

Past-paper walk-through

Photochemical Smog ■ 7.2

eXercise

Questions in this set

- 2023 Set 1 Q2
- 2019 Q4

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

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****

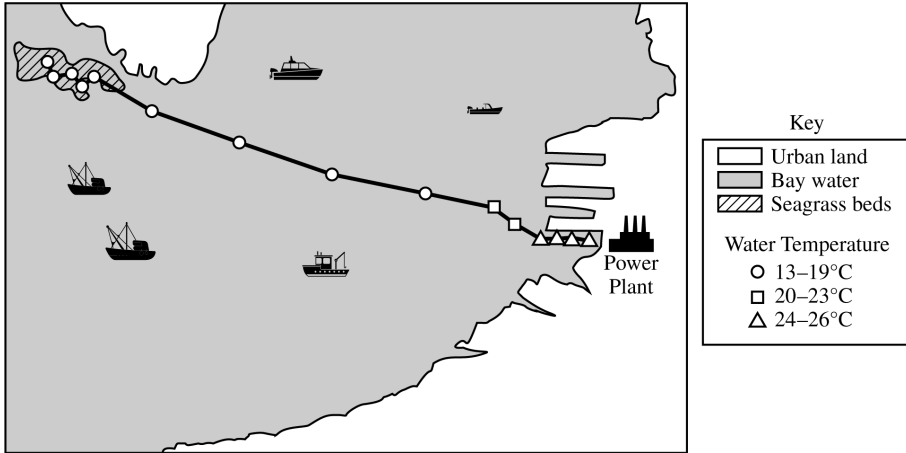
[Map diagram of a bay/river channel showing a coastline with urban land at upper left near a cluster of small circles (13-19°C markers) close to shore, and hatched "Seagrass beds" also near that shore. A black line with a series of point markers runs from the seagrass-bed/urban-land area near the top-left,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

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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.

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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.

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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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(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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(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.

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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.

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

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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 4

2019 ■ Q4

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.

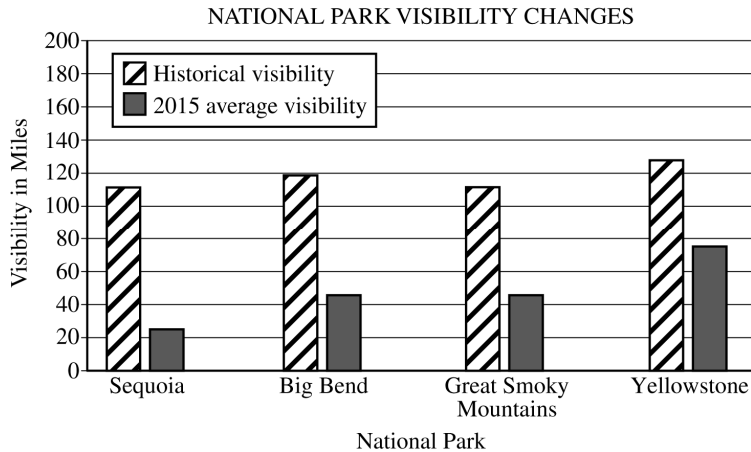
NATIONAL PARK VISIBILITY CHANGES

[Bar graph, x-axis “National Park” with four parks: Sequoia, Big Bend, Great Smoky Mountains, Yellowstone. y-axis “Visibility in Miles” from 0 to 200 in steps of 20. Two bars per park: hatched bar = Historical visibility; solid dark gray bar = 2015 average visibility. Approximate values - Sequoia: historical ~112, 2015 ~25; Big Bend: historical ~120, 2015 ~46; Great Smoky Mountains: historical ~113, 2015 ~46; Yellowstone: historical ~128, 2015 ~76.]

Question 4

(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.

Question 4



Question 4

2019 ■ Q4

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(b)(i) Visibility in national parks can be affected by many different air pollutants. Identify a primary air pollutant.

Question 4

- (b)(ii)** Describe how a primary air pollutant becomes part of the atmosphere.
- (b)(iii)** Identify a secondary air pollutant.
- (b)(iv)** Describe how a secondary air pollutant is formed within the atmosphere.

Question 4

2019 ■ Q4

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

Question 4

Calculate the percentage increase in visibility from 1990 to 2015.

(c)(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.

Question 4

2019 ■ Q4

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

Solution 4

(a)

Mark scheme

- National park with the greatest loss of visibility as of 2015 compared with historical natural visibility: Sequoia National Park.

Solution 4

(b)(i)

Mark scheme

- A primary air pollutant, e.g.: carbon dioxide (CO_2); carbon monoxide (CO); nitrogen oxides (NO_x); nitrous oxide (N_2O); particulate matter (PM); sulfur dioxide (SO_2); methane (CH_4); volatile organic compounds (VOCs). Full credit for any one valid primary pollutant.

Solution 4

(b)(ii)

Mark scheme

- How a primary air pollutant becomes part of the atmosphere: primary pollutants are released directly from a specific source, such as a smokestack, tailpipe, or leaking pipeline; released from the combustion of fossil fuels; some pollutants (CO, PM) result from incomplete combustion of hydrocarbons; some pollutants (methane, nitrous oxide, ammonia) are released directly from a biological source, such as cows or swamps. Full credit for any one correct description.

Solution 4

(b)(iii)

Mark scheme

- A secondary air pollutant, e.g.: ozone (O_3); sulfuric acid (H_2SO_4); sulfur trioxide (SO_3); nitric acid (HNO_3); peroxyacyl nitrates (PANs); nitrogen dioxide (NO_2); aldehydes. Full credit for any one valid secondary pollutant.

Solution 4

(b)(iv)

Mark scheme

- How a secondary air pollutant is formed within the atmosphere: secondary air pollutants are formed when primary pollutants react with other compounds — e.g. ozone (O_3) forms when primary pollutants such as NO_x and VOCs react with oxygen in the presence of sunlight; sulfuric acid forms when SO_x reacts with water; nitric acid forms when NO_x reacts with water. Full credit for any one correct description.

Solution 4

(c)(i)

Mark scheme

- Percentage increase in visibility from 1990 to 2015:

$$\frac{45 \text{ miles} - 25 \text{ miles}}{25 \text{ miles}} \times 100 = 80\% \text{ increase (1990 visibility given as 25 miles; 2015 visibility read from the graph as 45 miles). Students were not required to show work — the correct final percentage (80$$

Solution 4

(c)(ii) Mark scheme

- Discuss TWO specific actions the state or federal government could take/encourage to further improve visibility in Great Smoky Mountains National Park, 1 point per correct, realistic, specific discussion (max 2), e.g.: 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; 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 or natural-gas powered vehicles;

Solution 4

offer tax credits or subsidies to homeowners to increase use of renewable energy sources; limit incineration practices/prohibit campfires to reduce air pollutants.

Solution 4

(d) Mark scheme

- Excluding air pollution, discuss TWO additional ways national park ecosystems are being degraded by high levels of visitor use, 1 point per correct distinct discussion (max 2), e.g.: littering or inappropriate disposal of trash can negatively impact the health of wildlife or 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; light pollution can adversely impact wildlife by disrupting mating/ranging/foraging; interactions with humans or pets adversely impact wildlife by disrupting mating/ranging/foraging; visitors transporting

Solution 4

nonnative species results in an increase in invasive species; campfires 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.