Past-paper walk-through

Indoor Air Pollutants ▪ 7.5

eXercise

Questions in this set

- 2021 Set 2 Q3
- 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

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

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.

(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

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(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.

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.