

Atmospheric Pollution

AP Environmental Science ■ Unit 7

AP Environmental Science



What we will cover

- 1 Types of pollutants
- 2 Photochemical smog
- 3 Thermal inversion
- 4 CO₂ and indoor air
- 5 Acid rain
- 6 Reducing pollution



1

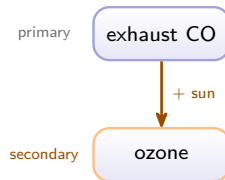
Types

Types of pollutants

Air pollution 空气污染 arrives two ways:

- **primary** 一次污染物: released already harmful (CO)
- **secondary** 二次污染物: forms *in* the air (ground-level ozone)

Burning **fossil fuels** 化石燃料 is the biggest source of **particulates** 颗粒物, **ozone** 臭氧, and **nitrogen oxides** 氮氧化物.



Primary and secondary pollutants are not the same thing

primary pollutants 一次污染物

emitted **directly** from a source: CO, NO_x, SO₂, particulates, **VOCs** 挥发性有机物

secondary pollutants 二次污染物

formed in the air when primaries react in sunlight – ground-level ozone is the standard example

electrostatic precipitators 静电除尘器

charge particulates so they stick to plates – fitted to power-station stacks

scrubbers 洗涤器

spray a slurry through the flue gas to strip SO₂ before it leaves the chimney

Ground-level ozone is a **pollutant**; the ozone **layer** high above is protective. The exam sets that confusion on purpose.

2

Smog

Photochemical smog

Brown city haze forms when pollutants bake in sunlight:

- nitrogen oxides + VOCs + sunlight
- → ground-level ozone

Ozone is the classic secondary pollutant – worst on hot, sunny, traffic-filled afternoons.



Photochemical smog over a traffic-filled city

3

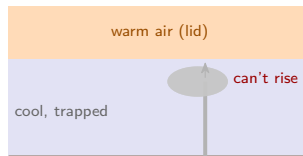
Inversion

Thermal inversion

Normally warm air rises and carries pollution up. A **thermal inversion** 逆温现象 puts a warm layer *on top*, like a lid.

- cool air below cannot rise
- pollution cannot **disperse** 扩散

A valley or basin traps it longer – deadly smog events build over days.



4

CO₂ and indoor

CO₂, particulates, and indoor air

Combustion 燃烧 releases **carbon dioxide** 二氧化碳 plus **particulate matter** 颗粒物.

Indoors can be worse: **radon** 氡, **carbon monoxide** 一氧化碳, **asbestos** 石棉. Fix: **ventilation** 通风.



Indoor air: cookstoves and poor ventilation

5

Acid rain

Acid rain

Acid rain 酸雨: **sulfur dioxide** 二氧化硫 (coal) and nitrogen oxides (cars) form acids in cloud water.

- drops **pH** 酸碱度 of soil and lakes below 4
- kills **forests** 森林 and fish, eats stone

Cut it at the source: **scrubbers** 洗滌器 and cleaner fuels.



Acid rain damages forests, lakes, and stone

Worked example – how much more acidic is acid rain?

Normal rain is about pH 5.6; an acid-rain sample measures pH 3.6. How many times more acidic is it?

- pH is a **base-10 logarithmic** scale: one unit is a $10\times$ change in $[\text{H}^+]$
- $10^{(5.6-3.6)} = 10^2 = 100$ times more acidic

A two-unit drop is a hundred-fold jump. That is why acid rain strips leaves, leaches soil nutrients and eats limestone so fast.

6

Reducing

Reducing pollution

Clean the exhaust, pass laws, switch fuels:

Catalytic converters 催化转化器

change exhaust into safer gases

Scrubbers 洗涤器

strip SO₂ from smokestacks

Legislation 立法

Clean Air Act sets limits

Cleaner energy 清洁能源

cut pollution at its root

Two of these clean the gas *after* it is made; two stop it being made at all. Say which kind your method is and the mark follows.

Atmospheric CO₂ and particulates

the source

rising atmospheric CO₂ comes from burning fossil fuels

the effect

it enhances the greenhouse effect and warms the climate

particulate matter 颗粒物

tiny solid or liquid particles suspended in air

its sources

combustion, industry, road dust and wildfires

its effect

respiratory and cardiovascular disease – and PM_{2.5} penetrates deepest

and on climate

particulates can cool by reflecting sunlight, which is the opposite sign to CO₂

The two act in opposite directions, which is why cleaning up particulate pollution can unmask warming that was already there.

Noise pollution

what it is

unwanted or harmful sound in the environment

sources

road traffic, aircraft, trains, industry, construction

effect on people

hearing loss 听力损失, **stress** 压力, sleep loss, raised blood pressure

effect on wildlife 野生动物

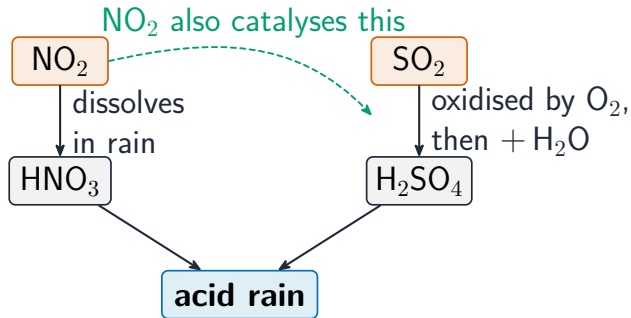
masks the sounds animals use to communicate, navigate and find mates;
ship noise is especially harmful to whales and dolphins

controls

sound barriers, quieter engines and mufflers, buffer zones around airports

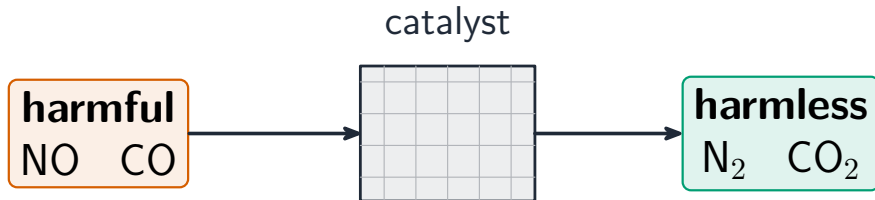
Noise is the pollutant with **no residue**: it harms while it is present and vanishes the moment it stops – which is exactly why it is under-regulated.

Acid Rain, continued



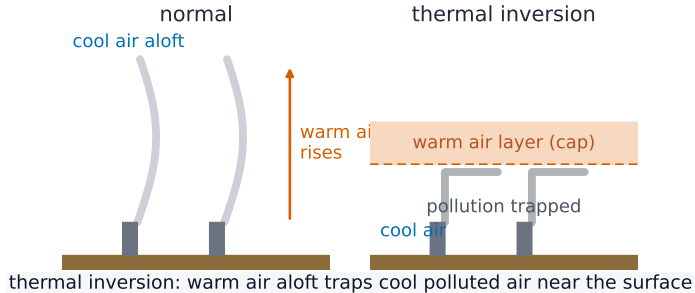
Nitrogen and sulfur oxides form nitric and sulfuric acid in rain

Reduction of Air Pollutants



A catalytic converter turns harmful NO and CO into harmless N₂ and CO₂

Thermal Inversion, continued



Normally warm air rises and disperses pollution; an inversion caps it near the ground

Exam tips

- Distinguish **primary** pollutants (emitted directly: CO, NO , SO , particulates) from **secondary** (form in the air: ground-level ozone).
- Ground-level ozone is a **pollutant**, but the ozone **layer** high up is protective – do not confuse them.
- Explain how a **thermal inversion** traps pollution near the ground.
- **Acid rain** (from SO and NO) often falls **far downwind**, making it an international problem.
- Link control methods to pollutants (catalytic converters, scrubbers, cleaner fuels, emission laws).

7

Recap

Worked example – photochemical smog

Why is photochemical smog worst on hot, sunny, windless afternoons in a city?

- Cars emit NO_x and VOCs in the morning rush hour.
- Sunlight drives the reaction: NO_2 splits, and the O atom makes ground-level ozone.
- Heat speeds it up, so ozone peaks in the afternoon, not at rush hour.
- No wind (often a thermal inversion) traps it $\Rightarrow$ a brown haze that irritates lungs.

Ground-level ozone is secondary – nothing emits it. Good ozone is up in the stratosphere; bad ozone is down here. A thermal inversion is the lid.

Unit 7 – key takeaways

1

Pollutant types

primary released; secondary forms in air (ozone)

2

Smog & inversion

$\text{NO}_x + \text{VOC} + \text{sun}$; a warm lid traps it

3

Acid rain

$\text{SO}_2 + \text{NO}_x \rightarrow \text{acids}$; lowers pH, kills life

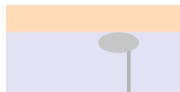
4

Reduce

converters, scrubbers, laws, cleaner fuel

Check yourself

- 1 Is ground-level ozone a primary or secondary pollutant?
- 2 What three ingredients make photochemical smog?
- 3 Why does a thermal inversion trap pollution?
- 4 What device cleans a car's exhaust gases?



Answers 1. secondary 2. NO_x , VOCs, sunlight 3. a warm lid stops cool air rising
4. catalytic converter