Past-paper walk-through

Introduction to Air Pollution ▪ 7.1

eXercise

Questions in this set

- 2025 Set 1 Q3
- 2025 Set 2 Q3
- 2023 Set 1 Q3
- 2022 Set 2 Q3
- 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 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 $\approx$ 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

2025 Set 2 ▪ Q3

The local government of a newly built town has contracted with an electrical company to provide energy to the town. The company generates electricity primarily through the burning of coal and has built a new power plant for the town. A nearby deposit of coal was discovered close to the surface. To access the coal, the company decides to remove the overburden and vegetation over the deposit.

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

(a) Identify a type of surface mining the company could use to access the coal.

Question 3

2025 Set 2 ▪ Q3

The local government of a newly built town has contracted with an electrical company to provide energy to the town. The company generates electricity primarily through the burning of coal and has built a new power plant for the town. A nearby deposit of coal was discovered close to the surface. To access the coal, the company decides to remove the overburden and vegetation over the deposit.

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

(b) Describe an environmental problem associated with surface mining.

Question 3

2025 Set 2 ▪ Q3

The local government of a newly built town has contracted with an electrical company to provide energy to the town. The company generates electricity primarily through the burning of coal and has built a new power plant for the town. A nearby deposit of coal was discovered close to the surface. To access the coal, the company decides to remove the overburden and vegetation over the deposit.

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

(c) The town is located downwind of the new coal-burning power plant.

Describe an environmental problem the town could experience as a result of the electricity generation at the coal-burning power plant.

Question 3

2025 Set 2 ▪ Q3

The local government of a newly built town has contracted with an electrical company to provide energy to the town. The company generates electricity primarily through the burning of coal and has built a new power plant for the town. A nearby deposit of coal was discovered close to the surface. To access the coal, the company decides to remove the overburden and vegetation over the deposit.

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

(d) The local government is concerned about the environmental consequences of using coal to generate electricity for the town.

Propose a realistic solution the local government could enact that would reduce the negative environmental consequences of using coal to generate electricity.

Question 3

2025 Set 2 ▪ Q3

The local government of a newly built town has contracted with an electrical company to provide energy to the town. The company generates electricity primarily through the burning of coal and has built a new power plant for the town. A nearby deposit of coal was discovered close to the surface. To access the coal, the company decides to remove the overburden and vegetation over the deposit.

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

(e) Burning one pound of coal produces an average of 0.88 kilowatt-hours (kWh) of electricity. An average household in the United States uses 1.064×10^4 kWh of electricity each year.

Calculate how many pounds of coal would need to be burned to generate enough electricity to power a town with 11,000 houses for a year. **Show** your work.

Question 3

2025 Set 2 ▪ Q3

The local government of a newly built town has contracted with an electrical company to provide energy to the town. The company generates electricity primarily through the burning of coal and has built a new power plant for the town. A nearby deposit of coal was discovered close to the surface. To access the coal, the company decides to remove the overburden and vegetation over the deposit.

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

(f) Researchers are concerned about the impact of noise pollution on songbirds in a forest near the power plant. Since the power plant was installed, bird species richness has declined from 7.5 species per hectare to 6.0 species per hectare.

Calculate the percent change in bird species per hectare since the power plant was installed. **Show** your work.

Question 3

2025 Set 2 ▪ Q3

The local government of a newly built town has contracted with an electrical company to provide energy to the town. The company generates electricity primarily through the burning of coal and has built a new power plant for the town. A nearby deposit of coal was discovered close to the surface. To access the coal, the company decides to remove the overburden and vegetation over the deposit.

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

(g) The town has been growing since it was built and had a growth rate of 5.38% in 2022, with a population of 26,250.

Assuming that the growth rate remains constant, **calculate** the year in which the population will reach 52,500. **Show** your work.

Solution 3

(a)

Mark scheme

- A type of surface mining the company could use to access the coal: strip mining, open pit mining, or mountaintop removal. 1 point for naming any one valid surface-mining type.

Solution 3

(b)

Mark scheme

- An environmental problem associated with surface mining: removal of vegetation/soil/rock causes loss/destruction of habitat (and resulting loss of biodiversity); removal of vegetation can increase erosion rates; surface mining can contaminate groundwater/surface water/waterways via runoff of sediments/pollutants; removal of vegetation/soil/bedrock/parent material can release dust particles/methane; or high energy/fossil fuel consumption to operate equipment leads to air pollution. 1 point for any one valid problem.

Solution 3

(c)

Mark scheme

- An environmental problem the downwind town could experience from the power plant's electricity generation: release of air pollutants/toxic metals/particulates/NOx/SOx could lower air quality and cause respiratory problems; release of sulfur dioxides/nitrogen oxides could cause acid rain; or greenhouse gas emissions (carbon dioxide/methane/water vapor) could alter precipitation/climate/weather/temperature patterns. 1 point for any one valid problem.

Solution 3

(d)

Mark scheme

- A realistic solution the local government could enact: require/incentivize the plant to install scrubbers/electrostatic precipitators; incentivize the use of alternative energy sources/energy-efficient appliances; or incentivize green building design/conservation landscaping/planting trees as carbon sinks. 1 point for any one valid, realistic solution.

Solution 3

(e) Mark scheme

- Setup (1 point): pounds of coal needed = (11,000 houses x 10,640 kWh per house) / 0.88 kWh per lb of coal, i.e. $\frac{11{,}000 \times 10{,}640}{0.88}$, using the given household usage of 1.064×10^4 kWh/year and the given 0.88 kWh generated per pound of coal burned. Calculation (1 point): approximately 133,000,000 lb of coal (i.e. 1.33×10^8 lb). Award 1 point for the correct setup (total kWh needed for the town divided by kWh generated per lb of coal) and 1 point for the correct final numeric value (accept equivalent or reasonably rounded answers).

Solution 3

(f)

Mark scheme

- Setup (1 point): percent change = (6.0 species/ha - 7.5 species/ha) / 7.5 species/ha x 100, i.e. $\frac{6.0 - 7.5}{7.5} \times 100$. Calculation (1 point): -20

Solution 3

(g)

Mark scheme

- Setup (1 point): since the target population of 52,500 is double the 2022 population of 26,250, use the Rule of 70 to estimate doubling time and add it to the starting year: $\left(\frac{70}{5.38}\right) + 2022$. Calculation (1 point): 2035 (doubling time of about 13 years added to 2022). Award 1 point for the correct setup (70 divided by the percent growth rate, plus the starting year) and 1 point for the correct final year (accept 2035 or a value from a reasonably equivalent growth calculation).

Question 3

2023 Set 1 ▪ Q3

3. Crude oil is extracted, transported, and refined for various uses by humans.

(a) **Describe** one environmental impact on marine ecosystems associated with extraction or transportation of crude oil.

(b) **Identify** an atmospheric pollutant released during the combustion of refined oil products.

(c) **Propose** a solution an individual can use to reduce their reliance on refined oil products for transportation.

(d) **Justify** the solution proposed in part (c) by providing a benefit to human health.

Other natural resources, such as gold and silver, are also extracted. These resources can be used to make components for the electronics humans use. One metric ton of gold ore contains 5.0 grams of gold.

(e) A deposit is estimated to contain 260 million metric tons of gold ore. **Calculate** the number of grams of gold that could be extracted from the deposit. **Show** your work.

Question 3

(f) Assuming the price of gold is $62.56 per gram, **calculate** the value of the gold that could be recovered from 1,000 metric tons of gold ore in the deposit. **Show** your work.

(g) A typical cell phone contains 0.034 grams of gold. **Calculate** how many metric tons of gold ore would need to be mined to extract enough gold to manufacture 100,000 cell phones. **Show** your work.

Begin your response to this question at the top of a new page in the separate Free Response booklet and fill in the appropriate circle at the top of each page to indicate the question number.

STOP

END OF EXAM

Solution 3

(a)

Mark scheme

- Any one environmental impact: marine life is harmed/killed by being coated/suffocated by oil from spills; animals are harmed/killed by ingesting spilled oil; oil slicks from spills can block sunlight from entering water and inhibit photosynthesis; oil that washes up on beaches/in marshes/in estuaries damages habitat; noise pollution disrupts marine animals' ability to communicate/mate/eat/evade prey; or CO2 from combustion of fuels in boats/equipment is absorbed by the ocean and contributes to ocean acidification.

Solution 3

(b)

Mark scheme

- Any one atmospheric pollutant: carbon dioxide (CO2); nitrogen oxides (NOx, NO, NO2, N2O); sulfur oxides (SOx, SO2, SO3); particulate matter (PM); carbon monoxide (CO); or volatile organic compounds (VOCs).

Solution 3

(c)

Mark scheme

- Any one solution: ride a bike/scooter/skateboard or walk instead of driving; replace a gasoline/diesel powered car with a hybrid or electric vehicle; replace a gasoline/diesel powered car with one that utilizes alternative fuel (biodiesel, ethanol, hydrogen); buy/drive a more fuel-efficient vehicle; work from home/telecommute to reduce miles driven; choose housing close to employment to reduce miles driven; take public transportation instead of driving; carpool instead of driving alone; or combine trips to reduce miles driven.

Solution 3

(d)

Mark scheme

- Fewer air pollutants (particulates, NOx, VOCs, smog) from the proposed solution lead to lower rates of respiratory illness/problems (such as asthma, COPD, lung cancer), lower rates of cardiovascular illness (such as heart attacks), and less eye irritation. If the solution proposed in (c) was active transport (biking/walking/scootering), an additional acceptable justification is improved health/decreased risk of disease/cardiovascular illness from more physical activity/exercise.

Solution 3

(e)

Mark scheme

- Setup (1 point): 260×10^6 metric tons $\times \dfrac{5 \text{ grams}}{1 \text{ metric ton}}$ (equivalently $5 \times 260{,}000{,}000$). Calculation (1 point): $260{,}000{,}000 \times 5 = 1{,}300{,}000{,}000$ grams of gold (i.e. 1.3×10^9 g). Award 1 point for the correct dimensional setup and 1 point for the correct final numeric answer (1,300,000,000 g or 1.3 x $10^9 g$).

Solution 3

(f)

Mark scheme

- Setup (1 point): $\dfrac{\$62.56}{1 \text{ gram}} \times 1{,}000 \text{ metric tons} \times \dfrac{5 \text{ grams}}{1 \text{ metric ton}}$ (equivalently $1{,}000 \times 5 \times \$62.56$). Calculation (1 point): $1{,}000 \times 5 \times 62.56 = 312{,}800$, so the gold recovered from 1,000 metric tons of ore is worth \$312,800. Award 1 point for the correct setup and 1 point for the correct final numeric answer (\$312,800).

Solution 3

(g) Mark scheme

- Setup (1 point): $\frac{0.034 \text{ grams}}{1 \text{ cell phone}} \times \frac{1 \text{ metric ton}}{5 \text{ grams}} \times 100{,}000$ cell phones (equivalently $\frac{0.034 \times 100{,}000}{5}$). Calculation (1 point): $\frac{0.034 \times 100{,}000}{5} = \frac{3{,}400}{5} = 680$ metric tons of gold ore. Award 1 point for the correct setup and 1 point for the correct final numeric answer (680 metric tons).

Question 3

2022 Set 2 ▪ Q3

North Carolina is one of the fastest-growing states by population in the United States, with most growth concentrated in major cities like Charlotte. Increased population leads to increased demands for resources such as power and water.

The majority of electrical energy in North Carolina is produced during the combustion of coal.

(a) Identify one negative human health effect linked to the exposure to pollutants resulting from the combustion of coal.

Question 3

2022 Set 2 ▪ Q3

North Carolina is one of the fastest-growing states by population in the United States, with most growth concentrated in major cities like Charlotte. Increased population leads to increased demands for resources such as power and water.

The majority of electrical energy in North Carolina is produced during the combustion of coal.

(b)(i) Coal ash, the powdery, solid substance that remains after coal combustion, presents a variety of potential environmental issues. Disposal of toxic coal ash is a growing concern in the state. Coal ash can be mixed with water and disposed of in large, unlined pits or as dry ash in landfills.

Describe an environmental problem associated with coal ash waste disposal.

(b)(ii) A proposed solution is to dispose of North Carolina's coal ash in clay-lined pits. **Justify** this solution by providing one advantage of using clay soil.

Question 3

2022 Set 2 ▪ Q3

North Carolina is one of the fastest-growing states by population in the United States, with most growth concentrated in major cities like Charlotte. Increased population leads to increased demands for resources such as power and water.

The majority of electrical energy in North Carolina is produced during the combustion of coal.

(c)(i) The population of Charlotte, North Carolina, has grown over the last few decades. The table shows the increase in the population size of Charlotte from 2013 to 2019.

Population of Charlotte, North Carolina, 2013–2019

Year	Population
2013	757,278
2014	774,807
2015	792,137
2016	808,834
2017	826,060
2018	841,611
2019	857,425

Question 3

Calculate the percent change in Charlotte's population from 2013 to 2019. **Show** your work.

(c)(ii) Based on Charlotte's 2019 growth rate of 1.88%, **calculate** the year when the population of Charlotte will double, assuming the growth rate stays the same. **Show** your work.

(c)(iii) The average Charlotte resident uses 90 gallons of water per day. **Calculate** the gallons of water used by the population of Charlotte in the year 2018. **Show** your work.

Question 3

2022 Set 2 ▪ Q3

North Carolina is one of the fastest-growing states by population in the United States, with most growth concentrated in major cities like Charlotte. Increased population leads to increased demands for resources such as power and water.

The majority of electrical energy in North Carolina is produced during the combustion of coal.

(d) Drought periods are becoming more frequent in North Carolina, causing water resources to become more scarce. **Describe** one realistic action that citizens could take to reduce domestic outdoor water use.

Solution 3

(a)

Mark scheme

- Any one negative human health effect linked to pollutant exposure from coal combustion: lung/respiratory disease (asthma, COPD, bronchitis, lung cancer); neurological damage; birth defects; heart disease; eye irritation/respiratory irritation/headaches.

Solution 3

(b)(i)

Mark scheme

- Any one environmental problem associated with coal ash waste disposal: leaching from landfills/clay-lined pits; overflowing of coal ash into bodies of water; leaking and contamination of groundwater, soil, or nearby bodies of water; coal ash washing into bodies of water during severe weather events; dry ash blowing/carrying into nearby bodies of water, increasing turbidity/decreasing photosynthesis.

Solution 3

(b)(ii)

Mark scheme

- Clay is less permeable than unlined pits and can prevent the leaching of coal ash into soil/groundwater.

Solution 3

(c)(i)

Mark scheme

- Percent change = [(857,425 people − 757,278 people) / 757,278 people] × 100, equivalently [(857,425/757,278) − 1] × 100. One point for this correct setup; one point for the correct result: ≈13% (13.22%, or 13.224602%).

(c)(ii)

Mark scheme

- Doubling time = 70 / growth rate(%) = 70 / 1.88 ≈ 37 years. One point for this correct setup. Adding 37 years to 2019 gives the doubling year: one point for the correct result, 2056.

Solution 3

(c)(iii)

Mark scheme

- Gallons used in 2018 = 90 gallons/person/day × 841,611 people × 365 days. One point for this correct setup. One point for the correct result: 27,646,921,350 gallons (accept 2.76×10^10, 2.8×10^10, or 3×10^10 gallons).

Solution 3

(d)

Mark scheme

- Any one realistic action to reduce domestic outdoor water use: plant drought-resistant species/use artificial landscaping/xeriscaping to reduce irrigation needs; eliminate/reduce nonessential water use such as washing cars or power washing; reduce sprinkler/irrigation use by monitoring soil/weather conditions or reducing frequency; collect rainwater or greywater for irrigation; water plants/lawn before sunrise/after sunset to limit evaporation; switch to drip irrigation to limit evaporation.

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.

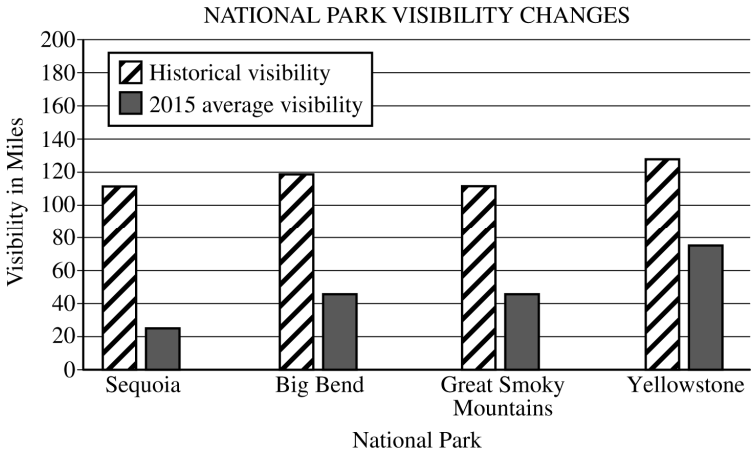
NATIONAL PARK VISIBILITY CHANGES

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