

## Chapter: Environmental Chemistry

### Exercise

**14.1.** Define environmental chemistry.

**Answer:** Environmental chemistry is the study of natural chemical and biochemical processes. It is concerned with the investigation of the origin, transport, reaction, effects, and fates of various chemical species in the environment.

**14.2.** Explain tropospheric pollution in 100 words.

**Answer:** Tropospheric pollution occurs as a result of the presence of unfavorable substances in the atmosphere's lowest layer.

The major gaseous pollutants are sulphur oxides, nitrogen oxides, carbon oxides, and hydrocarbons. The combustion of fossil fuels produces sulphur oxides ( $\text{SO}_2$  and  $\text{SO}_3$ ) and nitrogen oxides ( $\text{NO}_2$ ,  $\text{NO}$ ) (coal, automobile fuel). In the presence of atmospheric oxygen, these oxides react with water to form nitric acid ( $\text{HNO}_3$ ) and sulphuric acid ( $\text{H}_2\text{SO}_4$ ), resulting in the formation of 'Acid rain.'



Acid rain has a negative impact on agriculture, plants, and trees. It also causes a variety of respiratory problems.

Hydrocarbons are carbon and hydrogen-containing compounds that burn to form carbon oxides. Hydrocarbons are carcinogenic, and their byproducts are significant pollutants. Carbon monoxide ( $\text{CO}$ ) is poisonous in nature because it reacts with haemoglobin in blood, causing death. Despite the fact that carbon dioxide ( $\text{CO}_2$ ) is not toxic in nature, it contributes to global warming by trapping reflected IR rays. This causes the Earth's atmosphere to warm, resulting in the melting of icebergs and glaciers.

Particulates of smoke, dust, mist, and fume are hazardous to human health because they can clog a person's nasal passage, causing respiratory problems. During a cool, humid day, smoke and fog combine to form smog, reducing visibility significantly. The presence of PAN, ozone, formaldehyde, and

acrolein causes photochemical smog. It irritates the eyes, causes headaches, and causes chest pain. It also causes rubber to crack and causes plant damage.

**14.3.** Carbon monoxide gas is more dangerous than carbon dioxide gas. Why?

**Answer:** Various fuels emit carbon dioxide (CO<sub>2</sub>) and carbon monoxide (CO) gases during combustion. Carbon monoxide is toxic, whereas carbon dioxide is non-toxic.

Carbon monoxide is poisonous because it can form a more stable complex with haemoglobin (carboxyhaemoglobin) than the oxygen-haemoglobin complex. A carboxyhaemoglobin concentration of 3–4% reduces the oxygen-carrying capacity of blood. This causes headaches, blurred vision, nervousness, and cardiovascular problems. A higher level of concentration may even result in death.

Carbon dioxide is not toxic. It is only dangerous at extremely high concentrations.

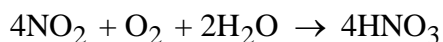
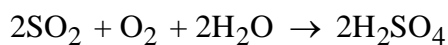
**14.4.** List gases which are responsible for greenhouse effect.

**Answer:** The major greenhouse gases are:

- 1) Carbon dioxide (CO<sub>2</sub>)
- 2) Methane (CH<sub>4</sub>)
- 3) Water (H<sub>2</sub>O)
- 4) Nitrous oxide (NO)
- 5) Ozone (O<sub>3</sub>)
- 6) Chlorofluorocarbons (CFCs)

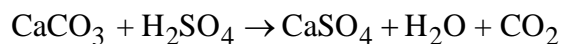
**14.5.** Statues and monuments in India are affected by acid rain. How?

**Answer:** Acid rain is a byproduct of various human activities that result in the release of sulphur and nitrogen oxides into the atmosphere. These oxides are oxidized before reacting with water vapour to form acids.



Buildings and structures made of stone and metal are harmed by acid rain. Limestone is a common stone used in the construction of monuments and statues in India, including the Taj Mahal.

Acid rain reacts with limestone in the following ways:



This causes monuments to lose their luster and color, resulting in their disfigurement.

**14.6.** What is smog? How is classical smog different from photochemical smog?

**Answer:** Smog is an example of air pollution. It's a mix of smoke and fog. Smog is classified into two types:

- (a) Classical smog
- (b) Photochemical smog

The two types of smog can be distinguished as follows:

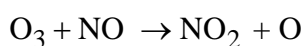
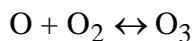
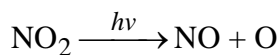
	Classical smog	Photochemical smog
Occurrence	It takes place in a cool, humid climate.	It takes place in a dry, sunny climate.
Components	Smoke, fog and sulphur dioxide.	PAN, acrolein, ozone, formaldehyde, nitric oxide.
Nature	It is reducing in nature	It is oxidizing in nature.

**14.7.** Write down the reactions involved during the formation of photochemical smog.

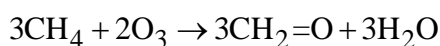
**Answer:** Photochemical smog is created when sunlight reacts with hydrocarbons and nitrogen oxides. Photochemical smog is commonly composed of ozone, nitric oxide, acrolein,

formaldehyde, and peroxyacetyl nitrate (PAN). The process of photochemical smog formation can be summarized as follows:

The combustion of fossil fuels emits hydrocarbons and nitrogen dioxide into the atmosphere. When there are high concentrations of these pollutants in the air, they interact with sunlight in the following ways:



While ozone is naturally toxic, both  $\text{NO}_2$  and  $\text{O}_3$  are oxidizing agents. They produce formaldehyde, PAN, and acrolein when they react with unburned hydrocarbons in the air.



**14.8.** What are the harmful effects of photochemical smog and how can they be controlled?

**Answer: EFFECTS OF PHOTOCHEMICAL SMOG:**

Because of the presence of  $\text{NO}_2$  and  $\text{O}_3$ , photochemical smog is an oxidizing smog that causes corrosion of metals, stones, rubber, and painted surfaces. PAN, acrolein, and formaldehyde are the other major components of photochemical smog. PAN and ozone are both eye irritants, while nitric oxide (formed from  $\text{NO}_2$ ) irritates the nose and throat. Photochemical smog causes chest pain, headaches, throat dryness, and a variety of respiratory ailments at higher concentrations.

**CONTROL MEASURES:**

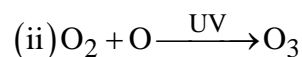
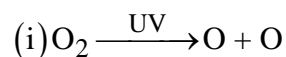
Photochemical smog is caused by the combustion of fossil fuels and automobile fuels, which emit  $\text{NO}_2$  and hydrocarbons, which are then converted into ozone, PAN, and other chemicals. It is recommended that automobiles use catalytic converters to prevent the release of  $\text{NO}_2$  and hydrocarbons into the atmosphere.

Planting of plants such as Pinus, Juniperus, Quercus, Pyrus, and Vitis is also recommended because these plants can metabolize  $\text{NO}_2$ .

14.9. What are the reactions involved for ozone layer depletion in the stratosphere?

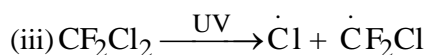
**Answer:**

In the stratosphere, ozone is a product of the action of UV radiations on dioxygen as:



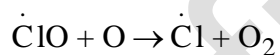
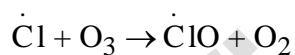
The dynamic equilibrium between the production and decomposition of ozone molecules is represented by reaction (ii). Any factor that disrupts the equilibrium has the potential to deplete the ozone layer through decomposition. The release of chlorofluorocarbon compounds is one such factor (CFCs). These are non-reactive, non-flammable molecules found in refrigerators, air conditioners, plastics, and electronics.

When CFCs are released into the atmosphere, they mix with atmospheric gases and travel to the stratosphere, where they are decomposed by UV radiation.



The chlorine free radical formed in reaction (iii) reacts with ozone in the following way:

(iv)

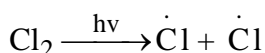
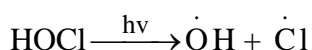
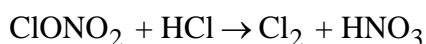
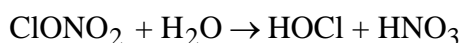


The radicals then react with atomic oxygen to produce more chlorine radicals, which are as follows:

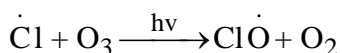
(v) The regeneration of causes a continuous breakdown of ozone in the stratosphere, causing chlorine radicals to damage the ozone layer.

**14.10.** What do you mean by ozone hole? What are its consequences?

**Answer:** In polar regions, stratospheric clouds serve as a surface for chlorine nitrate and hypochlorous acid, which combine to form molecular chlorine. Photolysis of molecular chlorine and HOCl produces chlorine-free radicals.



The chlorine-free radicals cause ozone decomposition as follows:



As a result, a chain reaction is set in motion. The chlorine-free radical is constantly regenerated, causing the ozone layer to deplete. This is referred to as the 'ozone hole.'

### Effects of depletion of ozone layer

The ozone layer shields the Earth from the sun's harmful UV radiation. As the layer depletes, more radiation enters the Earth's atmosphere. UV rays are harmful because they cause skin aging, cataracts, skin cancer, and sunburns. They cause the death of many phytoplanktons, which reduces fish productivity. Excessive exposure may even result in plant mutation.

Increased UV radiation reduces soil moisture content and damages both plants and fibers.

14.11. What are the major causes of water pollution? Explain.

**Answer:**

Water pollution is caused by a variety of human activities, which result in the presence of a variety of undesirable substances in water.

The following are the major water pollutants and their sources:

Pollutant	Source
Micro-organisms	Domestic sewage
Organic wastes	Domestic sewage, decaying animals and plants, animal excreta and waste, discharge from food processing industries
Plant nutrients	Chemical fertilizers
Toxic heavy metals	Chemical factories and industries
Sediments	Strip mining and soil erosion
Pesticides	Chemicals used for killing fungi, weed, insects
Radioactive substances	Mining of uranium-containing minerals
Heat	Water used for cooling in industries

The following are the roles that major pollutants play:

- 1. Pathogens:** Pathogens are bacteria and other organisms that pollute water. They enter the water through animal waste and domestic sewage. Bacteria found in human excreta (such as *E. coli* and *Streptococcus faecalis*) cause gastrointestinal diseases.
- 2. Organic wastes:** These are biodegradable wastes that pollute water through runoff. Excess organic waste in water reduces the amount of oxygen held by the water. This reduction in dissolved oxygen inhibits aquatic life.
- 3. Chemical pollutants:** These are water-soluble chemicals such as heavy metals like cadmium, mercury, nickel, and so on. The presence of these chemicals (in excess of the tolerance limit) can harm the kidneys, nervous system, and liver.

**14.12.** Have you ever observed any water pollution in your area? What measures would you suggest to control it?

**Answer:** Water pollution is caused by a variety of human activities. This includes wastewater treatment plant discharges, agricultural field runoff, storm-water drainage, and so on. Pollutants from these sources enter the water bodies, contaminating and impure the water.

Toxic heavy metals such as Fe, Mn, Al, and others, as well as organic wastes, are discharged into water by industries and chemical plants. Pathogenic contamination of water is also caused by domestic sewage and animal excreta. These pollutants render water unfit for human consumption.

As a result, before allowing toxic metals into a water body, all industrial and chemical discharges should be cleaned. The concentrations of these pollutants should be monitored on a regular basis. To avoid harmful chemicals entering ground water, compost should be preferred over chemical fertilizers in gardens and agricultural fields.

**14.13.** What do you mean by Biochemical Oxygen Demand (BOD)?

**Answer:** The amount of oxygen required by bacteria to decompose organic matter in a given volume of water is referred to as biochemical oxygen demand. A BOD value of less than 5 ppm indicates clean water, whereas a BOD value of 17 ppm or higher indicates highly polluted water.

**14.14.** Do you observe any soil pollution in your neighborhood? What efforts will you make for controlling the soil pollution?

**Answer:** Industrial wastes and agricultural pollutants such as pesticides and fertilizers are major sources of soil pollution.

It is critical to maintain soil quality and fertility in order to ensure and sustain plant and food crop growth.

DDT and other insecticides are not soluble in water. As a result, they remain in the soil for an extended period of time, contaminating root crops. Pesticides such as Aldrin and Dieldrin are not biodegradable and are extremely toxic in nature. They have the ability to enter higher trophic levels via food chains, causing metabolic and physiological problems. The same is true for industrial waste, which contains a variety of toxic metals such as Pb, As, Hg, Cd, and others.



As a result, the best way to reduce soil pollution is to avoid adding pollutants directly to the soil.

Waste should also be properly treated. They should be recycled first, and then disposed of.

**14.15.** What are pesticides and herbicides? Explain giving examples.

**Answer:** Pesticides are compounds made up of two or more substances. They are used to eliminate pests. Insects, plant pathogens, weeds, mollusks, and other organisms that destroy plant crops and spread disease are examples of pests. Some common pesticides include aldrin and dieldrin. Herbicides are pesticides that are specifically designed to kill weeds. For instance, sodium chlorate ( $\text{NaClO}_3$ ), sodium arsenite ( $\text{Na}_3\text{AsO}_3$ ), and so on.

**14.16.** What do you mean by green chemistry? How will it help decrease environmental pollution?

**Answer:** Green chemistry is a manufacturing process that aims to use existing chemistry knowledge and principles to develop and implement chemical products and processes that reduce the use and generation of environmentally hazardous substances. The release of various harmful chemicals (particulates, gases, organic and inorganic wastes) pollutes the environment. In green chemistry, the reactants used in chemical reactions are chosen in such a way that the end product yield is up to 100%. This prevents or limits the introduction of chemical pollutants into the environment.  $\text{H}_2\text{O}_2$  has replaced tetrachlorethane and chlorine gas in the drying and bleaching of paper thanks to the efforts of green chemists.

**14.17.** What would have happened if the greenhouse gases were totally missing in the earth's atmosphere? Discuss.

**Answer:**  $\text{CO}_2$ ,  $\text{CH}_4$ ,  $\text{O}_3$ , CFCs, and water vapour are the most abundant greenhouse gases on Earth. These gases can be found close to the Earth's surface. They absorb solar energy that is reflected back from the Earth's surface. The absorption of radiation causes the atmosphere to heat up. As a result, greenhouse gases are critical for maintaining the Earth's temperature in order to sustain life. Without greenhouse gases, the average temperature of the Earth will plummet, rendering it uninhabitable. Life on Earth would be impossible as a result.

**14.18.** A large number of fish are suddenly found floating dead on a lake. There is no evidence of toxic dumping but you find an abundance of phytoplankton. Suggest a reason for the fishkill.

**Answer:** Water contains a finite amount of dissolved oxygen. This dissolved oxygen is depleted due to the abundance of phytoplanktons. This is due to the fact that phytoplanktons are degraded by bacteria found in water. They require a large amount of oxygen to decompose. As a result, they consume the oxygen that has been dissolved in water. As a result, the BOD level in the water falls below 6 ppm, inhibiting fish growth and resulting in excessive fish-kill.

**14.19.** How can domestic waste be used as manure?

**Answer:** Domestic waste can be classified into two types based on its composition: biodegradable and non-biodegradable. Biodegradable waste, such as leaves and rotten food, should be disposed of in landfills, where it decomposes aerobically and anaerobically into manure. Non-biodegradable waste (that cannot be degraded) such as plastic, glass, metal scraps, and so on should be recycled.

**14.20.** For your agricultural field or garden you have developed a compost producing pit. Discuss the process in the light of bad odour, flies and recycling of wastes for a good produce.

**Answer:** It is critical to properly care for the compost producing pit in order to keep bad odours and flies at bay.

It should be kept covered to keep bad odors at bay and flies at bay. Recyclable waste should not be disposed of in the composting pit. It should be recycled by sending it to industries via vendors.