Chapter # 14
Atmosphere

ATMOSPHERE

- The atmosphere is a mixture of gases around the earth.
- It helps to make the life possible by giving us with air to breath.
- It protects earth from harmful ultra-violet (UV) radiations of the sun.
- It traps heat to warm the planet. It prevents extreme temperature difference between day and night.
- It is unique in supporting life. We can live several days without food and water. But without air we die in a few moments.
- Since, the start of industrial revolution, human actions have changed the atmosphere.

Composition of the Atmosphere

- The atmosphere is a sphere of different gases around the earth.
- The component of the atmospheres may be divided into major, minor and trace components.

  Major components are nitrogen (78.00%) and oxygen (21.01%).

  Minor components are argon (0.93%), carbon dioxide (0.04%).

  Trace components are, methane, hydrogen, neon, helium, krypton, and xenon.

> **Short Question**
> What is the composition of atmosphere?

Layers of The Atmospheres

- The atmosphere has four distinct layers.
- The layers are determined by the change in temperature with increasing altitude.
- These layers are troposphere, stratosphere, mesosphere, and thermosphere.
- The temperature of the atmosphere does not change in a gradual way.

> Most of the clouds you see in the sky are floating in the troposphere because 99% of water vapour in the atmosphere is found here.

Troposphere

- It is the lowest region of the atmosphere which extends up to 12 km.
- It includes all the major gases present in the atmosphere i.e., nitrogen, oxygen, and carbon-dioxide, etc.
- In this region, temperature decreases from 17 °C to -58 °C regularly.
- It is the densest layer of the atmosphere. The troposphere contains 75.0% of all air in the atmosphere.
- It is the layer in which major events such as rain, lightening, and hurricanes occur.

Thermosphere
Mesosphere
Stratosphere
Troposphere
80-600 km
50-80 km
12-50 km
0-12 km

Stratosphere

- Above the troposphere is the stratosphere.
- It lies at a distance of 12-50 km above the earth surface.
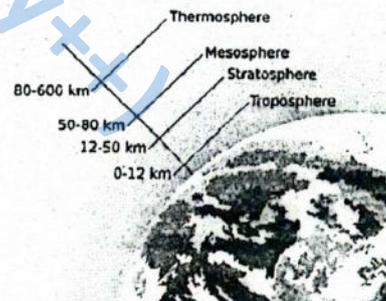
- Temperature increases from -58°C to -2°C.
- In the lower portion, the temperature remains nearly constant with increasing height.
- In the upper portion, the temperature increases rapidly with height. It is due to the presence of sunlight and ozone.
- Stratosphere is divided into three regions according to the distribution of ultraviolet radiations from the Sun.
- Ozone in the upper layer absorbs high energy ultraviolet radiations from the Sun. It breaks down into monoatomic oxygen and diatomic oxygen.

$$O_{3(g)} \rightarrow O_{2(g)} + O_{(g)}$$

- The middle layer has less ultraviolet radiations passing through it. Here, monoatomic oxygen and diatomic oxygen recombine to form ozone. This is an exothermic reaction, Thus, formation of ozone layer takes place and ozone layer exists in the mid stratosphere.

$$O_{2(g)} + O_{(g)} \rightarrow O_{3(g)}$$

- The lower layer receives very low ultraviolet radiations. Thus, monoatomic oxygen is not found here and ozone is not formed here.

Mesosphere

- The mesosphere is above the stratosphere.
- It extends to a height of about 50 – 85 km from the ground.
- Here, the temperature decreases with altitude from -2°C to -93°C.
- The coldest region of the atmosphere are located in this layer.

Thermosphere

- It extends from 85 km to 600 km above the earth surface.
- This is the region where the temperature increases as the altitude increases.
- The increase in the temperature is caused due to the absorption of energetic ultra-violet and X-rays coming from the sun by gases which are ionized as a result.
- Temperature in the upper thermosphere can range from 500 oC to 2000 °C or higher.

AIR POLLUTANTS

Pollutants
Pollutants are substances (gases, liquids and solids) that are harmful to the environment.

Air pollutants
All chemical and biological substances that modify the natural characteristics and composition of the atmosphere are referred to as 'air pollutants.

Pollutants sources
Natural sources : volcanic activities, oceans and forests etc.
Human activities: combustion of fossil fuels, transportation, power plant emissions or emissions from other industrial processes.

Primary pollutants
These are substances directly produced or emitted
Example: volcanic eruption or carbon monoxide gas from a motor vehicle exhaust.

Secondary pollutants
These are formed due to chemical reactions of primary pollutants.
Primary pollutants can be transformed in the lower atmosphere by solar radiation and into the secondary pollutants.
Example: ozone (O_3) and peroxyacetyl nitrate (PAN) pollutants.

The most important pollutants are mentioned below:

1. Oxides of Carbon (CO and CO_2)
2. Oxides of Nitrogen (NO and NO_2) collectively known as NO_x.
3. Oxides of Sulphur (SO_2 and SO_3) collectively known as SO_x.
4. Hydrocarbons (Methane, Ethane)
5. Low altitude Ozone (O_3)
6. Chlorofluorocarbons (CFCs)
7. Polycyclic Aromatic Hydrocarbon (PAHs)
8. Persistent Organic Pollutant (POPs)
9. Volatile Organic Compounds (VOCs)
10. Particulate Matter (PM)
11. Heavy Metals (Pb, Hg and Cd)

SOURCES OF AIR POLLUTION

There are two main sources of air pollution.

Natural sources

- The particulate matter (PM) can occur naturally. It includes dust from the ground, sea salt near coasts and biological material form plants and animals like pollen, spores and animal debris.
- Volcanic eruptions release large amounts of gases and particles into the air.
- Thunderbolts produces a lot of nitrogen oxides (NOx).
- A small amount of ozone (O_3) is found near the ground. It forms when sunlight causes a reaction between nitrogen oxides (NOx) and volatile organic compounds (VOCs).
- Other natural sources of air pollution include algae on the surface of oceans. These release hydrogen sulphide (H_2S).
- The wind erosion can introduce dust and particles into the air.
- Wet places like swamps, peat bogs, and shallow lakes release methane (CH_4).

Human-made sources

- In cities, most air pollution is caused by people.
- There are two main types of sources.
  - ✓ Mobile sources: e.g., cars, trucks, airplanes, and boats.
  - ✓ Point sources: e.g. factories and power plants.
- Burning fossil fuels like coal, oil, and natural gas makes pollution. This happens in vehicles, factories, and power plants. It produces gases like carbon dioxide (CO_2), carbon monoxide (CO), and methane (CH_4).
- Burning wood for cooking and coal in brick kilns also causes air pollution.

> **Short Question**
> What are two main types of human-made sources of air pollution?

## Quick Check 14.1

a) Mention important air pollutants.

Oxides of Carbon (CO and CO_2). Oxides of Nitrogen (NO and NO_2) collectively known as NO_x. Oxides of Sulphur (SO_2 and SO_3) collectively known as SO_x. Hydrocarbons (Methane, Ethane) Low altitude Ozone (O_3). Chlorofl uorocarbons (CFCs), Polycyclic Aromatic Hydrocarbon (PAHs)
Persistent Organic Pollutant (POPs). Volatile Organic Compounds (VOCs). Particulate Matter (PM)

b) Give the equations for the formation and depletion of ozone in the stratosphere.

- Ozone in the upper layer of stratosphere absorbs high energy UV radiations and breaks down into monoatomic oxygen and diatomic oxygen.

$$O_{3(g)} \rightarrow O_{2(g)} + O_{(g)}$$
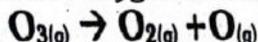
- In middle layer of stratosphere, monoatomic oxygen and diatomic oxygen recombine to form ozone. This is an exothermic reaction.

$$O_{2(g)} + O_{(g)} \rightarrow O_{3(g)}$$
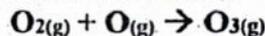
c) Write down the names and approximate height of different layers of atmosphere
- Troposphere: It is the lowest region of the atmosphere which extends up to 12 km.
- Stratosphere: It is above the troposphere. It lies at a distance of 12-50 km above the earth surface.
- Mesosphere: It is above the stratosphere. It extends to a height of about 50 – 85 km from the ground
- Thermosphere: It extends from 85 km to 600 km above the earth surface.

SOURCES OF AIR POLLUTANTS

Oxides of Carbon
There are two oxides of carbon i.e., carbon monoxide (CO) and carbon dioxide (CO_2).

Carbon monoxide (CO)
Carbon monoxide (CO) is produced mainly due to incomplete combustion of fossil fuels.

$$2C_{(s)} + O_{2(g)} \rightarrow 2CO_{(g)}$$

Why CO is highly poisonous?
Carbon monoxide is highly poisonous gas and cause suffocation if inhale. It binds blood hemoglobin more strongly than oxygen thus excluding oxygen from normal respiration. The CO poisonous can be reversed by giving high pressure oxygen. Exposes to high conc. of CO result in headache, fatigue, unconsciousness and eventually death.

Carbon dioxide (CO_2)
Carbon dioxide is the main greenhouse gas emitted by human activities like combustion of fossil fuels.
Carbon dioxide (CO_2) is a primary greenhouse gas that traps heat in the atmosphere, leading to global warming.

$$C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$$
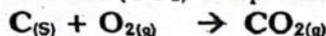
Carbon in fossil fuels burns with oxygen from the air to form CO_2. This reaction releases energy. This reaction is exothermic. It also adds to global warming.

Oxides of Nitrogen (NOx)
- Gases like nitric oxide (NO) and nitrogen dioxide (NO_2) are called NOx.
- NOx is formed when nitrogen and oxygen in the air react during thunderstorms.
- It is also made when fossil fuels are burned.
- NOx is created through the following chemical reactions.

$$N_{2(g)} + O_{2(g)} \rightarrow 2NO_{(g)} \quad \text{(Nitric oxide)}$$
$$2NO_{(g)} + O_2 \rightarrow 2NO_2 \quad \text{(Nitrogen-Dioxide)}$$
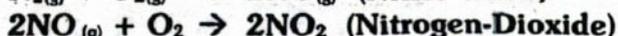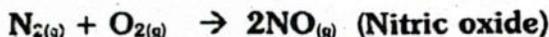
Short Question
What are NOx gases? What are the sources of NOx gases in atmosphere?

Nitrous oxide (N_2O)
Nitrous oxide is released by natural process and human activities.
Natural sources:
- It comes from soil and oceans. Bacteria in the soil and water break down nitrogen compounds. This process releases nitrous oxide.

Human activities
- These include agricultural activities e.g. synthetic fertilizers, industrial processes e.g. combustion of fossil fuels and waste water management.
- The increased levels of N_2O contribute to climate change. It can also affect air quality.
- It depletes the ozone layer.

Oxides of Sulphur (SOx)

- There are two main oxides of sulphur: sulphur dioxide (SO_2) and sulphur trioxide (SO_3). They are called SOx.
- SOx are primarily released when coal and oil are burned.
- SOx are also formed by oxidation of sulphur gases. The Sulphur gases are produced by decomposition of organic matter.
- SOx mix with water vapor and causes acid rain.
- Acid rain damages the ecosystem.
- SO_2 is the main cause of acid deposition in air. It can also cause breathing problems.

> Sulphur dioxide is a reducing agent. In the food industry, it is used as a preservative for foods and drinks. It is used as a preservative in jams, marmalade, tin fruits and juices. It is also used in "campdon" tablets which are sterilizing tablets used to sterilized brewing equipment and babies' bottles. When these dissolve in water, they give of SO_2.

Hydrocarbons

- Hydrocarbons are made of only carbon and hydrogen. They can pollute the air and harm the environment and human health.
- These compounds come from both natural and human-made sources (anthropogenic).
- Naturally they are produced through plants, wildfires, volcanoes, and seeps.
- Anthropogenic activities include incomplete burning fossil fuels, oil spills, industries and vehicle emission.
- Automobiles are the biggest source of hydrocarbon pollution.
- Methane is one type of hydrocarbon.
  - ✓ It enters the air from both nature and human actions.
  - ✓ Natural sources: Water land, termites, and oceans where organic matter decomposes in low oxygen.
  - ✓ Human sources: Use of fossil fuel, livestock digestion, rice paddies and landfills.

Low-Altitude Ozone (O_3)

- Ozone is a strong oxidizing agent.
- It is non-toxic in small concentration.
- If its concentration goes above 100 parts per million (ppm), it becomes toxic.
- It is harmful to humans, plants and other materials e.g rubber, fabric dyes, and paints. It affects adversely.
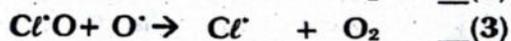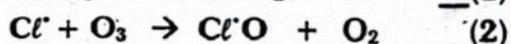
Chlorofluorocarbons (CFCs)

The decrease in the concentration of ozone in stratosphere is called depletion of ozone.

- The ozone has decreased so much in some places that a hole is formed. This is called the ozone hole.
- Through this hole, strong UV rays from the sun reach the Earth's surface. These rays can be harmful.
- This ozone loss is caused by organic compounds like chlorofluorocarbons (CFCs).
- CFCs are made of carbon, chlorine, and fluorine.
- They are gases or liquids with low boiling points.
- These are used in aerosol sprays or refrigerants.

> **Short Question**
> How do CFCs destroy ozone? Write mechanism

Role of CFCs in destroying ozone hole

- CFCs slowly move up into the stratosphere.
- These are broken by the UV radiations to give chlorine free radicals ($Cl^{\bullet}$).
- The chlorine free radicals are very reactive. They break down ozone molecules.

$$CFCl_3 \xrightarrow{UV} CFCl_2 + Cl^{\bullet} \quad \_(1)$$
$$Cl^{\bullet} + O_3 \rightarrow Cl^{\bullet}O + O_2 \quad \_(2)$$
$$Cl^{\bullet}O + O^{\bullet} \rightarrow Cl^{\bullet} + O_2 \quad \_(3)$$

- In the last step another chlorine free radical is formed. This can further break down another molecule of O_3.
- The 2nd and the 3rd steps are repeated many times.

Polycyclic Aromatic Hydrocarbon (PAHs)

- Polycyclic aromatic hydrocarbons (PAHs) are harmful chemicals. They are made of two or more fused aromatic rings. e.g. naphthalene, anthracene and phenanthrene.
- PAHs are common pollutants in the environment. They are mostly formed during incomplete combustion of fossil fuels like coal, oil, petrol or wood.
- They also come from vehicle emission, industries and even grilled food.
- PAHs may also come from some natural sources. These include open burning and leaks from oil and coal deposits.
- PAHs can be toxic. Some of them may even cause cancer.

Persistent Organic Pollutants (POPs)

- These are organic chemicals that do not break down easily.
- They are resistant to degradation through chemical, biological, and photolytic processes.
- They are toxic and can harm human health and the environment.
- Wind and water can carry them to other places.
- Most of these chemicals are made in one country, but they can affect people and animals in other countries.
- Due to their persistence, they accumulate in the environment.
- These can have significant adverse effects on human health.

> **Short Question**
> What are POPs in atmosphere? What are their harmful effects?

Sr. No.	Names of POPs	Uses
	Table: Some POPs with their uses	
1	Polychlorinated Biphenyls (PCBs)	Used in electrical equipment, surface coating ink, adhesives and paints
2	Dichlorobiphenyl tri-chloroethane (DDT)	An insecticide used in agriculture

Volatile Organic Compounds (VOCs)

- Volatile Organic Compounds (VOCs) are a large group of organic chemicals which evaporate easily at room temperature.

Sources

- VOCs come out as gases from some solids and liquids.
- Liquid fuels are a big source of VOCs that affect outdoor air quality.
- VOCs are released into atmosphere by automobile emission, burning liquid fossil fuels, wood and garbage.

Harmful effects

- Short-term exposure to VOCs can cause eye, nose, and throat irritation, headaches, and nausea.
- Long-term exposure can harm the liver, kidneys, and nervous system.

Particulate Matter (PM)

The term "particulate matter (PM)" refers to the wide variety of tiny substances that float in the air in the form of either solid particles or liquid droplets or both.

- PM is all the dust, smoke, and haze particles suspended in ambient air.
- PM consists of acids, organic chemicals, metals, and soil or dust particles.

Sources

Natural sources: Volcanoes, fires, dust storms, and aerosolized sea salt.

Man-made sources: Combustion in mechanical and industrial processes, vehicle emissions and tobacco smoke.

Harmful effects:

Increased respiratory problems, cardiovascular diseases, decreased lung function etc.

Heavy Metals (Lead, Mercury and Cadmium)

Heavy metal like lead, mercury and cadmium are significant air pollutants.

Sources:

(i) They are released into the atmosphere from various industrial process, transportation and other human activities.

(ii) Major sources are metallurgy, battery waste and incineration.

IMPACT OF HUMAN ACTIVITIES ON THE ATMOSPHERE

- Human activities affect the atmosphere significantly.
- Burning fossil fuels and cutting down trees are the main causes.
- These activates cause climate change, air pollution, and other environmental problems.
- In cities, most air pollution comes from human-made sources. These sources are of two types:
  - ✓ Mobile sources: cars, trucks, airplanes, and boats.
  - ✓ Point sources: factories and power plants.

Impact of Burning Fossil Fuels on the Atmosphere

- The burning of fossil fuels is the primary cause of climate change
- This alters the earth ecosystem and causes human health problems.
- The burning of fossil fuels affects the earth system in different ways. e.g., greenhouse gas emission, air pollution, volatile organic compounds.
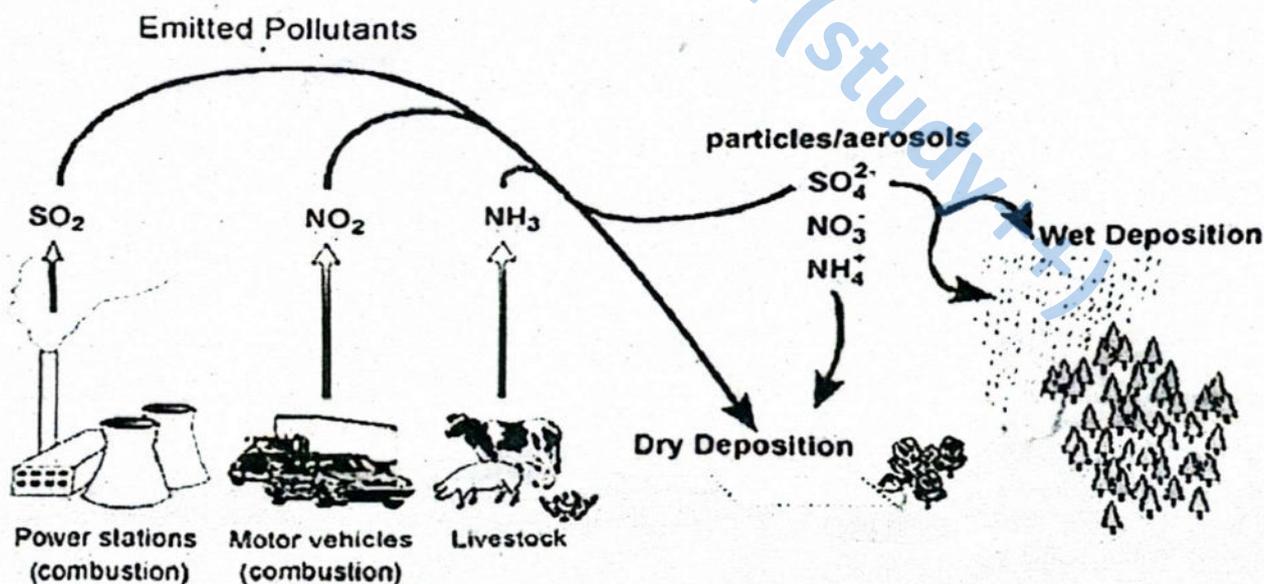
Impact of Deforestation on the Atmosphere

Deforestation is purposeful cleaning or thinning of forests by humans.

- Forests absorb greenhouse gases like carbon dioxide (CO_2). Thus, these help clean the air.
- Deforestation is a big problem for the world's climate and causes many problems.
- Deforestation has many negative impact on the environment. This includes loss of biodiversity climate change, soil degradation, and water cycle disruption.

Quick Check 14.2

a) Mention man-made sources of air pollution.
- (i) Burning fossil fuels produces gases like carbon dioxide (CO_2), carbon monoxide (CO).
- (ii) Landfills release hydrocarbons in air e.g. CH_4
- (iii) Automobiles emission releases several gases into the atmosphere. e.g. NOx, CO
- (iv) Liquid fuels are a big source of VOCs that affect outdoor air quality.
- (v) Deforestation: Forests absorb greenhouse gases like carbon dioxide (CO_2). Thus, these help clean the air. Deforestation is a big problem for the world's climate and causes many problems.

b) How do polycyclic aromatic hydrocarbons (PAHs) primarily enter the atmosphere?
- Polycyclic aromatic hydrocarbons (PAHs) are made of two or more fused aromatic rings. e.g. naphthalene, anthracene and phenanthrene.
- PAHs are common pollutants in the environment. They are mostly formed during incomplete combustion of fossil fuels like coal, oil, petrol or wood.
- They also come from vehicle emission, industries and even grilled food.
- PAHs may also come from some natural sources. These include open burning and leaks from oil and coal deposits.

c) How do volatile organic compounds (VOCs) affect air quality?
- Volatile Organic Compounds (VOCs) are a large group of organic chemicals which evaporate easily at room temperature.
- VOCs are released into atmosphere by automobile emission, burning liquid fossil fuels, wood and garbage.
- Short-term exposure to VOCs can cause eye, nose, and throat irritation, headaches, and nausea.
- Long-term exposure can harm the liver, kidneys, and nervous system.

d) What are major sources of heavy metals in the atmosphere?
- Heavy metal like lead, mercury and cadmium are significant air pollutant.
 They are released into the atmosphere from various industrial process, transportation and other human activities.
  Major sources are metallurgy, battery waste and incineration.

ADDITIONAL MCQs
(Answers on Page 452)

1. **Which layer of the atmosphere contains the most mass and weather events?**
   (A) Stratosphere (B) Troposphere (C) Mesosphere (D) Thermosphere
2. **What is the main cause of the temperature increase in the stratosphere?**
   (A) Lightning (B) Ozone absorption of UV rays (C) Wind currents (D) Volcanic activity
3. **Which of the following is a secondary air pollutant?**
   (A) Carbon monoxide (CO) (B) Ozone (O_3) (C) Sulphur dioxide (SO_2) (D) Methane (CH_4)

4. **Carbon monoxide (CO) is dangerous because it:**
   (A) Causes global warming   (B) Depletes the ozone layer
   (C) Causes acid rain   (D) Binds with hemoglobin and reduces oxygen transport
5. **Which gases are collectively known as NOx?**
   (A) CO and CO_2 (B) NO and NO_2 (C) SO_2 and SO_3 (D) CH_4 and C_2H_6
6. **Which air pollutant is primarily responsible for ozone layer depletion?**
   (A) Carbon dioxide   (B) Nitrogen oxides   (C) Methane   (D) Chlorofluorocarbons (CFCs)
7. **What is the main source of sulphur oxides (SOx) in the atmosphere?**
   (A) Deforestation   (B) Ocean waves   (C) Burning coal and oil   (D) Soil bacteria
8. **What makes Persistent Organic Pollutants (POPs) especially dangerous?**
   (A) They are only found in cities   (B) They evaporate quickly
   (C) They easily degrade in sunlight   (D) They accumulate and persist in the environment
   Answer: (D) They accumulate and persist in the environment
9. **Which of the following is a natural source of methane (CH_4)?**
   (A) Factories   (B) Swamps   (C) Car engines   (D) Brick kilns
10. **Which layer of the atmosphere has the coldest temperatures?**
    (A) Troposphere   (B) Stratosphere   (C) Mesosphere   (D) Thermosphere

EFFECTS OF AIR POLLUTANTS

The most common effects of air pollutants are formation of Smog and Acid Rain.

Formation of Smog

- *The word smog is a combination of two words "smoke" and "fog".*
- Smog is a kind of air pollution characterized by a thick haze.
- Smog mostly occurs in urban areas.
- It is caused by vehicle emission, industries and other pollution sources.
- Smog is made of fine dust or soot, condensed water vapors and poisonous gases like SO_2, NOx, O_3, CO and CO_2. It also has secondary pollutants like O_3, unburned hydrocarbons, VOCs and PM of size 10-2.5 micron.

Types of Smog

- Industrial or Classical Smog (London Smog)
- Photochemical smog (Los Angeles Smog)

Classical or Sulphureous Smog

- Industrial smog is also called as "Reducing smog or Classical Smog"
- It usually formed from high quantities of sulfur oxides (SOx) being released into the air.
- It is also called as "London smog".

Short Question
What is classical smog?

Photochemical smog

- Photochemical smog is formed when pollutants like nitrogen oxides (NOx), VOCs, and unburned fuels react with sunlight. These reactions create secondary pollutants like ozone and PAN (peroxyacetyl nitrates).
- This smog is very dangerous.
- It can cause heart problems, lung infections, and even lung cancer.
- It is also called as "Los Angeles Smog".

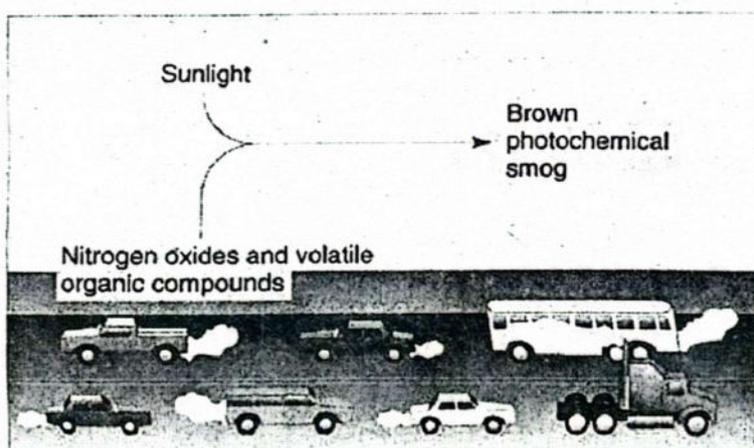**Short Question**
What is photochemical smog?

Fig. Illustration of Photochemical smog

Acid Rain

When rain water has pH less than 5.6, it is known as acid rain.
It refers to precipitation (rain, snow sheet or hail).

Cause of acid rain

- Burning of fossil fuels releases SOx and NOx into the atmosphere.
- These gases mix with the moisture in the air and form acids.
- Wind can carry these acidic droplets to large distance.
- Finally, these droplets return to the ground as acid rain, acid hail, snow and fog.
- Acid rain looks, feels and tastes like clean rain.
- *Its corrosive nature causes widespread damage to the environment.*

Reactions
Oxidation of SO_2 and NO
SO_2 from fossil fuels is oxidized to SO_3. NO from fossil fuels is oxidized to NO_2

$$2SO_{2(g)} + O_{2(g)} \rightarrow 2SO_{3(g)}$$
$$2NO_{(g)} + O_{2(g)} \rightarrow 2NO_{2(g)}$$
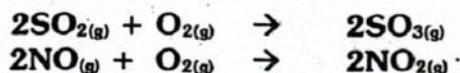
Combination with H_2O
SO_3 which then reacts with water to form sulphuric acid.
Nitrogen oxide reacts with water to produce nitric acid and nitrous acid.
$$SO_{3(g)} + H_2O_{(\ell)} \rightarrow H_2SO_{4(aq)}$$
$$3NO_{2(g)} + H_2O_{(\ell)} \rightarrow 2HNO_{3(aq)} + NO_{(aq)}$$
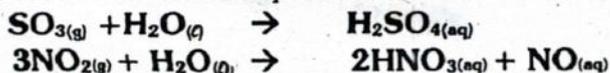
GREENHOUSE EFFECT AND GLOBAL WARNING

The progressive warming up of the earth's surface due to blanketing effect of greenhouse gases in the atmosphere is called the greenhouse effect

- Global warming means the average temperature of earth is going up over a long time due to human activities. The activities mostly burning fossil fuels. Burning fuels releases greenhouse gases (GHGs) into the air.
- Global warming is a big problem caused by air pollution.
- Carbon dioxide and water vapor in the air allows short wavelength infra-red solar radiations to reach earth.

- The earth heats up and reflected back the longer wavelength infra-red radiations. The GHGs trap longer-wavelength radiations and stop it from going back into space. Thus, the atmosphere becomes warm. This is called the greenhouse effect.
- During the day, the sun warms the earth by infra-red rays.
- At night, the earth radiate heat back to space.
- But some gases trap the heat from escaping. These are called greenhouse gases (GHGs).
- More the carbon dioxide and other GGGs, more heat is trapped.
- This makes the earth get hotter and causes global warming.
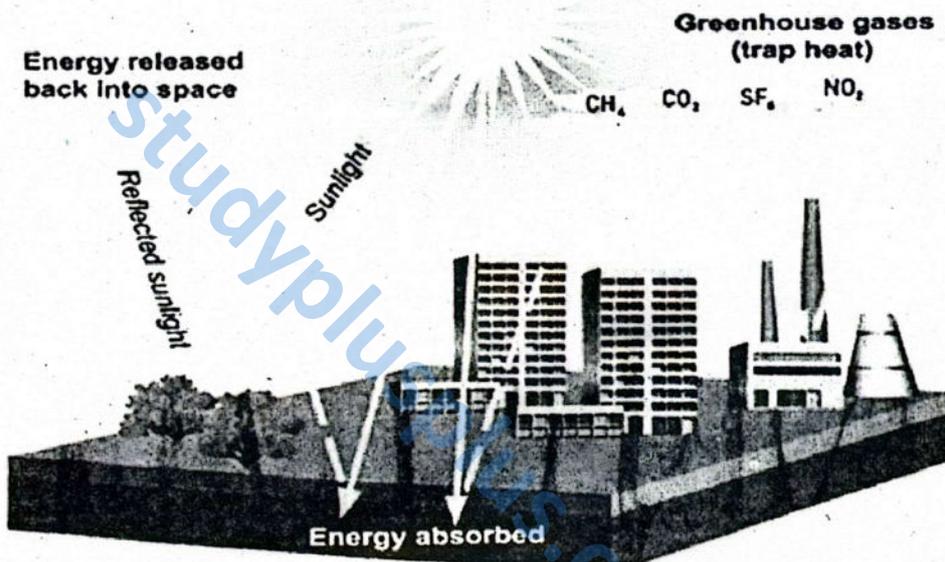
Quick Check 14.3

a) Differentiate classical and photochemical smog.

	Classical Smog	Photochemical Smog
1.	It is formed by burning of coal and other fossil fuels.	It is formed by reaction of pollutants like nitrogen oxides (NOx) and volatile organic compounds (VOCs) in the presence of sunlight.
2.	Its main components are: sulfur dioxide (SO_2), particulate matter (PM), smoke, and fog.	Its main components are: ozone (O_3), nitrogen oxides (NOx), VOCs, and secondary pollutants.
3.	It is formed in cold and humid conditions.	It is formed in warm and sunny conditions.
4.	It is reducing smog. Because it contains reducing agents like SO_2.	It is oxidizing smog. Because it contains oxidizing agents like O_3.
5.	It is also called London smog.	It is also called Los Angeles smog.

b) Name greenhouse gases (GHGs). How do these gases cause global warming?
- The greenhouse gasses are: water vapor, carbon dioxide, methane, nitrous oxide, ozone, and chlorofluorocarbons (CFCs).
- Global warming means the average temperature of earth is going up over a long time due to human activities. The GHGs e.g. carbon dioxide and water vapors allows short wavelength infra-red solar

radiations to reach earth. The earth heats up and reflected back the longer wavelength infra-red radiations. The GHGs trap longer-wavelength radiations and stop it from going back into space. Thus, the atmosphere becomes warm. This is called the greenhouse effect.

c) **Write a balanced equation, including the formation of sulfuric acid from atmospheric sulfur trioxide, SO_3.**

SO_3 which then reacts with water to form sulphuric acid.

$$SO_{3(g)} + H_2O_{(l)} \rightarrow H_2SO_{4(aq)}$$

d) **How HNO_3 is formed from NO in the atmosphere?**

Nitrogen oxide reacts with water to produce nitric acid.

$$3NO_{2(g)} + H_2O_{(l)} \rightarrow 2HNO_{3(aq)} + NO_{(aq)}$$

ADDITIONAL MCQs
(Answers on Page 452)

11. **Classical smog is also known as:**
   (A) Oxidizing smog   (B) Los Angeles smog   (C) Reducing smog   (D) Natural smog

12. **Photochemical smog is formed when pollutants react with:**
   (A) Heat   (B) Water   (C) Sunlight   (D) Carbon dioxide

13. **Which pollutant is a secondary component of photochemical smog?**
   (A) SO_2 (B) Ozone (O_3)   (C) CO   (D) NO

14. **Acid rain occurs when the pH of rainwater is:**
   (A) More than 7   (B) Exactly 7   (C) Less than 5.6   (D) Between 6 and 7

15. **Which gases are responsible for acid rain?**
   (A) CO and CH_4 (B) SO_x and NO_x (C) O_3 and VOCs   (D) H_2 and O_2

16. **Which of the following is a greenhouse gas?**
   (A) Oxygen   (B) Nitrogen   (C) Carbon dioxide   (D) Helium

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AIR QUALITY
Exercise Q 6: Long Q

- Air quality is measured in terms of Air Quality Index (AQI).
- It shows the amount of pollution in the air at a certain place.
- When air quality is good, the air is clear and has very little dust or chemicals.
- When air quality is bad, the air looks hazy and can be harmful to health and nature.
- An AQI below 50 means the air is clean and safe. Thus, it is safe to go outside without risk to health.
- An AQI over 300 is very dangerous. It can harm the health.
- Children under 18, older adults over 65 and people with heart or lung problems are at high risk.
- Outdoor workers are also at high risk because they spend more time outside.

> **Short Question**
> Describe the significance of AQI?

Factors Affecting Air Quality

Air quality is influenced by several key factors or sources.

i) **Emission sources**
- Burning of wood and fossil fuels can increase local pollution level.
- Factories and power plants use fossil fuels that release dangerous pollutants in air like SO_x and NO_x.
- Vehicles release CO, PM and VOCs.

ii) Meteorological conditions

- Wind, temperature and humidity affect pollutant dispersion and concentration.
- A layer of warm air trapping pollutants near the ground can lead to poor air quality.

iii) Natural Events

- Wild fires can release large amounts of smoke and PM into the atmosphere.
- Natural dust storms can significantly lower air quality.

iv) Seasonal Changes

- Temperature variations e.g. heating or cooling of buildings in different seasons can increase emissions of pollutants.
- Seasonal pollen concentration can contribute to poor air quality.

v) Population Density

Higher population density means increased vehicle use and industrial activities, leading to worst air quality.

Air Quality Index (AQI) Values	Levels of Health Concern	Colour
0 to 50	Good	Green
51 to 100	Moderate	Yellow
101 to 150	Unhealthy for Sensitive Groups	Orange
151 to 200	Unhealthy	Red
201 to 300	Very Unhealthy	Purple
301 to 500	Hazardous	Maroon

AIR QUALITY AND HUMAN HEALTH

- The link between air quality and human health is well-documented and significant.
- Poor air quality can have immediate and long-term health impacts.

Major Air Pollutants and their Health Effects

1. Particulate matter (PM)

- Particular matter (PM) consists of tiny particles suspended in the air. These include dust, dirt, soot and smoke. Their size range from 2.5 micrometer to 10.0 micrometer in diameter.
- Inhalation of these particulate matter (PM) can cause inflammation and irritation of airways. This leads to conditions such as asthma and bronchitis.

2. Nitrogen Dioxide (NO_2) and Sulphur Dioxide (SO_2)

- Short-term exposures can irritation of the respiratory system
- Long-term exposure can increase the risk of respiratory infection, asthma and bronchitis.

AIR POLLUTION HEALTH RISK

- Air pollution poses significant health risks to humans.
- It can cause *short-term (acute)* or *long-term (chronic)* health problems.
- *These vary depending on the type and concentration of pollutants, duration of exposure and individual weakness.*
- People who are already weak or sick can be more affected.

Respiratory Diseases

- Air pollutants such as ozone, particular matters (PM) and nitrogen dioxide (NO_2) can increase asthma symptoms and trigger asthma attack.
- Long term exposure may lead to chronic cough and respiratory infections like pneumonia.

Cardio Vascular Diseases

- Exposure to particular matters and other pollutants can increase the risk of heart attack.
- The pollutants cause inflammation, blood vessel damage, high blood pressure and finally heart stroke.

Cancer

Long-term exposure to certain air pollutants especially particulate matter (PM) and carcinogenic compounds (benzene formation) cause lung cancer.

Reproductive and Developmental Effects

- Exposure to air pollution may negatively impact reproductive health and fertility in both man and women.
- Premature birth and developmental problems in children.

Quick Check 14.4

a) Explain the impact of particulate matter (PM) on the air quality.

- Particular matter (PM) consists of tiny particles suspended in the air. These include dust, dirt, soot and smoke. Their size range from 2.5 micrometer to 10.0 micrometer in diameter. They increases AQI.
- Inhalation of these particulate matter (PM) can cause inflammation and irritation of airways. This leads to conditions such as asthma and bronchitis.

b) What is AQI? How does it measure air quality?

- Air quality is measured in terms of Air Quality Index (AQI).
- It shows the amount of pollution in the air at a certain place.
  Generally
  ✓ An AQI below 50 means the air is clean and safe. Thus, it is safe to go outside without risk to health.
  ✓ An AQI over 300 is very dangerous. It can harm the health.

c) What are different levels of AQI? Mention the safest and the most hazardous ranges of AQI.

Air Quality Index (AQI) Values	Levels of Health Concern
0 to 50	Good
51 to 100	Moderate
101 to 150	Unhealthy for Sensitive Groups
151 to 200	Unhealthy
201 to 300	Very Unhealthy
301 to 500	Hazardous

Thus, An AQI below 50 is the safest and an AQI above 300 is hazardous.

METHODS & TECHNIQUES TO MEASURE & MONITOR AIR QUALITY

- Measuring and monitoring air quality involves a combination of methods and techniques to assess the concentration of various pollutants in the air.

- The pollutants include particulates matter (PM), nitrogen dioxides (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), ozone (O_3) and volatile organic compounds (VOCs).

- There are various methods and techniques used by environmental engineers to measure air quality accurately.

- The instrument used to measure air quality index (AQI) is nephelometer. This is also called photometer.

- This is used to monitor PM such as dust, smoke, mist and fumes. It detects particles by measuring the total amount of light they scatter.

DIRECT MEASUREMENT METHODS

1. Continuous Emission Monitoring System (CEMS)
Continuous emission monitoring system (CEMS) can monitor gases like CO, O_3, SO_2, NO_2, VOCs and PM at industrial sites.

> **Short Question**
> What are CEMS and AQMS?

2. Air Quality Monitoring Stations (AQMS)
- Fixed monitoring stations are equipped with various sensors and analyzers. These measure pollutant level in real time.
- These stations are located in urban areas and industrial zones.

3. Remote Sensing Techniques
- Satellites equipped with sensors can measure atmospheric pollutants over large areas.
- Thus, these provide valuable data on regional and global air quality.

EXPERIMENTS AND DATA COLLECTION TO TEST HYPOTHESIS ABOUT AIR QUALITY

The design of experiments to test hypothesis about air quality involves careful planning, data collection and analysis.

Following steps should be done about the air quality.

1. Hypothesis
- First a hypothesis is developed to design an experiment.
- Example:
  Let the hypothesis is
  The concentration of airborne particulate matters (PM 2.5) and nitrogen dioxide (NO_2) in urban areas is higher during peak traffic hours as compared to non-peak hours.
- This hypothesis can be tested by collecting air quality data at different time of the day.

2. Designing the experiment
- The detail of the experiment including the variables and method of data collection is planned.
- Busy road sites and residential areas are selected for monitoring.

3. Data Collection
- The data on traffic volume during rush hours and non-rush hours is collected and compared.
- The reliable instruments and methods are used to collect air quality data.

4. Analyze Data and Interpret Air Quality Easurements and Trends
- The collected data is analyzed to confirm the truth or falseness of the hypothesis.
- The results of the analysis are interpreted and concluded. This involves measuring the concentration of various pollutants and identifying trends overtime.
- By carefully designing experiments, collecting and analyzing data, a hypothesis about air quality can be tested. Thus, the strategies for improving air quality can be made.

TECHNOLOGIES AND STRATIGIES USED TO EDUCE AIR POLLUTION AND IMPROVE AIR QUALITY

Technologies
A variety of technologies is used to reduce air pollution and improve air quality.
The following five types of technologies we can be used to control emission of air pollutants.

(i) Catalytic convertor (CC)
- Oxides of nitrogen and other gases e.g. CO and various unburnt hydrogen are emitted by the car engines.
- Most of the cars have catalytic convertors. This converts the harmful pollutants to harmless substances.
  - ✓ Carbon monoxide (CO) is oxidized to carbon dioxide (CO_2).
  - ✓ Oxides of nitrogen (NO_x) are reduced to nitrogen.
  - ✓ The unburnt hydrocarbon is converted to carbon dioxide and water.

(ii) Diesel Particulate Filter (DPF)
- Diesel particulate filter (DPF) is incorporated in modern diesel engines. This reduces the emission of harmful particulate matter (PM) from the exhaust gases.
- The primary function of diesel particulate filter is to capture and store soot particles from the exhaust gases.

(iii) Selective catalytic reduction (SCR)
- SCR is used in diesel engines to remove pollutants from the emission gases.
- It reduces oxides of nitrogen (NO_x) to nitrogen.
- It oxidizes CO and hydrocarbons to CO_2 and water vapours using catalysts such as titanium dioxide, zeolites, etc.
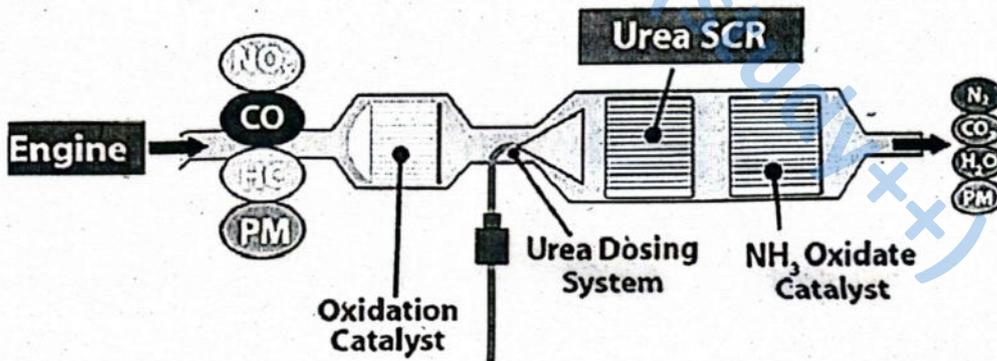

Fig. Selective Catalytic Reduction

(iv) Scrubbers
- Scrubbers can be used to control wide range of pollutants. e.g., SO_2, HCl, NH_3 and VOCs.
- Scrubbers use liquids (e.g. H_2O) to remove pollutants.

Short Question
How scrubbers remove pollutants?

LAWS AND REGULATIONS RELATED TO ATMOSPHERE

The rules and regulations to control air pollution in Pakistan are given below
(i) Pakistan Environmental Protection Act (PEPA 1997)
(ii) Natural Environmental Quality Standard (NEQS)
(iii) Provincial Regulations

> **Short Question**
> Name the rules and regulations to control air pollution in Paksitan?

Measures to Control Air Pollutions

1. **Vehicle Emission Standard:**
   - Enforcement of this standard is to reduce pollution from motor vehicles.
   - Promotion of cleaner fuels such as compressed natural gas (CNG), liquid petroleum gas (LPG) and sticker regulation on fuel quality.

2. **Industrial Emission Control:**
   - Reduce emission from industrial resources.
   - Encouragement of industries to adopt cleaner production techniques and pollution control technologies.

3. **Public Awareness Campaigns:**
   - Educating the public about the sources and effect of air pollution is a useful strategy.
   - Promotion of the use of public transport carpooling and non-motorized transport such as cycling and walking.

4. **Urban Planning and Green Infrastructure:**
   Development of green belts and parks in urban areas to improve air quality and to reduce traffic congestion.

5. **Smog Control Measures:**
   - Restrictions on the burning of crop residues.
   - Use of smog control towers.

6. **Prohibition of the use of open fire**
   Prohibit using open fire to bulk domestic and industrial waste. Because it can produce dust, smoke and significant amount of air pollutants.

ECONOMIC, SOCIAL & POLITICAL ISSUES RELATED TO AIR POLLUTION & AIR QUALITY

Air pollution and bad air quality is responsible for huge economic costs, social and potential issues.

Economic Issues

> What are economic issues of air pollution?

- Poor air quality can reduce worker productivity due to illness
- Air pollution and air quality can damage crops reducing agricultural yield and increasing food prices.
- Air pollution leading to acid rain.

Social Issues

> What are social issues of air pollution?

- Vulnerable populations, such as children, the elderly, and low-income communities are Chronic exposure to polluted air reduces the overall quality of life.
- Severe air pollution can force people to migrate leading to social displacement.

Political Issues

- Air pollution is not confined to borders and effective management requires International Corporation.
- Implementing air quality regulations requires strict governance.
- Addressing air pollution requires a multi-faceted approach, balancing socio-economic, and technological considerations.

17. **What does an AQI below 50 indicate?**
    (A) Poor air quality (B) Moderate pollution (C) Clean and safe air (D) Dangerous pollution

18. **Which group is at high risk due to bad air quality?**
    (A) Healthy adults (B) Children, elderly, and heart patients (C) Tourists (D) Students

19. **Which pollutant is captured using a Diesel Particulate Filter (DPF)?**
    (A) Ozone (B) Sulphur dioxide (C) Particulate matter (PM) (D) Carbon monoxide

20. **What instrument is used to measure the Air Quality Index (AQI)?**
    (A) Thermometer (B) Nephelometer (C) Barometer (D) Anemometer

21. **Which air pollutant is linked to lung cancer due to long-term exposure?**
    (A) Nitrogen (B) Particulate matter (PM) (C) Methane (D) Carbon monoxide

22. **Which law governs air pollution control in Pakistan?**
    (A) Clean Air Act (B) Pakistan Environmental Protection Act 1997
    (C) Eco Regulation Act (D) National Green Law 2000

23. **What is the main purpose of a catalytic converter?**
    (A) To increase engine speed (B) To trap dust
    (C) To convert harmful gases into less harmful ones (D) To cool exhaust gases

ANSWERS TO ADDITIONAL MCQs

Q#	Ans	Q#	Ans	Q#	Ans	Q#	Ans	Q#	Ans	Q#	Ans	Q#	Ans	Q#	Ans
1	A	2	B	3	B	4	D	5	B	6	D	7	C	8	D
9	B	10	C	11	C	12	C	13	B	14	C	15	B	16	C
17	C	18	B	19	C	20	B	21	B	22	B	23	C		

Exercise

Q1 MULTIPLE CHOICE QUESTIONS

I. **Which gas causes yellow color in photochemical smog?**
   a) CO   b) SO_3 c) NO_2 d) SO_2

II. **The depletion of Ozone in stratosphere region is mainly due to the reaction of O_3 with:**
   a) CO_2 b) SO_2 c) O_2 d) CFCs

III. **Which particulate matter size is considered the most harmful to human health?**
   a) PM 10.0   b) PM 5.0   c) PM 2.5   d) PM 1.0

IV. **Which of the following is a natural factor that can improve air quality?**
   a) Wildfire   b) Urbanization   c) Rainfall   d) Industrial emission

V. **What is a common human activity that led to increased level of carbon monoxide in the atmosphere?**
   a) Tree planting   b) Gasoline driven vehicles
   c) Using electric appliances   d) Solar panel installation

VI. **Chlorofluorocarbons (CFCs) have been primarily used in …….**
   a) Fertilizers   b) Refrigerants and aerosol propellants
   c) pharmaceutical   d) pesticides

VII. **What are the primary chemical processes that removes carbon dioxide from the atmosphere?**
   a) Combustion   b) Photosynthesis   c) Respiration   d) Volcanic activity

VIII. **An AQI value between 51 and 100 typically indicates which level of air quality?**
   a) Good   b) Moderate   c) Unhealthy   d) Fatal

IX. **Acid rain is primarily caused by the release of which of the following gases into the atmosphere?**
   a) Carbon dioxide (CO_2) and methane (CH_4)
   b) Sulfur dioxide (SO_2) and nitrogen oxides (NO_x
   c) Chlorofluorocarbons (CFCs) and halons
   d) Ozone (O_3) and carbon monoxide (CO)

X. **In the presence of sunlight and nitrogen oxides (NOx), VOCs can contribute to the formation of:**
   a) Acid rain   b) Ozone depletion   c) Photochemical smog   d) Greenhouse gases

XI. **Primary pollutants like nitrogen oxides (NOx) and volatile organic compounds (VOCs) react in the presence of sunlight to form a key component of photochemical smog, which is a:**
   a) Primary pollutant.   b) Secondary pollutant.
   c) Naturally occurring atmospheric gas   d) Harmless byproduct of combustion.

XII. **A key component that distinguishes photochemical smog from industrial smog is the presence of:**
   a) High concentrations of sulfur dioxide.
   b) A significant amount of ozone and other photochemical oxidants like PAN (peroxyacetyl nitrate).
   c) Reduced visibility due to fog and smoke particles.
   d) Formation primarily during the early morning hours.

ANSWERS TO MULTIPLE CHOICE QUESTIONS

No.	Ans	EXPLANATION
I.	c	NO_2 is a reddish brown gas. Thus, it gives yellow colour to photochemical smog
II.	d	CFCs are chloroflourocarbons. These destroy ozone in stratosphere.
III.	c	PM 2.5 is the most dangerous. It is because it can deeply penetrate the lungs and enter the bloodstream.
IV.	c	Rainfall can remove pollutants from air. Thus, it can improve air quality.
V.	b	Gasoline on combustion in engine produce significant amount of CO.
VI.	b	CFCs have been primarily used as refrigerants and aerosol propellents.
VII.	b	During photosynthesis, plants absorb CO_2 from air. Thus, this process help in removal of CO_2 from the atmosphere.
VIII.	b	This indicates a moderate level of health concern
IX.	b	SO_2 form sulphuric acid and NOx form nitric acid with water. Thus, they cause acid rain.
X.	c	Sunlight, NOx, VOCs leads to the formation of photochemical smog.
XI.	b	The reactions in smog produce peroxyacetyl nitrate (PAN) which is a secondary pollutant.
XII.	b	In photochemical smog, a significant amount of oxidants e.g. ozone and PAN is present.

Q2 SHORT QUESTIONS

a. Identify and briefly explain three major natural sources of air pollutants.

(i) The particulate matter (PM) can occur naturally. It includes dust from the ground, sea salt near coasts and biological material form plants and animals like pollen, spores and animal debris.

(ii) Volcanic eruptions release large amounts of gases and particles into the air.

(iii) Thunderbolts produces a lot of nitrogen oxides (NOx).

b. How can deforestation impact air quality?

Deforestation is purposeful cleaning or thinning of forests by humans.

Forests absorb greenhouse gases like carbon dioxide (CO_2). Thus, these help clean the air.

Deforestation has many negative impact on the environment. e.g. climate change, global warming.

c. Explain the reasons for the temperature trends observed in the troposphere and the stratosphere.

- Troposphere is the lowest region of the atmosphere which extends up to 12 km.
  In this region, temperature decreases from 17 °C to -58 °C regularly.
- Stratosphere is above the troposphere. It lies at a distance of 12-50 km above the earth surface
  Temperature increases from -58°C to -2°C.
  In the lower portion, the temperature remains nearly constant with increasing height.
  In the upper portion, the temperature increases rapidly with height. It is due to the presence of sunlight and ozone.

d. Describe four significant anthropogenic (human-caused) activities that contribute to the deterioration of air quality. For each activity, name at least one major pollutant released.

(i) Burning fossil fuels produces gases like carbon dioxide (CO_2), carbon monoxide (CO).

(ii) Landfills release hydrocarbons in air e.g. CH_4

(iii) Automobiles emission releases several gases into the atmosphere. e.g. NOx, CO

(iv) Liquid fuels are a big source of VOCs that affect outdoor air quality.

e. What are the environmental impacts of persistent organic pollutants (POPs)?

- These are organic chemicals that do not break down easily.
- Wind and water can carry them to other places. Most of these chemicals are made in one country, but they can affect people and animals in other countries.
- Due to their persistence, they accumulate in the environment.
- These can have significant adverse effects on human health. e.g. can cause cancer, nervous system problems, etc.

f. How does polycyclic aromatic hydrocarbon (PAHs) affect human health?

Polycyclic aromatic hydrocarbons (PAHs) are harmful chemicals.

They are made of two or more fused aromatic rings. e.g. naphthalene, anthracene and phenanthrene

PAHs can be toxic. Some of them may even cause cancer. They can also cause skin irritations, respiratory problems, etc.

g. What is photochemical smog? Under what conditions, it forms?

Photochemical smog is formed when pollutants like nitrogen oxides (NO_x), VOCs, and unburned fuels react with sunlight. These reactions create secondary pollutants like ozone and PAN (peroxyacetyl nitrates).

Conditions for the formation

(i) There must be sufficient NO, hydrocarbons and VOCs emitted by the vehicular traffic.

(ii) Sunlight, so that some of the chemical reactions may occur at a rapid rate.

(iii) The movement of air mass must be little so that reactions are not disturbed.

h. What type of data do air quality index (AQI) system provide?

Air quality is measured in terms of Air Quality Index (AQI). It shows the amount of pollution in the air at a certain place.

- An AQI below 50 means the air is clean and safe. Thus, it is safe to go outside without risk to health
- An AQI over 300 is very dangerous. It can harm the health.

i. Distinguish between PM10 and PM2.5, specifying the size ranges and describing why PM2.5 is generally considered more harmful to human health.

Particular matter (PM) consists of tiny particles suspended in the air. These include dust, dirt, soot and smoke. Their size range from 2.5 micrometer (PM 2.5) to 10.0 micrometer (PM 10) in diameter.

PM 2.5 comes from emissions from combustion of gasoline, diesel or wood. Their particle size is $\leq 2.5\ \mu m$

PM10 comes from dust from construction sites, landfills and pollens etc. Their particle size is $\leq 10\ \mu m$

PM 2.5 is the most dangerous. It is because it can deeply penetrate the lungs and enter the bloodstream.

j. What are the main chemical processes involved in the formation of acid rain?

When rain water has pH less than 5.6, it is known as acid rain.

Burning of fossil fuels releases SOx and NOx into the atmosphere.

These gases mix with the moisture in the air and form acids which return to the ground as acid rain, acid hail, snow and fog.

$$SO_{3(g)} + H_2O_{(l)} \rightarrow H_2SO_{4(aq)}$$
$$3NO_{2(g)} + H_2O_{(l)} \rightarrow 2HNO_{3(aq)} + NO_{(aq)}$$

k. What are the specific measures to control smog?

(i) Control Vehicle Emissions: Use catalytic converters in cars.

(ii) Regulate Industrial Pollution: Install scrubbers, filters in factories. Limit emissions of NOx and VOCs.

(iii) Reduce use of Fossil Fuels

(iv) Plant trees and create green belts to absorb pollutants.

1. **How does a catalytic converter reduce harmful vehicle emissions?**
   - Oxides of nitrogen and other gases e.g. CO and various unburnt hydrogen are emitted by the car engines.
   - The catalytic converters converts the harmful pollutants to harmless substances.
     - ✓ Carbon monoxide (CO) is oxidized to carbon dioxide (CO_2).
     - ✓ Oxides of nitrogen (NO_x) are reduced to nitrogen.
     - ✓ The unburnt hydrocarbon is converted to carbon dioxide and water.

m. **Describe the sources of lead and mercury pollution.**

   Heavy metal like lead, mercury and cadmium are significant air pollutants.
   - They are released into the atmosphere from various industrial process, transportation and other human activities.
   - Major sources are metallurgy, battery waste and incineration.

DESCRIPTIVE QUESTIONS

Q.3 Discuss sources and effects of following air pollutants on environment:
i) Heavy metals Page 441 ii) VOCs Page 440 iii) PAHs Page 440 iv) POPs Page 440

Q.4 Write short notes on the following:
i) CFCs and ozone layer depletion   Page 439
ii) Greenhouse effect and global warming Page 445

Q.5 How the fossil fuel burning causes acid rain? Discuss in detail with chemical reactions.
Page 444

Q.6 What is meant by air quality AQI? Describe the factors affecting the air quality.
Page 446

1. Which one of the following pollutants can cause death of a person by binding with haemoglobin of red blood cells? MCAT 2014
   (A) Chlorofluorocarbons   (B) Oxides of Sulphur   (C) Carbon monoxide   (D) Oxides of nitrogen
2. Unpolluted rain water has a pH of: MCAT 2013
   (A) 4.9   (B) 5.6   (C) 5.3   (D) 7.0
3. The pH range of acid rain is: MCAT 2012
   (A) 6.5 to 7   (B) 6.5 to 6   (C) 5.6 to 6   (D) less than 5
4. The unpolluted natural rain water is slightly acidic due to the reaction of rain water with: MCAT 2011
   (A) Sulphur dioxide   (B) Oxides of nitrogen   (C) Carbon dioxide   (D) Hydrogen present in air
5. _____ is an eye irritant. MCAT 2014
   (A) Peroxyacetyl nitrate   (B) Peroxyacetyl nitrite   (C) Peroxymethoxy aniline   (D) Peroxyacetyl aniline
6. The increase in concentration of oxidizing agents in smog like H_2O_2, HNO_3, PAN and ozone in the air is called MCAT 2012
   (A) Carbonated smog   (B) Nitrated smog   (C) Photochemical smog   (D) Sulphonated smog
7. The yellowish-brown color in photochemical smog is due to the presence of: MCAT 2013
   (A) Sulphur dioxide   (B) Carbon monoxide   (C) Carbon dioxide   (D) Nitrogen dioxide
8. Which of the following is responsible for the depletion of ozone layer? MDCAT 2013
   (A) chloroflourocarbons   (B) carbon tetrachloride   (C) methane   (D) hydrofluorocarbons
9. Freon is commonly known as? MDCAT 2022
   (A) Refrigerant   (B) A solvent   (C) Insecticides   (D) A fire extinguisher

ANSWERS

Q#	Ans	Q#	Ans	Q#	Ans	Q#	Ans	Q#	Ans	Q#	Ans	Q#	Ans	Q#	Ans
1	C	2	B	3	D	4	C	5	A	6	C	7	D	8	A
9	A														

OBJECTIVE: Time: 10 Minutes: Marks: 08

Q1. Choose the correct answer and encircle it.

1. The pH range of the acid rain is
   (A) 7-6.5   (B) 6.5-6   (C) 6-5.6   (D) less than 5
2. Peroxyacetylnitrate (PAN) is an irritant to human beings and it affects
   (A) eyes   (B) ears   (C) stomach   (D) nose
3. The mesosphere starts at which height from the surface of earth?
   (A) 5 km   (B) 25 km   (C) 50 km   (D) 85 km
4. Reducing smog contains high contents of
   (A) NO_2 (B) SO_2 (C) NO   (D) CO_2
5. Oxidizing smog consists of high concentration of
   (A) SO_2 (B) Ozone   (C) NO_2 (D) Cl_2
6. Which is responsible for the destruction of ozone?
   (A) Cl   (B) F   (C) O   (D) Br
7. Which particulate matter is most dangerous?
   (A) PM2.5   (B) PM10   (C) PM7.5   (D) PM9.5
8. Which of the following is a greenhouse gas?
   (A) Oxygen   (B) Nitrogen   (C) Carbon dioxide   (D) Helium

Fill in the correct option				Write Correct option here
1.	Ⓐ Ⓑ Ⓒ Ⓓ			
2.	Ⓐ Ⓑ Ⓒ Ⓓ			
3.	Ⓐ Ⓑ Ⓒ Ⓓ			
4.	Ⓐ Ⓑ Ⓒ Ⓓ			
5.	Ⓐ Ⓑ Ⓒ Ⓓ			
6.	Ⓐ Ⓑ Ⓒ Ⓓ			
7.	Ⓐ Ⓑ Ⓒ Ⓓ			
8.	Ⓐ Ⓑ Ⓒ Ⓓ			

SUBJECTIVE: Time: 60 minutes   Marks: 32

Section – I

Q2. Answer the following short questions.   (2×12=24)

(i)   Differentiate between primary and secondary pollutant?
(ii)   Write name and approximate heights of different layers of atmosphere
(iii) What are the sources of NOx in atmosphere?
(iv)   What is selective catalytic reduction?
(v)   How is SO_2 produced by human activities?
(vi)   Describe natural sources of methane (hydrocarbon) in atmosphere.
(vii) Discuss photochemical smog and give its properties
(viii) What are POPs?
(ix)   What is global warming?
(x)   Differentiate classical and photochemical smog.
(xi)   What is AQI? How does it measure air quality?
(xii) What are remote sensing techniques to monitor air quality?

Section – II

     (8×1=08)

Q3. (a) What measures should be taken to control air pollution? Explain   (04)
     (b) Discuss acid rain. How does it affect our environment?   (04)

ANSWERS TO MCQs: TEST YOUR SKILLS-I															
Q#	Ans	Q#	Ans	Q#	Ans	Q#	Ans	Q#	Ans	Q#	Ans	Q#	Ans	Q#	Ans
1	D	2	A	3	D	4	B	5	B	6	A	7	A	8	C