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FSc / ICS Part-II Chemistry — Punjab Board

CHAPTER 16 Environmental Chemistry

Layers of the Atmosphere

Thermosphere

85–500 km • very hot, auroras

Mesosphere

50–85 km • meteors burn up

Stratosphere

12–50 km • OZONE layer (UV shield)

Troposphere

0–12 km • weather, we live here

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Figure 16.1 — The layers of the atmosphere; the ozone layer in the stratosphere shields us from UV light.



1. Chapter Overview

Environmental chemistry studies the chemical processes that take place in our surroundings — the air, water and soil — and how human activities affect them. As populations and industries grow, pollution has become a serious threat to health and to the planet. This chapter looks at the structure of the atmosphere, the main air and water pollutants, and the major environmental problems of our time: acid rain, ozone depletion and the greenhouse effect (global warming). It also introduces the idea of controlling pollution and practising 'green' chemistry.

2. Learning Objectives

- Describe the main layers of the atmosphere and their importance.
- Identify the major air pollutants and their sources.
- Explain the causes and effects of acid rain.
- Explain ozone depletion and the role of CFCs.
- Explain the greenhouse effect and global warming.
- Describe water pollution and simple ways to control pollution.

3. Key Concepts

3.1 The Atmosphere

The atmosphere is the blanket of gases surrounding the Earth. It is divided into layers. The lowest is the troposphere, where we live and where weather occurs. Above it is the stratosphere, which contains the vital ozone layer that absorbs most of the Sun's harmful ultraviolet (UV) radiation. Higher still are the mesosphere and the thermosphere. The atmosphere protects life, provides the gases we breathe, and keeps the Earth warm enough to live on.

Layers of the Atmosphere

Thermosphere 85-500 km • very hot, auroras
Mesosphere 50-85 km • meteors burn up
Stratosphere 12-50 km • OZONE layer (UV shield)
Troposphere 0-12 km • weather, we live here

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Figure 16.2 — Layers of the atmosphere.



3.2 Air Pollution

Air pollution is the presence of harmful substances in the air. The main pollutants and their chief sources are shown below; most come from burning fossil fuels in vehicles, factories and power stations.

Pollutant	Main source	Harmful effect
Carbon monoxide (CO)	Incomplete burning of fuel	Poisonous; reduces oxygen in blood
Sulphur dioxide (SO ₂)	Burning coal and oil	Acid rain, breathing problems
Oxides of nitrogen (NO _x)	Vehicle and factory exhaust	Acid rain, smog
Carbon dioxide (CO ₂)	Burning all fossil fuels	Greenhouse gas → global warming
CFCs	Old aerosols, refrigerants	Destroy the ozone layer
Particulates (smoke, dust)	Combustion, industry	Lung and breathing diseases

3.3 Acid Rain

When fuels containing sulphur and nitrogen are burned, they release sulphur dioxide and oxides of nitrogen into the air. These gases react with oxygen and water vapour to form sulphuric acid and nitric acid, which fall to the ground dissolved in rain — this is acid rain. Acid rain damages plants and soil, corrodes buildings and statues (especially those made of marble/limestone), and kills fish by making lakes and rivers too acidic.

How Acid Rain Forms



Damages plants, soil, buildings (marble) and aquatic life.

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Figure 16.3 — Formation of acid rain.

Memory Trick

Acid rain culprits: SO₂ and NO_x → H₂SO₄ and HNO₃. 'Sulphur and Nitrogen make the rain sour.'

3.4 Ozone Depletion

The ozone layer in the stratosphere absorbs harmful UV radiation from the Sun. Certain man-made gases, especially chlorofluorocarbons (CFCs) once used in refrigerators, air-conditioners and aerosol sprays, rise into the stratosphere where UV light breaks them down to release chlorine atoms. These chlorine atoms destroy ozone molecules, thinning the ozone layer (the 'ozone hole'). A thinner ozone layer lets more UV reach the Earth, increasing skin cancer, eye



cataracts and crop damage. For this reason CFCs have been banned under international agreements.

Teacher's Note

Clarify a common confusion: ozone in the stratosphere is 'good' (it shields us from UV), but ozone at ground level is a harmful pollutant. The problem in this section is the LOSS of the good, high-level ozone.

3.5 The Greenhouse Effect and Global Warming

Certain gases in the atmosphere — mainly carbon dioxide, methane, water vapour and CFCs — let the Sun's light through to warm the Earth but trap much of the heat that the Earth radiates back. This natural warming, called the greenhouse effect, keeps the planet warm enough for life. However, burning huge amounts of fossil fuels has raised the level of carbon dioxide, so more heat is trapped and the Earth's average temperature is slowly rising — this is global warming. Its effects include melting glaciers, rising sea levels, and changes in weather and climate.

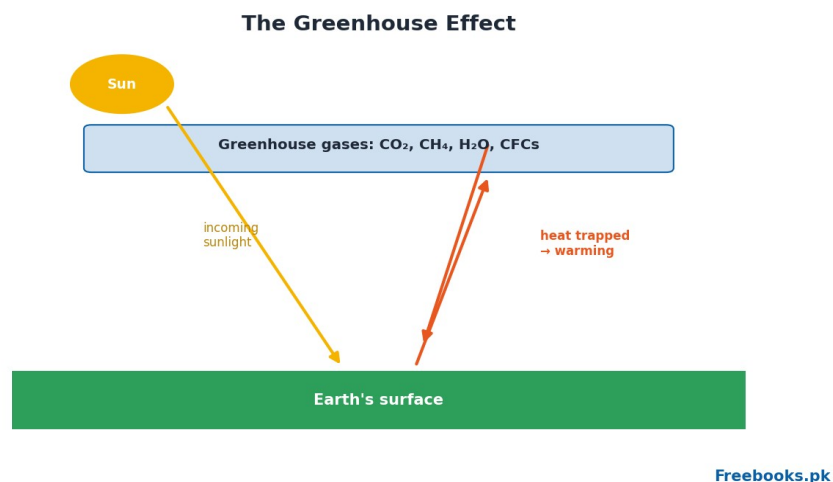


Figure 16.4 — The greenhouse effect.

3.6 Water Pollution and Its Control

Water pollution is caused by sewage, industrial waste, fertilizers and pesticides washing into rivers and lakes. It spreads disease and kills aquatic life. Pollution can be reduced by treating sewage and industrial waste before it is released, using cleaner fuels and catalytic converters in vehicles, controlling the use of fertilizers and pesticides, recycling waste, and planting trees. Practising 'green chemistry' — designing processes that make less waste and use safer chemicals — is an important long-term solution.

4. Important Definitions

Term	Definition
Environmental chemistry	The study of chemical processes and pollution in the air, water and soil.
Air pollution	The presence of harmful substances in the air.



Term	Definition
Acid rain	Rain made acidic by dissolved sulphuric and nitric acids from SO_2 and NO_x .
Ozone depletion	Thinning of the stratospheric ozone layer, mainly by CFCs.
Greenhouse effect	The trapping of heat in the atmosphere by gases such as CO_2 .
Global warming	The gradual rise in Earth's average temperature due to increased greenhouse gases.

5. Formulas / Rules

Must-Know Facts

Atmosphere layers: troposphere, stratosphere (ozone), mesosphere, thermosphere.

Acid rain: SO_2 and $\text{NO}_x \rightarrow \text{H}_2\text{SO}_4$ and HNO_3 .

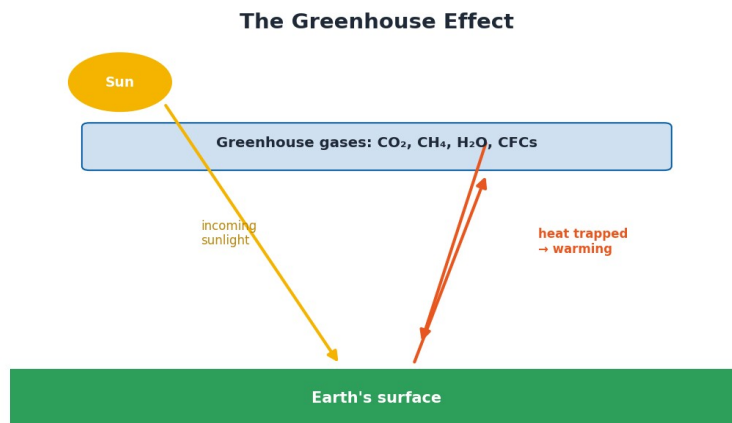
Ozone depletion: caused by CFCs releasing chlorine atoms.

Greenhouse gases: CO_2 , CH_4 , H_2O vapour, CFCs $\rightarrow$ global warming.

Control: treat waste, cleaner fuels, catalytic converters, recycling, tree planting.

6. Diagrams / Illustrations

Key diagrams for revision:



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Diagram 1 — The greenhouse effect.



How Acid Rain Forms



Damages plants, soil, buildings (marble) and aquatic life.

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Diagram 2 — Acid rain formation.

7. Solved Examples

Example 1 — Acid rain

Q: Which gases are mainly responsible for acid rain, and what acids do they form?

Solution: Sulphur dioxide (SO_2) and oxides of nitrogen (NO_x). They react with oxygen and water in the air to form sulphuric acid (H_2SO_4) and nitric acid (HNO_3), which fall as acid rain.

Example 2 — Ozone layer

Q: Why are CFCs harmful to the ozone layer?

Solution: In the stratosphere, UV light breaks CFCs to release chlorine atoms, which destroy ozone molecules. This thins the ozone layer and lets more harmful UV reach the Earth.

Example 3 — Greenhouse gas

Q: Name the main greenhouse gas and its chief source.

Solution: Carbon dioxide (CO_2); its chief source is the burning of fossil fuels in vehicles, factories and power stations.

8. Short Questions

Q1. What is environmental chemistry?

Ans. The study of chemical processes and pollution in the air, water and soil.

Q2. Name the layer of the atmosphere that contains the ozone layer.

Ans. The stratosphere.

Q3. Why is carbon monoxide dangerous?

Ans. It is poisonous; it combines with haemoglobin and reduces the oxygen carried by the blood.

Q4. What causes acid rain?

Ans. Sulphur dioxide and oxides of nitrogen, which form sulphuric and nitric acids in the air.

Q5. What are CFCs and why are they harmful?

Ans. Chlorofluorocarbons; they release chlorine in the stratosphere that destroys the ozone layer.

Q6. What is the greenhouse effect?



Ans. The trapping of the Earth's heat by gases such as CO_2 , which keeps the planet warm.

Q7. Name two greenhouse gases.

Ans. Carbon dioxide and methane (also water vapour and CFCs).

Q8. Give two ways to control air pollution.

Ans. Use cleaner fuels and fit catalytic converters to vehicles; also plant trees and treat waste gases.

9. Long Questions

Q1. Explain the causes and effects of acid rain.

Acid rain is rain that has become acidic because of pollutant gases in the air. Its main causes are the burning of fossil fuels that contain sulphur and nitrogen in power stations, factories and vehicles, which release sulphur dioxide and oxides of nitrogen into the atmosphere. High in the air these gases react with oxygen and with water vapour to form sulphuric acid and nitric acid, which dissolve in the rain and fall to the ground. The effects of acid rain are serious and wide-ranging. It makes soils and lakes acidic, which damages plants, kills fish and other aquatic life, and upsets whole ecosystems. It strips nutrients from the soil and harms forests. It also attacks buildings, bridges and statues, especially those made of marble and limestone, which are dissolved by the acid. Acid rain can be reduced by removing sulphur from fuels, by fitting equipment to trap SO_2 before it escapes, and by using cleaner sources of energy.

Q2. Explain ozone depletion and the greenhouse effect.

The ozone layer, high up in the stratosphere, is vital because it absorbs most of the Sun's harmful ultraviolet radiation. Ozone depletion is the thinning of this layer, caused mainly by man-made chlorofluorocarbons (CFCs) that were once used in refrigerators, air-conditioners and aerosol sprays. When CFCs drift up into the stratosphere, ultraviolet light breaks them apart to release chlorine atoms, and each chlorine atom can destroy many ozone molecules, creating thin areas known as 'ozone holes'. A thinner ozone layer lets more ultraviolet radiation reach the surface, increasing skin cancer, eye damage and harm to crops, which is why CFCs have been banned. The greenhouse effect is a separate problem, in the lower atmosphere. Gases such as carbon dioxide, methane and water vapour let sunlight through to warm the Earth but trap much of the heat that the Earth radiates back into space, keeping the planet warm. However, the huge amounts of carbon dioxide released by burning fossil fuels have strengthened this effect, trapping more heat and causing global warming — a slow rise in the Earth's temperature that is melting glaciers, raising sea levels and changing the climate.

Q3. Discuss the sources of air pollution and how it can be controlled.

Air pollution is the presence of harmful substances in the atmosphere, and most of it comes from burning fossil fuels. Vehicles release carbon monoxide (from incomplete combustion), oxides of nitrogen and unburnt hydrocarbons; power stations and factories that burn coal and oil release sulphur dioxide and carbon dioxide; and various industries release smoke and dust particles. Household and agricultural activities add further pollutants such as CFCs and smoke. These pollutants cause breathing diseases, acid rain, smog, ozone depletion and global warming. Air pollution can be controlled in several ways: by using cleaner fuels (such as natural gas) and removing sulphur from fuels; by fitting catalytic converters to vehicles to convert harmful gases



into less harmful ones; by trapping smoke and gases from factory chimneys before release; by banning harmful chemicals such as CFCs; by recycling waste to reduce burning; and by planting trees, which absorb carbon dioxide and release oxygen. Practising green chemistry — designing industrial processes that produce less waste and use safer materials — is an important long-term solution.

10. Multiple Choice Questions (MCQs)

1. The ozone layer is found in the:

- (A) troposphere (B) stratosphere (C) mesosphere (D) thermosphere

2. Which gas is responsible for acid rain?

- (A) CO₂ (B) SO₂ (C) O₂ (D) N₂

3. Acid rain contains mainly:

- (A) HCl and HF (B) H₂SO₄ and HNO₃ (C) H₂CO₃ only (D) NaOH

4. The ozone layer is destroyed mainly by:

- (A) CO₂ (B) CFCs (C) SO₂ (D) O₂

5. The main greenhouse gas is:

- (A) O₂ (B) N₂ (C) CO₂ (D) H₂

6. Carbon monoxide is dangerous because it:

- (A) causes acid rain (B) reduces oxygen in blood (C) destroys ozone (D) forms smog

7. Global warming is caused by an increase in:

- (A) oxygen (B) greenhouse gases (C) ozone (D) nitrogen

8. The ozone layer protects us from:

- (A) visible light (B) UV radiation (C) infrared (D) radio waves

9. Which device reduces vehicle pollution?

- (A) condenser (B) catalytic converter (C) transformer (D) carburettor only

10. Bagasse burning and fossil-fuel burning add ____ to the air:

- (A) oxygen (B) CO₂ (C) ozone (D) helium

MCQ Answer Key

1-B 2-B 3-B 4-B 5-C 6-B 7-B 8-B 9-B 10-B

11. Quick Revision / Summary

- Atmosphere: troposphere, stratosphere (ozone), mesosphere, thermosphere.
- Main pollutants: CO, SO₂, NO_x, CO₂, CFCs, particulates — mostly from burning fuels.
- Acid rain: SO₂ + NO_x → H₂SO₄ + HNO₃; harms plants, water, buildings.
- Ozone depletion: CFCs release chlorine that destroys ozone → more UV.
- Greenhouse effect: CO₂/CH₄ trap heat → global warming.
- Control: cleaner fuels, catalytic converters, treat waste, ban CFCs, plant trees.



12. Exam Tips

Teacher's Note

Match each pollutant to its source and harmful effect — a common table question.

For acid rain, name the gases (SO_2 , NO_x) AND the acids (H_2SO_4 , HNO_3).

Distinguish ozone depletion (CFCs, UV) from the greenhouse effect (CO_2 , heat) — do not mix them.

Remember the ozone layer is in the stratosphere and blocks UV.

List concrete control measures in pollution questions (catalytic converters, cleaner fuel, trees).

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