Past-paper walk-through

Atmospheric CO2 and Particulates ▪ 7.4

eXercise

Questions in this set

- 2025 Set 1 Q2
- 2021 Set 2 Q3

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

2025 Set 1 ▪ Q2

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Figure 1. Effects of Changes in Sea Surface Conditions in Equatorial Pacific Ocean

[Map of the equatorial Pacific Ocean region spanning from Africa/the Indian Ocean on the left to Australia and the western coast of South America on the right, with dashed horizontal reference lines at “30° North” and “Equator 0°”. A large hatched region (diagonal lines, labeled in the legend as “Ocean water cooler than average”) covers the

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western/central Pacific Ocean around and south of Australia and Indonesia. A large solid-shaded region (labeled "Ocean water warmer than average") lies to the west of the hatched region, overlapping the Indian Ocean/Indonesia area. A solid black patch (labeled "Increased chance of precipitation") sits over Australia. A bold horizontal arrow points from right (near South America) to left (toward Indonesia/Australia) along the Equator, labeled "Stronger than normal trade winds". A compass rose (N/S/E/W) is shown in the lower right. Legend: (diagonal hatch) = Ocean water cooler than average; (grey fill) = Ocean water warmer than average; (black fill) = Increased chance of precipitation; ← (bold arrow) = Stronger than normal trade winds.]

Figure 2. Polar Jet Stream and Climate Conditions in North America

[Map of North America showing a thick curved arrow labeled "Polar Jet Stream" that dips from the northwest, curves down over the western/central United States, and rises

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back up toward the northeast (Atlantic Canada), with an arrowhead at the northeast end. A region labeled "A" (dashed-outline circle, dotted fill pattern) is located over the northwestern/western Canada-US border area. A dotted-fill band (same pattern as region A, labeled in the legend as "Increased chance of precipitation") stretches along the path under the jet stream curve across the northern/central US. A region labeled "B" (dashed-outline box, solid grey fill) sits over the south-central/southeastern United States, within a larger grey-shaded band (labeled "Decreased chance of precipitation"). A diagonally hatched region (labeled "Warmer than average") covers the southeastern United States. A compass rose (N/S/E/W) is shown in the lower left. Legend: (dotted outline/fill) = Increased chance of precipitation; (solid grey fill) = Decreased chance of precipitation; (dotted fill, different pattern) = Cooler than average; (diagonal hatch) = Warmer than average.]

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(a) Identify the sea surface condition for the eastern equatorial area of the Pacific Ocean illustrated in Figure 1.

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(b) Based on the information in Figure 1, identify the climate phenomenon associated with the sea surface conditions shown in the equatorial area of the Pacific Ocean.

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(c) Based on the information in Figure 2, describe a difference in climate patterns between the regions A and B.

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(d) Increases in regional precipitation can lead to increased flooding in certain locations. Describe one reason why there is an increased risk of flooding in urban areas during extended periods of precipitation.

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(e) Propose a realistic solution a city could implement to decrease the risk of flooding in urban areas.

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(f) Justify the solution proposed in part E by providing an additional advantage other than a reduction in the risk of flooding.

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(g) Terrestrial biomes are primarily determined by temperature and precipitation patterns. Describe one difference between the climate of a temperate seasonal forest and that of a savanna.

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(h) Droughts are one environmental problem that can affect the frequency and severity of forest fires. Identify the ecological process that occurs following a forest fire that leaves the soil intact.

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2025 Set 1 ▪ Q2

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(i) Describe one way burning forests contribute to atmospheric pollution.

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(j) Describe one sustainable forestry practice that could be used to reduce the occurrence or severity of forest fires.

Solution 2

(a)

Mark scheme

- The sea surface condition in the eastern equatorial Pacific shown in Figure 1: ocean water is cooler than average.

Solution 2

(b)

Mark scheme

- The climate phenomenon associated with these cooler-than-average equatorial Pacific sea surface conditions is La Niña.

Solution 2

(c)

Mark scheme

- Difference in climate patterns between regions A and B (Figure 2): Region A has an increased chance of precipitation while Region B has a decreased chance of precipitation — i.e., Region A will be wetter while Region B will be drier.

Solution 2

(d)

Mark scheme

- One reason for increased flood risk in urban areas during extended precipitation: impervious/paved surfaces (parking lots, roads, buildings, sidewalks) increase runoff and reduce infiltration/absorption; urban areas also have less vegetation, further reducing infiltration/absorption.

Solution 2

(e)

Mark scheme

- A realistic city solution to decrease urban flood risk: use permeable pavement; or plant vegetation/establish parks/create rain gardens/build green roofs; or install retention ponds/stormwater basins.

Solution 2

(f) Mark scheme

- Justify the part-E solution with an advantage beyond flood reduction, matched to the chosen solution. Permeable pavement: increased recharge of nearby aquifers/groundwater; decreased pollution in runoff. Vegetation/parks/rain gardens/green roofs: absorbs pollutants; stores carbon dioxide/produces oxygen; decreases erosion; increases/restores wildlife habitat and biodiversity; reduces the urban heat island effect; improves aesthetic enjoyment/quality of life; creates landscaping/park-maintenance jobs. Retention ponds/stormwater basins: decreased pollution in runoff; increased habitat/biodiversity.

Solution 2

(g)

Mark scheme

- One climate difference between a temperate seasonal forest and a savanna: temperate seasonal forests have a cooler climate with a stronger/colder winter and four distinct seasons, and receive more annual precipitation (spread throughout the year), whereas savannas are warmer with a distinct rainy season and dry season and do not have four distinct seasons.

Solution 2

(h)

Mark scheme

- The ecological process that occurs following a forest fire that leaves the soil intact is secondary succession.

Solution 2

(i)

Mark scheme

- One way burning forests contributes to atmospheric pollution: burning trees releases CO2, CO, NOx, particulate matter, and/or VOCs into the atmosphere.

Solution 2

(j)

Mark scheme

- One sustainable forestry practice to reduce the occurrence/severity of forest fires: prescribed burns (remove excess fuel/dead leaves/underbrush); brush removal (removes excess fuel); selective cutting (creates a fire break); agroforestry, where ground crops that might otherwise become fuel are harvested/removed.

Question 3

2021 Set 2 ▪ Q3

Approximately 350 coal-fired power plants in the United States are older than the 30-year anticipated life-span for a coal generator. One problem with these aging power plants is that many lack the necessary modern air pollution controls. Additionally, there are concerns about rising fuel costs, so many utility companies are planning to retire coal-fired plants and build new natural-gas power plants.

(a) Describe why coal is considered a nonrenewable energy source.

Question 3

2021 Set 2 ▪ Q3

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(b) Describe one potential environmental advantage of replacing a coal-fired power plant with a natural-gas power plant.

Question 3

2021 Set 2 ▪ Q3

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(c) Describe one economic advantage of using natural gas, rather than coal, in producing electricity.

Question 3

2021 Set 2 ▪ Q3

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(d) When natural gas is used to heat homes, it can produce carbon monoxide gas, which can lead to carbon monoxide poisoning in humans. Propose a solution to reduce the incidence of carbon monoxide poisoning in humans.

Particulate matter is another common pollutant in emissions from vehicles, coal-fired power plants, and various other sources. One size of particulates, $PM_{2.5}$, presents a particular risk to human health.

Question 3

ATMOSPHERIC CONCENTRATION OF PARTICULATE MATTER IN 1990 AND 2016

| Year | Average Annual Atmospheric Concentration of $PM_{2.5}$ ($\mu g/m^3$) | |—|—| | 1990 | 85 | | 2016 | 188 |

Question 3

2021 Set 2 ▪ Q3

Approximately 350 coal-fired power plants in the United States are older than the 30-year anticipated life-span for a coal generator. One problem with these aging power plants is that many lack the necessary modern air pollution controls. Additionally, there are concerns about rising fuel costs, so many utility companies are planning to retire coal-fired plants and build new natural-gas power plants.

(e) Calculate the percent change in the average annual $PM_{2.5}$ concentration in the air from 1990 to 2016. Show your work.

Question 3

2021 Set 2 ▪ Q3

Approximately 350 coal-fired power plants in the United States are older than the 30-year anticipated life-span for a coal generator. One problem with these aging power plants is that many lack the necessary modern air pollution controls. Additionally, there are concerns about rising fuel costs, so many utility companies are planning to retire coal-fired plants and build new natural-gas power plants.

(f) Trees can remove $PM_{2.5}$ from the atmosphere when particulates settle on the leaves and are subsequently washed onto soil by rain. The average annual removal of $PM_{2.5}$ is 2.3 kilograms per hectare. Calculate the decrease in $PM_{2.5}$ removal in kilograms if logging reduced a forested area from 50,000 hectares to 43,000 hectares. Show your work.

Question 3

2021 Set 2 ▪ Q3

Approximately 350 coal-fired power plants in the United States are older than the 30-year anticipated life-span for a coal generator. One problem with these aging power plants is that many lack the necessary modern air pollution controls. Additionally, there are concerns about rising fuel costs, so many utility companies are planning to retire coal-fired plants and build new natural-gas power plants.

(g) Research has shown that hospital admissions for cardiovascular problems increase 1

Solution 3

(a)

Mark scheme

- Coal is considered nonrenewable because it exists in a fixed/finite/limited amount – its natural formation rate is far slower than the rate at which it is consumed/combusted.

Solution 3

(b)

Mark scheme

- One environmental advantage of replacing a coal-fired plant with a natural-gas plant: natural gas combustion emits fewer greenhouse gases/less CO2; does not emit mercury/lead/cadmium/uranium; emits less NOx/SOx, reducing acid precipitation; produces less/no particulate matter/soot/smog; requires less habitat destruction/fossil-fuel use to transport than coal; avoids habitat destruction from impoundment of coal ash or coal slurry; or avoids the habitat destruction of strip mining/mountaintop removal used to extract coal.

Solution 3

(c) Mark scheme

- One economic advantage of natural gas over coal in producing electricity: pipeline transport of natural gas costs less than rail transport of coal; natural gas (methane) harvested from decomposition (landfills, wastewater treatment plants, biodigesters) costs less than coal; fewer health-related costs are linked to burning natural gas than coal; fewer pollution controls are needed for a natural-gas plant, lowering operating/construction/permitting costs; lower combustion-residue disposal costs than coal-burning plants; or natural-gas plants are more efficient (more electricity output per unit energy input), leading to lower fuel costs.

Solution 3

(d) Mark scheme

- A solution to reduce carbon monoxide poisoning: install/use/replace/update carbon monoxide detectors/alarms/sensors (or replace their batteries); perform regular maintenance on natural-gas furnaces so minimal carbon monoxide is produced and combustion products are properly vented/exhausted; create laws/regulations mandating carbon monoxide detectors in all homes; use PSAs, billboards, or other methods to educate the public about carbon monoxide poisoning; or change the home heating system to a method that does not involve combustion of a fuel that could produce carbon monoxide.

Solution 3

(e)

Mark scheme

- Percent change = [(188 micrograms/m^3 - 85 micrograms/m^3) / 85 micrograms/m^3] x 100 ~= 121% (accept 120% or 121.2%). One point for the correct setup (must include units and multiplication by 100 to yield a true percentage: (188-85)/85 x 100); one point for the correct numeric result (121%, 120%, or 121.2%).

Solution 3

(f)

Mark scheme

- Decrease in PM2.5 removal = (50,000 ha - 43,000 ha) x 2.3 kg/ha = 7,000 ha x 2.3 kg/ha = 16,100 kg (accept 16,000 kg). Equivalently: 50,000 ha x 2.3 kg/ha = 115,000 kg; 43,000 ha x 2.3 kg/ha = 98,900 kg; 115,000 kg - 98,900 kg = 16,100 kg. One point for the correct setup (must include units); one point for the correct numeric result (16,100 kg or 16,000 kg).

Solution 3

(g)

Mark scheme

- Increase in admissions = (0.23/0.10) x 0.01 x 7,390 admissions, equivalently (23%/10%) x 1% x 7,390 admissions $\sim=$ 169-170 more admissions (accept 169 or 170). One point for the correct setup; one point for the correct numeric result.