8.3 Urban air pollution

Name: _____ Class: _____ Date: _____ **Total: 17 marks**

KEY WORDS primary pollutant • secondary pollutant • photochemical smog • temperature inversion • particulate matter • low-emission zone

Objective

Build the skills to answer exam questions on **urban air pollution** : primary and secondary pollutants, **photochemical smog** , **temperature inversions** , health impacts and management.

You must be able to:

- distinguish primary and secondary pollutants, with sources
- explain how photochemical smog forms and how a temperature inversion traps it
- interpret air-quality data
- evaluate strategies to reduce urban air pollution

1 Key knowledge and worked examples

Urban air pollution

type	examples	main sources
primary (released directly)	nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon monoxide (CO), particulate matter ($PM_{2.5}$, PM_{10}), volatile organic compounds (VOCs)	vehicle exhausts, power stations, industry, burning coal and wood
secondary (formed in the air)	**tropospheric ozone** (O_3), PAN	NO_x + VOCs react in **sunlight**

Photochemical smog: in sunny, still weather, NO_x and VOCs from traffic react in sunlight to form ozone and other chemicals: a brown haze. It is worst in big, sunny, car-dependent cities.

Temperature inversion: normally air cools with height, so warm polluted air rises and spreads. In an inversion, a layer of **warm air sits above cool air** near the ground. The cool air cannot rise, so pollution is trapped. It is common in valleys and basins, on calm, clear nights and in winter.

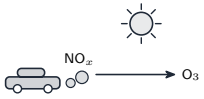
Health effects: $PM_{2.5}$ goes deep into the lungs and blood; asthma, bronchitis, heart and lung disease. Ozone irritates eyes and airways and damages crops. Outdoor air pollution causes millions of early deaths each year (WHO).

Management: catalytic converters; cleaner fuels; electric vehicles; public transport; low-emission or congestion zones; moving industry away from homes; filters on power stations; air-quality warnings.

Answer shapes: name the pollutant, its source, how it forms or moves, and its effect.

2 Practice

2.1 Distinguish between primary and secondary pollutants, giving **one** example of each. [2]



2.2 Explain how a temperature inversion traps air pollution in a city. [3]



2.3 Explain how photochemical smog forms. [3]



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3 Exam-style questions

3.1 The graph shows the monthly mean $PM_{2.5}$ concentration in a northern city.

(a) Describe the pattern shown. [2]



(b) Suggest **two** reasons for the pattern. [2]

3.2 A city plans a **low-emission zone**: older, more polluting vehicles must pay a daily charge to enter the centre.

(a) Outline **two** health effects of urban air pollution. [2]

(b) Evaluate the low-emission zone. [3]



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Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

primary: released directly from a source, e.g. NO_x, CO, SO_2, particulates from vehicles; secondary: formed in the air by reactions of primary pollutants, e.g. tropospheric ozone

2.2

normally air cools with height, so warm polluted air rises and disperses; in an inversion a layer of warm air lies above cooler air near the ground; the cool, dense air cannot rise through it, so pollutants build up near the ground

2.3

vehicles release nitrogen oxides and volatile organic compounds; in strong sunlight these react together; they form secondary pollutants such as tropospheric ozone and PAN, which make a brown haze

3.1

(a) highest in winter (December–February), lowest in summer (June–August); winter values are about three times the summer values

(b) more burning of coal and wood for heating in winter; more temperature inversions and calm air in winter trap pollution / more summer rain washes particles out

3.2

(a) any two: asthma and other breathing problems; heart disease and stroke; lung cancer; early death; eye irritation

(b) strength: fewer old polluting vehicles in the centre, so less NO_x and particulates where most people are; limitation: poorer drivers and small businesses may pay most; traffic and pollution may move to roads outside the zone; judgement: effective when combined with better public transport and help to replace old vehicles

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