Atmospheric Pollution

AP Environmental Science

Introduction to Air Pollution

Air pollution is harmful substances in the atmosphere. **Primary pollutants** are emitted directly (carbon monoxide, nitrogen oxides, sulfur dioxide, particulates); **secondary pollutants** form in the air from reactions (like ozone in smog). Most come from **burning fossil fuels** in vehicles, power plants, and industry.

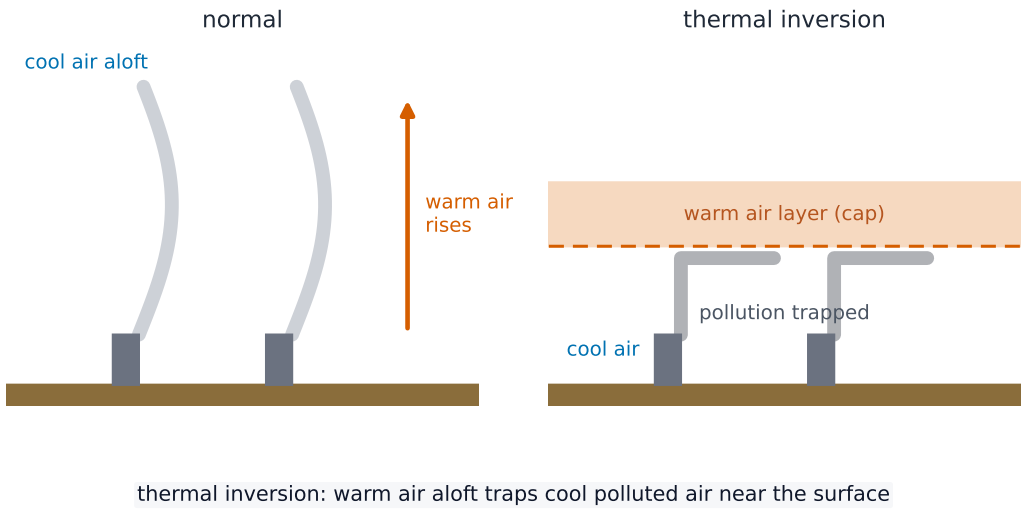
Photochemical Smog

Photochemical smog forms when **sunlight** drives reactions among nitrogen oxides and volatile organic compounds from car exhaust, producing ground-level **ozone**. It is worst in sunny, car-heavy cities and harms lungs. (Ground-level ozone is a pollutant, unlike the protective ozone layer high up.)

Photochemical smog over Los Angeles: on a sunny day, car exhaust reacts in the light to make a brown haze that hides the skyline

Thermal Inversion

A **thermal inversion** traps pollution near the ground. Normally warm air rises and carries pollutants away, but in an inversion a layer of warm air sits **above** cooler air, capping it. Pollutants accumulate below – causing dangerous smog episodes, especially in valleys.



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

Atmospheric CO2 and Particulates

Rising **atmospheric CO_2** from fossil fuels enhances the greenhouse effect and warms the climate. **Particulate matter** (tiny solid/liquid particles, PM2.5 and PM10) penetrates deep into lungs, causing respiratory and heart disease, and reduces visibility.

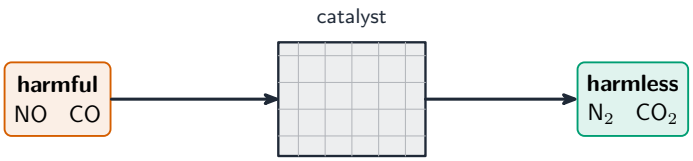
Indoor Air Pollutants

Indoor air can be more polluted than outdoor. Common **indoor pollutants** include **radon** (radioactive gas from the ground, a lung-cancer risk), **carbon monoxide**, **asbestos**, tobacco smoke, mold, and **VOCs** from paints and furnishings. Ventilation and source control reduce exposure.

An indoor cookstove: biomass smoke is a major indoor air pollutant in many homes worldwide

Reduction of Air Pollutants

Air pollution is cut by technology and policy: **catalytic converters** on cars, **scrubbers** and **electrostatic precipitators** on smokestacks, cleaner fuels, and laws like the **Clean Air Act** setting emission limits. Reducing fossil-fuel use addresses the root cause.

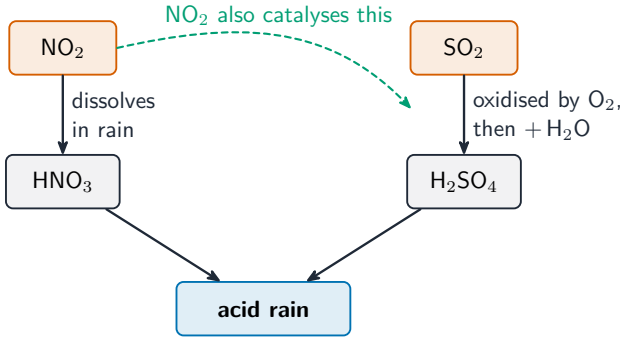


$$2NO + 2CO \rightarrow N_2 + 2CO_2$$

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

Acid Rain

Acid rain forms when **sulfur dioxide** and **nitrogen oxides** react with water in the air to make sulfuric and nitric acids, which fall far downwind. It acidifies lakes and soils (harming fish and trees), leaches nutrients, and corrodes buildings. Reducing SO_2 and NO_x emissions is the fix.



Nitrogen and sulfur oxides form nitric and sulfuric acid in rain

Forest dieback: acid deposition from SO2 and NOx can damage trees far downwind of the source

Noise Pollution

Noise pollution is unwanted or harmful sound in the environment. Major sources are road traffic, aircraft, trains, industry, and construction. In people, long or loud exposure causes **hearing loss**, **stress**, sleep loss, and higher blood pressure. It also disturbs **wildlife**: it masks the sounds animals use to communicate, navigate, and find mates, and underwater noise from ships is especially harmful to whales and dolphins. It is reduced by sound barriers, quieter engines and mufflers, and land-use planning such as buffer zones around airports.

> **Worked example.** Normal rain has a pH of about 5.6; an acid-rain sample measures pH 3.6. Because pH is a base-10 logarithmic scale, each unit is a 10× change in hydrogen-ion concentration, so pH 3.6 is $10^{(5.6-3.6)} = 10^2 = 100$ times more acidic than normal rain. That hundred-fold jump is why acid rain damages leaves, soils, and limestone so quickly.

Exam tips

- Distinguish **primary** pollutants (emitted directly: CO, NO_x, SO_2, 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_2 and NO_x) often falls **far downwind**, making it an international problem.
- Link control methods to pollutants (catalytic converters, scrubbers, cleaner fuels, emission laws).