Past-paper walk-through

Reduction of Air Pollutants ▪ 7.6

eXercise

Questions in this set

- 2025 Set 1 Q3
- 2024 Set 1 Q3
- 2022 Set 1 Q2
- 2019 Q4
- 2018 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 3

2025 Set 1 ▪ Q3

Respond to parts A, B, C, D, E, F, and G.

(a) One major environmental problem is air pollution. Air pollution can come from natural or anthropogenic sources. Motor vehicles can be a source of particulate matter (PM) and other pollutants.

Identify an anthropogenic source of particulate matter, other than from motor vehicles.

Question 3

2025 Set 1 ▪ Q3

Respond to parts A, B, C, D, E, F, and G.

(b) One way to reduce pollutants associated with motor vehicles is to use a vapor recovery nozzle. Describe one way a vapor recovery nozzle is used to reduce atmospheric pollution.

Question 3

2025 Set 1 ▪ Q3

Respond to parts A, B, C, D, E, F, and G.

(c) Acid rain is another air pollutant linked to motor vehicles. Over the past few years, there has been an increase in the number of people working from home, so fewer people are commuting to work in their personal vehicles.

Explain how a decrease in the number of people commuting to work in their personal vehicles could lead to a reduction in acid rain.

Question 3

2025 Set 1 ▪ Q3

Respond to parts A, B, C, D, E, F, and G.

(d) The average gas mileage for a small gasoline-powered sport utility vehicle (SUV) is 22 miles per gallon (mpg) in the city. The average gas mileage for a small hybrid SUV is 36 mpg in the city. One commuter sells their gasoline-powered SUV and replaces it with a hybrid SUV.

Calculate the percent change in gas mileage between the gasoline-powered SUV and the hybrid SUV based on the data provided. Show your work.

Question 3

2025 Set 1 ▪ Q3

Respond to parts A, B, C, D, E, F, and G.

(e) Both the gasoline-powered SUV and the hybrid SUV have 14-gallon gas tanks. As stated in part D, the average gas mileage for a small gasoline-powered sport utility vehicle (SUV) is 22 miles per gallon (mpg) in the city. The average gas mileage for a small hybrid SUV is 36 mpg in the city.

Calculate how many more miles the owner can drive in the hybrid SUV in the city than they could have driven in the gasoline-powered SUV. Show your work.

Question 3

2025 Set 1 ▪ Q3

Respond to parts A, B, C, D, E, F, and G.

(f) In addition to vehicles, buildings such as schools often have high energy consumption. The primary sources of energy use in many buildings are heating, cooling, and lighting.

Propose a realistic solution that schools could implement to decrease energy use for heating and cooling, other than a reduction in the amount of time the school building is occupied.

Question 3

2025 Set 1 ▪ Q3

Respond to parts A, B, C, D, E, F, and G.

(g) The school plans to upgrade its lighting to save money and reduce both its electricity use and its ecological footprint. The sustainability committee proposes that the school reduce its electricity use by switching to energy-efficient light-emitting diode (LED) bulbs. The school building uses 2.8×10^4 bulbs. The LED bulbs would each use 0.0085 kilowatts per hour. Each bulb would be used for an average of 2,340 hours per year.

Calculate the energy use in the school building in kilowatts per year using LED light bulbs. Show your work.

Solution 3

(a)

Mark scheme

- An anthropogenic source of particulate matter other than motor vehicles: coal/fossil fuel combustion; industrial exhaust; construction/demolition; waste incineration; mining; burning of biomass; anthropogenically caused wildfires; unpaved roads; or agricultural fields.

Solution 3

(b)

Mark scheme

- A vapor recovery nozzle reduces atmospheric pollution by preventing fumes/vapors from escaping into the atmosphere while gassing/fueling a motor vehicle.

Solution 3

(c)

Mark scheme

- A decrease in personal-vehicle commuting reduces acid rain because it results in lower nitrogen oxide/sulfur oxide emissions from cars, which leads to less nitric acid/sulfuric acid forming in the atmosphere.

Solution 3

(d)

Mark scheme

- Calculate percent change in gas mileage from 22 mpg (gasoline SUV) to 36 mpg (hybrid SUV). Setup (1 pt): % change = (36 mpg - 22 mpg) / 22 mpg x 100. Calculation (1 pt): (36-22)/22 x 100 = 14/22 x 100   63.6% increase (accept 63.6, 64%, or 64).

Solution 3

(e)

Mark scheme

- Calculate the extra miles drivable in the hybrid SUV vs. the gasoline SUV, both with 14-gallon tanks (36 mpg vs. 22 mpg). Setup (1 pt): (14 gal x 36 mpg) - (14 gal x 22 mpg), i.e., 14 x (36-22). Calculation (1 pt): 14x36 - 14x22 = 504 - 308 = 196 more miles (accept ~200).

Solution 3

(f)

Mark scheme

- A realistic school solution to decrease heating/cooling energy use (other than reducing occupied time): implement green building design features; open windows to reduce air-conditioning use; use energy-efficient heating and cooling equipment; adjust the thermostat to reduce heating/cooling use; or install conservation landscaping.

Solution 3

(g)

Mark scheme

- Calculate the school's annual LED lighting energy use: 2.8x10^4 bulbs, each using 0.0085 kW, used 2,340 hours/year. Setup (1 pt): (2.8x10^4 bulbs) x 0.0085 kW x 2,340 hours. Calculation (1 pt): 28,000 x 0.0085 x 2,340 = 556,920 kWh/year (accept ~5.6x10^5 or 5.6E5; kWh/year or kW/year units both accepted).

Question 3

2024 Set 1 ▪ Q3

Earth's climate has changed over time by the addition of greenhouse gasses to the atmosphere. One approach to mitigate climate change is the use of nuclear power, rather than coal-burning power plants, for electricity generation.

(a) Identify a fuel used in a nuclear power plant.

Question 3

2024 Set 1 ▪ Q3

Earth's climate has changed over time by the addition of greenhouse gasses to the atmosphere. One approach to mitigate climate change is the use of nuclear power, rather than coal-burning power plants, for electricity generation.

(b) Describe a negative environmental impact on nearby bodies of water that is caused by using water for cooling in nuclear power plants.

Question 3

2024 Set 1 ▪ Q3

Earth's climate has changed over time by the addition of greenhouse gasses to the atmosphere. One approach to mitigate climate change is the use of nuclear power, rather than coal-burning power plants, for electricity generation.

(c) In 2021, 4.1×10^{12} kilowatt hours (kWh) of commercial electricity was generated in the United States. Nuclear power accounted for 18.9

Another approach to reduce greenhouse gas emissions is to switch from coal-burning power plants to natural gas power plants.

Question 3

2024 Set 1 ▪ Q3

Earth's climate has changed over time by the addition of greenhouse gasses to the atmosphere. One approach to mitigate climate change is the use of nuclear power, rather than coal-burning power plants, for electricity generation.

(d) In addition to reducing greenhouse gas emissions, **describe** how switching from coal-burning power plants to natural gas power plants will improve air quality.

Researchers have proposed large-scale tree planting as a solution to reduce the effects of fossil fuel combustion on global climate change.

Question 3

2024 Set 1 ▪ Q3

Earth's climate has changed over time by the addition of greenhouse gasses to the atmosphere. One approach to mitigate climate change is the use of nuclear power, rather than coal-burning power plants, for electricity generation.

(e) Justify the proposed solution by explaining an additional advantage, other than the reduction of atmospheric greenhouse gases.

Question 3

2024 Set 1 ▪ Q3

Earth's climate has changed over time by the addition of greenhouse gasses to the atmosphere. One approach to mitigate climate change is the use of nuclear power, rather than coal-burning power plants, for electricity generation.

(f) 7.4×10^7 cubic meters of natural gas were extracted from a large deposit in 2020. An average of 4.76 kWh of electricity can be generated from each cubic meter of natural gas combusted. In 2020, an average home consumed 10,715 kWh of electricity. **Calculate** how many homes could have been provided with electricity by natural gas extracted from the large deposit in 2020. **Show** your work.

Question 3

2024 Set 1 ▪ Q3

Earth's climate has changed over time by the addition of greenhouse gasses to the atmosphere. One approach to mitigate climate change is the use of nuclear power, rather than coal-burning power plants, for electricity generation.

(g) In 2021, 8.99×10^{11} kWh of electricity was generated through the combustion of coal. One kilogram of carbon dioxide is produced per kWh of electricity generated by combusting coal, while 0.42 kilograms of carbon dioxide is produced by combusting natural gas. **Calculate** how much less carbon dioxide would have been produced in 2021 if all coal-burning power plants were replaced with natural gas-burning power plants. **Show** your work.

Solution 3

(a)

Mark scheme

- A fuel used in a nuclear power plant: Uranium (U-235) or Plutonium.

Solution 3

(b)

Mark scheme

- Using water for cooling in nuclear power plants causes thermal pollution: discharged water raises the temperature of nearby bodies of water outside organisms' range of tolerance and/or decreases dissolved oxygen; organisms can also be wounded or killed at the water intake; and water loss through evaporation can decrease stream flow/volume.

Solution 3

(c)

Mark scheme

- Calculate electricity generated by nuclear power in the US in 2021 (2 points: 1 for setup, 1 for the answer). Setup: (4.1$\times$10^12 kWh) $\times$ 18.9% $=$ (4.1$\times$10^12) $\times$ 0.189. Calculation: 4.1$\times$10^12 $\times$ 0.189 $=$ 7.749$\times$10^11 kWh 774,900,000,000 kWh (accept 7.75$\times$10^11 or 7.7$\times$10^11 kWh).

Solution 3

(d)

Mark scheme

- Switching from coal-burning to natural gas power plants improves air quality because burning natural gas produces less NOx, SOx, ash, particulates, toxic metals, and smog compared to burning coal.

Solution 3

(e)

Mark scheme

- An additional advantage of large-scale tree planting beyond reducing atmospheric greenhouse gases: provides forest habitat/increases biodiversity/diversifies niches; creates jobs (planting, recreation, wood harvesting); creates a more aesthetically pleasing environment/enhances cultural ecosystem services; decreases soil loss/erosion/sedimentation in waterways; provides shade/decreases ambient temperature; or slows water runoff/reduces flooding.

Solution 3

(f)

Mark scheme

- Calculate how many homes could be powered by the natural gas extracted (2 points: 1 for setup, 1 for the answer). Setup: ($7.4\times10\hat{}7$ m^3) $\times$ (4.76 kWh / 1 m^3) $\times$ (1 home / 10,715 kWh). Calculation: $7.4\times10\hat{}7 \times 4.76 / 10{,}715$ 32,874 homes (accept 32,873 or 33,000).

Solution 3

(g)

Mark scheme

- Calculate how much less $CO2$ would be produced if all coal plants were replaced by natural gas plants in 2021 (2 points: 1 for setup, 1 for the answer). Setup: difference in emission rate $\times$ total kWh from coal $=$ (1.0 kg CO2/kWh $-$ 0.42 kg CO2/kWh) $\times$ ($8.99\times10\hat{}11$ kWh); equivalently compute CO2 from coal ($8.99\times10\hat{}11$ kWh $\times$ 1.0 kg/kWh $=$ $8.99\times10\hat{}11$ kg) minus CO2 if that electricity were from natural gas ($8.99\times10\hat{}11$ kWh $\times$ 0.42 kg/kWh $=$ $3.776\times10\hat{}11$ kg). Calculation: $0.58 \times 8.99\times10\hat{}11 =$ $5.2142\times10\hat{}11$ kg 521 billion kg (accept 521,420,000,000 kg, $5.21\times10\hat{}11$ kg, or $5.2\times10\hat{}11$ kg).

Question 2

2022 Set 1 ▪ Q2

Developments in advanced hydraulic fracturing (fracking) technologies have allowed the total oil and gas production in the United States to increase rapidly.
[Scatter graph titled "METHANE CONCENTRATION IN DRINKING WATER WELLS IN PENNSYLVANIA." Y-axis: "Methane Concentration in Well Water (mg/L)," scale 0 to 70 in increments of 10. X-axis: "Distance to Nearest Fracking Well (m)," scale 0 to 6,000 in increments of 1,000. A horizontal reference line is drawn at y = 10 mg/L, with an upward arrow above it labeled "Hazardous concentrations, mitigation required" and a downward arrow below it labeled "No mitigation required." Data points (labeled "Well water sample" in the legend, shown as filled circles) are heavily concentrated at small distances (roughly 0–500 m) with methane concentrations ranging widely from near 0 up to about 64 mg/L (points near approximately 64, 60, 53, 52, 51, 42, 34, 33, 29, 24, 20, and several points below 10 clustered near x = 0–300 m). A few points

Question 2

appear farther out: around x 1,300–1,500 m with y 13–17 mg/L, and isolated lower points scattered out to about x = 3,600 m (y 6), x = 3,700 m (y 3), and x = 4,300 m (y 1), with most points beyond about x = 1,000 m sitting at or near y = 0, extending out to about x = 5,700 m.]

(a)(i) The graph shows the methane concentration in drinking water from home wells and the distance to the nearest fracking well in Pennsylvania. Based on the data in the graph, **identify** the highest methane concentration found in well water in Pennsylvania.

(a)(ii) Based on the data in the graph, **describe** the relationship between the concentration of methane in well water and the distance to a fracking well.

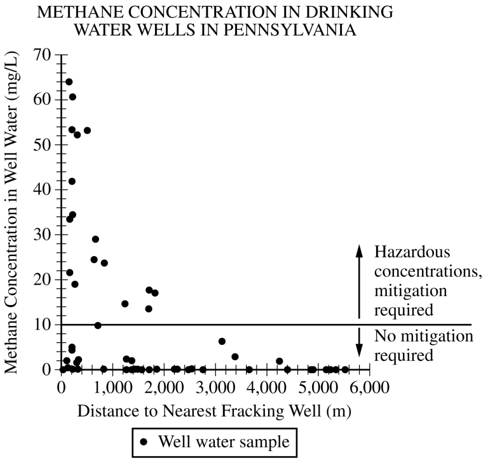
(a)(iii) Based on the data in the graph, **identify** the minimum safe distance that a new water well should be located from an existing fracking well.

(a)(iv) Explain how fracking fluid is used to access oil and natural gas in sedimentary rock, such as shale, during the fracking process.

Question 2

(a)(v) Identify one negative geologic effect in an area where hydraulic fracturing (fracking) occurs.

Question 2


METHANE CONCENTRATION IN DRINKING WATER WELLS IN PENNSYLVANIA
Methane Concentration in Well Water (mg/L)
70
60
50
40
30
20
10
0
0
1,000
2,000
3,000
4,000
5,000
6,000
Distance to Nearest Fracking Well (m)
Hazardous concentrations, mitigation required
No mitigation required
Well water sample

Question 2

2022 Set 1 ▪ Q2

Developments in advanced hydraulic fracturing (fracking) technologies have allowed the total oil and gas production in the United States to increase rapidly.

[Scatter graph titled "METHANE CONCENTRATION IN DRINKING WATER WELLS IN PENNSYLVANIA." Y-axis: "Methane Concentration in Well Water (mg/L)," scale 0 to 70 in increments of 10. X-axis: "Distance to Nearest Fracking Well (m)," scale 0 to 6,000 in increments of 1,000. A horizontal reference line is drawn at $y = 10$ mg/L, with an upward arrow above it labeled "Hazardous concentrations, mitigation required" and a downward arrow below it labeled "No mitigation required." Data points (labeled "Well water sample" in the legend, shown as filled circles) are heavily concentrated at small distances (roughly 0–500 m) with methane concentrations ranging widely from near 0 up to about 64 mg/L (points near approximately 64, 60, 53, 52, 51, 42, 34, 33, 29, 24, 20, and several points below 10 clustered near $x =$ 0–300 m). A few points appear farther out: around x 1,300–1,500 m with y 13–17

Question 2

mg/L, and isolated lower points scattered out to about x = 3,600 m (y 6), x = 3,700 m (y 3), and x = 4,300 m (y 1), with most points beyond about x = 1,000 m sitting at or near y = 0, extending out to about x = 5,700 m.]

(b)(i) The volume of water used for oil and gas extraction is 28 times greater than it was fifteen years ago. Much of the water used for oil and gas extraction comes from groundwater sources in arid or semiarid regions. This increased use of water for fracking may mean that less water is available for local use. The use of groundwater for fracking is an example of individuals using a shared resource for their own self-interest. **Identify** the environmental concept illustrated by this example of overuse of a shared resource.

(b)(ii) **Describe** one environmental problem that may result from increased use of groundwater for fracking in arid or semiarid regions.

Question 2

(b)(iii) Describe how overuse of coastal groundwater supplies can result in water that is unsuitable for human consumption.

Question 2

2022 Set 1 ▪ Q2

Developments in advanced hydraulic fracturing (fracking) technologies have allowed the total oil and gas production in the United States to increase rapidly.

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Question 2

mg/L, and isolated lower points scattered out to about x = 3,600 m (y 6), x = 3,700 m (y 3), and x = 4,300 m (y 1), with most points beyond about x = 1,000 m sitting at or near y = 0, extending out to about x = 5,700 m.]

(c)(i) In addition to water quality issues caused by fossil fuel extraction, air quality can also be negatively affected by combustion of oil and natural gas. **Make a claim** for a realistic governmental action to improve air quality by reducing consumption of oil.

(c)(ii) Justify the action proposed in part (c)(i) by stating a potential environmental advantage of that action, other than slowing global climate change.

Solution 2

(a)(i)

Mark scheme

- The highest methane concentration found in well water in Pennsylvania is 64 mg/L.

(a)(ii)

Mark scheme

- Methane concentration in well water decreases as distance from the fracking well increases — an inverse/nonlinear, negative relationship between the two variables.

Solution 2

(a)(iii)

Mark scheme

- Any value between 1,800 and 2,200 meters is an acceptable minimum safe distance for a new water well from an existing fracking well.

Solution 2

(a)(iv)

Mark scheme

- Fracking fluid is injected/pumped into the well under high pressure, opening fissures in the shale/sedimentary rock and releasing the oil and natural gas; sand grains suspended in the fluid prop open the newly formed cracks/fractures so the oil and gas can flow up the well.

(a)(v)

Mark scheme

- One negative geologic effect of fracking: earthquakes/increased seismic activity, or ground subsidence/sinkholes.

Solution 2

(b)(i)

Mark scheme

- The environmental concept illustrated is the Tragedy of the Commons.

Solution 2

(b)(ii)

Mark scheme

- One environmental problem from increased groundwater use for fracking in arid/semiarid regions: loss of habitat/productivity in spring-fed ecosystems as springs dry up; loss of habitat/productivity or degraded water quality in streams and estuaries fed by groundwater discharge; soil erosion as vegetation dies due to a lowered water table and roots no longer hold soil; or desertification resulting from a lowered water table.

Solution 2

(b)(iii)

Mark scheme

- Overuse of coastal groundwater lowers the water table, allowing ocean water to flow into the aquifer (saltwater intrusion), contaminating it with saltwater and making it unfit for human consumption.

Solution 2

(c)(i)

Mark scheme

- A realistic governmental action to improve air quality by reducing oil consumption, e.g.: increase fuel economy standards for motor vehicles; invest in renewable energy resources; use tax incentives to encourage hybrid/electric vehicle sales; subsidize public transportation/walking/cycling projects; create tax incentives for work-from-home options; or increase the gasoline tax/reduce oil subsidies.

Solution 2

(c)(ii)

Mark scheme

- Justification must state a benefit (other than slowing climate change) tied to the action named in (c)(i) — e.g. decreased oil/fuel consumption leads to reduced particulates, surface ozone/photochemical smog, or acid rain; decreased oil consumption leads to fewer oil spills and decreased groundwater depletion/contamination from fracking/drilling; or decreased oil consumption leads to less disruption to wildlife/habitats (fragmentation, noise pollution) from drilling operations.

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.

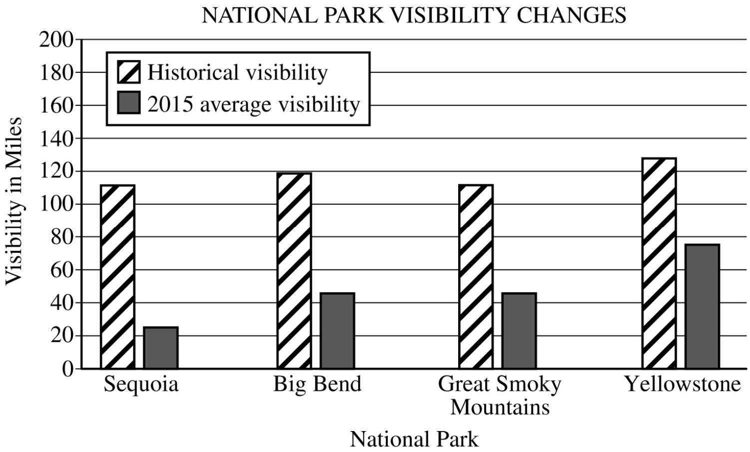
NATIONAL PARK VISIBILITY CHANGES

[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


NATIONAL PARK VISIBILITY CHANGES
Historical visibility
2015 average visibility
Visibility in Miles
200
180
160
140
120
100
80
60
40
20
0
Sequoia
Big Bend
Great Smoky Mountains
Yellowstone
National Park

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.]

(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

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.]

(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

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.]

(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:
  $\dfrac{45 \text{ miles} - 25 \text{ miles}}{25 \text{ miles}} \times 100 = 80\%$ 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.

Question 4

2018 ▪ Q4

In many parts of the world, biomass like peat, wood, and animal waste is burned indoors for cooking and home heating. Combustion of these fuels releases harmful household air pollutants that pose a health threat to billions of people, mostly in less developed countries.

(a)(i) Air pollutants are released during the burning of biomass indoors for cooking and heating.

Identify TWO air pollutants released during the burning of biomass indoors for cooking and heating.

(a)(ii) Identify a specific human respiratory illness that one of the pollutants you identified may cause.

Question 4

Indoor Air Pollutant	Source	Method for Reducing Exposure

Question 4

2018 ▪ Q4

In many parts of the world, biomass like peat, wood, and animal waste is burned indoors for cooking and home heating. Combustion of these fuels releases harmful household air pollutants that pose a health threat to billions of people, mostly in less developed countries.

(b) Identify one realistic approach, other than banning the practice of burning biomass indoors, that could be used to reduce the impact of biomass combustion indoors on human respiratory health. Describe how this approach could reduce the incidence of respiratory illness.

Question 4

2018 ▪ Q4

In many parts of the world, biomass like peat, wood, and animal waste is burned indoors for cooking and home heating. Combustion of these fuels releases harmful household air pollutants that pose a health threat to billions of people, mostly in less developed countries.

(c) In 2016 approximately four million people died from illnesses attributed to household air pollutants from burning biomass indoors. More than 10 percent of these deaths occurred in children under the age of five in less developed countries.
Discuss one reason children under the age of five are at a greater risk than adults for illnesses linked to household air pollutants.

Question 4

2018 ▪ Q4

In many parts of the world, biomass like peat, wood, and animal waste is burned indoors for cooking and home heating. Combustion of these fuels releases harmful household air pollutants that pose a health threat to billions of people, mostly in less developed countries.

(d) In more developed countries, indoor air pollution is also a problem. Common indoor air pollutants in developed countries include:

- asbestos
- radon
- mold

Question 4

Choose TWO of the three common indoor air pollutants (asbestos, radon, mold) listed above and complete the following table.

Indoor Air Pollutant	Source	Method for Reducing Exposure

(i) Identify a source for each indoor air pollutant.
(ii) Describe a method for reducing exposure to each of the two pollutants you chose.

Solution 4

(a)(i)

Mark scheme

- 2 points, 1 point per correctly identified air pollutant released during indoor biomass burning (up to 2). Accept any two of: carbon monoxide (CO); particulate matter (PM); nitrogen oxides (NOx); sulfur oxides (SOx); trace metals such as lead, mercury, arsenic, and cadmium; methane (CH4); volatile organic compounds (VOCs).

Solution 4

(a)(ii)

Mark scheme

- 1 point for correctly identifying a specific human respiratory illness linked to one of the identified pollutants. Accept, matched to the pollutant: CO $\rightarrow$ CO poisoning; PM $\rightarrow$ asthma, chronic obstructive pulmonary disease (COPD), emphysema, bronchitis, or lung cancer; NOx $\rightarrow$ pneumonia or asthma; SOx $\rightarrow$ bronchitis, emphysema, or asthma; trace metals (lead, mercury, arsenic, cadmium) $\rightarrow$ bronchitis; methane $\rightarrow$ bronchitis; VOCs $\rightarrow$ bronchitis or asthma.

Solution 4

(b) Mark scheme

- 2 points: 1 for identifying a realistic approach (other than banning indoor biomass burning) to reduce its impact on respiratory health, 1 for describing how that identified approach reduces the incidence of respiratory illness. Accept any one matched pair: ventilate through structural change (chimney construction, opening windows and doors) — removes some or all of the air pollution from indoors/transfers pollutants out of the home, leading to less respiratory illness; switch to a cleaner-burning/more efficient cooking stove — requires less fuel to be burned, releasing fewer air pollutants into the home; switch to a different energy source (solar, natural gas, biogas, electric) — produces less or no indoor air

Solution 4

pollutants; cook outdoors — moves the source of air pollutant outside/leads to less or no concentrated air pollution inside.

Solution 4

(c)

Mark scheme

- 1 point for a correct discussion of why children under age five are at greater risk than adults for illnesses linked to household air pollutants. Accept any one of: children have an underdeveloped/less-developed immune system, leading to a greater risk of illness following exposure; children have a lower body mass, leading to a higher relative dose of air pollution; children spend more time indoors, leading to higher exposure to air pollution; children have smaller respiratory systems (narrow airways) so mild inflammation may cause more severe respiratory distress.

Solution 4

(d) Mark scheme

- 4 points total for choosing TWO of asbestos/radon/mold and completing the table: 1 point for each correctly identified source (up to 2, one per chosen pollutant) and 1 point for each correctly described method of reducing exposure (up to 2, one per chosen pollutant). Asbestos — source: building materials (cement, floor tiles, ceiling panels, drywall, popcorn ceiling), insulation, or naturally occurring in soil/rock in a dirt-floor basement/crawlspace; method: safely remove asbestos-containing materials/abatement, encapsulate/cover/seal materials or construct a temporary enclosure, or leave undisturbed. Radon — source: soil, rocks, Earth's crust; gas from uranium-containing rocks; gas penetrating the foundation; method: seal floors/walls/joints, install structural

Solution 4

exhaust venting, or install a subfloor depressurizing system. Mold — source: water from flooding/natural disasters/leaks, or poorly vented/maintained damp environments; method: replace or repair damaged surfaces/structures, clean/disinfect affected areas, dehumidify or ventilate inside air, or improve drainage (from roof or yard, sump pump the basement). Award points for any two of the three pollutants chosen.