CHEMISTRY

Unit 14

THE ATMOSPHERE

MCQs • Short Questions • Long Questions

Complete Study Booklet with Answer Keys

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Section 1 | Multiple Choice Questions

Tick the correct option. Correct answers are highlighted in green with a check mark.

1. Which gas causes yellow color in photochemical smog?

(a) CO
(b) SO3
✓ **(c) NO2**
(d) SO2

2. The depletion of Ozone in stratosphere region is mainly due to the reaction of O3 with:

(a) CO2
(b) SO2
(c) O2
✓ **(d) CFCs**

3. 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

4. Which of the following is a natural factor that can improve air quality?

(a) Wildfire
(b) Urbanization
✓ **(c) Rainfall**
(d) Industrial emission

5. 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

6. Chlorofluorocarbons (CFCs) have been primarily used in:

(a) Fertilizers
✓ **(b) Refrigerants and aerosol propellants**
(c) Pharmaceuticals
(d) Pesticides

7. What are the primary chemical processes that removes carbon dioxide from the atmosphere?

(a) Combustion
✓ **(b) Photosynthesis**
(c) Respiration
(d) Volcanic activity

8. An AQI value between 51 and 100 typically indicates which level of air quality?

(a) Good
✓ **(b) Moderate**
(c) Unhealthy
(d) Fatal

9. Acid rain is primarily caused by the release of which of the following gases into the atmosphere?

(a) CO2 and CH4

✓ **(b) SO2 and NOx**

(c) CFCs and halogens

(d) O3 and CO

10. 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

11. 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

12. Which layer of the atmosphere contains most of the Earth's weather phenomena?

(a) Thermosphere

(b) Stratosphere

(c) Mesosphere

✓ **(d) Troposphere**

13. 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

14. Percentage of oxygen in atmosphere:

(a) 78.09%

✓ **(b) 21.01%**

(c) 0.04%

(d) 0.93%

15. Weather events occur in which layer of atmosphere:

(a) Mesosphere

(b) Thermosphere

(c) Stratosphere

✓ **(d) Troposphere**

16. Temperature increases with altitude in which of the following layers?

(a) Troposphere only

✓ **(b) Stratosphere only**

(c) Mesosphere only

(d) Troposphere and Mesosphere

17. Which of the following is a trace gas but important for greenhouse effect?

(a) Oxygen

(b) Nitrogen
✓ **(c) Carbon dioxide**
(d) Neon

18. Water vapour in the atmosphere is important because it:
✓ **(a) Is a greenhouse gas and essential for cloud formation**
(b) Makes up most of the atmosphere's mass
(c) Is chemically inert and unimportant
(d) Absorbs all visible light

19. Primary pollutants are:
✓ **(a) Emitted directly from sources into the atmosphere**
(b) Formed in the atmosphere by reactions
(c) Only natural in origin
(d) Harmless gases

20. Which of the following limits emission of particulate matter in air?
(a) Scrubbers
(b) Catalytic converter
✓ **(c) Diesel particulate filter**
(d) None of these

21. Which particulate matter is considered to be most harmful particulate matter?
(a) PM 10
(b) PM 0.5
✓ **(c) PM 2.5**
(d) All are equally hazardous

22. Which of the following is a heavy metal?
(a) Cadmium
(b) Lead
(c) Mercury
✓ **(d) All of these**

23. Dichlorobiphenyl trichloroethane (DDT) is used as:
(a) Fertilizer
✓ **(b) Insecticide**
(c) Adhesive
(d) Paint

24. How forests contribute to lowering the temperature of earth?
(a) Forests cool themselves
✓ **(b) Forests absorb greenhouse gases**
(c) Forests do most effect temperature of earth
(d) Forests help wild life

25. Which is point source of pollution?
(a) Cars
(b) Airplanes
✓ **(c) Factories**
(d) All of these

26. Effects of deforestation include:
(a) Loss of biodiversity
(b) Soil degradation

(c) Water cycle disruption
✓ **(d) All of these**

27. Which of the following is carcinogenic?
✓ **(a) Polycyclic aromatic hydrocarbons**
(b) Oxides of sulfur
(c) Oxides of nitrogen
(d) None of these

28. Ash from volcanic eruption is:
✓ **(a) Primary pollutant**
(b) Secondary pollutant
(c) Tertiary pollutant
(d) None of these

29. Which of the following is a secondary pollutant?
(a) Sulphur dioxide (SO2)
(b) Carbon monoxide (CO)
✓ **(c) Ground-level ozone (O3)**
(d) Particulate matter (PM10) emitted directly

30. Vehicular exhaust mainly contributes to which pollutants?
✓ **(a) CO, NOx, hydrocarbons, particulates**
(b) Ozone layer recovery
(c) Only nitrogen gas (N2)
(d) Pure oxygen (O2)

31. Which is considered a natural source of air pollution?
(a) Industrial smokestacks only
✓ **(b) Volcanic eruptions and dust storms**
(c) Automobile exhaust only
(d) Power plants only

32. Carbon monoxide (CO) is dangerous because it:
(a) Is highly flammable only
(b) Reacts to produce ozone directly
(c) Is inert and harmless
✓ **(d) Binds with haemoglobin preventing oxygen transport**

33. Major human source of CO2 increase in atmosphere is:
(a) Photosynthesis
✓ **(b) Fossil fuel combustion and deforestation**
(c) Ocean uptake
(d) Nitrogen fixation

34. Which statement about carbon dioxide is correct?
✓ **(a) CO2 is a greenhouse gas that absorbs infrared radiation**
(b) CO2 destroys the ozone layer
(c) CO2 is lighter than air and escapes to space
(d) CO2 is the major component of the atmosphere

35. Incomplete combustion of carbon-based fuels tends to form:
(a) CO2 only
✓ **(b) CO and soot (carbon particulates)**
(c) Ozone directly

(d) Nitrogen gas only

36. Major source of NOx in the atmosphere is:

(a) Photosynthesis

✓ **(b) High-temperature combustion in vehicles and power plants**

(c) Ocean evaporation

(d) Volcanic ash only

37. NO2 in the atmosphere contributes to:

✓ **(a) Acid rain formation and photochemical smog**

(b) Ozone layer repair

(c) Decreasing greenhouse effect only

(d) Building of clouds only

38. Which reaction is important in forming nitric acid (HNO3) in the atmosphere?

✓ **(a) 3NO2 + H2O -> 2HNO3 + NO**

(b) CO2 + H2O -> HNO3

(c) O2 + N2 -> HNO3

(d) SO2 + O2 -> HNO3

39. How do NOx emissions affect human health primarily?

(a) Cause tooth decay

✓ **(b) Irritate respiratory system and reduce lung function**

(c) Cause immediate blindness

(d) Improve air quality

40. The "good" ozone that protects life from UV radiation is located in the:

(a) Troposphere

(b) Hydrosphere

(c) Mesosphere

✓ **(d) Stratosphere**

41. Which of the following causes ozone depletion?

(a) Oxides of nitrogen

(b) Oxides of sulfur

(c) Hydrocarbons

✓ **(d) None of these**

42. Low altitude ozone is toxic above which concentration:

(a) At low concentration

✓ **(b) 100 ppm**

(c) 10 ppm

(d) 20 ppm

43. The chemical specie responsible for ozone depletion by chlorofluorocarbons is:

(a) CFC molecule itself

✓ **(b) Chloride free radical**

(c) UV rays

(d) Organic compounds

44. Ground-level ozone (bad ozone) is mainly formed from:

(a) Direct emission from factories

(b) Evaporation of water

✓ **(c) Photochemical reactions of NOx and VOCs in sunlight**

(d) Chlorofluorocarbons only

45. Which substance was primarily responsible for stratospheric ozone depletion?

(a) Carbon dioxide

(b) Methane

✓ **(c) Chlorofluorocarbons (CFCs)**

(d) Ozone itself

46. Exposure to high levels of ground-level ozone causes:

(a) Improved athletic performance

✓ **(b) Respiratory irritation and reduced lung function**

(c) Instant immunity to infections

(d) Strengthening of materials

47. Which statement is true about stratospheric ozone and temperature?

(a) More ozone in stratosphere cools it down

(b) Ozone reflects infrared and makes it colder

(c) Ozone has no effect on temperature

✓ **(d) Ozone absorbs UV and warms the stratosphere**

Section 2 | Short Questions

Q1. Identify and briefly explain three major natural sources of air pollutants.

Dust and biological materials: particulate matter from earth's surface, plus pollen, spores, and animal debris.

Volcanic eruptions: introduce large quantities of gases and particulate matter into the atmosphere.

Thunderbolts (lightning): produce significant quantities of nitrogen oxides (NOx).

Other natural sources: algae on ocean surfaces (releases H2S), wind erosion (introduces PM), and humid zones like swamps/peat-bogs (produce methane).

Q2. How can deforestation impact air quality?

Deforestation is the purposeful clearing or thinning of forests. Since forests absorb greenhouse gases (like CO2) and help clean the air, deforestation deteriorates air quality.

Negative impacts: loss of biodiversity, climate change, soil degradation, and water cycle disruption.

Q5. What are the environmental impacts of persistent organic pollutants (POPs)?

POPs are organic compounds resistant to chemical, biological, and photolytic degradation - they are toxic and adversely affect human health and the environment, traveling by wind and water.

Because of their persistence, POPs generated in one country can affect people and wildlife far away, and they accumulate in the environment. Examples: PCBs, DDT.

Q6. How do polycyclic aromatic hydrocarbons (PAHs) affect human health?

PAHs are composed of fused multiple aromatic rings and are common environmental pollutants.

Effects: potential toxicity and carcinogenic properties. Examples: naphthalene, anthracene, phenanthrene.

Q7. What is photochemical smog? Under what conditions does it form?

Photochemical smog forms when primary pollutants (NOx, VOCs, unburned hydrocarbons) undergo photochemical reactions in sunlight, forming secondary pollutants like ozone and PAN.

Conditions required: sunlight, presence of VOCs, presence of NOx, and low wind movement.

Q8. What type of data do air quality index (AQI) systems provide?

AQI systems provide data on the presence and concentration of pollutants including particulate matter (PM), NO2, SO2, CO, O3, and VOCs.

This data is used to inform policies and laws aimed at reducing pollution.

Q9. Distinguish between PM10 and PM2.5, and explain why PM2.5 is more harmful.

PM10: particles 10 micrometers or less in size. PM2.5: particles 2.5 micrometers or less.

PM2.5 is more harmful because its small size lets it penetrate deep into the human respiratory system, bypassing natural protective mechanisms.

Q10. What are the main chemical processes involved in the formation of acid rain?

Sulfuric acid formation: 2SO2(g)+O2(g) -> 2SO3(g); SO3(g)+H2O(l) -> H2SO4(aq).

Nitric acid formation: 2NO(g)+O2(g) -> 2NO2(g); 3NO2(g)+H2O(l) -> 2HNO3(aq)+NO(aq).

SO2 from fossil fuels oxidizes to SO3, which reacts with water to form sulfuric acid; nitrogen oxides similarly react with water to form nitric acid.

Q11. What are specific measures to control smog?

Restrict the burning of crop residues, a major contributor to smog, especially during winter months.

Use smog towers and other technologies to reduce particulate matter in the air.

Q12. How does a catalytic converter reduce harmful vehicle emissions?

Vehicle engines emit NOx, CO, and unburnt hydrocarbons. Catalytic converters convert these into harmless substances: CO is oxidized to CO2; NOx are reduced to N2; unburnt hydrocarbons are converted to CO2 and H2O.

Q13. Describe the sources of lead and mercury pollution.

Heavy metals like lead, mercury, and cadmium come from: industrial processes, transportation, metallurgy, battery waste, and incineration.

Q14. What is the troposphere? Why is it important?

The lowest atmospheric layer, extending up to about 8-16 km. It contains most of the atmospheric mass and nearly all water vapour.

Weather phenomena (clouds, rain, storms) occur here, and temperature decreases with altitude.

Q15. What is the stratosphere and its significance?

Lies above the troposphere, up to about 50 km altitude. Contains the ozone layer, which absorbs harmful UV radiation.

Unlike the troposphere, its temperature increases with height due to UV absorption - important for protecting life from UV damage.

Q16. Describe the mesosphere.

Extends from about 50 km to 80 km. The coldest atmospheric layer, with temperatures dropping to -90 deg C.

Most meteoroids burn up here due to atmospheric friction. The top boundary is called the mesopause.

Q17. What is the exosphere?

The outermost layer, extending from about 500 km to thousands of kilometres. Air is extremely thin, and molecules can escape into space.

Mainly contains hydrogen and helium atoms, and gradually merges with outer space.

Q18. What are the major gases in dry air?

Nitrogen (N2): 78%; Oxygen (O2): 21%; Argon (Ar): 0.93%; Carbon dioxide (CO2): 0.04%; trace gases: neon, helium, methane, ozone.

Q19. Why is nitrogen important in the atmosphere?

Nitrogen is inert and forms the largest portion of the atmosphere. It dilutes oxygen, preventing rapid combustion.

It is essential for living organisms, being a key element in amino acids and proteins, entering the food chain via nitrogen fixation.

Q20. What is the significance of water vapour in the atmosphere?

Important for cloud formation and precipitation, absorbing heat and contributing to the greenhouse effect, and Earth's energy balance and weather systems.

Its amount varies with temperature and location.

Q21. What are primary pollutants?

Pollutants emitted directly into the atmosphere from sources like vehicles, industries, and natural processes - examples include CO, SO2, NO, and particulate matter.

Q22. Give sources and effects of chlorofluorocarbons.

Sources: used as propellants in aerosols and as coolant in refrigerators and air conditioners.

Effects: CFCs are about 100,000 times more effective than CO2 at trapping heat; one CFC molecule's decomposition can destroy up to 100,000 ozone molecules. Mechanism: CFCl3 -> CFCl2+Cl. (UV); Cl.+O3 -> ClO.+O2; ClO.+O -> Cl.+O2.

Q23. What are secondary pollutants?

Pollutants not emitted directly but formed in the atmosphere by reactions of primary pollutants - examples include ground-level ozone and PANs, often driven by sunlight (as in photochemical smog).

Q25. Write the effect of particulate matter on human health.

PM consists of tiny suspended particles (dust, dirt, soot, smoke) ranging from 2.5 to 10.0 micrometers. Inhalation can cause inflammation and irritation of airways, asthma, and bronchitis.

Q26. What harms do oxides of nitrogen and sulphur pose to human health?

Short-term exposure irritates the respiratory system; long-term exposure increases the risk of respiratory infection, asthma, and bronchitis.

Q29. Differentiate between dry deposition and wet deposition of air pollutants.

Dry deposition: transfer of pollutants from air to the earth's surface directly by gravity or wind.

Wet deposition: transfer of pollutants to land via absorption into precipitation.

Q30. What is carbon monoxide and why is it harmful?

A colourless, odourless gas from incomplete combustion of carbon fuels. It binds to haemoglobin more strongly than oxygen, reducing oxygen transport in the body - high exposure can cause death.

Q36. Why don't the large amounts of O2 and N2 in the atmosphere normally react to form nitrogen oxides?

Because the reaction requires a large amount of energy, not ordinarily available in the atmosphere.

N2(g)+O2(g) -> 2NO(g) (at high temperature); 2NO(g)+O2(g) -> 2NO2(g).

Q38. What causes ozone layer depletion?

Mainly caused by chlorofluorocarbons (CFCs) and other halogenated compounds, which release chlorine and bromine atoms in the stratosphere that destroy ozone molecules.

Q42. Define ozone layer. Where is it present?

The layer where the maximum concentration of ozone is present is called the ozone layer, located in the stratosphere (the second layer of the atmosphere).

Q43. What is meant by an ozone hole?

The region where the ozone layer significantly depletes, especially over the Antarctic region during the Southern Hemisphere's spring (August to October).

Q48. What is industrial smog?

Forms from burning coal and oil in cool, humid conditions. Contains SO2, soot, and water droplets, giving it a grey colour - historically common in cities like London.

Section 3 | Descriptive Questions

Q3 (Descriptive). Discuss sources and effects of: (i) heavy metals (ii) VOCs (iii) PAHs (iv) POPs.

Heavy metals (Pb, Hg, Cd): sources include industrial processes, transportation, metallurgy, battery waste, and incineration - significant air pollutants affecting human health.

VOCs (e.g. benzene, toluene, formaldehyde): sourced from liquid fuels, vehicle exhaust, and burning fossil fuels/wood/garbage; short-term effects include eye/nose/throat irritation and headache; long-term effects include liver, kidney, and nervous system damage.

PAHs (e.g. naphthalene, anthracene): formed by incomplete combustion of fossil fuels, vehicle emissions, industrial processes, and grilled foods; effects include toxicity and carcinogenic properties.

POPs (e.g. PCBs, DDT): resistant to degradation, travel by wind and water, and accumulate in the environment, causing significant adverse health effects far from their source.

Q4 (Descriptive). Write short notes on: (i) CFCs and ozone layer depletion (ii) Greenhouse effect and global warming.

CFCs and ozone depletion: CFCs used as aerosol propellants/coolants diffuse into the stratosphere, where UV breaks them down into chlorine radicals ($CFCl_3 \rightarrow CFCl_2 + Cl\cdot$), which then catalytically destroy ozone ($Cl\cdot + O_3 \rightarrow ClO\cdot + O_2$; $ClO\cdot + O \rightarrow Cl\cdot + O_2$) - one CFC molecule can destroy up to 100,000 ozone molecules.

Greenhouse effect and global warming: greenhouse gases (CO_2, methane, NO_2, SF_6) trap outgoing heat radiation in the atmosphere, warming Earth's surface; rising GHG emissions from human activity (burning fossil fuels) drive long-term global warming.

Q5 (Descriptive). How does fossil fuel burning cause acid rain? Discuss with chemical reactions.

Burning fossil fuels releases SO_2 and NOx, which react with atmospheric moisture and oxygen to form acids that fall as acid rain.

Sulfuric acid: $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$; $SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$. Nitric acid: $2NO(g) + O_2(g) \rightarrow 2NO_2(g)$; $3NO_2(g) + H_2O(l) \rightarrow 2HNO_3(aq) + NO(g)$. Wind can carry these acidic droplets long distances before they fall as acid rain/snow/fog.

Q6 (Descriptive). What is meant by air quality (AQI)? Describe the factors affecting air quality.

AQI is a measure of pollutant concentrations in the air at a location; AQI under 50 is good (safe outdoors), while AQI over 300 is hazardous.

Factors affecting air quality: emission sources (burning fuels, factories, vehicles), meteorological conditions (wind, temperature, humidity affecting dispersion), natural events (wildfires, dust storms), and seasonal changes (temperature variation, pollen levels).

Section 4 | Long Questions

Q1. Define atmosphere. Explain its components and layers.

Atmosphere

Definition: the atmosphere is a sphere of different gases surrounding the earth.

Components

Major components: Nitrogen (78.00%), Oxygen (21.01%).

Minor components: Argon (0.93%), Carbon dioxide (0.04%).

Trace components: Methane, Hydrogen, Neon, Helium, Krypton, and Xenon.

Layers of the Atmosphere

The atmosphere has four (plus a fifth outer) distinct layers, determined by how temperature changes with altitude.

(i) Troposphere: 0-12 km, temperature decreases from 17 to -58 deg C; includes all major gases (N2, O2, CO2); the densest layer; site of rain, lightning, and hurricanes.

(ii) Stratosphere: 12-50 km, temperature increases from -58 to -2 deg C; contains three regions based on UV distribution - upper (O3->O2+O*, UV light), middle (O2+O*->O3, exothermic ozone formation), and lower (very low UV, no ozone formation).

(iii) Mesosphere: 50-85 km, temperature decreases from -2 to -93 deg C - the coldest region.

(iv) Thermosphere: 85-600 km, temperature increases (500-2000+ deg C) due to absorption of energetic UV and X-rays.

Q2. What are air pollutants? Give their natural and human-made sources.

Air Pollutants

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

Important pollutants: oxides of carbon (CO, CO2), oxides of nitrogen (NOx), oxides of sulphur (SOx), hydrocarbons, low-altitude ozone, CFCs, PAHs, POPs, VOCs, particulate matter (PM), and heavy metals (Pb, Hg, Cd).

Sources of Air Pollution

(i) Natural: dust from earth's surface, biological materials (pollens, spores, animal debris), volcanic eruptions, thunderbolts (NOx), algae on ocean surfaces (H2S), wind erosion (PM), and humid zones (methane from swamps/peat-bogs).

(ii) Human-made: mobile sources (cars, trucks, airplanes, marine engines), point sources (factories, power plants), combustion of fossil fuels (coal, fuel oils, natural gas), burning wood as domestic fuel, and coal in brick kilns.

Quick Check 14.1

Ozone formation and depletion equations: O3(g) -> O(g)*+O2(g) (UV light, depletion); O(g)*+O2(g) -> O3(g) (formation).

Q3. Describe oxides of carbon, nitrogen, sulfur, hydrocarbons, and low-altitude ozone as air pollutants.

(i) Oxides of Carbon

Carbon monoxide (CO): produced mainly by incomplete combustion of fossil fuels; a highly poisonous gas causing suffocation by binding to haemoglobin more strongly than oxygen. Equation: 2C(s)+O2(g) -> 2CO(g).

Carbon dioxide (CO2): a key greenhouse gas emitted by human activities, trapping heat and leading to global warming. Equation: C(s)+O2(g) -> CO2(g).

(ii) Oxides of Nitrogen (NOx)

NO and NO2, produced from burning fossil fuels: N2(g)+O2(g) -> 2NO(g) (high temperature); 2NO(g)+O2(g) -> 2NO2(g).

Natural sources: microbial processes in soil/oceans. Artificial sources: agricultural fertilizers, fossil fuel combustion. Effects: depletes ozone layer, contributes to climate change.

(iii) Oxides of Sulphur (SOx)

SO2 and SO3, emitted primarily by burning coal and oil; when combined with water vapour, causes acid rain and damages ecosystems.

(iv) Hydrocarbons

Natural sources: vegetation, wildfires, volcanoes. Artificial sources: incomplete fossil fuel burning, oil spills, industrial and vehicular emissions. Major source: automobiles; most common pollutant hydrocarbon: methane.

(v) Low-Altitude Ozone

A powerful oxidizing agent, non-toxic in small concentrations, but toxic above 100 ppm - harmful to humans, plants, rubber, fabric dyes, and paints.

Q4. Discuss CFCs, PAHs, POPs, VOCs, particulate matter, and heavy metals as air pollutants.

(i) Chlorofluorocarbons (CFCs)

Sources: used as aerosols and refrigerant/AC coolants, existing as gases or low-boiling liquids.

Effects: diffuse into the stratosphere, where UV radiation breaks them down into chlorine radicals. Equations: CFCl3 -> CFCl2+Cl. (UV); Cl.+O3 -> ClO.+O2; ClO.+O -> Cl.+O2.

Key fact: one CFC molecule can destroy up to 100,000 ozone molecules, and CFCs are about 100,000 times more effective than CO2 at trapping heat.

(ii) Polycyclic Aromatic Hydrocarbons (PAHs)

Definition: composed of fused multiple aromatic rings; common environmental pollutants (e.g. naphthalene, anthracene, phenanthrene).

Sources: incomplete combustion of fossil fuels, vehicle emissions, industrial processes, grilled foods, and natural open burning/petroleum seepage. Effects: potential toxicity and carcinogenic properties.

(iii) Persistent Organic Pollutants (POPs)

Definition: organic compounds resistant to chemical, biological, and photolytic degradation.

Characteristics: toxic, harmful to human health and the environment, travel by wind and water, and accumulate in the environment. Examples: PCBs (used in electrical equipment, coatings, adhesives), DDT (used as an insecticide).

(iv) Volatile Organic Compounds (VOCs)

Definition: organic compounds that evaporate easily at room temperature.

Sources: liquid fuels, vehicle exhaust, burning liquid fossil fuels/wood/garbage. Examples: benzene, xylene, toluene, ethanol, formaldehyde, acetone.

Effects: short-term irritation of eyes/nose/throat, headache, nausea; long-term liver/kidney/nervous system damage; contributes to indoor and outdoor air pollution.

(v) Particulate Matter (PM)

Definition: tiny substances floating in the air as solid particles or liquid droplets, composed of acids, organic chemicals, metals, soil, or dust.

Sources: natural (volcanoes, fires, dust storms, sea salt aerosols) and man-made (combustion, vehicle emissions, tobacco smoke).

(vi) Heavy Metals (Lead, Mercury, Cadmium)

Sources: industrial processes, transportation, metallurgy, battery waste, and incineration - significant air pollutants affecting human health.

Q5. Explain the impact of human activities on the atmosphere.

Impact of Burning Fossil Fuels

Combustion of fossil fuels is a primary cause of current climate change, altering earth's ecosystems and causing human/environmental health problems.

Effects: greenhouse gas emission, air pollution, and release of volatile organic compounds.

Impact of Deforestation

Definition: purposeful clearing or thinning of forests by humans.

Effects: loss of biodiversity, climate change, soil degradation, and water cycle disruption. Forests normally absorb greenhouse gases (like CO2) and help clean the air.

Q6. Discuss the causes, types, and effects of smog.

Smog

Definition: a type of air pollution characterized by a thick haze - a combination of 'smoke' and 'fog'.

Causes: primarily occurs in urban areas from vehicle emissions, industrial activities, and other sources.

Composition: fine dust/soot particles, condensed water vapour, poisonous gases (SO2, NOx, O3, CO, CO2), secondary pollutants (O3, unburned hydrocarbons, VOCs), and PM of size 2.5-10 microns.

(i) Industrial/Classical Smog (London Smog)

Also called 'reducing smog'. Results from high quantities of sulfur oxides (SOx) released into the air - reducing in nature.

(ii) Photochemical Smog (Los Angeles Smog)

Primary pollutants (NOx, VOCs, unburned hydrocarbons) undergo photochemical reactions in sunlight, forming secondary pollutants like ozone and PAN. Effects: heart palpitations, pneumonia, lung cancer - oxidizing in nature.

Q7. Write a note on (i) acid rain and (ii) the greenhouse effect.

Acid Rain

Definition: precipitation (rain, snow, sleet, or hail) with pH less than 5.6.

Mechanism: burning fossil fuels releases SOx and NOx, which mix with atmospheric moisture to form acids; wind carries acidic droplets long distances before they fall as acid rain, hail, snow, or fog.

Chemical reactions - Sulfuric acid: $2SO_2(g)+O_2(g) \rightarrow 2SO_3(g)$; $SO_3(g)+H_2O(l) \rightarrow H_2SO_4(aq)$. Nitric acid: $2NO(g)+O_2(g) \rightarrow 2NO_2(g)$; $3NO_2(g)+H_2O(l) \rightarrow 2HNO_3(aq)+NO$.

Appearance: looks, feels, and tastes like clean rain. Effects: corrosive, damages buildings/soil/paper/paints, and makes toxic heavy metal ions (mercury, lead, cadmium) soluble in groundwater.

Greenhouse Effect

Definition: the progressive warming of the earth's surface due to the blanketing effect of greenhouse gases.

Global warming: the long-term rise in Earth's average surface temperature, driven mainly by human GHG emissions from burning fossil fuels.

Mechanism: CO_2 and water vapour transmit short-wavelength solar radiation in, but reflect back longer-wavelength heat radiation from the warmed surface; some atmospheric gases trap this heat, preventing its loss. Higher GHG concentration means greater thermal radiation absorption and greater global temperature increase.

Key GHGs: carbon dioxide, methane, nitrogen dioxide, SF_6.

Q8. What is meant by air quality (AQI)? Describe the factors affecting air quality.

Air Quality Index (AQI)

Definition: a measure of the concentration of pollutants present in the air at a particular location.

Interpretation: AQI under 50 is good (safe to spend time outdoors); AQI over 300 is hazardous.

High-risk populations: children under 18, adults over 65, people with chronic heart/lung diseases, and outdoor workers.

Factors Affecting Air Quality

(i) Emission sources: burning wood/fossil fuels, factories/power plants (SOx, NOx), vehicles (CO, PM, VOCs).

(ii) Meteorological conditions: wind, temperature, and humidity affect pollutant dispersion - warm air trapping pollutants near the ground worsens air quality.

(iii) Natural events: wildfires (smoke, PM), dust storms (significantly lower air quality).

(iv) Seasonal changes: temperature variations (heating/cooling of buildings), seasonal pollen concentration.

Q9. Explain the effects of air quality on human health and health risks from air pollutants.

Effects of Specific Pollutants

Particulate Matter (PM, 2.5-10.0 micrometers): causes inflammation and irritation of airways, asthma, bronchitis, and lung cancer.

NO2 and SO2: short-term exposure irritates the respiratory system; long-term exposure causes respiratory infections, asthma, and bronchitis.

Health Risks Associated with Air Pollution

(i) Respiratory diseases: from ozone, PM, NO2 - causing asthma symptoms, chronic cough, and respiratory infections (pneumonia).

(ii) Cardiovascular diseases: from PM and other pollutants - causing heart attack, inflammation, blood vessel damage, high blood pressure, and stroke.

(iii) Cancer: from PM and carcinogenic compounds (e.g. benzene) - causing lung cancer.

(iv) Reproductive/developmental effects: negative impact on fertility, premature birth, and developmental problems in children.

Q10. How is air quality measured? Give experiments and data collection methods to test hypotheses about air quality.

Methods to Measure Air Quality

Nephelometer: measures AQI by monitoring PM (dust, smoke, mist, fumes), detecting particles via the amount of light they scatter.

(i) Continuous Emission Monitoring System (CEMS): monitors CO, O3, SO2, NO2, VOCs, PM at industrial sites.

(ii) Air Quality Monitoring Stations (AQMs): fixed stations with sensors/analyzers measuring pollutant levels in real time in urban/industrial areas.

(iii) Remote Sensing Techniques (RST): satellites measure atmospheric pollutants over large areas, providing regional/global air quality data.

Designing Experiments to Test a Hypothesis

(i) Hypothesis development: e.g. 'PM2.5 and NO2 concentrations in urban areas are higher during peak traffic hours than non-peak hours.'

(ii) Designing the experiment: select busy roads and residential areas, plan variables and data collection methods.

(iii) Data collection: gather traffic volume data during rush/non-rush hours using reliable instruments.

(iv) Analyze and interpret: measure pollutant concentrations, identify trends over time, and confirm or refute the hypothesis.

Q11. Explain the strategies to reduce air pollution.

Technologies to Control Air Pollution

(i) Catalytic Converter: controls CO, NOx, and unburnt hydrocarbons, converting CO to CO2, NOx to N2, and hydrocarbons to CO2+H2O.

(ii) Diesel Particulate Filter (DPF): used in modern diesel engines to capture and store soot particles (PM) from exhaust gases.

(iii) Selective Catalytic Reduction (SCR): used in diesel engines to convert NOx to N2 and CO/hydrocarbons to CO2+H2O, using catalysts like TiO2 and zeolites.

(iv) Scrubbers: control PM, SO2, HCl, NH3, and VOCs, using liquids (e.g. water) to remove pollutants from exhaust streams.

Q12. Discuss laws and measures to control air pollution, and the economic, social, and political issues involved.

Laws and Regulations in Pakistan

Pakistan Environmental Protection Act (PEPA 1997); National Environmental Quality Standards (NEQS); Punjab Environmental Protection (Amendment) Act 2012.

Measures to Control Air Pollutants

(i) Vehicle emission standards: reduce pollution from vehicles, promote cleaner fuels (CNG, LPG), and enforce fuel-quality regulations.

(ii) Industrial emission control: reduce emissions, encourage cleaner production and pollution-control technologies.

(iii) Public awareness campaigns: educate about pollution sources/effects, promote public transport, carpooling, cycling, and walking.

(iv) Urban planning and green infrastructure: develop green belts and parks, reduce traffic congestion, promote sustainable transport.

(v) Smog control measures: restrict crop-residue burning, use smog towers and related technologies.

(vi) Prohibit open burning of domestic/industrial waste.

(vii) Use low-sulphur diesel to reduce permissible sulphur levels.

Social, Economic, and Political Issues

(i) Economic: reduced worker productivity (illness/absenteeism), crop damage (reduced yield, higher food prices), and acid rain damage.

(ii) Social: vulnerable populations affected (children, elderly, low-income communities), reduced quality of life, migration due to severe pollution.

(iii) Political: air pollution crosses borders (requiring international cooperation), strict governance needed for regulation enforcement, and balancing socio-economic and technological considerations.

Section 5 | Answer Key & Formula Summary

MCQ Answer Key (Q1-Q47)

Q.No	Ans	Q.No	Ans	Q.No	Ans	Q.No	Ans
1	C	13	B	25	C	37	A
2	D	14	B	26	D	38	A
3	C	15	D	27	A	39	B
4	C	16	B	28	A	40	D
5	B	17	C	29	C	41	D
6	B	18	A	30	A	42	B
7	B	19	A	31	B	43	B
8	B	20	C	32	D	44	C
9	B	21	C	33	B	45	C
10	C	22	D	34	A	46	B
11	B	23	B	35	B	47	D
12	D	24	B	36	B		

Important Formulas

Formula	Description
O3(g) -> O2(g) + O(g)*	Ozone depletion in upper stratosphere (UV light)
O2(g) + O(g)* -> O3(g)	Ozone formation in middle stratosphere (exothermic)
CFCl3 -> CFCl2 + Cl.	CFC breakdown by UV radiation, forming a chlorine radical
Cl. + O3 -> ClO. + O2	Ozone-destroying step 1 (catalytic cycle)
ClO. + O -> Cl. + O2	Ozone-destroying step 2 (Cl radical regenerated)
2SO2(g) + O2(g) -> 2SO3(g)	Sulfur oxidation (acid rain precursor)
SO3(g) + H2O(l) -> H2SO4(aq)	Sulfuric acid formation (acid rain)
N2(g) + O2(g) -> 2NO(g)	Nitric oxide formation (high temperature combustion)
2NO(g) + O2(g) -> 2NO2(g)	Nitrogen dioxide formation
3NO2(g) + H2O(l) -> 2HNO3(aq) + NO(g)	Nitric acid formation (acid rain)

Key Constants & Notes

Constant/Note	Value
Nitrogen (N2) in dry air	78%
Oxygen (O2) in dry air	21%
Argon (Ar) in dry air	0.93%

Carbon dioxide (CO2) in dry air	0.04%
Troposphere height	0-12 km (temperature 17 to -58 deg C)
Stratosphere height	12-50 km (temperature -58 to -2 deg C)
Mesosphere height	50-85 km (temperature -2 to -93 deg C, coldest layer)
Thermosphere height	85-600 km (temperature 500-2000 deg C)
Acid rain pH threshold	below 5.6
PM2.5 size	2.5 micrometers or less
PM10 size	10 micrometers or less
Low-altitude ozone toxicity threshold	above 100 ppm

Layers of the Atmosphere

Layer	Height	Temperature Trend	Key Feature
Troposphere	0-12 km	Decreases (17 to -58 deg C)	Weather phenomena, densest layer
Stratosphere	12-50 km	Increases (-58 to -2 deg C)	Contains the ozone layer
Mesosphere	50-85 km	Decreases (-2 to -93 deg C)	Coldest layer; meteors burn up
Thermosphere	85-600 km	Increases (500-2000 deg C)	Absorbs UV/X-rays
Exosphere	500+ km	N/A	Merges with outer space

Air Quality Index (AQI) Scale

AQI Range	Health Concern Level	Colour
0-50	Good	Green
51-100	Moderate	Yellow
101-150	Unhealthy for Sensitive Groups	Orange
151-200	Unhealthy	Red
201-300	Very Unhealthy	Purple

Primary vs Secondary Pollutants

Type	Description
Primary Pollutants	Emitted directly (e.g. ash from volcanoes, CO from vehicle exhaust). Examples: oxides of carbon, nitrogen, sulfur.
Secondary Pollutants	Formed by chemical reactions of primary pollutants. Examples: ground-level ozone, PAN, sulfuric acid.

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