

Past-paper walk-through

Eutrophication ■ 8.5

eXercise

Questions in this set

- 2026 Q2
- 2024 Set 2 Q1
- 2023 Set 1 Q2
- 2023 Set 2 Q1
- 2022 Set 2 Q1
- 2017 Q1
- 2015 Q1

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- **//** separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = “or words to that effect” – the wording need not match.

Question 2

2026 ■ Q2

The following information applies to parts A, B, C, D, E, F, and G.

The following graph shows the number of quadrillion British thermal units (BTUs) that were consumed in the United States using five different energy sources from 1950 to 2020.

Energy Consumption by Source in the United States, 1950-2020

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Question 2

- Petroleum (thick dotted): starts around 14 in 1950, rises steadily to a peak near 38 around 1978, dips to about 30 around 1983, rises again with fluctuations to a peak near 40 around 2005, declines to about 34 around 2012, rises slightly then drops sharply to about 33 by 2020.
- Natural gas (dashed): starts around 6 in 1950, rises to about 22 by 1970, dips slightly through the 1970s-80s to about 18, rises again through the 1990s-2000s to about 23 around 2000-2010, then rises sharply after 2010 to about 32 by 2020.
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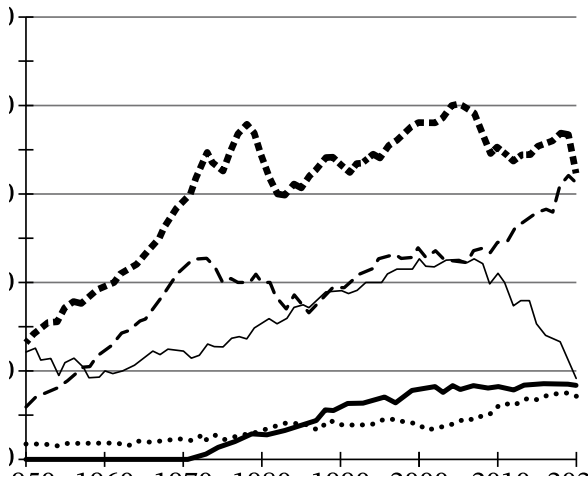
The following information applies to parts H and I.

Researchers studied an aquatic ecosystem near an area of land that had been converted to agricultural use. They reported an increase in nutrients, such as nitrates and phosphates, in the water.

2. Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

(a) Identify one renewable energy source that is used to generate electricity.

Question 2



Question 2

2026 ■ Q2

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The following graph shows the number of quadrillion British thermal units (BTUs) that were consumed in the United States using five different energy sources from 1950 to 2020.

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Researchers studied an aquatic ecosystem near an area of land that had been converted to agricultural use. They reported an increase in nutrients, such as nitrates and phosphates, in the water.

2. Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

(b) Based on the data in the graph, **identify** the energy source that had the highest consumption in 2010.

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2026 ■ Q2

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Researchers studied an aquatic ecosystem near an area of land that had been converted to agricultural use. They reported an increase in nutrients, such as nitrates and phosphates, in the water.

2. Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

(c) Based on the data in the graph, **describe** the pattern in the energy consumption from coal in the United States from 1960 to 2020.

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Researchers studied an aquatic ecosystem near an area of land that had been converted to agricultural use. They reported an increase in nutrients, such as nitrates and phosphates, in the water.

2. Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

(d) Based on the data in the graph and your knowledge of energy consumption, **explain** one likely reason why the use of coal for energy changed between 2010 and 2020.

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2. Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

(e) Explain how fossil fuels are used to generate electricity.

Question 2

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2. Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

(f) In addition to fossil fuels, nuclear power can be used to generate electricity.

Identify one negative impact associated with nuclear energy.

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2. Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

(g) Fossil fuel combustion leads to ocean warming. **Describe** one environmental problem other than coral bleaching that is associated with warming oceans.

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2. Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

(h) Explain how an increase in nutrients, such as nitrates and phosphates, can negatively affect an aquatic ecosystem.

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2. Respond to parts A, B, C, D, E, F, G, H, and I, and all subparts.

(ii) Propose a realistic solution that would reduce nutrient pollution of waterways, while still allowing cultivation of crops.

(iii) Justify the solution proposed in part I (i) by explaining one potential advantage other than reducing nutrient runoff.

Question 1

2024 Set 2 ■ Q1

The following diagram shows how an area changed over time. The dominant vegetation in each stage is labeled in the diagram. Each roman numeral represents a stage in the ecological process.

[Diagram: A cross-section showing ecological succession over time, divided into six stages labeled with roman numerals I through VI, with a key showing “Bedrock” (dotted pattern) and “Soil” (solid gray). A horizontal arrow below labeled “Time” points left to right. The cross-section shows bedrock and soil layers progressively deepening from left (mostly exposed bedrock) to right (thick soil layer) as vegetation on top becomes progressively taller and denser. The six stages are labeled below the diagram:

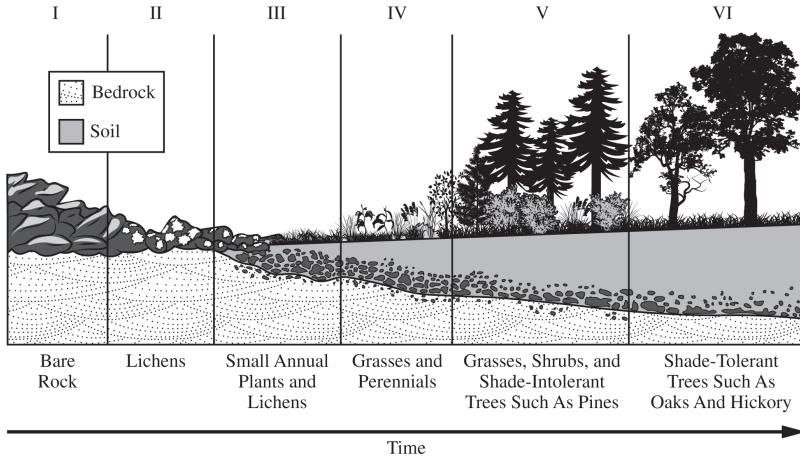
- Stage I: Bare Rock

Question 1

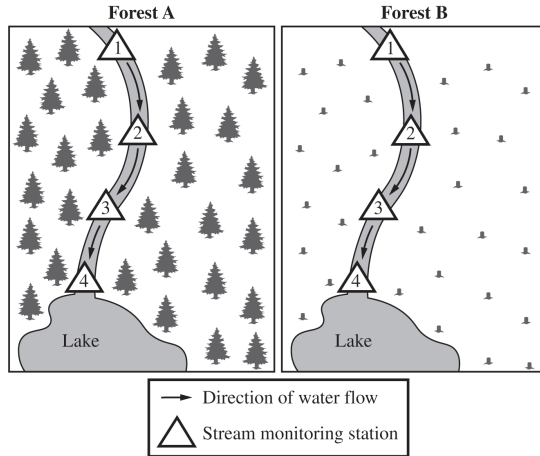
- Stage II: Lichens
- Stage III: Small Annual Plants and Lichens
- Stage IV: Grasses and Perennials
- Stage V: Grasses, Shrubs, and Shade-Intolerant Trees Such As Pines
- Stage VI: Shade-Tolerant Trees Such As Oaks And Hickory]

(a) Identify the ecological change over time illustrated in the diagram.

Question 1



Question 1



Question 1

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- Stage I: Bare Rock
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Question 1

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(b) Identify the stage in which pioneer species first appear.

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(c) Describe how soil forms from stage II to stage III.

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(d) Identify a cultural ecosystem service that may be provided by a mature forest.

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(e) Researchers are interested in investigating the effect of the removal of trees on the water quality of nearby waterways. To conduct their experiment, the researchers locate two identical forest watersheds, both with a river running through them. Forest A is an intact forest and forest B is a clear-cut forest. Four stream monitoring stations are set up in each forest study area. Each station monitors a variety of water quality indicators, including water temperature, at various locations along the river. The experimental setup is shown in the following diagrams. The arrows shown in the rivers represent the direction of water flow. The triangles in the river show the location of the stream monitoring stations.

Question 1

[Diagram: Two side-by-side maps labeled “Forest A” and “Forest B”, each showing a river flowing from the top of the map down to a “Lake” at the bottom, with 4 numbered triangular stream monitoring stations (labeled 1 at the top near where the river enters, 2, 3, and 4 near the lake) placed along the river’s path. Arrows along the river indicate the direction of water flow, flowing downward toward the lake. Forest A is densely covered with many tree symbols (an intact forest). Forest B has only a few scattered tree symbols, showing that most trees have been cleared (a clear-cut forest). A legend below both maps indicates: an arrow icon = “Direction of water flow”; a triangle icon = “Stream monitoring station”.]

Identify a testable hypothesis being investigated by the researchers.

Question 1

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(f) Identify the independent variable in the experiment.

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(g) Describe the purpose of forest A in the experiment.

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(h) Explain why the water temperature might change because of clear-cutting trees in forest B.

Question 1

2024 Set 2 ■ Q1

The following diagram shows how an area changed over time. The dominant vegetation in each stage is labeled in the diagram. Each roman numeral represents a stage in the ecological process.

[Diagram: A cross-section showing ecological succession over time, divided into six stages labeled with roman numerals I through VI, with a key showing “Bedrock” (dotted pattern) and “Soil” (solid gray). A horizontal arrow below labeled “Time” points left to right. The cross-section shows bedrock and soil layers progressively deepening from left (mostly exposed bedrock) to right (thick soil layer) as vegetation on top becomes progressively taller and denser. The six stages are labeled below the diagram:

- Stage I: Bare Rock
- Stage II: Lichens
- Stage III: Small Annual Plants and Lichens

Question 1

- Stage IV: Grasses and Perennials
- Stage V: Grasses, Shrubs, and Shade-Intolerant Trees Such As Pines
- Stage VI: Shade-Tolerant Trees Such As Oaks And Hickory]

(i) After the experiment was completed, land developers constructed a golf course in the clear-cut area of forest B. To prepare the land, developers removed any remaining stumps and newly grown trees and began planting and fertilizing new grass. The researchers are interested in the effect the golf course may have on the water quality of the river. To monitor the river in forest B, the researchers repeated the experiment once the golf course had been constructed.

Explain why an indicator of water quality other than temperature could be altered by the golf course in forest B.

Question 1

2024 Set 2 ■ Q1

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Question 1

- Stage IV: Grasses and Perennials
- Stage V: Grasses, Shrubs, and Shade-Intolerant Trees Such As Pines
- Stage VI: Shade-Tolerant Trees Such As Oaks And Hickory]

(j) Explain how the aquatic organisms living in the lake illustrated in the diagram of forest B are likely to be affected by the new golf course.

Solution 1

(a)

Mark scheme

- The diagram shows primary succession – the stepwise development of an ecosystem starting on bare rock/parent material with no pre-existing soil, progressing through stages to a mature community. Full credit for identifying 'primary succession.'

Solution 1

(b)

Mark scheme

- Pioneer species first appear in Stage II (labeled '2' in the diagram) – the stage where organisms like lichens, algae, or fungi first colonize the bare rock. Full credit for identifying stage II/2.

Solution 1

(c)

Mark scheme

- Soil forms from stage II to stage III through weathering and biological activity. Accept any one of: (1) wind/rain/weather erodes the rock/parent material; (2) wind/rain breaks rocks down into smaller particles; (3) pioneer species (lichens/algae/fungi) die off, adding small amounts of organic material to the forming soil; (4) pioneer species (lichens/algae/fungi) help break down the rock. Full credit for any one mechanism.

Solution 1

(d)

Mark scheme

- A cultural ecosystem service from a mature forest: any one of recreation, aesthetic enjoyment, spiritual use, ecotourism, or education. Full credit for naming one such non-material benefit.

Solution 1

(e)

Mark scheme

- A testable hypothesis for the experiment, e.g.: removal of trees/clear-cutting will lead to an increase/decrease in a water-quality indicator (temperature, turbidity, or dissolved oxygen) compared with the intact forest, OR the null form – clear-cutting will have no effect on water quality; equivalently, water quality will/will not change between stations. Full credit for any hypothesis stating a predicted increase/decrease/no-change relationship between clear-cutting (or station location) and a water-quality indicator.

Solution 1

(f)

Mark scheme

- Independent variable: presence or absence of clear-cutting (intact forest A vs. clear-cut forest B), equivalently the intact-or-clearcut status of the forest or the location of the stream monitoring stations. Full credit for identifying this manipulated/comparison variable.

Solution 1

(g)

Mark scheme

- Forest A (the intact forest) serves as the control – it lets researchers compare water quality (temperature/turbidity) in the clear-cut area (forest B) against an intact, unaltered baseline. Full credit for describing forest A's role as the control/comparison for forest B.

Solution 1

(h)

Mark scheme

- Water temperature in forest B is likely to increase after clear-cutting. Accept any one mechanism: (1) fewer/no trees to block sunlight from reaching the water, so it warms more; (2) additional sediment from erosion affects the water; (3) more direct sunlight reaches the water surface without the tree canopy. Full credit for any one causal explanation linking tree removal to warmer water.

Solution 1

(i)

Mark scheme

- A water-quality indicator besides temperature (e.g. dissolved oxygen, turbidity, or nutrients) could be altered by the golf course. Accept any one: (1) dissolved oxygen could decrease because fertilizer runoff causes algal blooms/eutrophication; (2) sedimentation/turbidity could decrease because grass reduces erosion compared with bare clear-cut land; (3) nitrates/phosphates could increase due to fertilizer runoff, driving algal growth/bloom. Full credit for any one linked mechanism.

Solution 1

(j)

Mark scheme

- Effect on aquatic organisms in the forest B lake from the new golf course. Accept any one: (1) organisms die off from lack of oxygen caused by decomposition of algae/eutrophication (from fertilizer runoff); (2) organisms survive at a higher rate because less sediment clogs their gills (grass reduces erosion versus clear-cut land); (3) organisms die off due to increased toxicity from pesticide runoff. Full credit for any one plausible, correctly reasoned effect.

Question 2

2023 Set 1 ■ Q2

The diagram shows the movement of one adult manatee over a 12-hour period across an active shipping channel during the winter. Manatees are large, aquatic, herbivorous mammals that primarily eat seagrass. Manatees can travel several miles to graze.

Manatees mature slowly, have low biotic potential, and inhabit warm coastal waters. They cannot survive in water below 20°C for extended periods of time.

****Satellite Track and Water Temperature Log of the Movement of One Adult Manatee Over a 12-Hour Period****

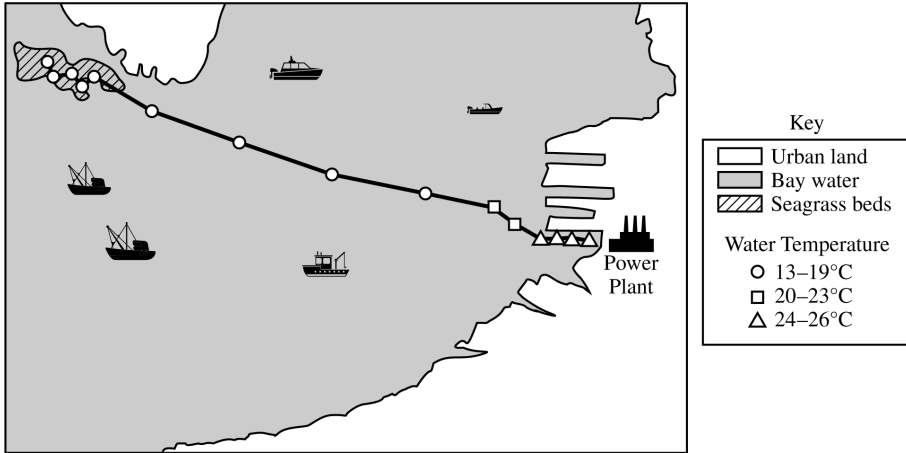
[Map diagram of a bay/river channel showing a coastline with urban land at upper left near a cluster of small circles (13-19°C markers) close to shore, and hatched "Seagrass beds" also near that shore. A black line with a series of point markers runs from the seagrass-bed/urban-land area near the top-left, diagonally down and to the right across open bay water, passing several boats (fishing boats and small craft scattered across

Question 2

the bay), and ending at the lower right near a "Power Plant" (with smokestack icon) on the opposite shore. The markers along this track are open circles ($13-19^{\circ}\text{C}$) for most of the track's length across the open bay, changing to open squares ($20-23^{\circ}\text{C}$) near the shore closer to the power plant, and open triangles ($24-26^{\circ}\text{C}$) immediately adjacent to the power plant outflow. Key: Urban land = open/white box; Bay water = gray shaded box; Seagrass beds = diagonal-hatched box. Water Temperature legend: circle = $13-19^{\circ}\text{C}$, square = $20-23^{\circ}\text{C}$, triangle = $24-26^{\circ}\text{C}$.]

(a) Based on the information in the diagram, identify the temperature range of the water through which the majority of the adult manatee's daily movement occurs.

Question 2



Question 2

2023 Set 1 ■ Q2

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(b) Large groups of manatees are often observed in shallow waters near the waste water released by the electrical power plant during the winter. Based on the information in the diagram, identify a characteristic of the power plant waste water that would attract the manatees.

Question 2

2023 Set 1 ■ Q2

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(c) Based on the information in the diagram, describe a potential negative impact of the waste water released by the power plant on other aquatic species.

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2023 Set 1 ■ Q2

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(d) Seagrass beds have declined significantly over the last several years. In 2021 manatee mortality was three times higher than the previous five-year average.

(d)(i) Describe a characteristic of the manatees that increases their vulnerability to the recent decline of seagrasses.

(d)(ii) Describe the change in energy flow through the trophic levels that occurs when there is a significant loss of seagrasses.

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2023 Set 1 ■ Q2

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(e) Research has shown increased nutrient and sediment runoff can cause seagrass beds to decline.

(e)(i) Propose a solution to reduce nutrient or sediment pollution in an estuary that is surrounded by urban development.

(e)(ii) Justify the solution proposed in part (e)(i) by providing an additional advantage of reduced nutrients in an estuary, other than one related to manatees.

Question 2

2023 Set 1 ■ Q2

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(f) Urban areas have a heavy dependence on automobiles and often experience photochemical smog.

Describe how summertime weather conditions can increase the frequency of photochemical smog.

Question 2

2023 Set 1 ■ Q2

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(g) Identify one ecological problem that results from exposure to photochemical smog.

Question 2

2023 Set 1 ■ Q2

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(h) A potential solution to reduce photochemical smog in urban areas with high automobile traffic is to replace gasoline-powered cars with cars powered by hydrogen fuel cells.

Describe a potential disadvantage of using hydrogen fuel cells to power automobiles.

Solution 2

(a)

Mark scheme

- 13-19 degrees C, based on the temperature range through which the majority of adult manatee daily movement occurs in the diagram.

Solution 2

(b)

Mark scheme

- The waste water is warm (approximately 24-26 degrees C), which is why manatees are attracted to it in winter.

Solution 2

(c)

Mark scheme

- Any one of: warming of the water near the outfall reduces the dissolved oxygen available for aquatic organisms to use/breathe; the warming could impact the survival/health of species with a range of tolerance for the original (lower) water temperature; or the warming could alter/affect the timing of reproductive cycles for aquatic species.

Solution 2

(d)

Mark scheme

- This line is introductory/context text (seagrass decline and the 2021 manatee mortality spike) setting up parts (d)(i) and (d)(ii) below; it carries no points of its own – see 2di and 2dii.

Solution 2

(d)(i)

Mark scheme

- Any one of: manatees are herbivores/eat seagrass, so they would have less food and could starve; they require a lot of energy to survive, so a reduced food supply threatens them; they inhabit warm water, so they would need to travel farther to colder waters to find remaining seagrass/food; or they have a low reproductive/maturation rate, so they would take longer to recover from the loss of their food source.

Solution 2

(d)(ii)

Mark scheme

- Less energy flows to/is available for organisms at higher trophic levels, because less energy from the Sun is captured/stored by producers (seagrass) once seagrass is significantly lost.

Solution 2

(e)

Mark scheme

- This line is introductory/context text (nutrient and sediment runoff causing seagrass decline) setting up parts (e)(i) and (e)(ii) below; it carries no points of its own – see 2ei and 2eii.

Solution 2

(e)(i)

Mark scheme

- Any one solution: replace existing pavement with permeable pavement; add vegetation (e.g., a riparian buffer) where it will intercept runoff; reduce fertilizer use in the area; install barriers/construct fences where they will intercept runoff; or improve wastewater treatment plants in the area.

Solution 2

(e)(ii)

Mark scheme

- Any one additional advantage (not related to manatees): reduces eutrophication; increases biodiversity/species richness; improves water clarity; increases ecotourism; reduces the cost of water treatment; or increases profits for commercial fishermen.

Solution 2

(f)

Mark scheme

- Any one of: sunlight is more intense/there is more sunlight in summer, so more primary pollutants (nitrogen oxides/ NO_x) react in sunlight; summertime temperatures are warmer than other seasons, and chemical reactions occur more quickly at warmer temperatures; or trees release more VOCs in summer, leading to more reactions that form photochemical smog.

Solution 2

(g)

Mark scheme

- Any one ecological problem: causes respiratory problems/eye irritation in animals; reduces photosynthesis; slows/inhibits/stunts plant growth; or increases the susceptibility of plants to pests and disease.

Solution 2

(h)

Mark scheme

- Any one disadvantage: high cost to manufacture hydrogen-fuel-cell automobiles; obtaining hydrogen requires a lot of energy and may consume more energy than the hydrogen fuel can produce; hydrogen is explosive/flammable (may catch fire); there is a lack of infrastructure (such as fueling stations) for hydrogen fuel; or hydrogen must be obtained by separating it from natural gas or water (often using fossil fuels).

Question 1

2023 Set 2 ■ Q1

Two restoration methods designed to reclaim the overburden piles removed from open pit coal mines in temperate forests of eastern Europe were studied over several years. The first method was spontaneous restoration, where the soil and rock were dumped in noncompacted, random piles and not replanted with vegetation. The second method was technical restoration, where the land was leveled by heavy machinery, organic material was added, and eight plant species were added. Technical restoration started 5 years after the piles were formed, so no bar is included in the 1-5 year range in the graph.

Number of Plant Species in Spontaneous and Technically Restored Overburden Piles over Time

Question 1

[Bar graph titled “Number of Plant Species in Spontaneous and Technically Restored Overburden Piles over Time”. Y-axis: “Average Number of Plant Species”, from 0 to 20, gridlines at 0, 10, 20. X-axis: “Age (years) of Overburden Piles”, with six categories: 1-5, 6-10, 11-15, 16-25, 26-35, >35. Two bars per category (legend: light gray = Spontaneous restoration piles, dark/black = Technical restoration piles). Approximate bar heights: 1-5: Spontaneous ~6.5, Technical (none, no bar); 6-10: Spontaneous ~12, Technical ~9.5; 11-15: Spontaneous ~13, Technical ~11.5; 16-25: Spontaneous ~13, Technical ~8.5; 26-35: Spontaneous ~14, Technical ~8; >35: Spontaneous ~17.5, Technical ~8.]

Scientists hypothesized that after 35 years, the number of animal species in the spontaneously restored piles would be higher than the number of animal species in the technically restored piles.

Question 1

Limiting runoff on disturbed land improves soil and water quality. To model water runoff, students set up three large plastic trays and filled each tray with loam soil to 1 centimeter below the edge. Loam soil is a balance of sand, silt, and clay soil. One tray was seeded with wheatgrass and grown for 30 days, one tray was covered with small wood chips, and one tray was soil only. Five hundred milliliters of water was sprinkled evenly onto the soil surface of each tray. All three trays were placed on a slight slope, and water that ran off the surface was collected. The results are shown in the following table.

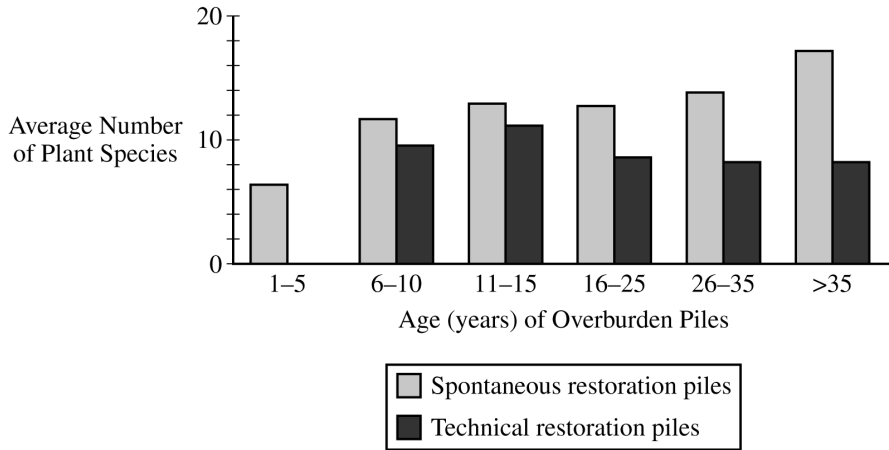
Tray	Water Collected (mL)	Water Appearance
Wheatgrass grown in soil; no small wood chips	190	Clear
Small wood chips covered soil; no wheatgrass	300	Transparent; light brown
Soil only; no wheatgrass or small wood chips	360	Cloudy; dark brown

Question 1

Runoff from mining waste can also affect water quality.

(a) Based on the data in the graph, **identify** the average number of species found in technically restored piles 16-25 years after restoration started.

Question 1



Question 1

2023 Set 2 ■ Q1

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