Chemistry

(Chapter – 14) (Environmental Chemistry)

(Class – XI)

Question 14.1:

Define environmental chemistry.

Answer 14.1:

Environmental chemistry is the study of chemical and biochemical processes occurring in nature. It deals with the study of origin, transport, reaction, effects, and fates of various chemical species in the environment.

Question 14.2:

Explain tropospheric pollution in 100 words.

Answer 14.2:

Tropospheric pollution arises due to the presence of undesirable substances in the lowest layer of the atmosphere.

Oxides of sulphur, nitrogen, carbon, and hydrocarbons are the major gaseous pollutants. Oxides of sulphur (SO_2 and SO_3) and nitrogen (NO_2, NO) are produced as a result of burning of fossil fuels (coal, automobile fuel). These oxides react with water in the presence of atmospheric oxygen to form nitric acid (HNO_3) and sulphuric acid (H_2SO_4), which leads to the formation of 'Acid rain'.

$$2SO_{2(g)} + O_{2(g)} + 2H_2O_{(l)} \longrightarrow 2H_2SO_{4(aq)}$$

$$4NO_{2(g)} + O_{2(g)} + 2H_2O_{(l)} \longrightarrow 4HNO_{3(aq)}$$

Acid rain causes harm to agriculture, plants, and trees. It also leads to various respiratory ailments.

Hydrocarbons are carbon and hydrogen containing compounds that burn to produce oxides of carbon. Hydrocarbons are carcinogenic and their products are also major pollutants. Carbon monoxide (CO) is poisonous in nature as it reacts with the haemoglobin of blood, which can even result in death. Though carbon dioxide (CO_2) is not toxic in nature, yet it contributes towards global warming by trapping the reflected IR rays. This results in the heating up of the Earth's atmosphere, thereby leading to the melting of icebergs and glaciers.

Particulates of smoke, dust, mist, and fume are harmful for human health as they are likely to block the nasal passage of a person, causing respiratory ailments. Smoke and fog combine to produce smog during a cool, humid day, thereby reducing visibility to a large

extent. Photochemical smog is formed due to the presence of PAN, ozone, formaldehyde, and acrolein. It causes eye irritation, headaches, and chest pain. It also leads to the cracking of rubber and does damage to plants.

Question 14.3:

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

Answer 14.3:

Carbon dioxide (CO_2) and carbon monoxide (CO) gases are emitted during the combustion of various fuels. Carbon monoxide is poisonous, whereas carbon-dioxide is non-toxic in nature.

Carbon monoxide is poisonous because it is capable of forming a complex with haemoglobin (carboxyhaemoglobin), which is more stable than the oxygen-haemoglobin complex. The concentration range of 3–4% of carboxyhaemoglobin decreases the oxygen-carrying capacity of blood. This results in headaches, weak eyesight, nervousness, and cardiovascular disorders. A more increased concentration may even lead to death.

Carbon dioxide is not poisonous. It proves harmful only at very high concentrations.

Question 14.4:

List gases which are responsible for greenhouse effect.

Answer 14.4:

The major greenhouse gases are:

1) Carbon dioxide (CO_2)

2) Methane (CH_4)

3) Water (H_2O)

4) Nitrous oxide (NO)

5) Ozone (O_3)

6) Chlorofluorocarbons (CFCs)

Question 14.5:

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

Answer 14.5:

Acid rain is a byproduct of various human activities that leads to the emission of oxides of sulphur and nitrogen in the atmosphere. These oxides undergo oxidation and then react with water vapour to form acids.

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

Acid rain causes damage to buildings and structures made of stone and metal. In India, limestone is a major stone used in the construction of various monuments and statues, including the Taj Mahal.

Acid rain reacts with limestone as:

$$CaCO_3 + H_2SO_4 \longrightarrow CaSO_4 + H_2O + CO_2$$

This results in the loss of lustre and colour of monuments, leading to their disfiguration.

Question 14.6:

What is smog? How is classical smog different from photochemical smog?

Answer 14.6:

Smog is a kind of air pollution. It is the blend of smoke and fog. There are two kinds of smog:

a) Classical smog

b) Photochemical smog

The two smogs can be differentiated as follows:

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

Question 14.7:

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

Answer 14.7:

Photochemical smog is formed as a result of the reaction of sunlight with hydrocarbons and nitrogen oxides. Ozone, nitric oxide, acrolein, formaldehyde and peroxyacetyl nitrate (PAN) are common components of photochemical smog. The formation of photochemical smog can be summarized as follows:

Burning of fossil fuels leads to the emission of hydrocarbons and nitrogen dioxide in the atmosphere. High concentrations of these pollutants in air results in their interaction with sunlight as follows:

$$NO_{2(g)} \xrightarrow{h\nu} NO_{(g)} + O_{(g)}$$

Nitrogen dioxide — Nitric oxide

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

$$O_{3(g)} + NO_{(g)} \longrightarrow NO_{2(g)} + O_{2(g)}$$

While ozone is toxic in nature, both NO_2 and O_3 are oxidizing agents. They react with the unburnt hydrocarbons in air to produce formaldehyde, PAN, and acrolein.

$$3CH_4 + 2O_3 \rightarrow 3CH_2{=}O + 3H_2O$$

Formaldehyde

Question 14.8:

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

Answer 14.8:

EFFECTS OF PHOTOCHEMICAL SMOG:

Photochemical smog is oxidizing smog owing to the presence of NO_2 and O_3, causing corrosion of metals, stones, rubber, and painted surfaces. The other major components of photochemical smog are PAN, acrolein, and formaldehyde. Both PAN and ozone are eye irritants, while nitric oxide (formed from NO_2) causes nose and throat irritation. At higher concentrations, photochemical smog causes chest pain, headaches, throat dryness, and various respiratory ailments.

CONTROL MEASURES:

Photochemical smog results from the burring of fossil fuels and automobile fuels that emit NO_2 and hydrocarbons, which in turn form ozone, PAN, and other chemicals. The use of catalytic converters in automobiles is recommended to prevent the release of NO_2 and hydrocarbons into the atmosphere.

Plantation of plants such as *Pinus*, *Juniparur*, *Quercus*, *Pyrus,* and *Vitis* is also advised as these plants have the capability to metabolize NO_2.

Question 14.9:

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

Answer 14.9:

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

(i) $O_{2(g)} \xrightarrow{UV} O_{(g)} + O_{(g)}$

(ii) $O_{2(g)} + O_{(g)} \xleftrightarrow{UV} O_{3(g)}$

Reaction (ii) indicates the dynamic equilibrium existing between the production and decomposition of ozone molecules. Any factor that disturbs the equilibrium may cause depletion of ozone layer by its decomposition. One such factor is the release of chlorofluorocarbon compounds (CFCs). These are non-reactive, non-flammable molecules that are used in refrigerators, air conditioners, plastics, and electronic industries.

Once released CFCs mix with atmospheric gases and reach the stratosphere, where they are decomposed by UV radiations.

(iii) $CF_2Cl_{2(g)} \xrightarrow{UV} \dot{C}l_{(g)} + \dot{C}F_2Cl_{(g)}$

The chlorine free radical produced in reaction (iii) reacts with ozone as:

(iv) $\dot{C}l_{(g)} + O_{3(g)} \longrightarrow Cl\dot{O}_{(g)} + O_{2(g)}$

$\dot{C}l_{(g)}$

$Cl\dot{O}_{(g)} + O_{(g)} \longrightarrow \dot{C}l_{(g)} + O_{2(g)}$

The radicals further react with atomic oxygen to produce more chlorine radicals as:

(v) The regeneration of causes a continuous breakdown of ozone present in the stratosphere, damaging $\dot{C}l_{(g)}$ the ozone layer.

Question 14.10:

What do you mean by ozone hole? What are its consequences?

Answer 14.10:

In Polar regions, stratospheric clouds provide the surface for chlorine nitrate and hypochlorous acid, which react further to give molecular chlorine. Molecular chlorine and HOCl are photolysed to give chlorine-free radicals.

$$ClONO_{2(g)} + H_2O_{(g)} \longrightarrow HOCl_{(g)} + HNO_{3(g)}$$

$$ClONO_{2(g)} + HCl_{(g)} \longrightarrow Cl_{2(g)} + HNO_{3(g)}$$

$$HOCl_{(g)} \xrightarrow{h\nu} \dot{O}H_{(g)} + \dot{C}l_{(g)}$$

$$Cl_{2(g)} \xrightarrow{h\nu} \dot{C}l_{(g)} + \dot{C}l_{(g)}$$

The chlorine-free radicals lead to the decomposition of ozone as:

$$\dot{Cl}_{(g)} + O_{3(g)} \longrightarrow Cl\dot{O}_{(g)} + O_{2(g)}$$

Hence, a chain reaction is initiated. The chlorine-free radical is continuously regenerated, thereby depleting the ozone layer. This phenomenon is known as the as 'ozone hole'.

Effects of depletion of ozone layer

The ozone layer protects the Earth from the harmful UV radiations of the sun. With the depletion of the layer, more radiation will enter the Earth's atmosphere. UV radiations are harmful because they lead to the ageing of skin, cataract, skin cancer, and sunburns. They cause death of many phytoplanktons, which leads to a decrease of fish productivity. Excess exposure may even cause mutation in plants.

Increase in UV radiations, decreases the moisture content of the soil and damages both plants and fibres.

Question 14.11:

What are the major causes of water pollution? Explain.

Answer 14.11:

Water pollution arises as a result of several human activities, which leads to the presence of several undesirable substances in water.

Major water pollutants with their sources have been tabulated as follows:

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

Roles played by major pollutants are:

1. **Pathogens:** These water pollutants include bacteria and other organisms. They enter water from animal excreta and domestic sewage. Bacteria present in human excreta (for example, *Escherichia coli* and *Streptococcus faecalis*) cause gastrointestinal diseases.

2. **Organic wastes:** These are biodegradable wastes that pollute water as a result of run off. The presence of excess organic wastes in water decreases the amount of oxygen held by water. This decrease in the amount of dissolved oxygen inhibits aquatic life.

3. **Chemical pollutants:** These are water soluble chemicals like heavy metals such as cadmium, mercury, nickel, etc. The presence of these chemicals (above the tolerance limit) can damage the kidneys, central nervous system, and liver.

Question 14.12:

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

Answer 14.12:

Water pollution arises as a result of various human activities. This includes discharges from wastewater treatment plants, run-off from agricultural fields, storm-water drainage, etc. Pollutants from these sources enter the water bodies, thereby contaminating the water and rendering it impure.

Industries and chemical factories discharge toxic, heavy metals such as Fe, Mn, Al, etc., along with organic wastes into water. Domestic sewage and animal excreta are also responsible for pathogenic contamination of water. These pollutants make water unfit for drinking.

Therefore, all industrial and chemical discharges should be made free from toxic metals before allowing them to enter a water body. The concentration of these pollutants should be checked regularly. Compost should be preferred over chemical fertilizers in gardens and agricultural fields to avoid harmful chemicals from entering ground water.

Question 14.13:

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

Answer 14.13:

Biochemical oxygen demand is the amount of oxygen required by bacteria to decompose organic matter in a certain volume of sample of water. Clean water would have a BOD value of less than 5 ppm, whereas highly polluted water has a BOD value of 17 ppm or more.

Question 14.14:

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

Answer 14.14:

Major sources of soil pollution are industrial wastes and agricultural pollutants such as pesticides, fertilizers, etc.

It is very important to maintain the quality and fertility of soil to ensure and sustain the growth of plants and food crops.

Insecticides like DDT are not soluble in water. For this reason, they remain in soil for a long time, contaminating the root crops. Pesticides like Aldrin and Dieldrin are non-biodegradable and highly toxic in nature. They can enter the higher trophic levels through food chains, causing metabolic and physiological disorders. The same is true for industrial wastes that comprises of several toxic metals like Pb, As, Hg, Cd, etc.

Hence, the best way to check soil pollution is to avoid direct addition of pollutants to the soil. Also, wastes should undergo proper treatment. They should be recycled and only then, allowed to be dumped.

Question 14.15:

What are pesticides and herbicides? Explain giving examples.

Answer 14.15:

Pesticides are a mixture of two or more substances. They are used for killing pests. Pests include insects, plant pathogens, weeds, mollusks, etc., that destroy the plant crop and spread diseases. Aldrin and dieldrin are the names of some common pesticides

Herbicides are pesticides specially meant for killing weeds. For example, sodium chlorate ($NACIO_3$), sodium arsenite (Na_3AsO_3), etc.

Question 14.16:

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

Answer 14.16:

Green chemistry is a production process that aims at using the existing knowledge and principles of chemistry for developing and implementing chemical products and processes to reduce the use and generation of substances hazardous to the environment. The release of different harmful chemicals (particulates, gases, organic and inorganic wastes) causes environmental pollution. In green chemistry, the reactants to be used in chemical reactions are chosen in such a way that the yield of the end products is up to 100%. This prevents or limits chemical pollutants from being introduced into the environment. Through the efforts of green chemists, H_2O_2 has replaced tetrachlorethane and chlorine gas in drying and bleaching of paper.

Question 14.17:

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

Answer 14.17:

Earth's most abundant greenhouse gases are CO_2, CH_4, O_3, CFCs, and water vapour. These gases are present near the Earth's surface. They absorb solar energy that is radiated back from the surface of the Earth. The absorption of radiation results in the heating up of the atmosphere. Hence, greenhouse gases are essential for maintaining the temperature of the Earth for the sustenance of life.

In the absence of greenhouse gases, the average temperature of the Earth will decrease drastically, making it uninhabitable. As a result, life on Earth would be impossible.

Question 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 fish kill.

Answer 14.18:

The amount of dissolved oxygen present in water is limited. The abundance of phytoplanktons causes depletion of this dissolved oxygen. This is because, phytoplanktons are degraded by bacteria present in water. For their decomposition, they require a large amount of oxygen. Hence, they consume the oxygen dissolved in water. As a result, the BOD level of water drops below 6 ppm, inhibiting the growth of fish and causing excessive fish-kill.

Question 14.19:

How can domestic waste be used as manure?

Answer 14.19:

Depending upon the nature of the waste, domestic waste can be segregated into two categories i.e., biodegradable and non–biodegradable. Biodegradable waste such as leaves, rotten food, etc. should be deposited in land fills, where they get decomposed aerobically and anaerobically into manure. Non-biodegradable waste (which cannot be degraded) such as plastic, glass, metal scraps etc. should be sent for recycling.

Question 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 14.20:

It is essential to take proper care of the compost producing pit in order to protect ourselves from bad odour and flies.

It should be kept covered to minimize bad odour and prevent flies from entering it. The recyclable waste should not be dumped in the compost producing pit. It should be sent to the industries through vendors for recycling.