

Unit 7: Atmospheric Pollution

Unit 7 covers the air you breathe and what gets into it. It starts with where air pollutants come from, follows the chemistry that turns exhaust into photochemical smog, explains the weather pattern that traps pollution near the ground, covers the pollutants that build up indoors, lays out the devices that clean emissions, traces acid rain from its sources to its downwind damage, and closes with noise pollution.

AP Environmental Science

Atmospheric Pollution

About 15 minutes to read

How to use this guide

Read it in order the first time. The unit follows a cause-and-effect path: sources release pollutants, sunlight and heat turn some of them into smog, inversions trap whatever is in the air, indoor spaces concentrate their own set of pollutants, control devices cut emissions at the source, and acid deposition shows what happens downwind. After the first read, use the trap boxes and the comparison table to review the distinctions that exam questions test most often. Finish with the practice questions, then complete the recall check on the last page out loud and note any items you cannot explain yet.

What this unit is worth. Atmospheric Pollution is about 7 to 10 percent of the AP Environmental Science exam. It also feeds directly into Unit 9, where stratospheric ozone depletion and climate change build on the atmospheric chemistry you learn here. The precursor chemistry in 7.2 and the acid rain chemistry in 7.7 are the parts most likely to show up in free-response questions.

7.1 Introduction to Air Pollution

Air pollution starts with combustion. Burning coal in power plants releases carbon dioxide, sulfur dioxide, toxic metals, and particulates. Burning fossil fuels more broadly releases nitrogen oxides, which lead to ozone production, the formation of photochemical smog, and nitric acid that causes acid rain. Fossil fuel combustion also releases carbon monoxide, hydrocarbons, and particulate matter. Sulfur dioxide in particular comes from burning high-sulfur coal in power plants and industrial facilities.

The exam sorts pollutants into two groups. A **primary pollutant** is emitted directly from a source, like carbon monoxide from a car exhaust or sulfur dioxide from a smokestack. A **secondary pollutant** forms in the atmosphere through chemical reactions. This distinction matters because some of the most damaging pollutants are never emitted by anything at all.

Trap. Ground-level ozone is a secondary pollutant. No car or factory emits it. It forms in the air when nitrogen oxides and volatile organic compounds react in sunlight. When a question asks which pollutant is secondary, ozone is usually the answer.

The main law in this unit is the **Clean Air Act**, the federal law that regulates emissions of pollutants affecting human health. Under it, the EPA curbed lead use, particularly in fuels, which dramatically decreased atmospheric lead.

7.2 Photochemical Smog

Photochemical smog forms when nitrogen oxides and volatile organic compounds react in heat and sunlight, producing a mix of pollutants that includes ground-level ozone. It is an urban problem because cities have the most motor vehicles, and vehicles are a major source of both nitrogen oxides and VOCs.

Several environmental factors affect how much smog forms: sunlight, temperature, wind, and topography. More sunlight and higher temperatures speed up the reactions. Still air lets pollutants sit and react instead of dispersing. Hills and valleys can trap the air mass in place.

Volatile organic compounds are chemicals such as formaldehyde and gasoline that evaporate or sublime at room temperature. Trees are a natural source, but in cities the dominant sources are vehicles, solvents, and industrial processes.

Trap. Photochemical smog is a summer and afternoon problem, not a winter and morning one. The reactions need sunlight and heat. A question that describes brownish haze over a city on a hot, still July afternoon is describing photochemical smog, and the precursor it wants named is nitrogen oxides or VOCs, not sulfur dioxide.

Smog follows a daily and seasonal rhythm that the exam tests directly. Nitrogen oxide is produced early in the day, when morning traffic is heaviest. Ozone concentrations peak in the afternoon, after hours of sunlight have driven the reactions forward. Ozone is also higher in the summer, when days are longer and hotter.

Trap. The worst smog arrives in the afternoon, not during morning rush hour. Morning traffic supplies the raw material, nitrogen oxide, but ozone needs hours of sunlight to build up. If a question asks when ozone peaks, the answer is afternoon. If it asks when nitrogen oxide peaks, the answer is morning.

Cutting smog means cutting its precursors: nitrogen oxides and volatile organic compounds. The tools include catalytic converters on vehicles, controls on power plants, vapor recovery nozzles at fueling stations, and low-VOC products. For people, photochemical smog causes respiratory problems and eye irritation.

7.3 Thermal Inversion

Normally, air temperature falls as altitude rises. Warm air at the surface rises, carrying pollutants upward and dispersing them. A **thermal inversion** flips this pattern: a layer of cool surface air sits trapped beneath warmer air above. The warm layer acts like a lid. Pollution, especially smog and particulates, stays close to the ground and builds up instead of dispersing.

Trap. An inversion does not create pollution. It traps pollution that is already being emitted. If an exam scenario describes air quality collapsing during a cold, still winter morning, the inversion explains why the pollution accumulated, not why it exists.

7.4 Atmospheric CO₂ and Particulates

Some gases and particles in the atmosphere come from nature, and the exam expects you to know these sources. Carbon dioxide enters the atmosphere naturally through respiration, decomposition, and volcanic eruptions. Particulate matter comes naturally from volcanic eruptions, dust storms, and wildfires.

Trap. Natural does not mean harmless. Volcanic ash, wildfire smoke, and dust storms are genuine air quality hazards. When a question asks for natural sources of particulates, reach for volcanoes, dust storms, and wildfires, not human activities.

7.5 Indoor Air Pollutants

Indoor air gets its own topic because pollutants build up in enclosed spaces, and most people spend most of their time inside. Indoor pollutants fall into three groups. Building materials and furnishings release formaldehyde, VOCs, and lead from old paint. Combustion produces carbon monoxide, nitrogen oxides, and tobacco smoke. Natural infiltration brings in radon from soil, mold, and dust. The indoor particulates to know are asbestos, dust, and smoke.

Carbon monoxide deserves special attention. It is classified as an asphyxiant, meaning it deprives the body of oxygen, and faulty combustion appliances are a classic indoor source.

Trap. Do not confuse carbon monoxide with carbon dioxide. Carbon monoxide is the indoor asphyxiant produced by incomplete combustion. Carbon dioxide is the greenhouse gas. The exam tests this pairing directly, and the wrong answer is always the other one.

Radon-222 is the most dangerous indoor pollutant in this unit, and it is completely natural. It is a radioactive gas produced by the decay of uranium in rocks and soils. It moves up through the soil and enters homes through basements and cracks in walls or foundations, and it can also dissolve in groundwater that enters through a well. Long-term exposure causes lung cancer, and radon is the second leading cause of lung cancer in the United States.

Trap. The deadliest indoor air pollutant in this unit is natural, not human-made. Students tend to focus on factories and cars and forget that radon seeps into homes from the ground itself. When a question asks about indoor air, radon should be your first thought.

7.6 Reduction of Air Pollutants

Air pollution can be cut four ways: emission regulations such as Clean Air Act standards, control devices on sources, conservation that reduces fuel use, and switching to cleaner fuels. The control devices are the part the exam asks about most, and each one belongs to a specific source.

DEVICE	WHERE IT IS INSTALLED	WHAT IT DOES
Catalytic converter	Motor vehicles	Converts carbon monoxide, nitrogen oxides, and hydrocarbons in exhaust into less harmful molecules: carbon dioxide, nitrogen gas, and water
Scrubber	Industrial exhaust, coal-burning power plants	Wet or dry systems that remove particulates and gases such as sulfur dioxide from exhaust streams
Electrostatic precipitator	Coal-burning power plants	Uses an electric charge to pull particulates out of the exhaust stream
Vapor recovery nozzle	Gasoline pumps	Captures fumes during fueling so volatile organic compounds do not escape into the atmosphere

Trap. Match the device to the source. Catalytic converters go on vehicles. Scrubbers and electrostatic precipitators go on power plants and industrial exhaust. Vapor recovery nozzles go on gasoline pumps. The exam asks this pairing directly, and the wrong answers always swap the locations.

7.7 Acid Rain

Acid deposition comes from nitrogen oxides and sulfur oxides in the atmosphere. The nitric oxides that cause it come from motor vehicles and coal-burning power plants. The sulfur dioxides that cause it come from coal-burning power plants. Once airborne, these gases convert to acids and fall as rain, snow, fog, or dry particles.

The effects are wide-ranging. Acid deposition acidifies soils and bodies of water and corrodes human-made structures. The damage falls hardest on communities **downwind** of coal-burning power plants, because winds carry the pollutants far from where they were emitted before they land.

Geology changes the outcome. Regional differences in soils and bedrock decide how hard acid deposition hits an area. Limestone bedrock neutralizes the acid, so lakes and ponds in limestone regions are buffered against its effects. Regions without that buffering suffer more.

Trap. The place damaged by acid rain is usually downwind of the source, not next to it. The atmosphere separates where pollution is emitted from where it lands. If a question describes a remote lake acidifying with no local industry nearby, look upwind for the coal plant.

7.8 Noise Pollution

Noise pollution is sound at levels high enough to cause physiological stress and hearing loss. In cities it comes from transportation, construction, and domestic and industrial activity.

Animals suffer from it too. Noise causes stress, masks the sounds animals use to communicate or hunt, damages hearing, and can change migratory routes. On the exam, noise pollution questions usually ask for a source or an ecological effect, and the animal effects are the part students forget.

Confusions That Cost Points

PAIR	HOW TO KEEP THEM STRAIGHT
Primary vs secondary pollutant	Primary is emitted directly from a source. Secondary forms through reactions in the air. Ground-level ozone is secondary.
Nitrogen oxide vs ozone timing	Nitrogen oxide is emitted early in the day with morning traffic. Ozone peaks in the afternoon after sunlight drives the reactions.
Carbon monoxide vs carbon dioxide	CO is the indoor asphyxiant from incomplete combustion. CO ₂ is the greenhouse gas.
Catalytic converter vs scrubber	The converter goes on vehicles. The scrubber goes on industrial and power-plant exhaust.
Where acid rain is emitted vs where it lands	Emitted by coal plants and vehicles. Damage hits downwind communities, and limestone bedrock buffers the effect.
Photochemical smog vs thermal inversion	Smog is chemistry: sunlight reacting with pollutants to make new ones. An inversion is a weather cap that traps whatever is already in the air.

Practice Questions

Original questions written for this guide in the style of the AP exam. Answers and explanations are on the next page, so complete the questions before checking them.

1. Which of the following is a secondary air pollutant?

- A. Carbon monoxide
- B. Sulfur dioxide
- C. Ground-level ozone
- D. Particulate matter from a dust storm

2. A city records its highest ground-level ozone readings at 3 p.m. on summer afternoons. Which statement best explains this pattern?

- A. Afternoon commuter traffic emits the most ozone directly
- B. Sunlight and heat drive the reactions that produce ozone, so it builds up through the day
- C. Thermal inversions form each afternoon and generate ozone
- D. Power plants burn the most coal in the afternoon

3. Radon-222 is best described as

- A. a human-made gas released by building insulation
- B. a radioactive gas from uranium decay that seeps into homes through the soil
- C. a combustion byproduct of natural gas furnaces
- D. a volatile organic compound released by new carpeting

4. Which pairing correctly matches the control device with where it is installed?

- A. Catalytic converter: coal-burning power plant
- B. Scrubber: automobile exhaust system
- C. Electrostatic precipitator: coal-burning power plant
- D. Vapor recovery nozzle: industrial smokestack

Answer Key

- 1. C.** Ground-level ozone forms in the atmosphere through reactions of nitrogen oxides and volatile organic compounds in sunlight. It is never emitted directly, which is what makes it secondary. A and B are primary pollutants emitted directly by combustion. D is a primary pollutant with a natural source.
- 2. B.** Morning traffic emits nitrogen oxide, the raw material. Hours of sunlight and heat then drive the reactions that produce ozone, so concentrations peak in the afternoon and run higher in summer. A is wrong because vehicles emit nitrogen oxide, not ozone. C is wrong because an inversion traps pollution but does not generate ozone, and inversions are typically a morning or winter phenomenon. D invents a pattern with no basis.
- 3. B.** Radon-222 is a naturally occurring radioactive gas produced by uranium decay in rocks and soils. It moves up through the soil and enters homes through basements and foundation cracks. A describes insulation and VOCs from furnishings. C describes carbon monoxide and nitrogen oxides from combustion. D describes formaldehyde and VOCs from building materials.
- 4. C.** Electrostatic precipitators are installed on coal-burning power plants to pull particulates out of the exhaust stream. A is wrong because catalytic converters go on motor vehicles, not power plants. B is wrong because scrubbers go on industrial and power-plant exhaust, not cars. D is wrong because vapor recovery nozzles go on gasoline pumps, not smokestacks.

One-Page Recall Check

- List the pollutants released by coal combustion.
- Explain the difference between a primary and a secondary pollutant, with an example of each.
- Describe how photochemical smog forms, naming the two precursor groups and the role of sunlight.
- Name four environmental factors that affect smog formation.
- Explain why ozone peaks in the afternoon and runs higher in summer.
- Define a thermal inversion and explain why it worsens air quality.
- List natural sources of atmospheric carbon dioxide and of particulate matter.
- Name the three groups of indoor air pollutant sources, with two examples of each.
- Explain the difference between carbon monoxide and carbon dioxide.
- Describe how radon-222 enters homes and why it is dangerous.
- Match each control device (catalytic converter, scrubber, electrostatic precipitator, vapor recovery nozzle) to the source it serves.
- Name the sources of the nitrogen oxides and sulfur dioxides behind acid deposition.
- Explain why acid rain damages downwind communities and how limestone bedrock changes the outcome.
- List three sources of noise pollution and two effects on animals.

Where to go next. In Rycal, open the AP Environmental Science deck and drill the Atmospheric Pollution cards until you can explain each term without looking. If you have a test date, add it in the Test Planner so your review sessions land before the exam. You can also start a review with a Brain Dump, then check what you missed against this guide.

Key terms for this unit

Air pollutants from coal combustion, Air pollutants from fossil fuel combustion, Sulfur dioxide from fossil fuels, Clean Air Act, Primary vs. secondary pollutants, Photochemical smog formation, Environmental factors in smog formation, Daily and seasonal smog patterns, Volatile Organic Compounds (VOCs), Urban photochemical smog, Reducing photochemical smog, Health effects of photochemical smog, Thermal inversion, Inversion and trapped pollution, Natural sources of CO₂, Natural sources of particulate matter, Carbon monoxide (indoor), Indoor particulates, Sources of indoor air pollutants, Natural indoor air pollutants, Human-made indoor air pollutants, Combustion indoor air pollutants, Radon-222, Radon infiltration of homes, Radon-induced lung cancer, Methods to reduce air pollutants, Vapor recovery nozzle, Catalytic converter, Scrubbers, Coal plant pollution controls, Acid deposition, Sources of acid deposition, Downwind effects of acid deposition, Effects of acid deposition, Limestone buffering of acid rain, Noise pollution, Sources of noise pollution, Noise pollution effects on animals.

About this guide. Written for Rycal and aligned to the College Board AP Environmental Science course framework, Unit 7. All questions and explanations are original Rycal writing. Rycal is independent and is not affiliated with or endorsed by the College Board.