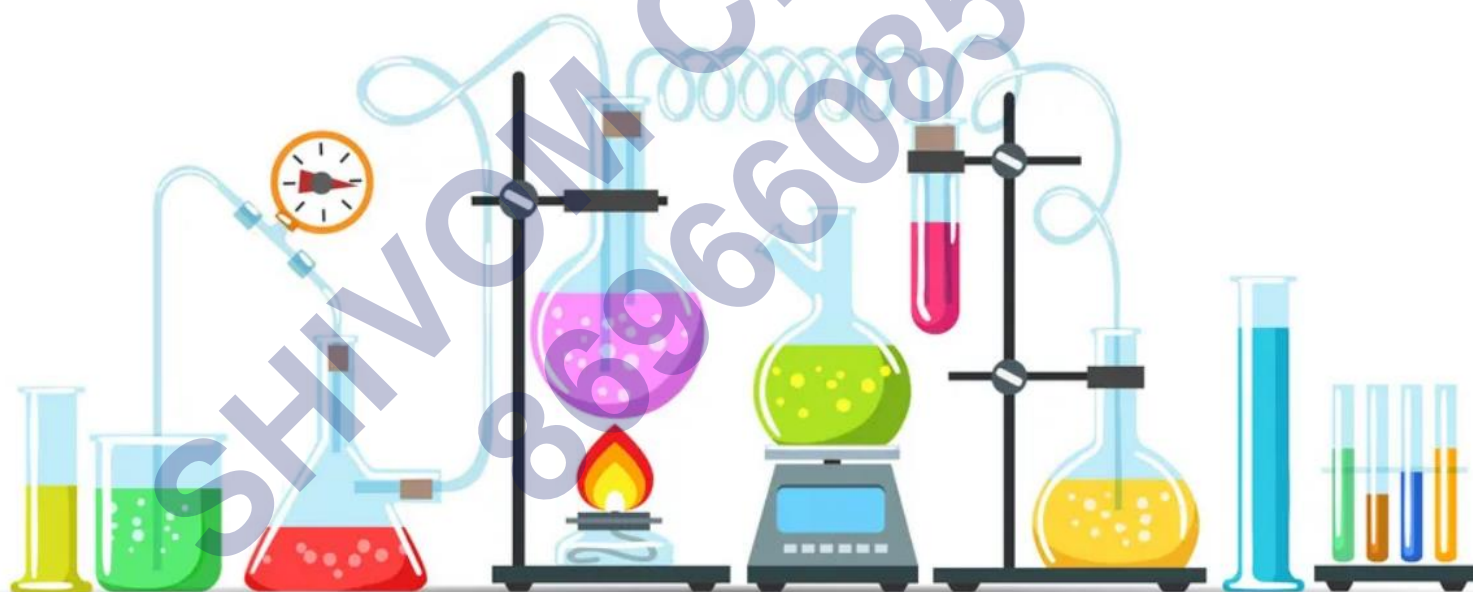


# CHEMISTRY

## CHAPTER 14: ENVIRONMENTAL CHEMISTRY



# ENVIRONMENTAL CHEMISTRY

## Introduction

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Interrelation of biological, social, economical, physical and chemical studies with our surrounding is called environmental studies. Environmental pollution is the greatest health hazard all over the world. Environmental chemistry deals with the study of the origin, transport, reactions, effects and fates of chemical species in the environment.

An undesirable change in physical, chemical or biological characteristics of air, water and land that is harmful to human life and other living organisms, living conditions, cultural assets, industrial progress and harms our resources is called pollution.

## Environmental Pollution

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Undesirable changes that have harmful effects on plants, animals and human beings in our surrounding is called environmental pollution.

### Pollutant

The substance which causes pollution and is harmful for environment is called pollutant. Pollutants are of two types:

#### 1. Biodegradable

Those substances which are degraded rapidly by natural process or artificial methods are called biodegradable pollutants. Ex- discarded vegetables.

#### 2. Non-biodegradable

Those substances which degrade at very slow rate or does not degrade by natural biological process, for example, DDT, arsenic salts of heavy metals, radioactive materials and plastics are non-biodegradable pollutants.

## Atmospheric Pollution

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Lowest layer of atmosphere is troposphere which have dust, water vapour and clouds, it contains dust, water vapour and clouds while stratosphere contains ozone. Atmospheric pollution includes both troposphere and stratosphere pollution.

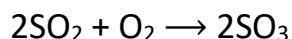
### Tropospheric Pollution

Tropospheric pollution occurs due to the presence of undesirable solid or gaseous particles

in the air.

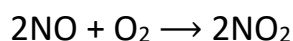
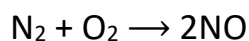
### 1. Gaseous air pollutants:

i. **Oxides of Sulphur:** Oxides of sulphur are produced when sulphur containing fossil fuel is burnt. The most common species, sulphur dioxide, is a gas that is poisonous to both animals and plants. It has been reported that even a low concentration of sulphur dioxide causes respiratory diseases e.g., asthma, bronchitis, emphysema in human beings. Sulphur dioxide causes irritation to the eyes, resulting in tears and redness.



ii. **Oxides of Nitrogen:** Mainly produced by combustion of fossil fuels at high temperature in automobile engines mainly NO and NO<sub>2</sub>.

These produce reddish brown haze or brown air NO<sub>2</sub> is more dangerous than NO. These oxides can cause pulmonary oedema, dilation of arteries, eye irritation, heart problems, injury to liver and kidneys and also causes acid rains.



iii. **Hydrocarbons:** Produced naturally (e.g., marsh gas) as well as due to incomplete combustion. These are carcinogenic and causes irritation of mucous membrane, eyes. They causes ageing, breakdown of tissues, shedding of flower, leaves and twigs in plants.

iv. **Carbon monoxide:** It is colourless, odourless gas. It is produced by incomplete combustion of fuels, naturally it is produced by oceans or by decaying of organic matter by bacteria. It is poisonous because it combines with hemoglobin to form 300 more times stable carboxyhemoglobin which reduces oxygen-carrying capacity of blood and results into giddiness, headache, decreased vision, cardiovascular malfunction and asphyxia. Cigarette smoke also contains a lot of CO which induces premature birth deformed babies and spontaneous abortions in pregnant women.

v. **Carbon dioxide:** It is produced naturally by volcanic eruptions, respiration. It is also produced by burning of fossil fuels. Increased level of CO<sub>2</sub> is controlled by green plants during photosynthesis. It is a greenhouse gas and responsible for global warming. It causes headache nausea and asphyxiation.

### 2. Greenhouse Effect

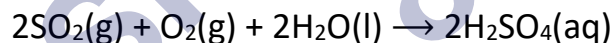
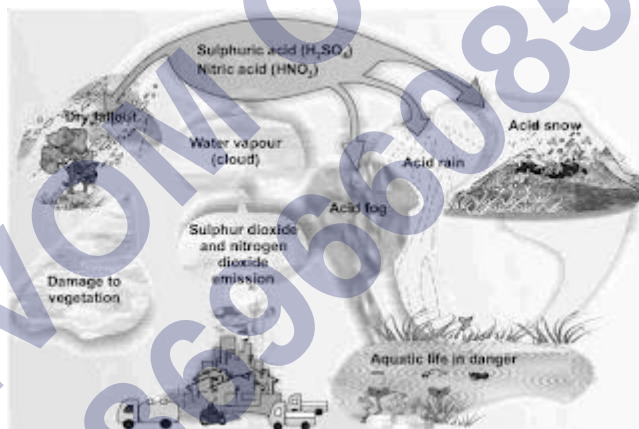
This effect was discovered by Fourier and the term was coined by Arrhenius. 75% of solar radiation is absorbed by earth surface and remaining is reflected back. Some of which is absorbed by greenhouse gases such as carbon dioxide, methane, ozone, chlorofluorocarbon compounds (CFCs) and water vapour in the atmosphere which

increases temperature of atmosphere is called greenhouse effect.



### 3. Acid Rain

When the pH value of the rain water drops below 5.6, it is known as acid rain. Acid rain is a byproduct of a variety of human activities that emit the oxides of sulphur and nitrogen in the atmosphere.

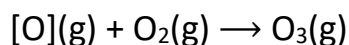
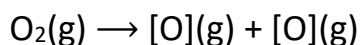


### Stratospheric Pollution

#### 1. Ozone Hole

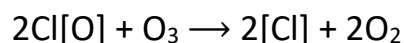
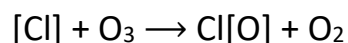
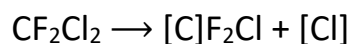
Depletion in the concentration of ozone over a restricted area as over Antarctica is called ozone hole. Stratospheric clouds are formed over Antarctica.

Molecular oxygen splits into free oxygen atoms by UV radiations which combine with molecular oxygen to form ozone.



As ozone is thermodynamically unstable hence, there exists dynamic equilibrium

between its decomposition and formation. Ultraviolet radiations dissociate chlorofluorocarbon to give chlorine-free radical, which combines with ozone to form chlorine monoxide radical which combines with free oxygen to form more chlorine-free radicals.



### Effects of Depletion of The Ozone Layer:

Bad ozone is formed in troposphere that harms plants and animals while good ozone is formed in stratosphere which acts as shield. UV rays can enter in earth's atmosphere.

- It is harmful as can cause skin cancer.
- It increases transpiration hence decreases soil moisture.
- It damages paints and fibres, causing them to fade faster.

## Water Pollution

Any unwanted change which deteriorate quality of water and make it unfit for drinking is called water pollution. Pollution of water originates from human activities.

### Causes of Water Pollution

1. Organic matter such as leaves, grass, trash etc. as well as excessive phytoplankton growth in water causes water pollution as this matter is decomposed through microbial activity is known as putrescibility which requires oxygen. Degree of impurity of water due to organic matter is measured in terms of Biochemical Oxygen Demand (BOD).
2. **Pathogens:** Disease-causing agents are called pathogens e.g., viruses, bacteria, protozoa, helminthes, algae etc. Human excreta contains E.coli and Streptococcus faecalis bacteria which cause gastrointestinal diseases.
3. **Chemical pollutants:** These are of two types, inorganic and organic.
4. Inorganic pollutants constitute acids, salts, heavy metals such as Cd, Hg, Ni etc. Heavy metals can damage central nervous system, liver and kidneys.
5. Organic pollutants constitute, pesticides, petroleum pollutants, PCBs, detergents, fertilizers etc. PCBs (Polychlorinated Biphenyls) are carcinogenic and phosphatic fertilizers increase algae growth. Acidic water is harmful for aquatic life as well as for drinking.

## Soil Pollution

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It is unfavourable alteration of soil by addition or removal of substances and factors which decrease soil productivity, quality of plants and ground water is called soil pollution. Mainly caused by chemicals added into soil as pesticides, herbicides and fertilizers for better productivity.

### Causes of Soil Pollution

1. **Pesticides:** These are actually synthetic toxic chemicals with ecological repercussions. These are used in killing pathogens, pests and in inhibiting unwanted growth in agriculture, horticulture, forestry and water.
2. **Fertilizers:** Excessive use of fertilizers decreases natural microflora hence deteriorate soil. Therefore, now a days organic farming is encouraged which involves organic pesticides, biofertilizers and disease resistant varieties.
3. **Industrial wastes:** These are both solid and liquid and are dumped over the soil. These contain toxic chemicals like mercury, copper, zinc, lead, cadmium, cyanides, acid, alkalies etc.

## Strategies to Control Environmental Pollution

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Two sources of environment pollutant are household waste and industrial waste. Following method can be used to control them.

1. **Recycling:** Waste are recycled into manufacturing of new material. For example, scrap iron, broken glass, clothes can be made from recycled plastic waste and soon becomes available in market. We can also recover energy from burning combustible waste.
2. **Digestion:** Waste material can be degraded by anaerobic micro-organisms in absence of air. It can be used to produce electricity. First biodegradable and non-biodegradable waste are separated then biodegradable wastes are mixed with water and cultured by bacterial species which produce methane.
3. **Dumping:** Sewage sludge acts as fertilizer because it contains nitrogen and phosphorus hence, it is dumped in land areas which increases soil fertility.

## Green Chemistry

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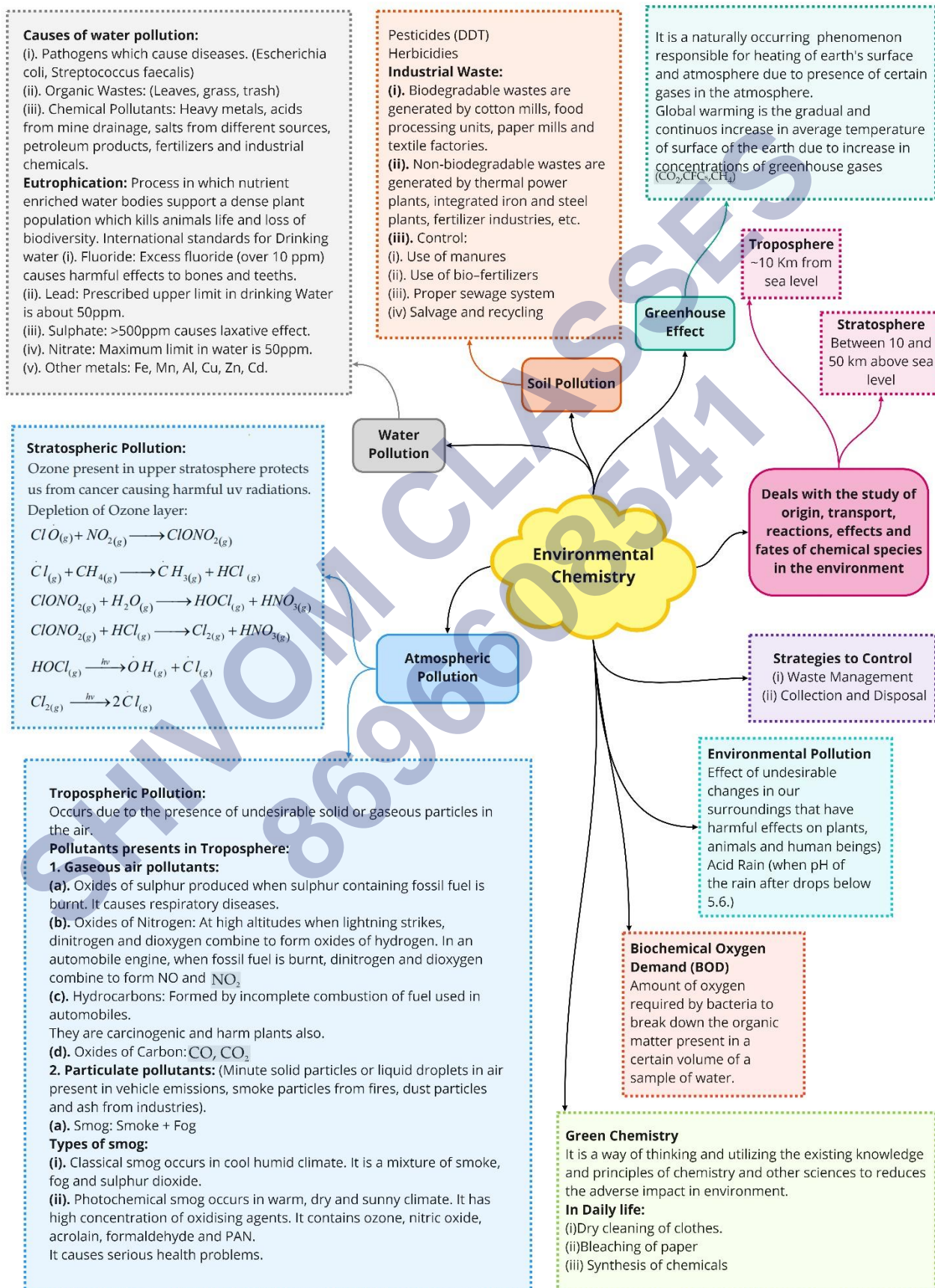
Green chemistry is a way of thinking and is about utilizing the existing knowledge and principles of chemistry and other sciences to reduce the adverse impact on environment.

Utilization of existing knowledge base for reducing the chemical hazards along with the development activities are the foundation of green chemistry.

### Summary-

1. Environmental pollution causes undesirable changes in our surrounding that have harmful effect on plants, animals and human beings.
2. Atmospheric pollution is studied as tropospheric pollution and stratospheric pollution.
3. Smog and global warming take place due to tropospheric pollution.
4. Stratospheric pollution causes depletion of ozone layer.
5. Water pollution is caused by pathogens, organic wastes and chemical pollutants.
6. Soil pollution is caused by insecticides, pesticides and herbicides.
7. Industrial waste is of two type, biodegradable and non-biodegradable.
8. Green chemistry is a way of thinking and is about to utilize the existing knowledge and principles of chemistry and other sciences to reduce the adverse impact on environment.

Class : 11th Chemistry  
Chapter- 14: Environmental Chemistry





## Important Questions

### Multiple Choice questions-

1. Photochemical smog normally does not contain
  - (a) Chlorofluorocarbons
  - (b) Peroxyacetyl nitrate
  - (c) Ozone
  - (d) Acrolein
2. Depletion of the ozone layer is caused due to
  - (a) Ferrocene
  - (b) Fullerenes
  - (c) Freons
  - (d) Polyhalogens
3. Find the incorrect statement
  - (a) BOD value of clean water is less than 5 ppm
  - (b) Drinking water pH should be between 5.5-9.5
  - (c) carbon, sulphur and nitrogen oxides are the most widespread air pollutants
  - (d) dissolved oxygen concentration below 5 ppm is ideal for the growth of fish
4. Find the secondary pollutant among these
  - (a) PAN
  - (b)  $N_2O$
  - (c)  $SO_2$
  - (d)  $CO_2$
5. The reaction responsible for the radiant energy of the Sun is
  - (a) nuclear fission
  - (b) nuclear fusion
  - (c) chemical reaction
  - (d) combustion

6. Alum's capacity to purify water is due to
- (a) softens hard water
  - (b) pathogenic bacteria get destroyed
  - (c) impurities' coagulation
  - (d) it improves taste
7. The coldest region of the atmosphere
- (a) Troposphere
  - (b) Thermosphere
  - (c) Stratosphere
  - (d) Mesosphere
8. Which of the oxide of nitrogen is not a common pollutant?
- (a)  $N_2O_5$
  - (b)  $N_2O$
  - (c) NO
  - (d)  $NO_2$
9. The compound essential for the process of photosynthesis has this element
- (a) Ca
  - (b) Ba
  - (c) Fe
  - (d) Mg
10. In the air,  $N_2$  and  $O_2$  occur naturally but they do not react to form oxides of nitrogen because
- (a) oxides of nitrogen are unstable
  - (b) catalyst is required for the reaction
  - (c) the reaction is endothermic
  - (d)  $N_2$  and  $O_2$  do not react with each other
11. This about carbon monoxide is incorrect.
- (a) It is produced due to incomplete combustion
  - (b) The carboxyhaemoglobin (haemoglobin bound to CO) is less stable than oxyhaemoglobin

- (c) It reduces the oxygen-carrying ability of blood  
(d) It forms carboxyhaemoglobin
12. This is a sink for CO
- (a) Haemoglobin  
(b) Oceans  
(c) Micro organisms present in the soil  
(d) Plants
13. DDT is
- (a) Nitrogen containing insecticide  
(b) Biodegradable pollutant  
(c) Non-Biodegradable pollutant  
(d) An antibiotic
14. Which of the following techniques is/are used in controlling water pollution?
- (a) Reverse osmosis  
(b) Ion exchange process  
(c) Adsorption process  
(d) All of these
15. Which of the following pollutants cannot be degraded by natural process?
- (a) Heavy metals  
(b) DDT  
(c) Nuclear waste  
(d) All of these

### Very Short:

1. What is the troposphere?
2. Name some gaseous air pollutants.
3. What are the diseases caused by sulphur dioxide?
4. List gases that are responsible for the greenhouse effect?
5. What is the effect of CFC's on the ozone layer?
6. What is the greenhouse effect?
7. Which disease is caused due to ozone layer depletion?

8. What is smog?
9. The London smog is caused in which season and time of the day?
10. Name two gases that form acid rain.

### Short Questions:

1. What is the role of the ozone layer in the stratosphere?
2. What includes stratospheric pollutants? Give examples.
3. Why is carbon monoxide considered to be poisonous?
4. What are the ill effects of hydrocarbons?
5. Give one main reason for ozone depletion?
6. Which zone is called the ozonosphere?
7. What is the 'greenhouse effect'? How does it affect the global climate?

### Long Questions:

1. What is the difference between London (classical) smog and photochemical (Los Angeles) smog?
2. Explain how does green house effect cause global warming.
3. Green plants use carbon dioxide for photosynthesis and return oxygen to the atmosphere, even then carbon dioxide is considered to be responsible for green house effect. Explain why?

### Assertion Reason Questions:

1. In the following questions a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below each question.

**Assertion (A) :** Greenhouse effect was observed in houses used to grow plants and these are made of green glass.

**Reason (R) :** Greenhouse name has been given because glass houses are made of green glass.

- (i) Both A and R are correct and R is the correct explanation of A.
- (ii) Both A and R are correct but R is not the correct explanation of A.
- (iii) Both A and R are not correct.

(iv) A is not correct but R is correct.

2. In the following questions a statement of Assertion (A) followed by a statement of Reason (R) is given. Choose the correct option out of the choices given below each question.

**Assertion (A) :** The pH of acid rain is less than 5.6

**Reason (R) :** Carbon dioxide present in the atmosphere dissolves in rain water and forms carbonic acid.

- (i) Both A and R are correct and R is the correct explanation of A.  
 (ii) Both A and R are correct but R is not the correct explanation of A.  
 (iii) Both A and R are not correct.  
 (iv) A is not correct but R is correct..

### Answer Key:

#### MCQ

1. (a) Chlorofluorocarbons
2. (c) Freons
3. (d) dissolved oxygen concentration below 5 ppm is ideal for the growth of fish
4. (a) PAN
5. (b) nuclear fusion
6. (c) impurities' coagulation
7. (d) Mesosphere
8. (a) N<sub>2</sub>O<sub>5</sub>
9. (d) Mg
10. (c) the reaction is endothermic
11. (b) The carboxyhaemoglobin (haemoglobin bound to CO) is less stable than oxyhaemoglobin
12. (c) Micro organisms present in the soil
13. (c) Non-Biodegradable pollutant
14. (d) All of these
15. (d) All of these

### Very Short Answer:

1. The troposphere is the lowest layer of the atmosphere, where humans and other creatures live. It reaches a height of approximately 10 kilometres above sea level.
2. Sulfur, nitrogen, and carbon oxides, hydrogen sulphide, hydrocarbons, ozone, and other oxidants are examples of gaseous air pollution.
3. In humans, sulphur dioxide causes respiratory disorders such as asthma, bronchitis, and emphysema. In addition, sulphur dioxide causes eye irritation, resulting in tears and redness.
4. The gases responsible for the greenhouse effect are: carbon dioxide, methane, water vapours, nitrous oxide, CFC's.
5. CFC's also known as chlorofluorocarbons tend to damage the ozone layer and creates holes in the ozone layer.
6. The greenhouse effect is the process through which solar energy is absorbed by greenhouse gases instead of being reflected back into space. This keeps the earth's surface warm and prevents it from freezing.
7. Skin cancer is caused when the ozone layer is depleted from the atmosphere. The ultraviolet rays from the sun reach the earth through the holes present in the ozone layer and cause skin related diseases.
8. Smog is a type of air pollution that was named from the combination of smoke and fog in the atmosphere. Smog is created by a mixture of smoke and sulphur dioxide and occurs when significant amounts of coal are burned in a certain area.
9. The London smog is caused by the hot weather in the summer, especially in the afternoon.
10. Acid rain is caused by the oxides of sulphur and nitrogen and the gases involved in it are sulphur dioxide ( $\text{SO}_2$ ) and nitrogen dioxide ( $\text{NO}_2$ ).

### Short Answer:

1. The existence of ozone in the stratosphere blocks 99.5 per cent of the sun's damaging ultraviolet (UV) light from reaching the earth's surface, shielding people and other animals from its destructive effects.
2. The outcome of stratospheric pollution is the depletion of the ozone layer in the stratosphere, which allows dangerous ultraviolet light to reach the earth. This depletion is caused by the existence of chlorofluorocarbons in the environment.
3. When carbon monoxide is released into the atmosphere, it is inhaled by animals and humans. Inside the body, carbon monoxide links to haemoglobin to create carboxyl-haemoglobin, which is 300 times more stable than oxygen-haemoglobin. This oxygen deprivation causes headaches, blurred vision, anxiety, and cardiovascular problems.
4. Hydrocarbons are carcinogenic i.e; they cause cancer. Plants are harmed by them because they cause ageing, tissue degradation, and the dropping of leaves, flowers, and trigs.
5. The major cause of ozone layer depletion is chlorofluorocarbons (CFCs). Solvents, spray aerosols, freezers, and air conditioners, among other things, emit ultraviolet radiation. Ultraviolet radiations break down chlorofluorocarbon molecules in the stratosphere, releasing chlorine atoms.
6. The ozonosphere is an area or zone in the stratospheric layer of the atmosphere with a high concentration of ozone gas molecules.
7. The greenhouse effect is the warming of the planet or global warming caused by the re-emission of sun's energy collected by the earth, absorption by  $\text{CO}_2$  molecules and  $\text{H}_2\text{O}$  vapours existing in the atmosphere near the earth's surface, and then radiation back to the ground. Greenhouse affects the climate. If the pace at which solar radiation reaches the earth continues, the entire global climate will alter dramatically.

### Long Answer:

1.

Classical (London) smog	Photochemical (Los Angeles) Smog
1. This type of smog was first observed in London in 1952.	1. This type of smog was first observed in Los Angeles in 1950.

2. It is formed due to the presence of SO <sub>2</sub> and humidity in the air which combines to form H <sub>2</sub> SO <sub>4</sub> fog which gets deposited on the particulates.	2. It is formed due to a photochemical reaction taking place when the air contains NO <sub>2</sub> and hydrocarbons.
3. It involves smoke and fog.	3. It does not involve any smoke or fog. The word smog is a misnomer here.
4. It is formed in the months of winter particularly in the morning hours when the temperature is low.	4. It is formed during the months of summer during the afternoon when there is bright sunlight so that photochemical reaction can take place.
5. It causes a problem in the lungs.	5. It causes irritation in the eyes.
6. It is reducing in character.	6. It is oxidising in character.

2. The greenhouse effect is defined as the trapping of the sun's heat in the lower atmosphere as a result of increased pollution-causing chemicals such as carbon dioxide. Water vapour, carbon dioxide (CO<sub>2</sub>), methane, nitrous oxides, and chlorofluorocarbons are some of the gases that contribute to the greenhouse effect (CFCs).

The sun's radiation is partially absorbed by the earth, with the remainder being reflected back into the atmosphere and escaping. However, greenhouse gases form a blanket in the atmosphere, trapping radiation and preventing it from leaving. As a result, the earth's



temperature rises, resulting in global warming.

3. Carbon dioxide is a naturally occurring component of the atmosphere that is essential for all plant life. It makes up around 0.033 per cent of the atmosphere's volume. It aids in maintaining the earth's temperature, which is necessary for living beings. CO<sub>2</sub> balance is maintained in the atmosphere because CO<sub>2</sub> is created by respiration, fossil fuel combustion, and limestone disintegration, but it is also consumed by plants during photosynthesis.

However, human activities have disrupted this equilibrium, and CO<sub>2</sub> levels in the atmosphere are rising. This is because deforestation has increased by around 25% in the last century. The average temperature of the earth has risen by 0.4°C to 0.8°C over the last approximately 120 years. According to current estimates, a doubling CO<sub>2</sub> concentration will result in a temperature increase of between 1.0°C and 3.5°C. The contribution of CO<sub>2</sub> to the greenhouse effect is 50%, and the contribution of other trace gases is similarly about 50%.

### Assertion Reason Answer:

1. (iii) Both A and R are not correct.
2. (ii) Both A and R are correct but R is not the correct explanation of A.