Question 14.1:

Define environmental chemistry.

Answer 14.1:

Environmental chemistry refers to the study of biochemical and chemical processes that occur in our nature. It also delves into the reaction, origin, effects and transport of the chemical species in our earth.

Question 14.2:

Explain tropospheric pollution in 100 words.

Answer 14.2:

The presence of unwanted substances in the troposphere's lowest layer cause tropospheric pollution

The major pollutants include oxides of nitrogen, sulphur, carbon and hydrocarbons.

- Oxides of nitrogen (NO2, NO) and sulphur (SO2 and SO3) which are formed due to the burning of coal, automobile fuel and other fossil fuels, form nitric acid (HNO3) and sulphuric acid (H2SO4) by reacting with water in the presence of atmospheric oxygen. This results in 'Acid rain'.

$$2SO_{2(g)} + O_{2(g)} + 2H_20_{(l)} \longrightarrow 2H_2SO_{4(aq)}$$

$$4NO_{(g)} + O_{2(g)} + 2H_20_{(l)} \longrightarrow 4HNO_{3(aq)}$$

Acid rain harms plants, agriculture and trees. It also causes respiratory problems in humans.

- Hydrocarbons are compounds that contain carbon and hydrogen in them. They burn to form oxides of carbon. They are carcinogenic in nature and are also regarded as major pollutants.
- Carbon monoxide (CO) reacts with the hemoglobin in our blood and is poisonous in nature and can even be fatal. Even though carbon dioxide (CO2)is not toxic by itself, it contributes to the increase in global warming by trapping extra sun rays. This results in a heating effect upon the earth thus increasing the earth's temperature.
- Particulates like dust, smoke, fume and mist block our nasal passage and are considered harmful for our health.
- Smog is caused due to the combination of smoke and fog which reduces the visibility of traffic.

Photochemical smog is formed as a result of the presence of ozone, PAN, acrolein and formaldehyde. It causes headaches, eye irritation, and chest pain in humans. It cracks the rubber tires and also damages the plants.

Question 14.3:

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

Answer 14.3:

Both Carbon dioxide (CO2) and carbon monoxide (CO) are emitted during the combustion of various fuels. Carbon monoxide is toxic in nature whereas carbon-dioxide is non- poisonous in nature.

Carbon monoxide is deemed toxic since it forms a complex with

hemoglobin (carboxyhemoglobin), which is more stable than the oxygen-hemoglobin complex. A range of 3–4% of carboxyhemoglobin can decrease the oxygen-carrying capacity of our blood. This can result in weak eyesight, headaches, cardiovascular disorders and nervousness. A little increase over the above concentration can even be fatal.

Carbon dioxide is harmful only at very high concentrations.

Question 14.4

List gases which are responsible for greenhouse effect.

Answer 14.4:

The major gases that cause greenhouse effect are:

1) Chlorofluorocarbons (CFCs)

2) Methane (CH_4)

3) Carbon dioxide (CO_2)

4) Nitrous oxide (NO)

5) Water (H_2O)

6) Ozone (O_3)

Question 14.5:

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

Answer 14.5:

Oxides of nitrogen (NO_2, NO) and sulphur (SO_2 and SO_3) which are formed due to the burning of coal, automobile fuel and other fossil fuels, form nitric acid (HNO_3) and sulphuric acid (H_2SO_4) by reacting with water in the presence of atmospheric oxygen. This results in 'Acid rain'.

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Acid rain harms plants, agriculture and trees. It also causes respiratory problems in humans.

Acid rain damages buildings and structures made of metal and stone. Limestone is a major constituent used in various monuments and statues like Taj Mahal in India.

Acid rain when reacting with limestone causes loss of colour and lustre of monuments, resulting in their disfiguration.

The reaction is as follows:

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

Question 14.6:

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

Answer 14.6:

Smog is a combination of smoke and fog which causes air pollution. There are two types of smog:

a) Photochemical smog

b) Classical smog

They can be differentiated as follows:

	Photochemical smog	***Classical smog***
Components	formaldehyde, nitric oxide, ozone, PAN, acrolein	Smoke, fog and ulphurdioxide.
Occurrence	dry, sunny climate	cool, humid climate
Nature	Oxidizing in nature	Reducing in nature

Question 14.7:

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

Answer 14.7:

Photochemical smog is formed due to the reaction of sunlight with nitrogen oxides and hydrocarbons. Formaldehyde, nitric oxide, ozone, PAN, acrolein are the main components of photochemical smog. The steps involved in the formation of photochemical smog are:

Hydrocarbons and nitrogen dioxide are released into the atmosphere as a result of burning of fossil fuels. Due to high concentrations of these pollutants, they react with sunlight. The reactions proceed as shown below:

$NO_2 \xrightarrow{h\gamma} NO + O$

(Nitrogen di oxide) (Nitric oxide)

$O + O_2 \leftrightarrow O_3$

$O_3 + NO \dashrightarrow NO_2 + O_2$

Since, NO_2 and O_3 are oxidizing agents, they react with the unburnt hydrocarbons to produce acrolein, PAN and formaldehyde.

Question 14.8:

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

Answer 14.8:

- Photochemical smog is oxidizing in nature since it is composed of NO_2 and O_3, which are responsible for corrosion of rubber, stones, metals and painted surfaces. Photochemical smog also contains formaldehyde, PAN and acrolein. Both ozone and PAN and cause eye irritation while nitric oxide (derived from NO_2) is responsible for throat and nose irritation. At higher levels, this type of smog can also cause headaches, throat dryness, chest pain and other respiratory ailments.

CONTROL MEASURES:

Use of catalytic converters can be used to prevent the release of NO_2 into the atmosphere.

Plants such as *Pyrus, Pinus*, *Quercus*, *Juniparur*, and *Vitis* can planted as these 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 actually formed by the action of UV rays on Dioxygen molecules(O_2).

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

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

The second reaction shows that there is a dynamic equilibrium between the decomposition and production of ozone molecules. Any factor that disturbs this equilibrium may lead to the ozone layer getting depleted due to its decomposition. One such example of these factors is the chlorofluorocarbon compounds (CFCs). These are non-flammable and non-reactive molecules that find a usage in air

conditioners, refrigerators, plastics, and electronic industries.

Once it is released into the atmosphere, these CFCs get mixed with atmospheric gases and then, reach the stratosphere, where they get decomposed due to reactions with UV radiations.

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

The chlorine free radical which is produced in the third reaction reacts with ozone as shown below:

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

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

The radicals, on further reaction with atomic oxygen, result in production of more chlorine radicals.

This regeneration of chlorine free radicals results in a continuous breakdown of ozone in the stratosphere, thus almost permanently damaging the ozone layer.

Question 14.10:

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

Answer 14.10:

Stratospheric clouds present in Polar Regions provide a surface for the reaction of hypochlorous acid and chlorine nitrate which on further reaction, gives molecular chlorine. HOCl and Molecular chlorine get photolysed to provide chlorine-free radicals.

The radicals, on reaction with atomic oxygen, result in production of more chlorine radicals.

This regeneration of chlorine free radicals results in a continuous breakdown of ozone in the stratosphere, thus almost permanently damaging the ozone layer.

This phenomenon is known as the 'ozone hole'.

Effects of ozone layer depletion:

The Earth is shielded from the harmful UV radiations of the sun by the ozone layer. When this layer gets depleted, greater amount of radiations will enter the earth's atmosphere. They are deemed harmful since they lead to skin cancer, cataract, ageing of skin and also cause sunburns. They also prove fatal to phytoplankton, thus resulting in a decline in fish productivity. Excess exposure to these rays may, in some cases, also lead to mutation in plants. The moisture content of the soil decreases with increase in exposure to UV radiations.

Question 14.11:

What are the major causes of water pollution? Explain.

Answer 14.11:

Water pollution occurs when undesirable and unwanted substances are added to the water bodies thus choking the aquatic life in those water bodies.

The major sources of water pollutants are as given below:

Pollutant	Source
Organic wastes	Domestic sewage, discharge from food processing industries, animal excreta and waste, decaying animals and plants
Micro-organisms	Domestic sewage
Sediments	Strip mining and soil erosion
Plant nutrients	Chemical fertilizers
Radioactive substances	Mining of uranium ores

Pesticides	Chemicals used for killing fungi, weed, insects
Toxic heavy metals	Chemical factories and industries
Heat	Water used for cooling in industries

The major pollutants are:

1. Pathogens: Bacteria and other micro-organisms come under this category. They get into water bodies through domestic sewage and animal excreta. Bacteria like *Escherichia coli* and *Streptococcus faecalis* which are found in human excreta are known vectors of gastrointestinal diseases.

2. Organic wastes: They are generally bio-degradable wastes that pollute the water bodies by mixing with them during their run- off phase. An excess amount of organic matter in water bodies suck up the dissolved oxygen in water thus inhibiting aquatic life in these water bodies.

3. Chemical pollutants: Heavy metals like mercury, cadmium and nickel come under this category. These chemicals when present above the allowable limit can result in damage of the central nervous system, kidneys 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:

Human activities like storm-water drainage, run-off from agricultural fields, discharges from wastewater treatment plants etc, result in water pollution.

Toxic metals like Fe, Al and Mn are released into water bodies by industries and factories. So, it should be made sure that the water released from these industries are free of this type of toxicity. Their discharges should be frequently checked for traces of these metals and then released into water bodies.

Instead of using fertilizers, manure and compost can be used effectively, so that these fertilizers don't get into water bodies and pollute them.

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 a sample of water. Clean water will have a BOD of below 5 ppm whereas a highly polluted water source will have a BOD of more than 17 ppm.

Question 14.14:

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

Answer 14.14:

Pesticides and fertilizers are the major pollutants that cause soil pollution. When insecticides like DDT are used, they get stuck in the soil for a longer time since they are not soluble in water and thus contaminating the crops and soil. Moreover, pesticides and insecticides are not biodegradable in nature and when they enter the food chain, they go till the highest trophic levels and thus affect the whole biodiversity of an area.

Thus, soil pollution can be controlled by controlling the addition of pesticides and fertilizers and instead use manures and compost.

Question 14.15:

What are pesticides and herbicides? Explain giving examples.

Answer 14.15:

A mixture of two or more substances that are used to kill pests is called a Pesticide. Pests that need to

be killed are plant pathogens, weeds, insects, mollusks etc., which affect the plants and lead to their death. Some common pesticides include Dieldrin and Aldrin.

Herbicides are similar to pesticides but are used to kill weeds. Examples include sodium arsenite (Na_3AsO_3), sodium chlorate ($NACIO_3$).

Question 14.16:

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

Answer 14.16:

The production process which uses the existing knowledge that we have on the principles of chemistry to create, develop and implement chemical compounds and products to decrease the amount of hazardous substances in the environment.

Green chemistry aims to make sure that the end products yield is 100% so that there are no harmful substances released into the environment.

For example, we now use H_2O_2 instead of tetrachlorethane and chlorine gas in the process of bleaching and drying 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:

The greenhouses gases that are present in our atmosphere trap the UV rays coming from Sun and heat up the earth.

In the absence of greenhouse gases, the earth won't be able to retain any heat which is essential for the survival for most of the species on earth.

Without greenhouse gases, the earth's average temperature will decline thus making this planet uninhabitable.

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:

Phytoplankton are consumed by bacteria which require dissolved oxygen for this process. Thus, higher the amount of Phytoplankton, larger is the use of dissolved oxygen by bacteria to consume Phytoplankton. Thus, all the oxygen in the lake is used up and BOD drops below 6 ppm, suffocating the fish.

Question 14.19:

How can domestic waste be used as manure?

Answer 14.19:

Firstly, the waste has to be segregated into bio- degradable and non-biodegradable wastes. Those that can be degraded by bacteria such as leaves, food wastes are bio- degradable and dumped in landfills along with micro-organisms that decompose it. The decomposed matter called Humus can be used as manure. The rest of the wastes, which are non-biodegradable have to be recycled.

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:

- The compost pit should be covered to prevent bad odour and flies.
- Non-biodegradable wastes should not be dropped into the compost pit so as not interfere in the decomposition of the wastes. Instead, they should be sent for recycling.