise pollution can adversely impact wildlife by disrupting mating, ranging, foraging, etc.
- Light pollution can adversely impact wildlife by disrupting mating, ranging, foraging, etc.
- Interactions with humans or pets adversely impacts wildlife by disrupting mating, ranging, foraging, etc.
- Visitors transporting nonnative species to the park results in an increase in invasive species.
- Camp fires from visitors can lead to wildfires.
- Removal of individual organisms for food, trophies, or human use can disrupt the food web.
- Water used for bathing and sanitation can lead to pollution of water resources.