

# ENVIRONMENTAL CHEMISTRY

## Environmental Chemistry

It is the branch of chemistry which deals with the chemicals and other pollutants in the environment resulting directly and indirectly from human activities.

In this we study the sources, chemical reactions, transportation of the chemicals and their adverse effects on human beings.

## COMPONENTS OF THE ENVIRONMENT

- (1) Atmosphere → The layer of gases which surrounds the earth.
- (2) Hydrosphere → Concerned with all water bodies i.e. ocean, rivers, streams lakes, glaciers and ground water reservoirs.
- (3) Lithosphere → Concerned with hard and rigid rocky earth crust.
- (4) Biosphere → Area on earth which supports life i.e. air, lakes, etc.

## Atmosphere

- The layer of gases which surrounds the earth is called atmosphere.
- It consists of gases i.e.  $N_2$ , CO, He, Ne, Kr, Xe and water vapours.
- Its thickness is about 1000 km above the surface of earth.

The gases present in the atmosphere are very important in the following ways:

- (i) These gases absorb harmful radiations (cosmic rays and electromagnetic radiation) of sun to protect life on earth. Otherwise these rays are very harmful to living things on earth.
- (ii)  $N_2$  is used by nitrogen fixing bacteria
- (iii)  $O_2$  is necessary for breathing in animals.
- (iv)  $CO_2$  is necessary for photosynthesis in plants
- (v) Water vapours are responsible for sustaining life on earth.

Actually our atmosphere has been divided into four layers:

- 1- Troposphere
- 2- Stratosphere
- 3- Mesosphere
- 4- Thermosphere.

## Atmosphere

LAYERS	HEIGHT (km)	TEMPERATURE	CHARACTERISTICS
Troposphere	0 – 20	Decreasing	Climate changes
Stratosphere	21 – 40 (Ozone is at 23 km)	Increasing	Ozone layer (Photodissociation process)
Mesosphere	41 – 60	Decreasing	It is the transition zone
Ionosphere	61 – 80	Increasing	Contains ions and free electrons (plasma)
Exosphere	Above 80	Low	Critical level of escape (gases mostly hydrogen escape into the outer space)



# A) Chemistry of Troposphere

Troposphere is very close to earth in which we live. It extends up to 20km. It contains all those gases which are present in our atmosphere.

In this part of our atmosphere, we will discuss

- (1) Different pollutants (Their sources and effects and smog (development and chemistry))
- (2) Effects and chemical reactions which occur during acid rain, greenhouse effect and global warming
- (3) Role of automobile in air pollution

## Smog

"It is a combination of smoke and fog i.e. 'sm' from smoke and 'og' from fog"

Under the right conditions, the smoke and sulfur dioxide produced from the burning of coal can combine with fog to create industrial smog.

There are two types of smog:

### (i) Reducing Smog

This smog contains high contents of  $\text{SO}_2$ . It is chemically reducing in nature and is known as reducing smog. The main cause of reducing smog is combustion of coal.

### (ii) Oxidizing Smog (Photochemical Smog)

"The photochemical smog consists of higher concentrations of oxidants like ozone and is also termed as oxidizing smog."

- It is a yellowish brownish grey haze which is formed in the presence of water droplets and chemical reactions of pollutants in the air.
- It has unpleasant odour because of its gaseous components. The main reactants of photochemical smog are nitric oxide (NO) and unburnt hydrocarbons. Nitric oxide is oxidized to nitrogen dioxide within minutes to hours depending upon the concentration of pollutant gas.
- The yellow colour in photochemical smog is due to the presence of nitrogen dioxide.

### Conditions for Smog Formation

Photochemical smog is a condition that develops when primary pollutants (oxides of nitrogen and volatile organic compounds created from fossil fuel combustion) interact under the influence of sunlight to produce a mixture of hundreds of different and hazardous chemicals known as secondary pollutants.

### Major Chemical Pollutants in Photochemical Smog:

(Sources and Environmental Effects)

Toxic Chemical	Sources (Natural and Human)	Environmental Effects	Additional Notes
Nitrogen Oxides (NO and $\text{NO}_2$ )	<ul style="list-style-type: none"> <li>- Combustion of oil, coal, gas in both automobiles and industry.</li> <li>- bacterial action in soil</li> <li>- forest fires</li> <li>- volcanic eruption</li> <li>- lightning</li> </ul>	<ul style="list-style-type: none"> <li>- Decreased visibility due to yellowish color of <math>\text{NO}_2</math></li> <li>- <math>\text{NO}_2</math> contributes to heart and lung problems</li> <li>- <math>\text{NO}_2</math> can suppress plant growth.</li> <li>- decreased resistance to infection</li> <li>- may encourage the spread of cancer</li> </ul>	<ul style="list-style-type: none"> <li>- All combustion processes account for only 5 % of <math>\text{NO}_2</math> in the atmosphere, most is formed from reactions involving NO</li> <li>- concentrations likely to rise in the future</li> </ul>
Volatile Organic Compounds (VOCs)	<ul style="list-style-type: none"> <li>- evaporation of solvents</li> <li>- evaporation of fuels</li> <li>- incomplete combustion of fossil fuels</li> <li>- naturally occurring compounds like terpenes from trees</li> </ul>	<ul style="list-style-type: none"> <li>- eye irritation</li> <li>- respiratory irritation</li> <li>- some are carcinogenic</li> <li>- decreased visibility due to blue-brown haze</li> </ul>	<ul style="list-style-type: none"> <li>- the effects of VOCs are dependent on the type of chemical</li> <li>- samples show over 600 different VOCs in atmosphere</li> <li>- concentrations likely to continue to rise in future</li> </ul>



Ozone ( $O_3$ )	<ul style="list-style-type: none"> <li>- formed from photolysis of <math>NO_2</math></li> <li>- sometimes results from stratospheric ozone intrusions</li> </ul>	<ul style="list-style-type: none"> <li>- bronchial constriction</li> <li>- coughing, Sneezing</li> <li>- respiratory irritation</li> <li>- eye irritation</li> <li>- decreases crop yields</li> <li>- retards plant growth</li> <li>- damages plastics</li> <li>- breaks down rubber</li> <li>- harsh odor</li> </ul>	<ul style="list-style-type: none"> <li>- concentrations of 0.1 parts per million can reduce photosynthesis by 50 %</li> <li>- people with asthma and respiratory problems are influenced the most</li> <li>- can only be formed during daylight hours</li> </ul>
Peroxyacetyl Nitrates (PAN)	<ul style="list-style-type: none"> <li>- formed by the reaction of <math>NO_2</math> with VOCs (can be formed naturally in some environments)</li> </ul>	<ul style="list-style-type: none"> <li>- eye irritation</li> <li>- high toxicity to plants</li> <li>- respiratory irritation</li> <li>- damaging to proteins</li> </ul>	<ul style="list-style-type: none"> <li>- was not detected until recognized in smog</li> <li>- higher toxicity to plants than ozone</li> </ul>
Carbon Oxide (CO and $CO_2$ )	<ul style="list-style-type: none"> <li>- Incomplete combustion of carbon containing fuels. (CO)</li> <li>- Incomplete combustion of agricultural or slush matter, (CO)</li> <li>- During the reaction in blast furnace (CO)</li> <li>- Cigarette smoke (CO)</li> <li>- Burning of fossil fuels produce <math>CO_2</math></li> <li>- Cultivation of Soil (<math>CO_2</math>)</li> <li>- Eruption of Volcanoes (<math>CO_2</math>)</li> <li>- Respiration of living organism. (<math>CO_2</math>)</li> </ul>	<ul style="list-style-type: none"> <li>- Causes Anoxia (Oxygen Starvation) result suffocation</li> <li>- Causes Green house effect and Global Warming results climatic changes.</li> <li>- Respiratory irritation</li> </ul>	
Oxides of Sulphur ( $SO_2, SO_3$ )	<ul style="list-style-type: none"> <li>- Volcanic Eruption</li> <li>- Burnt of oil &amp; coal.</li> <li>- Sulphide ores are roasted</li> </ul>	<ul style="list-style-type: none"> <li>- Causes acid rain</li> <li>- Respiratory irritation.</li> <li>- Loss of green color in plants</li> <li>- Fading in color of Fabrics, leathers, paper and paints.</li> </ul>	

### Chemistry of Photochemical Smog (Chemical Reactions in the Atmosphere)

The development of photochemical smog is primarily determined by an abundance of nitrogen oxides and volatile organic compounds in the atmosphere and the presence of particular environmental conditions. To begin the chemical process of photochemical smog development the following conditions must occur:

- Sunlight.
- The production of oxides of nitrogen ( $NO_x$ ).
- The production of volatile organic compounds ( $VOC_s$ ).
- Temperatures greater than  $18^\circ C$ .

If the above criteria are met, several reactions will occur producing the toxic chemical constituents of photochemical smog. The following discussion outlines the processes required for the formation of two most dominant toxic components: ozone ( $O_3$ ) and peroxyacetyl nitrate (PAN) which is primarily created from volatile organic compounds. Other oxidizing agents are  $H_2O_2$ ,  $HNO_3$  etc. PAN is an eye irritant and is also toxic through plants.

1. What is environmental chemistry?

Ans. **Environmental Chemistry:**

It is the branch of chemistry which deals with the chemicals and other pollutants in the environment resulting directly and indirectly from human activities.

2. What is smog? What are its types?

Ans. The word smog is a combination of smoke and fog. There are two types of smog.

- (i) Reducing smog      (ii) Oxidizing smog

3. What are different sources and environmental effects of: (i) Ozone (ii) Carbon oxides (iii) Sulphur oxides.

Ans.

Compound	Natural & Human resources	Environmental Effects
Ozone	<ul style="list-style-type: none"> <li>formed from photolysis of <math>\text{NO}_2</math></li> <li>sometimes results from stratospheric ozone intrusions</li> </ul>	<ul style="list-style-type: none"> <li>bronchial constriction</li> <li>coughing, Sneezing</li> <li>respiratory irritation</li> <li>eye irritation</li> <li>decreases crop yields</li> <li>retards plant growth</li> <li>damages plastics</li> <li>breaks down rubber</li> <li>harsh odor</li> </ul>
Carbon oxides ( $\text{CO}$ & $\text{CO}_2$ )	<ul style="list-style-type: none"> <li>Incomplete combustion of carbon containing fuels. (<math>\text{CO}</math>)</li> <li>Incomplete combustion of agricultural of slush matter, (<math>\text{CO}</math>)</li> <li>During the reaction in blast furnace (<math>\text{CO}</math>)</li> <li>Cigarette smoke (<math>\text{CO}</math>)</li> <li>Burning of fossil fuels produce <math>\text{CO}_2</math></li> <li>Cultivation of Soil (<math>\text{CO}_2</math>)</li> <li>Eruption of Volcanoes (<math>\text{CO}_2</math>)</li> <li>Respiration of living organism. (<math>\text{CO}_2</math>)</li> </ul>	<ul style="list-style-type: none"> <li>Causes Anoxia (Oxygen Starvation) result suffocation</li> <li>Causes Greenhouse effect and Global Warming results climatic changes.</li> <li>Respiratory irritation</li> </ul>
Sulphur oxides ( $\text{SO}_2$ & $\text{SO}_3$ )	<ul style="list-style-type: none"> <li>Volcanic Eruption</li> <li>Burnt of oil &amp; coal.</li> <li>Sulphide ores are roasted</li> </ul>	<ul style="list-style-type: none"> <li>Causes acid rain</li> <li>Respiratory irritation.</li> <li>Loss of green color in plants</li> <li>Fading in color of Fabrics, leathers, paper and paints.</li> </ul>

4. For the development of photochemical smog, what conditions are necessary?

Ans. **Conditions for Smog Formation**

The following conditions are required for the formation of smog.

- There must be sufficient  $\text{NO}$ , hydrocarbons and volatile organic compounds (VOC) emitted by the vehicles.
- Sunlight, so that some of the chemical reactions may occur at a rapid rate.
- The movement of air mass must be little so that reactions are not disturbed.
- Temperature greater than  $18^\circ\text{C}$ .



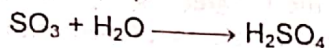
**Exercise: Q.3(ii) Write a comprehensive note on acid rain.**

**Acid Rain**

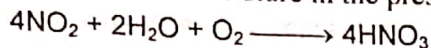
**"Rain water having pH less than 5 is termed as acid rain."**

We know that air contains  $\text{SO}_2$ ,  $\text{NO}_2$  and  $\text{CO}_2$ .

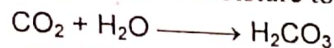
- (1)  $\text{SO}_2$  present in air undergoes photolytic and catalytic oxidation to form  $\text{SO}_3$  which reacts with rainy water or moisture to form  $\text{H}_2\text{SO}_4$  i.e.



- (2)  $\text{NO}_2$  reacts with rainy water or moisture in the presence of  $\text{O}_2$  and  $\text{O}_3$  and produces  $\text{HNO}_3$  i.e.



- (3)  $\text{CO}_2$  reacts with rainy water or moisture to form  $\text{H}_2\text{CO}_3$  i.e.



$\text{H}_2\text{SO}_4$ ,  $\text{HNO}_3$  and  $\text{H}_2\text{CO}_3$  formed as above come down the atmosphere as acid rain or acid snow. As far as  $\text{H}_2\text{CO}_3$  is concerned, it has no severe effects on animals, plants or any other things.

In some countries due to release of  $\text{HCl}$  by volcanic eruption, there is temporary acid rain.

**Harmful effects of Acid Rain**

- (1) It makes the lakes so acidic that they can no longer support fish life.
- (2) The yield of agricultural crops is also reduced.
- (3)  $\text{HNO}_3$  acid rain gradually eats up lime stone and marble of the buildings and corrodes metals.
- (4) It fades the color of fabrics (e.g. cotton, nylon and rayon), leather and paper
- (5) It causes extensive leaf-drop in plants.
- (6) It is very corrosive and attacks skin.
- (7) Acidification of soil and rocks can leach metals like  $\text{Al}$ ,  $\text{Hg}$ ,  $\text{Pb}$  and  $\text{Ca}$  and discharge them into water bodies. Then these heavy metals are eaten by fishes which proves very much dangerous for those animals and birds which eat these fishes.
- (8) It also damages steel, paint, plastic, cement, masonry work and sculptural materials.



1. What is acid rain?

Ans. The rain water having pH less than 5 is called acid rain.

2. Write down different effects of acid rain?

Ans. Harmful effects of Acid Rain

- (1) It makes the lakes so acidic that they can no longer support fish life.
- (2) The yield of agricultural crops is also reduced.
- (3)  $\text{HNO}_3$  acid rain gradually eats up lime stone and marble of the buildings and corrodes metals.
- (4) It fades the color of fabrics (e.g. cotton, nylon and rayon), leather and paper
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- (8) It also damages steel, paint, plastic, cement, masonry work and sculptural materials.

3. List out those acid present in acid rain.

Ans. (i) Sulphuric acid ( $\text{H}_2\text{SO}_4$ ), (ii) Nitric acid ( $\text{HNO}_3$ ), (iii) Carbonic acid ( $\text{H}_2\text{CO}_3$ )

4. Name those heavy metals which leach due to acidification of soil.

Ans. Aluminium ( $\text{Al}$ ), Mercury ( $\text{Hg}$ ), Lead ( $\text{Pb}$ ) and Calcium ( $\text{Ca}$ ).



## Green House Effect and Global Warming

The greenhouse effect is the warming that happened when certain gases in earth atmosphere trap it. These gases lets in light but keep heat from escaping, like the glass walls of a greenhouse.

### Greenhouse Effect

The heat causes the atoms in the earth's surface to vibrate and radiate heat and infrared radiation. Neither  $O_2$  nor  $N_2$  absorbs infrared radiation; however, other substances in the atmosphere, especially  $CO_2$  and  $H_2O$ , do absorb infrared radiation. This absorption warms the atmosphere, which then radiates the infrared rays. The effect is to trap the sun's warmth. Thus, some of the heat, the earth must lose in order to be in equilibrium, is trapped in the atmosphere, and that temperature eases which produce a war effect on the earth. Two gases  $CO_2$  and water vapours in the air, by absorbing infrared radiation, act as an insulating blanket to prevent heat from escaping, this is often referred to as a greenhouse effect. The trapping of heat on the surface of earth by  $CO_2$  and water vapour in the atmosphere is known as greenhouse effect.

### Global Warming

In the atmosphere, water vapour absorbs more infrared radiation than  $CO_2$  because its concentration is higher. The concentration of  $CO_2$  in the atmosphere is low (about 330 PPM) but is known to be increasing. Concentration of  $CO_2$  is increased up to 400 ppm than temperature should rise as much as  $1^\circ C$ . The main global temperature at Earth's surface is about  $15^\circ C$ . This temperature is determined by a delicate balance between the energy which is absorbed by the sun and the energy emitted back into space by the Earth. Any case in the amount of energy absorbed or emitted by the Earth could upset this balance, effecting our climate.

The average global temperature and concentration of  $CO_2$  have fluctuated on a cycle of hundred of thousand of years and Earth's position relative the sun has varied. As result, ice ages have come and gone.

Occasionally, other factors briefly inflating global temperatures. Volcanic eruptions, for example, emit particles that temporarily cool Earth's surface. But these have no lasting effect beyond a few years. Other cycles, such as El Nino, also work on fairly short and predictable cycles.

Now, human have increase the amount of  $CO_2$  in the atmosphere by more than a third since the industrial revolution. Changes this large have historically taken thousands of years, but are now happening over the course of decades.

Scientists are already seeing some of the changes occurring more quickly than they had expected. According to the intergovernmental panel on climate change, eleven of the twelve hottest years since thermometer readings became available occurred between 1995 and 2006.



1. Is  $CO_2$  responsible for green house effect? If yes then how?

**Ans.** The presence of  $CO_2$  in the atmosphere does not allow the infra-red radiation reflected by the earth's surface to go out of the atmosphere. In other words, we can say that the layer of  $CO_2$  gas in the atmosphere traps all the infra-red radiations coming from the earth's surface. These trapped infra-red rays heat the earth's atmosphere. The heating up of earth due to the trapping of infrared radiations (reflected from the earth's surface by  $CO_2$  layer in the atmosphere is called "green-house-effect".

2. What is the importance of green house effect?

**Ans.** The greenhouse effect, produced by the presence of  $CO_2$  layer in the atmosphere, is very necessary for our existence on the earth. We have seen that, due to greenhouse effect,  $CO_2$  gas in the atmosphere does not allow the long wavelength infrared radiations reflected by the earth, to go out of the atmosphere and hence the temperature of the earth's surface and its atmosphere is increased. The rise in temperature of the earth is very necessary for our existence on earth, because without it the whole earth would be converted into extremely cold planet and consequently we shall not be able to have a normal life.

3. High concentration of  $CO_2$  is responsible for climate changes. Comment.

**Ans.** If the atmosphere contains too much quantity of  $CO_2$ , the greenhouse effect is considerably increased i.e. the atmosphere; the temperature of the earth is increased too much. This too much high temperature melts all the glaciers (snow-mountains) floods the low-lying areas of the earth, changes the biological activity of oceans and the



patterns of cropping etc. Thus we see that the presence of the excess of  $\text{CO}_2$  in the atmosphere brings about climate changes.

### Automobile (Pollutants and Converter)

In automobiles during incomplete combustion of petrol, we get smoke of different gases which pollute our atmosphere. The engine used in these motor vehicles are called internal combustion engines because the petrol which is used as a fuel is burnt inside the engine and contains  $\text{CO}$ ,  $\text{NO}$ ,  $\text{NO}_2$ , un-burnt carbon particles, some lead compounds, some alcohol and acids. All these substances are poisonous and hence pollute air.

#### Production of Pollutants:

- Petrol is used as a fuel in automobile (car) engine. The main components of petrol are hydrocarbons. These hydrocarbons have general formula  $\text{C}_n\text{H}_{2n+2}$  of which octane ( $\text{C}_8\text{H}_{18}$ ) is the major hydrocarbon.
- Petrol burns very fast in a car engine. Due to short time available for burning, incomplete combustions of petrol takes place and some  $\text{CO}$ , unburnt carbon particles,  $\text{CO}_2$ , water vapors, some alcohol and acids are produced.  $\text{CO}$  and carbon particles are emitted into the air and thus air is polluted.
- When petrol burns in a car engine, a very high temperature is produced. At this high temperature,  $\text{N}_2$  and  $\text{O}_2$  present in air of the engine combine together and form  $\text{NO}$  and  $\text{NO}_2$ . These gases also pollute the air.

#### Control Measure:

In order to control the air pollution caused by hydrocarbons and  $\text{CO}$  etc the following methods are used:

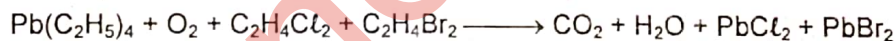
##### (1) By adding tetraethyl lead, TEL, $\text{Pb}(\text{C}_2\text{H}_5)_4$ to petrol:

Suppose a vehicle uses petrol as fuel. Petrol burns very fast in the vehicle engine, e.g. the rate of combustion of petrol is very high and hence the time taken by the petrol for its combustion is very short. Due to this short time, the combustion of petrol is incomplete.

$\text{TEL}$ ,  $\text{Pb}(\text{C}_2\text{H}_5)_4$  is added to the petrol to slow down the rate of combustion of petrol.  $\text{TEL}$ ,  $\text{Pb}(\text{C}_2\text{H}_5)_4$  provides more time to the petrol for its combustion and hence enables it to burn more completely. Due to this the quantity of unburnt hydrocarbons and  $\text{CO}$  coming out of the engine, with exhaust gases is reduced and hence air pollution is also minimized.

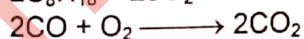
##### Disadvantage and prevention:

$\text{Pb}(\text{C}_2\text{H}_5)_4$  is oxidized to  $\text{PbO}$  which gets deposited on the spark plugs and valves. In order to prevent the deposition of  $\text{PbO}$ , suitable amount of  $\text{C}_2\text{H}_4\text{Cl}_2$  and  $\text{C}_2\text{H}_4\text{Br}_2$  are also added to the petrol along with  $\text{Pb}(\text{C}_2\text{H}_5)_4$ . These halides convert  $\text{PbO}$  into  $\text{PbCl}_2$  and  $\text{PbBr}_2$  both of which are volatile and hence come out along with the exhaust gases emitted by the vehicle engine.



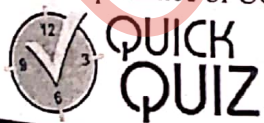
Although the addition of  $\text{Pb}(\text{C}_2\text{H}_5)_4$  minimize the air pollution caused by unburnt hydrocarbons and  $\text{CO}$ , the air gets polluted with dangerous  $\text{PbCl}_2$  and  $\text{PbBr}_2$ .

##### (2) Catalytic oxidation/Converter: The pollution of air caused by unburnt hydrocarbons and $\text{CO}$ present in the exhaust gases of the vehicle's engine can also be reduced by attaching gas device with the vehicle's engine, in which the exhaust gases can be mixed with more air and then burnt completely in the presence of platinum catalyst before they are discharged into the environment. Hydrocarbons and $\text{CO}$ are oxidized by $\text{O}_2$ of the air in presence of platinum catalyst.



##### Disadvantage:

The disadvantage of this method is that the platinum catalyst gets poisoned by  $\text{PbCl}_2$  and  $\text{PbBr}_2$  which are produced by the reaction between  $\text{Pb}(\text{C}_2\text{H}_5)_4$ ,  $\text{C}_2\text{H}_4\text{Cl}_2$  and  $\text{C}_2\text{H}_4\text{Br}_2$  (these compounds are added to the petrol) in presence of  $\text{CO}_2$ .



1. What is the role of tetraethyl lead in minimizing the air pollution?

Ans.  $\text{TEL}$ ,  $\text{Pb}(\text{C}_2\text{H}_5)_4$  is added to the petrol to slow down the rate of combustion of petrol.  $\text{TEL}$ ,  $\text{Pb}(\text{C}_2\text{H}_5)_4$  provides



more time to the petrol for its combustion and hence enables it to burn more completely. Due to this the quantity of unburnt hydrocarbons and CO coming out of the engine, with exhaust gases is reduced and hence air pollution is also minimized.

## 2. What is internal combustion engine?

**Ans.** The engines used in the motor vehicles are called internal combustion engines because the petrol which is used as a fuel is burnt inside the engine.

## 3. Name those pollutants produced in automobile engines.

**Ans.** (i) Carbon monoxide (CO) (ii) Nitrogen oxides (NO, NO<sub>2</sub>) (iii) Un-burnt carbon particles  
(iv) Lead compounds (v) Alcohols (vi) Acids

## 4. What gas is produced due to high temperature of engine?

**Ans.** When petrol burns in a car engine, a very high temperature is produced. At this high temperature, N<sub>2</sub> and O<sub>2</sub> present in air of the engine combine together and form NO and NO<sub>2</sub>. These gases also pollute the air.

## 5. What is drawback of lead tetraethyl used to control air pollution?

**Ans.** Drawbacks of TEL

- (i) (C<sub>2</sub>H<sub>5</sub>)<sub>4</sub>Pb is oxidized to PbO which gets deposited on the spark plugs and valves. This decreases their efficiency.
- (ii) TEL has one serious disadvantage; its combustion product, lead oxide, is reduced to metallic lead which is discharged into the air through the exhaust pipe and causes air pollution. It causes blindness and mental retardation in infant children.

## (B) Chemistry of the Stratosphere

This layer of atmosphere is present 20-40 km above the earth and ozone is present in this layer at a height of about 23 - 28 kilometers. The concentration of ozone in this layer is 10 ppm (10 parts per million)

### (a) Production of O<sub>3</sub> and its toxic effects

Some O<sub>3</sub> is produced during various combustion processes taking place in the air around us. Traces of O<sub>3</sub> in air do not harm but O<sub>3</sub> of concentration more than 0.1 ppm is toxic and harmful to human beings. O<sub>3</sub> also attacks rubber products. O<sub>3</sub> is also produced in the upper part of the atmosphere by the action of sunlight on O<sub>2</sub>.



### (b) Protective action of ozone layer in the atmosphere

The thickest layer of O<sub>3</sub> exists at a height of 23 km from the surface of the earth. Since O<sub>3</sub> present in this layer absorbs harmful ultraviolet radiations coming from the sun. If these radiations reach the earth, they will cause skin cancer and will destroy the organic molecules necessary for life. O<sub>3</sub> layer saves us from these radiations.

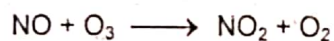
If O<sub>3</sub> layer in the atmosphere disappears completely, then all the harmful ultra-violet radiations coming from the sun would reach the earth and would cause skin cancer in men and animals and will also damage the plants. All the life on earth would then gradually be destroyed.

### (c) Sources of destruction/destroying the ozone layer present in stratosphere

In 1980 scientists showed that there is a hole in the O<sub>3</sub> layer. This hole was detected over the region of Antarctica. Due to the absence of O<sub>3</sub> layer, the ultraviolet rays coming from the sun can pass through the hole and thus can reach the earth's surface. It is observed that the amount of O<sub>3</sub> present in stratosphere is getting reduced day by day and thus the ozone layer is becoming thinner and thinner.

The depletion of the ozone layer is due to the following sources:

- (i) **Oxides of Nitrogen:** The oxides of nitrogen present in the atmosphere decompose O<sub>3</sub> into O<sub>2</sub> and are themselves regenerated.

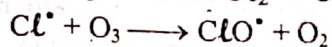
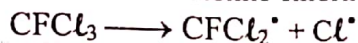


Thus we see that the presence of nitrogen oxides in the atmosphere destroys the ozone layer. These oxides destroy about 70% of O<sub>3</sub> found in the stratosphere. Greater is the amount of the oxides in the atmosphere greater is the percentage of O<sub>3</sub> which is destroyed.

- (ii) **Nuclear Tests:** Nuclear tests being conducted in the world generate high temperature. At high temperature, atmospheric nitrogen is favorably oxidized to NO. NO thus formed destroys ozone layer.



- (iii) **Use of Chloro-Fluoro Carbons:** Fluoro-chloro-carbons are the fluoro-chloro methanes like, Freon-1 ( $\text{CFCl}_3$ ) and Freon 12 ( $\text{CF}_2\text{Cl}_2$ ). These are stable compounds. These are chemically inert and hence do not react with the substances. These are used as aerosol spray propellants, refrigerants, firefighting reagent and solvents for cleaning electronic components. When they enter stratosphere, they absorb ultraviolet solar radiations and get broken down into free atomic chlorine. This atomic chlorine decomposes  $\text{O}_3$  into  $\text{O}_2$  (NO also breaks  $\text{O}_3$  into  $\text{O}_2$ ).



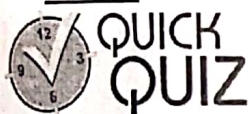
#### (d) Protection of Ozone Layer

Scientists are worried over the gradual destruction of ozone layer by the oxides of nitrogen and fluoro chloro carbons. In order to save the destruction of  $\text{O}_3$  layer by fluoro-chloro carbons, their use should be banned or some new types of substances should be discovered which may be used as aerosol spray propellants and should not react with  $\text{O}_3$  layer, so that it may be saved.

#### Some Alternatives to Chloro-Fluoro Carbons (CFCs):

- The first CFC substituents to be introduced were HCFCs such as  $\text{CF}_3\text{CHCl}_2$  and  $\text{CHF}_2\text{Cl}$  compounds that have fewer chlorine atoms than other CFCs. HCFCs break down more readily in the atmosphere than CFCs and thus are less likely to reach the stratosphere. However, because they can cause some  $\text{O}_3$  destruction, they are scheduled to be phased out by 2030.
- Much better substituents for CFCs are hydrofluoro carbons which contain no chlorine. One of them  $\text{CF}_3\text{CH}_2\text{F}$  has been used successfully as a refrigerant and since 1994 has replaced Freon in nearly all car air conditioners. In electronic industries, soapy water followed by rinsing and air drying is now used instead of CFCs to clean micro circuits. Unfortunately, a serious problem is associated with the long term use of HFC. Like CFC and HCFCs they contribute to climate change.

However researches are going on to find chemicals that are both effective refrigerant and environmental friendly.



1. Ozone acts both useful as well as harmful. Justify the statement.

**Ans. Usefulness of Ozone:**

The ozone layer filters most of the harmful ultraviolet (UV) rays in the sunlight before they could reach on the earth.

**Harmfulness of Ozone:**

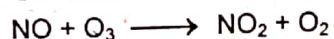
It acts as a pollutant and causes various health problems i.e., damages eyes and aggravates asthma, decreases the elasticity of lung tissues, coughing, chest discomfort, etc. It is harmful to the plants and other materials i.e., attacks rubber, reduces durability and appearance of paint and causes fabric dyes to fade. The amount of ozone is less in the regions closer to the equator.

2. Enlist the possible alternatives to the use of CFC.

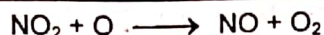
- Ans.**
- The first CFC substituents to be introduced were HCFCs such as  $\text{CF}_3\text{CHCl}_2$  and  $\text{CHF}_2\text{Cl}$  compounds that have fewer chlorine atoms than other CFC. HCFCs break down more readily in the atmosphere than CFC and thus are less likely to reach the stratosphere.
  - Much better substituents for CFC are hydrofluoro carbons which contain no chlorine. One of them  $\text{CF}_3\text{CH}_2\text{F}$  has been used successfully as a refrigerant and since 1994 has replaced Freon in nearly all car air conditioners.

3. How  $\text{O}_3$  is decomposed by oxides of nitrogen?

**Ans.** The oxides of nitrogen present in the atmosphere decompose  $\text{O}_3$  into  $\text{O}_2$  and are themselves regenerated.







Thus we see that the presence of nitrogen oxides in the atmosphere destroys the ozone layer. These oxides destroy about 70% of  $\text{O}_3$  found in the stratosphere. Greater is the amount of the oxides in the atmosphere greater is the percentage of  $\text{O}_3$  which is destroyed.

#### 4. How ozone is produced?

- Ans. (i) Some  $\text{O}_3$  is produced during various combustion processes taking place in the air around us.  
 (ii)  $\text{O}_3$  is also produced in the upper part of the atmosphere by the action of sunlight on  $\text{O}_2$ .



## WATER POLLUTION AND WATER TREATMENT

The contamination of water with the substances which have adverse effects on human beings, animals and plants is called water pollution and the substances whose presence in the water makes it polluted are called water pollutants.

### Types of Water Pollutants

Water is essential for life on Earth. 2/3 of the population of the world is devoid of clean drinking water. In spite of abundance of water on the earth, clean and fresh water is vital for survival of all human being and recently WHO has raised the slogan of clean water for all. Clean, drinkable water is called portable water as against unportable water.

Water pollutants are of following two types:

#### (A) Suspended Solids and Sediments

These are wastes which are not completely soluble but suspended in the water. These wastes include:

##### (i) Oil Spillage:

Petroleum is a complex mixture of many compounds which are mainly hydrocarbons. It is transported from one place to another through sea.

We know that petroleum products are used as: fuel, lubricants manufacture of petrochemicals, plastics, electrical appliances, synthetic rubber and detergents.

In order to prepare such a large varieties of substances, petroleum is handled on large scale in the world. So the oil spillage can take place and it creates serious problems.

##### Pollution of water by petroleum:

Water gets polluted by:

- (i) accidental oil spills
- (ii) leakage from cargo oil tankers in sea
- (iii) tanker trucks
- (iv) pipelines leakage during offshore exploration
- (v) leakage of underground storage tanks

##### Oil Spillage and animal life:

Many petroleum products are poisonous and create serious health problems to humans, animals and aquatic life.

Polycyclic hydrocarbons are carcinogenic even at very low concentration. Marine animals are seriously affected by soluble aromatic fractions of oil. The spilled oil damages the feather of the birds or fur of animals and sometimes causes their death.

##### Petroleum and under water plants:

When oil is spilled on the surface of sea then the light transmission is affected. The process of photosynthesis of plants does not remain much efficient. As a result the concentration of oxygen in water is decreased.

##### (ii) Live-Stock Waste:

Livestock waste is dumped on open land. Sometimes it is discharged into sewage, canals or rivers. This practice pollutes the surface and ground water. In this way serious problem are created for the population.

Bacteria are present in the livestock waste. It contaminates the surface and ground water. This causes the diseases like:

- (a) Dysentery
- (b) Typhoid
- (c) Hepatitis



**(iii) Industrial Wastes:****Sources:**

Industries which are producing large quantities of industrial effluents are leather tanneries, fertilizers, oil refineries, petrochemicals, textiles, foods, sugar, paper pulp, paper board, rubber products etc. the waste products may be waste heat, smoke solid or water effluent.

**Pollutants:**

The industrial pollutants are highly toxic organic compounds and heavy metals like Pb, Cd, Cr, Hg, As, Sb etc. Oil greases, Mineral acids are also released in small quantities. These pollutants result in contamination of water and make it unfit for irrigation and drinking purposes.

**Effects of Industrial pollutants:**

Heavy metal particles are highly toxic and do not have any safe limits. When they are continuously ingested through food or water they get accumulated in the organisms and cause serious health problems like anemia, kidney diseases, nervous disorder, high blood pressure etc.

**(iv) Leather Tanneries:**

There are many leather tanning units working in Pakistan. Their sizes vary from cottage scale to big industrial units. Leather industries use chromium salts which have +6 oxidation state of chromium. Only a few industries have the facility of waste treatment. This can be done by reducing  $\text{Cr}^{+6}$  oxidation states to  $\text{Cr}^{+3}$  oxidation state.  $\text{Cr}^{+3}$  is precipitated as  $\text{Cr}(\text{OH})_3$ .  $\text{Cr}^{+6}$  salts are highly toxic and cause cancer.

**(B) Dissolved Solids**

These are wastes which are dissolved / soluble in water completely. These wastes include:

**(i) Detergents:**

Detergents are used in homes and industries for washing. After washing these detergents are thrown into water reservoirs. The amount of detergents in reservoirs is increasing day by day. This waste water containing detergents goes into rivers and finally reaches the ocean, which is harmful for life in seas. The detergents bound heavy metal ions like Pb, Cd and Hg and transport it from sediments into water. These metals particles are very toxic.

**(ii) Pesticides:**

The pesticides are both toxic and persistent. Analysis of polluted water has shown that it contains pesticides which are toxic to fish.

- Endrin, even in traces, is reported to be toxic for catfish and other varieties of fish.
- D.D.T. affects the central nervous system of fish.
- Toxaphene has been reported to cause bone degeneration in fish.

**(iii) Chemical Fertilizers:**

Nitrate/phosphate salts are generally used as fertilizers, to increase the yield of the crops. When these fertilizers are used in excess, some of their unused quantity is washed away from the agriculture lands into the ponds, lakes and river with rain water and thus pollute the water. This water is polluted, since it contains unused nitrate/phosphate salts. Similarly the waste water coming from the fertilizer industries also contains nitrogenous/phosphatic fertilizers which, when washed away into the lakes and river with rain water, make the water polluted. The presence of nitrogenous/phosphatic fertilizers in water is harmful to the aquatic life and human beings in the following ways:

- (a) The presence of the fertilizers in the polluted water increases the growth of algae and other aquatic plants which, later on undergo decomposition and produce disagreeable odour. These plants also deplete the amount of  $\text{O}_2$  dissolved in water and hence the survival of aquatic life becomes difficult or impossible.
- (b) After a long period the lakes and slow moving waters which contains plant nutrients are converted into swamps (A swamp is an area of very wet land with wild plants growing in it) and marshes (A marsh is an area of land which is very wet and muddy).
- (c) The water containing nitrate salt is not fit for drinking by human beings. Moreover, this polluted water cannot be purified for drinking purposes.



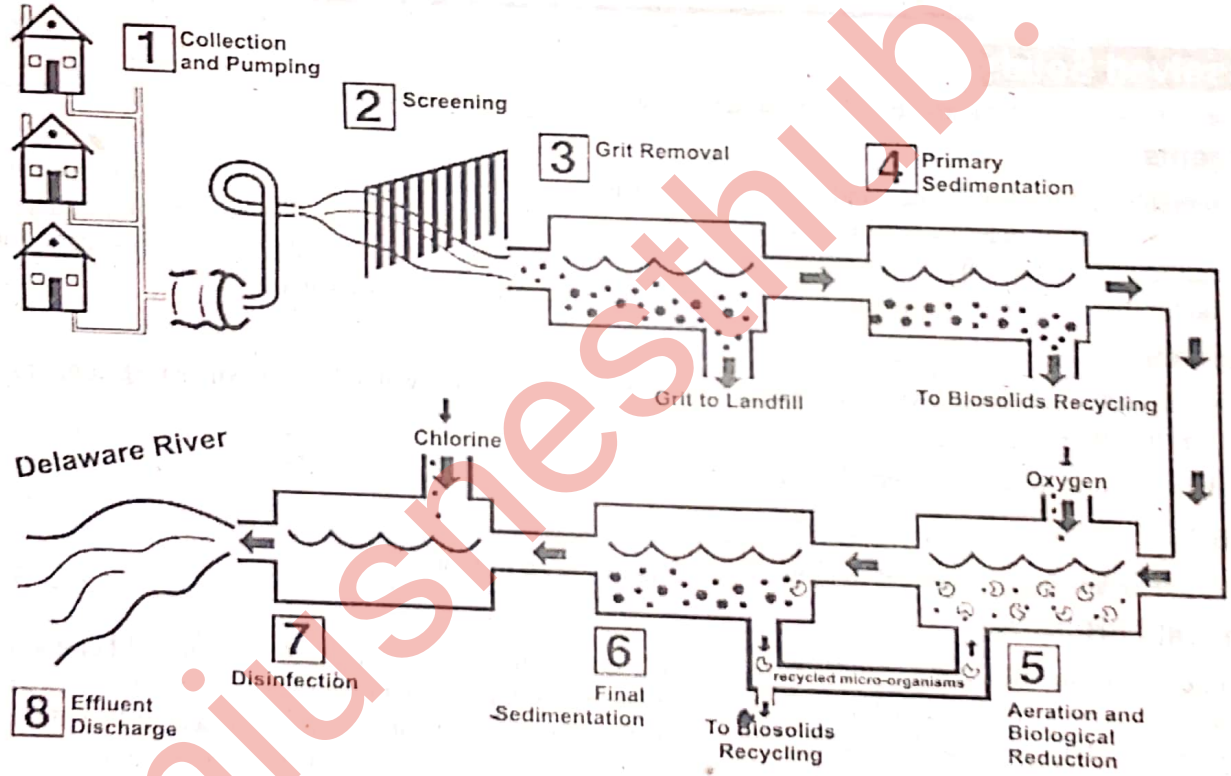
**Exercise Q.3(iv) What is Thermal Pollution? Discuss its sources and environmental effects.**

**Thermal Pollution**

Thermal pollution takes place because many electric generating companies use water in the process of cooling their generator. This heated water is then released into the system from which it was drawn, causing a warming trend of the surface water. Thermal pollution results when the heated effluent is released into poorly flushed system. In these cases permanent temperature increase often result, which tend to decrease the solubility of dissolved oxygen. In lakes it also becomes possible to bring about nutrient redistributions and prolong summer stagnation periods.

When heated water gets released into large, well-flushed marine systems there is little if any permanent temperature rise. There are however problems related to the operation of plants utilizing marine water in the cooling process. Evidence reveals that seawater tends to corrode the cooling pipes, which are generally constructed of a copper nickel alloy termed Monel. These metals readily dissolved in the heated seawater and are then released into the marine environment together with the heated effluent. This adds to the nickel and copper concentrations of these systems. In addition the screens covering the water intake pipes rapidly foul with marine organism, which decrease the flow of water into the plant. The screens have been commonly cleaned by using a concentrated detergent solution or copper sulfate. These cleaning materials have been then released into the contaminated waters in the surrounding.

**Waste Water Treatment  
Analysis/Purification of Water**



**Do you know?**

About 97% of the water on earth is found in the oceans. Most of the rest is frozen in the polar ice caps and in glaciers.

**Industrial wastewater treatment** covers the mechanisms and processes used to treat waters that have been contaminated in some way by man's industrial or commercial activities prior to its release into the environment or its re-use.

Most industries produce some wet waste although recent trends in the developed world have been to minimize such production or recycle such waste within the production process. However, many industries remain dependent on processes that produce water based waste stream.



**Exercise Q.3(v) What is waste water treatment? Discuss different methods of it.**

**Treatment of industrial waste water**

The different types of contamination of waste water requires a variety of strategies to remove the contamination.

**(a) Solids removal**

Most solids can be removed using simple sedimentation techniques with the solids recovered as slurry or sludge.

**(b) Oils and greases**

Many oils can be recovered from open water surfaces by skimming devices. However, hydraulic oils and the majority of oils that have degraded to any extent will also have a soluble or emulsified component that will require further treatment to eliminate.

**(c) Soft organics**

Organic material of plant or animal origin is usually possible to treat using extended conventional waste water treatment processes. Problems can arise if the waste water is excessively diluted with washing water. The presence of cleaning agents, disinfectants, pesticides, or antibiotics can have detrimental impacts on treatment processes.

**(d) Hard organics**

Synthetic organic materials including solvents, paints, pharmaceuticals, pesticides, cooking products can be very difficult to treat. Treatment methods are often specific to the material being treated. Methods include distillation, adsorption, nitrification, incineration, chemical immobilization or landfill disposal.

**(e) Acids and alkalis**

Acids and alkalis can usually be neutralized under controlled conditions. Neutralization frequently produces a precipitate that will require treatment as a solid residue that may also be toxic. In some cases, gases may be evolved requiring treatment for the gas stream.

**(f) Toxic materials**

Toxic materials including many organic materials, metals (such as zinc, silver, cadmium, thallium etc.) acids, alkalis, non-metallic elements (such as arsenic or selenium) are generally resistant to biological processes unless very dilute. Metals can often be precipitated out by changing the pH or by treatment with other chemicals. Many, however, are resistant to treatment or mitigation and may require concentration followed by land filling or recycling.



**1. Briefly describe about oil spillage as a source of water pollution and its effects on environment.**

**Ans. Oil spillage as a source of water pollution:**

Petroleum or crude oil is a complex mixture of many compounds mainly hydrocarbons. Sea water gets polluted by accidental oil spills and leakage from cargo oil tankers in sea, tanker trucks, pipelines leakage during off shore exploration and leakage of underground storage tanks. Many petroleum products are poisonous and pose serious health problems to human, animals and aquatic life. Hydrocarbons particularly **polycyclic aromatics** are known to be **carcinogenic** even at very low concentrations.

**Effects on environment:**

The marine organisms are severally affected by soluble aromatic fractions of oil (C-10 or less). The spilled oil damages the **marine life** often causing death. The light transmission through surface of water is affected by oily layer on it thus photosynthesis of the plants and dissolved oxygen in water is decreased.

**2. Enlist the diseases caused by livestock waste.**

**Ans. Livestock waste causes the diseases like:**

- (a) Dysentery (b) Typhoid (c) Hepatitis

**3. How industrial wastes pollute water? -**

**Ans. The industrial pollutants are highly toxic organic compounds and heavy metals like Pb, Cd, Cr, Hg, As, Sb etc. Oil**



greases, Mineral acids are also release in small quantities. These pollutants result in contamination of water and make it unfit for irrigation and drinking purposes. Heavy metal particles are highly toxic and do not have any safe limits. When they are continuously ingested through food or water they get accumulated in the organisms and cause serious health problems like anemia, kidney diseases, nervous disorder, high blood pressure etc.

**4. How chemicals fertilizers pollute water?**

**Ans.** When chemical fertilizers are used in excess, some of their unused quantity is washed away from the agriculture lands into the ponds, lakes and river with rain water and thus pollute the water. This water is polluted, since it contains unused nitrate/phosphate salts.

**5. How solubility of oxygen in water is reduced by thermal pollution?**

**Ans.** Thermal pollution results when the heated effluent is released into poorly flushed system. In these cases permanent temperature increase often result, which tend to decrease the solubility of dissolved oxygen. In lakes it also becomes possible to bring about nutrient redistributions and prolong summer stagnation periods.

**6. What is swamp?**

**Ans.** A swamp is an area of very wet land with wild plants growing in it) and marshes (A marsh is an area of land which is very wet and muddy).

**Various Parameters of Water Analysis**

Following table will help us to determine the water quality.

<b>Parameter</b>	General indicator of water quality; source of O <sub>2</sub> for respiration.	Minimum acceptable level, 4-5 mg/liter; 10-15 mg/liter for reproduction of desirable fish.
<b>Total suspended solids</b>	Clog fish gills, bury eggs, reduce light penetration, increase heat absorption.	Dependent on location.
<b>Total dissolved solids</b>	Represents total mineral content which may or may not be toxic.	A maximum of 400 mg/liter for diverse fish populations.
<b>BOD Biological Oxygen Demand</b>	Amount of dissolved oxygen removed during decomposition of organic matter in a given time; a general indicator of contamination due to biodegradable organics.	BOD water status 1 mg/liter very clean, 2 mg/liter clean, 3 mg/liter fairly clean, 5 mg/liter doubtful clean, 10 mg/liter contaminated
<b>COD Chemical Oxygen Demand</b>	Indicates the concentration of materials oxidizable by chemical reaction.	0-5 mg/liter indicates very clean streams.
<b>pH</b>	Indicates the addition of acids of bases.	pH depends on actual system.
<b>Iron</b>	Excessive amounts can clog fish gills; indicates drainage from iron bearing sediments, mines, industrial processes.	A maximum of 1 mg/liter is a common criterion for stream quality.
<b>Copper</b>	Indicates drainage from copper-bearing sediment, mines, plating, or other industrial sources.	A maximum of 0.02-10 mg/liter is a common criterion for stream quality.
<b>Zinc</b>	Indicates mine drainage or industrial input.	A maximum of 1 mg/liter is a common criterion for stream quality.
<b>Hg, Cd, Pb, Ni, Cr, Ag, etc.</b>	Indicates industrial input.	A maximum of 1 mg/liter is a common criterion for stream quality.
<b>Nitrate</b>	A major plant nutrient; in high-concentrations it can promote excessive plant growth; major sources are fertilizers, sludge and sewage.	A maximum of 0.03-0.04 mg/liter total inorganic phosphate is a common criterion.



Exercise: Q.3(vi) Write a note on Green Chemistry.

## GREEN CHEMISTRY

The term green chemistry, coined in 1991, is defined as "the design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances."

Green chemistry emphasizes the design and creation of chemicals that are not hazardous to people or the environment. It has been applied to a wide range of industrial and consumer goods, including paints, dyes, fertilizers, pesticides, plastics, medicines, electronics, dry cleaning, energy generation, and water purification.

### Why Green Chemistry?

Green chemistry is effective in reducing the impact of chemicals on human health and the environment. In addition, many companies have found that it can be cheaper and even profitable to meet environmental goals. Profits derive from higher efficiency, less waste, better product quality, and reduced liability. Many environmental laws and regulations target hazardous chemicals, and following all these requirements can be complicated. But green chemistry allows companies to comply with the law in much simpler and cheaper ways. Finally, green chemistry is a fundamental science-based approach. Addressing the problem of hazard at the molecular level, it can be applied to all kinds of environmental issues.

Since 1991, there have been many advances in green chemistry, in both academic research and industrial implementation. For example, **Spinosad**, an insecticide manufactured by fermenting a naturally occurring soil organism, was registered by the EPA as a reduced-risk insecticide in 1997. Spinosad does not leach, bioaccumulate, volatilize, or persist in the environment and in field tests left 70 to 90 percent of beneficial insects unharmed. It has relatively low toxicity to mammals and birds and is slightly to moderately toxic to aquatic organisms, but is toxic to bees until it dries.

### The 12 Principles of Green Chemistry

The aim of green chemistry is to reduce chemical related impact on human health and virtually eliminate contamination of the environment through dedicated, sustainable prevention programs. Green chemistry searches for alternative, environmentally friendly reaction media and at the same time strives to increase reaction rates and lower reaction temperatures. The green chemistry concept applies innovative scientific solutions to solve environmental issues posed in the laboratory. **Paul T. Anastas**, an organic chemist working in the office of pollution prevention and toxins at the EPA, and **John C. Warner** developed the Twelve Principles of Green Chemistry in 1991. These principles can be grouped into "Reducing Risk" and "Minimizing the Environmental Footprint."

#### I - Reducing Risk in the Laboratory

Sigma-Aldrich is dedicated to providing alternative products designed with the health and safety of its employees, customers, and the public in mind.

- **Use Safer Chemicals** – Utilize performance chemicals that have the lowest levels of toxicity.
- **Design Less Hazardous Synthesis Methods** – Where feasible, make use of synthetic or biosynthetic methods that pose little or no toxicity to human health and the environment.
- **Use Safer Solvents and Reaction Conditions** – Search for the most up-to-date information on green solvents that will optimize your process and provide a safer working environment.
- **Accident Prevention** – Select substances that minimize the potential for explosions, fires and chemical releases into the environment.

#### II - Minimizing the Environmental Footprint

The 12 Principles focus on reducing the volumes of chemicals used and pollution prevention.

- **Waste Minimization and Prevention** – Develop chemical synthesis techniques, which reduce or prevent waste. It is better to prevent waste than to clean it up after its creation.
- **Use of Catalysts Instead of Stoichiometric Quantities** – Catalytic reactions inherently use smaller quantities of chemicals to carry out a specified transformation.
- **Reduce the Use of Chemical Derivatives** – The use of protecting groups or other forms of temporary modification of a functionality adds to the total waste incurred in a synthetic route.



- **Synthetic Efficiency (Atom Economy)** – An efficient chemical process ensures the maximum amount of your starting materials is used in the final product so that no atom is wasted.
- **Taking Advantage of Chemicals Designed for Degradation** – Reduce the effect on the environment by using chemicals that are designed to be biodegradable.
- **Establishment of In Process Controls for Pollution Prevention** – To avoid the formation of hazardous substances, adopt real-time analysis and in process monitoring during synthesis.
- **Use of Renewable Feedstocks** – Use raw materials or renewable feedstocks (waste from other processes or products derived from agricultural streams) whenever technically or economically feasible.
- **Encourage Energy Efficiency** – The realization of the economical and environmental impact of energy use in a chemical process and the development of alternative means to reduce the impact.



1. What is green chemistry?

Ans. The design of chemical products and processes that reduce or eliminate the use and generation of hazardous substances is called green chemistry.

2. Give importance of green chemistry.

Ans. The aim of green chemistry is to reduce chemical related impact on human health and virtually eliminate contamination of the environment through dedicated, sustainable prevention programs. Green chemistry searches for alternative, environmentally friendly reaction media and at the same time strives to increase reaction rates and lower reaction temperatures.

3. What is spinosad?

Ans. Spinosad is an insecticide manufactured by fermenting a naturally occurring soil organism.

- Spinosad does not leach, bioaccumulate, volatilize, or persist in the environment and in field tests left 70 to 90 percent of beneficial insects unharmed.
- It has a relatively low toxicity to mammals and birds and is slightly to moderately toxic to aquatic organisms, but is toxic to bees until it dries.

4. Give principle of green chemistry.

Ans. Green chemistry searches for alternative, environmentally friendly reaction media and at the same time strives to increase reaction rates and lower reaction temperatures. The green chemistry concept applies innovative scientific solutions to solve environmental issues posed in the laboratory. The Twelve Principles of Green Chemistry can be grouped into "Reducing Risk" and "Minimizing the Environmental Footprint."

5. What is synthetic efficiency?

Ans. An efficient chemical process ensures the maximum amount of your starting materials is used in the final product so that no atom is wasted.

6. Give use of renewable feed stocks.

Ans. Use raw materials or renewable feedstocks (waste from other processes or products derived from agricultural streams) whenever technically or economically feasible.



## Radiation Pollution

Q. What is radioactive pollution?

Ans. Radioactive substances and nuclear radiations produced during nuclear reaction affect our environment adversely and thus radioactive pollution created.



**Q. Write down the Sources of radioactive pollution and its effects.**

**Ans. Sources of radioactive pollution and its effects:**

1. Low level radioactive liquid wastes, radioactive gaseous wastes, and dusts are released during nuclear explosions. The radioactive gaseous wastes are injected into the upper layer of atmosphere where, due to cooling they condense to fine dust particles and thus radioactive cloud is formed. This cloud moves in the direction of the wind, settles down slowly to the surface of the earth and thus pollutes air, water and soil.
2. The radioactive substances produce energy which is so strong that the living cells are damaged or destroyed.
3. People working with radioactive elements develop tumors.
4. Radioactive element like strontium 90 affects our soil and through this human beings and animals are also affected adversely.
5. Nuclear explosions which are operated in sea make sea water polluted. This affects the aquatic life.
6. Among the radioactive radiations, gamma radiations are the most dangerous, since they have high energy and big penetrating power. These radiations can, therefore, pass freely in the human body, where they lose energy, which destroys the living cells by converting them into charged particles (ions). These charged particles are chemically very reactive and hence disrupt cell membrane, reduce the effectiveness of enzymes and even damage genes and chromosomes. All this results in diseases like leukaemia and cancer.
7. We know that in a nuclear reactor  $U_{235}$  is used as a nuclear fuel, which undergoes nuclear fission and energy is produced. Nuclear radiations are produced in the processes viz mining and enrichment of  $U_{235}$  taking place in the nuclear reactor. These radiations can leak from the reactor and therefore, damage the health of the human beings and animals.

### **Control measures for minimizing radioactive pollution**

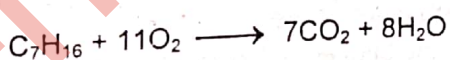
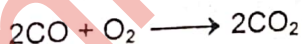
The waste material produced in the mining, enrichment and fission of  $U_{235}$  inside the reactor are collectively called nuclear wastes. At present most of the nuclear wastes are being sorted in strong leak proof containers. These will be disposed off whenever a safe method of their disposal is found out.

### **Using catalytic Converters**

A catalytic converter removes pollutant gases from the exhaust by oxidizing or reducing them. The exhaust gases pass through a converter containing a precious metal catalyst, usually an alloy of platinum and rhodium. Several reactions may take place.  $NO_x$  and CO may take part in a redox reaction which neatly removes both of them at the same time:  $NO_x$  oxidizes CO to  $CO_2$  and is reduced to harmless nitrogen gas.



CO and  $C_xH_y$  are oxidized by air;



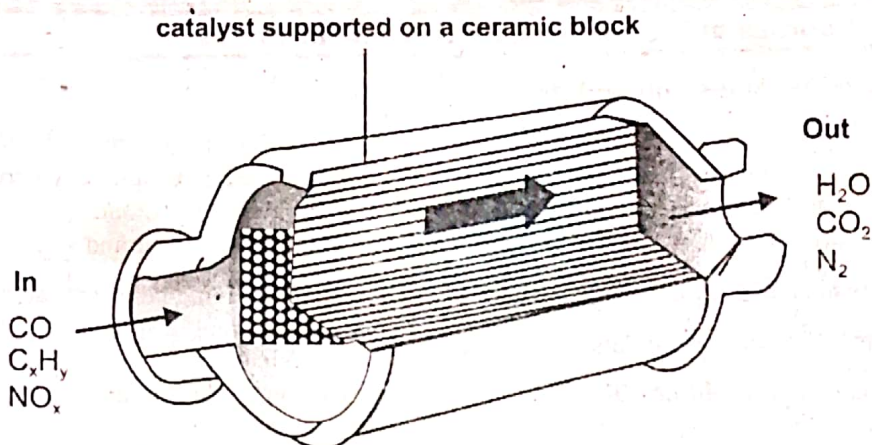
(Using  $C_7H_{16}$  to represent a typical hydrocarbon.)

For all three of these reactions happen, it is necessary to use a three way converter and to have an oxygen monitor fitted to the engine, this checks the quantity of oxygen going into the engine to make sure there is enough to carry out the oxidation reactions.

The overall result of passing exhaust gases through this kind of catalyst system is to convert CO,  $NO_x$  and  $C_xH_y$  to relatively harmless  $N_2$ ,  $CO_2$  and  $H_2O$ .

The catalytic reactions do not start working until the catalyst has reached a temperature of about  $200^\circ C$  so they are not effective until the engine has warmed up.





Catalyst systems of this type cost several hundred pounds, mainly because of the high cost of the precious metal they contain. The catalyst is poisoned by lead, so unleaded fuel must always be used.

### **Waste water from household and industries without treatment to river is dangerous**

When we think about river pollution, we might assume it comes from places like factories, farms and industry. Waste water from manufacturing or chemical processes in industries contributes to water pollution. Industrial waste water usually contains specific and readily identifiable chemical compounds yet, in many cases the pollution in our rivers comes from a much less obvious source - our homes. Incorrect plumbing could mean that waste water from dishwashers, washing machines, sinks, baths and even toilets. Other impurities includes organic materials and plant nutrients that tend to rot. The main organic materials are food and vegetable waste, plant nutrient come from chemical soaps, washing powders, etc. these flushed directly into a local river. These 'misconnected' pipes are a common cause of pollution to rivers and streams, especially in towns and cities.

There are normally two forms of drainage - surface water and foul water.

Surface water drains, or 'storm drains' carry rainwater from road surfaces and rooftops into local rivers and streams and flows into the river untreated.

Foul water drains carry waste water from toilets, sinks, baths and household appliances to the sewage treatment works. This water is treated before it can safely flow back into river and streams.

Today, many people dump their garbage into streams, lakes, rivers, and seas, thus making water bodies the final resting place of cans, bottles, plastics, and other household products. The various substances that we use for keeping our houses clean add to water pollution as they contain harmful chemicals.

Americans generate 1.6 million tons of household hazardous waste per year. The average home can accumulate as much as 100 pounds of household hazardous waste in the basement or garage and in storage closets. When improperly disposed of, household hazardous waste can create a risk to people and the environment. Paints, cleaners, oils, batteries, and pesticides are examples of just a few of the common household hazardous wastes that need special disposal.

When fresh water is artificially supplemented with nutrients, it results in an abnormal increase in the growth of water plants. This is known as eutrophication. The discharge of waste from industries, agriculture, and urban communities into water bodies generally stretches the biological capacities of aquatic systems. Chemical run-off from fields also adds nutrients to water. Excess nutrients cause the water body to become choked with organic substances and organisms. When organic matter exceeds the capacity of the micro-organisms in water that break down and recycle the organic matter, it encourages rapid growth, or blooms, of algae. When they die, the remains of the algae add to the organic wastes already in the water; eventually, the water becomes deficient in oxygen. Anaerobic organisms (those that do not require oxygen to live) then attack the organic wastes, releasing gases such as methane and hydrogen sulphide, which are harmful to the oxygen-requiring (aerobic) forms of life. The result is a foul-smelling, waste-filled body of water. Untreated sewage blanket and in more severe cases the river can no longer support fish, insects and animals that live in and around the water.

Polluted water is unsuitable for drinking, recreation, agriculture, and industry. It diminishes the aesthetic quality of lakes and rivers. More seriously, contaminated water destroys aquatic life and reduces its reproductive ability.



Eventually, it is a hazard to human health. Nobody can escape the effects of water pollution.

Once an aquifer is contaminated, it may be unusable for decades. The residence time, as noted earlier, can be anywhere from two weeks or 10 000 years.

### Alternatives to ozone-depleting halocarbons

Hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) are alternative halocarbons being used to replace ODS in industrial and commercial applications and their use is becoming more widespread. Other alternatives to ODS include ammonia, carbon dioxide and hydrocarbons.

### The relationship between ozone-depleting substances and their halocarbon alternatives and global warming

Ozone-depleting substances (ODS) and their halocarbon alternatives have a direct global warming potential and contribute to climate change. The production of some ozone depleting substances (e.g. CFCs) has been ceased worldwide resulting in emission reductions of ozone-depleting substances into the atmosphere. However, emissions of other ODS (e.g. hydrochlorofluorocarbons [HCFCs]) and ODS alternatives (e.g. hydrofluorocarbons [HFCs]) is expected to continue to increase.

HFCs are ODS refrigerants alternatives and their use is becoming more widespread. Although HFCs have no ozone-depletion potential they do have high global-warming potential and are thousands times more potent greenhouse gases than carbon dioxide.

Regulations that prevent or minimize ODS and other halocarbons emissions serve a dual environmental benefit of lowering emissions that destroy the ozone layer and contribute to climate change.

### Are ozone-depleting substances still an important environmental concern?

Although the production and use of many ODS has been phased out, the control of ODS emissions continues to be an important environmental issue, as the destruction of the earth's protective stratospheric ozone layer causes increased health risks and environmental impacts, such as cataracts, skin cancer and climate change.

### Air Pollution ...

- In past there was bull cart, donkey carts animals were used but now a days aeroplane, cars, buses and trains are used for transportations. These vehicles need energy for their working in the form of petrol or gas. to provide energy for motion of vehicle. The end product of this burning include energy plus different gasses include hydrocarbons, nitrogen oxides, carbon monoxide, sulphur, heavy metals and particles. These gases enter into air and pollute in, when human breath in such polluted environment it causes asthma, coughing nausea, chest pain, bronchitis diseases etc.
- It is estimated that usually 24000 deaths per annum occur due to air pollution because pollution damage central Nervous System.
- Automobiles are responsible for depletion of ozone in stratosphere sheet because of source of CFCs entering the atmosphere which is escape from vehicle air condition (ACs)
  - Vehicles are responsible for 80% pollution in metropolitan region three fold increases in per capita energy consumption for global warming as burning of fuel produces CO<sub>2</sub>.
- Ways to improve impacts of car like uses of small cars, clearer cars, efficient engine catalytic converters are compulsory and use of biocheral.
  - Fuel cells cause only water comes out as its exhaust electrical vehicle pose problem because of range of batteries and sepe. Hybrid electric petrol they are providing solution for this pollution they cut down the fuel wastage and effect the high energy fuel on board.
  - Restricts the occurs to the cities or part of cities e.g. Chester York, oxford have driven the apparently to pack and ride they have given free space for parking at the edge of town.
  - Improve information about road condition and public transport.
- Technological changes to reduce cooling zone of engine wall and reduce hydrocarbon and carbon monoxide emission. Computer control at IC engine.
  - Catalytic converter technology (CCT) emission
  - Trap oxidizers ad ceramic filter an Diesel vehicles
  - Direct injection fuel efficient Diesel



## Ozone

Ozone layer is found in the stratosphere approximately 10-50 km above the earth surface. Ozone molecules have three atoms of oxygen instead of the normal two. The ozone layer protects us from the harmful effects of certain wave lengths of ultra violet (UV) light coming from the sun, especially UV. Any significant decrease in ozone in the atmosphere would result in an increase of UV radiation reaching the earth surface. Increase in levels at UV radiation can result in the increase in skin cancer; suppress the immune system, eye disorder including cataract and effect plants, animals and plastic materials.

## Ozone Depletion

In 1985, scientists discovered that there is severe ozone depletion in the Antarctic region, which was confirmed by American Satellite observations.

Chlorofluorocarbons (CFCs) were invented in 1928 found many used in foams, refrigeration, air conditioners, solvent, fire extinguishers etc. these CFCs are long lived and their emissions reach stratosphere and cause ozone depletion. This has been dramatically confirmed through Antarctic ozone hole.

The United Nations Environment Programme (UNEP) has been addressing the issue of depletion of the ozone layer since 1977 and in 1981 UNEP's Governing Council set up a working group to prepare nine global framework conventions for protection of ozone layer.

By reducing the use of CFCs we can protect ozone layer for saving the environment from harmful effects. Montreal protocol on substances that deplete the ozone layer was finally agreed upon on 16<sup>th</sup> September 1987 and adopted by the Government in this protocol ozone depleting substances are banned.

## Natural Water Purification Methods

There are several, natural ways that you can purify water.

In the event of an emergency it may become necessary to purify the water that you drink to avoid getting sick. Though many people think purifying water is difficult, there are a number of simple, natural means of purifying water that can easily be used in an emergency.

### Sand

- One of the most common ways that water is purified is by passing it through sand and soil. If contaminated water (say urine) is poured onto fine sand, the water is going to travel down until it reaches the saturation level. The other chemicals that are mixed with the water, though, will be held back by the sand until only the water is left. This is the same method of water purification used in many sewage treatment facilities as a big part of separating water out of the waste that goes through the plant.

### Boiling

- Water can be boiled to make it more pure. Boiling water kills bacteria and other germs in the water, which makes it safer to drink. Or, build a water still that functions off boiling. Water is poured into a sealed pot, with a tube leading out of it. The water turns into steam, and the steam escapes through the tube. The tube transports the steam to another container, where the steam condenses back into water. This process can eliminate more contaminants from water (such as salt), but it's also more complicated.

### Cloth Filtration

- Cloth filters can be used to help keep larger contaminants out of water. This process is very simple; pour the water through a cloth, or through several layers of cloth, and the cloths' weave will strain the water and hold back impurities. This is the same process that happens when a coffee filter is used, except that the filter is paper rather than cloth. Paper can work as well, and if you have coffee filters or similar devices you can easily use those instead of a clean cloth to strain your water.



## How rain water seepage through hazardous waste dumpsites can dissolve in drinking water supplies

### Hazardous waste:

Hazardous waste is waste that is dangerous or potentially harmful to our health or the environment. Hazardous wastes can be liquids, solids, gases, or sludges. They can be discarded commercial products, like cleaning fluids or pesticides, or the by-products of manufacturing processes. It is very important to dispose off hazardous waste carefully otherwise it contaminate the air, water, and soil.



## Groundwater:

Groundwater is rain water or water from surface water bodies, like lakes or streams, that soaks into the soil and bedrock and is stored underground in the tiny spaces between rocks and particles of soil.

Groundwater contaminants come from two categories of sources: point sources and distributed, or non-point sources. Landfills, leaking gasoline storage tanks, leaking septic tanks, and accidental spills are examples of point sources. Infiltration from farm land treated with pesticides and fertilizers is an example of a non-point source.

Among the more significant point sources are municipal landfills and industrial waste disposal sites. When either of these occur in or near sand and gravel aquifers, the potential for widespread contamination is the greatest.

Leaks of petroleum products have been increasing over the last two decades because underground steel tanks installed in large numbers in the 1950s and 1960s have become corroded. Before 1980, most underground tanks were made of steel. Without adequate corrosion protection, up to half of them leak by the time they are 15 years old.

Groundwater dissolves many different compounds, and most of these substances have the potential to contaminate large quantities of water. For example, one litre of gasoline can contaminate 1 000 000 litres of groundwater. This problem is particularly severe in the Atlantic provinces where there is a high usage of groundwater. In many cases, the problem is noticed long after the aquifer is contaminated, for example, when consumers start tasting or smelling gasoline.

Groundwater can become contaminated in many ways. Chemicals from hazardous wastes buried in unsecured landfills. If rain water or surface water comes into contact with contaminated soil while seeping into the ground, it can become polluted and can carry the pollution from the soil to the groundwater. From here, contaminants can spread to wells or surface water, making it unsafe to drink.

Groundwater can also become contaminated when liquid hazardous substances themselves soak down through the soil or rock into the groundwater. Some liquid hazardous substances do not mix with the groundwater but remain pooled within the soil or bedrock. These pooled substances can act as long-term sources of groundwater contamination as the groundwater flows through the soil or rock and comes into contact with them. Groundwater contamination is extremely difficult, and sometimes impossible, to clean up.

Apart from chemical pollutants the major culprits are Bacteria and Viruses which cause most of the commonly found water borne diseases.

**Bacterial diseases:** Gastro-enteritis, Typhoid, Cholera, Paratyphoid, Dysentery and Diarrhea.

**Viral diseases:** Polio, Dysentery, Gastro-enteritis, Diarrhea and Jaundice (Hepatitis)

## Replacing CFCs

Few compounds have CFCs combination of non-flammability, non-toxicity and inertness, and for uses such as refrigeration and aerosols it is necessary to find compounds with exactly the right boiling point.

Some of the important replacements for these uses are the hydrofluorocarbons, (also known as hydrofluorocarbon or HFCs.). An example is 1,1,1,2-tetrafluoroethane,  $CF_3CH_2F$ , which is used as a refrigerant. HFCs have the advantage that they contain no  $Cl$  atoms, so they do not release damaging  $Cl$  radicals in the stratosphere. Moreover, their molecules include  $C-H$  bonds, which are relatively reactive, which means that these compounds break down in the atmosphere more quickly than CFCs so they do not persist for so long.

## KEY POINTS

- Actually our atmosphere has been divided into four layers:
- 1-Troposphere 2-Stratosphere 3-Mesosphere 4-Thermosphere.
- Photochemical smog is formed only when the atmosphere contains soot particles, hydrocarbons and oxides of nitrogen (mainly  $NO_2$ ).
- $H_2SO_4$ ,  $HNO_3$  and  $H_2CO_3$  formed in air come down the atmosphere as acid rain or acid snow.
- In automobiles during incomplete combustion of petrol, we get smoke of different gases which pollute our atmosphere. The engines used in these motor vehicles are called internal combustion engines.
- When petrol burns in a car engine, a very high temperature is produced. At this high temperature,  $N_2$  and  $O_2$  present in air of the engine combine together and form  $NO$  and  $NO_2$ . These gases pollute the air.



- Nuclear tests being conducted in the world generate high temperature. At high temperature, atmospheric nitrogen is favorably oxidized to  $\text{NO}$ .  $\text{NO}$  thus formed destroys ozone layer.
- By keeping the vehicle properly tuned for the optimum ignition of fuels. This method also prevents air pollution caused by  $\text{CO}$  and hydrocarbons present in the exhaust fumes of the vehicles.
- Use of fluoro-chloro carbons (e.g. Freon-1 and Freon-12) as aerosol spray propellant destroys the  $\text{O}_3$  layer, as oxides of nitrogen do.
- Water gets polluted by accidental oil spills, leakage from cargo oil tankers in sea, tanker trucks, pipelines leakage during offshore exploration, leakage of underground storage tanks
- Polycyclic hydrocarbons are carcinogenic even at very low concentration. Marine animals are seriously affected by soluble aromatic fractions of oil. The spilled oil damages the feather of the birds or fur of animals and sometimes causes their death.
- Surfactants are organic compounds having polar or hydrophilic groups such as  $-\text{COOH}$ ,  $-\text{SO}_3\text{H}$ ,  $\text{NH}_2$  or non-polar or lyophilic groups soluble in water.
- The waste heat from electrical generating stations is transferred to cooling water obtained from local water bodies such as a river, lake, or ocean.
- Water purification is a process of removing harmful substances and odor from a raw water source.

## EXERCISE

**Q1. Multiple Choice Questions. Encircle the correct answer:**

- ⊙ Read the question carefully.
- ⊙ Try to answer the question yourself before reading the answer choices.
- ⊙ Guess only if you can eliminate one or more answer choices.
- ⊙ Drawing a picture can help.
- ⊙ Don't spend too much time on any one question.
- ⊙ In-depth calculations are not necessary; approximate the answer by rounding.

- (1) Air is polluted by:
 

(a) toxic materials	(b) hydrocarbons	(c) harmful gases	(d) all of above
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- (2) Which of following gas is not pollution?
 

(a) $\text{SO}_2$	(b) $\text{CO}$	(c) $\text{CO}_2$	(d) $\text{NO}_2$
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- (3) Oxides of sulfur and nitrogen react with oxygen to form:
 

(a) bases	(b) acids	(c) salts	(d) all of above
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- (4) Oxidizing smog consists of high concentration of:
 

(a) $\text{SO}_2$	(b) Ozone	(c) $\text{NO}_2$	(d) $\text{Cl}_2$
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- (5) Thickness of ozone is:
 

(a) 20-25 km	(b) 25-28 km	(c) 30-32 km	(d) 20-30 km
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- (6) Ozone is destroyed by:
 

(a) $\text{SO}_2$	(b) $\text{NO}_2$	(c) Chlorofluorocarbons	(d) None of above
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- (7) In leather industry:
 

(a) chromium (VI) is used	(b) chromium (III) is used	(c) nickel is used	(d) aluminum is used
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- (8) Water is purified:
 

(a) aeration	(b) coagulation	(c) disinfection	(d) all of above
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- (9) The Ecosystem is the smaller unit of:
 

(a) biosphere	(b) lithosphere	(c) atmosphere	(d) hydrosphere
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- (10) When chlorine is passed through water then the disinfection is done due to the production?
 

(a) $\text{HCl}$	(b) $\text{HOCl}$	(c) $\text{NOCl}$	(d) $\text{HClO}_2$
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- (11) Peroxyacetylnitrate (PAN) is an irritant to human beings and it affects
 

(a) eyes	(b) ears	(c) stomach	(d) nose
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(12) Fungicides are the pesticides which

(a) control the growth of fungus

(c) kill plants

(b) kill insects

(d) kill herbs

## SOLVED EXERCISE MCQs

Q. No	Answer	Reason
(1)	(d) all of above	Air polluted by harmful gases like CO, NO <sub>x</sub> , SO <sub>2</sub> , Ozone, Hydrocarbons and toxic material.
(2)	(c) CO <sub>2</sub>	CO <sub>2</sub> is not a pollutant gas as it is required for photosynthesis.
(3)	(b) acids	In the atmosphere SO <sub>2</sub> and NO <sub>x</sub> are transformed by reactions with oxygen and water into H <sub>2</sub> SO <sub>4</sub> and HNO <sub>3</sub> respectively. These acids get mixed with rain. The acid deposition includes both wet (rain, snow, fog) and dry acidic deposition. $\text{SO}_2 + \frac{1}{2} \text{O}_2 + \text{H}_2\text{O} \xrightarrow{\text{Hydrocarbon, smoke, Metal oxide}} \text{H}_2\text{SO}_4$
(4)	(b) ozone	The photochemical smog consists of higher concentrations of oxidants like ozone and is also termed as oxidizing smog.
(5)	(b) 25-28km	The blue sky above us is ozone layer. Its thickness is 3km arranging from 25-28km.
(6)	(c) Chlorofluorocarbons	Chlorofluorocarbons used as refrigerants in air conditioning and in aerosol sprays are inert in the troposphere but slowly diffuse into stratosphere, where they are subjected to ultraviolet radiation generating Cl <sup>•</sup> free radicals. Chlorofluorocarbons (CFCs) play an effective role in removing O <sub>3</sub> in the stratosphere.
(7)	(a) chromium (VI) is used	Lather tanneries use big quantities of chromium (VI) salt for leather tanning. They are producing good variety of exportable leather but only some units have the facility of waste water treatment by reducing Cr (VI) into trivalent state followed by alkaline precipitation of Cr (OH) <sub>3</sub> .
(8)	(d) all of above	Surface water has various contaminations in it and required some treatment before use. Water is purified by the following stages: (i) Aeration (ii) Coagulation (iii) Water disinfections by Chlorine
(9)	(a) biosphere	Ecosystem consists of community of organisms and their interaction with environment while biosphere consists of all regions of earth capable of supporting life.
(10)	(b) HOCl	$\text{Cl}_2 + \text{H}_2\text{O} \longrightarrow \text{HOCl} + \text{H}^+ + \text{Cl}^-$
(11)	(a) eyes	PAN is an oxidizing agent and is irritant to eyes.
(12)	(a) control the growth of fungus	Fungicide → fungi (fungus) + cide (to kill)

## SHORT ANSWERS QUESTIONS

2. Give brief answers for the following questions.

(i) What are the components of Environment?

Ans. Components of the Environment

The environment consists of the following components.

(i) Atmosphere

(ii) Hydrosphere

(iii) Lithosphere

(iv) Biosphere



(ii) Briefly discuss the role of atmosphere in our environment.

Ans. The gases present in the atmosphere are very important in the following ways:

These gases absorb harmful radiations (cosmic rays and electromagnetic radiation) of sun to protect life on earth. Otherwise these rays are very harmful to living things on earth.  $N_2$  is used by nitrogen fixing bacteria  $O_2$  is necessary for breathing in animals.  $CO_2$  is necessary for photosynthesis in plant. Water vapours are responsible for sustaining life on earth.

(iii) What are the sources of air pollution?

Ans. Natural sources:

Pollutant gases like:  $CO$ ,  $NO_x$ ,  $SO_2$  and hydrocarbons are naturally produced by volcanic eruption, natural gas emission, bacterial action and decomposition of organic matter.

Human activities:

Fuel burning in various types of transportation *i.e.*, motor vehicles, railways and aircraft is the major source (75%) of pollution in the atmosphere. Other sources are forest fires, combustion of fossil fuel and agricultural products.

(iv) What are the important air pollutants?

Ans. The important air pollutants are:

(i) Primary pollutants ( $SO_2$ ,  $SO_3$ ,  $CO$ ,  $NH_3$ , Hydrocarbons etc.)

(ii) Secondary pollutants ( $H_2SO_4$ ,  $H_2CO_3$ ,  $HCl$ , PAN, Ozone etc)

(v) What are the sources of  $CO$  emission? Discuss its effects.

Ans. Sources of  $CO$  emission:

- Natural sources of carbon monoxide emission are volcanic eruption, natural gas emission and oxidation of methane in the atmosphere.
- Fuel burning in various types of vehicles.
- Other sources of carbon monoxide emission are forest fires, combustion of fossil fuel and agricultural products.
- Incomplete combustion and dissociation of  $CO_2$  at high temperature also produces  $CO$ .

Effects of  $CO$ :

- It causes suffocation if inhaled.
- It binds bloods hemoglobin more strongly than oxygen thus excluding oxygen from normal respiration.
- Exposure to high concentration of  $CO$  results in headache, fatigue, unconsciousness and eventually death (if such exposure is sustained for longer period).

(vi) Differentiate between:

(i) Industrial and Photochemical Smog (ii) Primary and Secondary Pollutants.

Ans. (i) Industrial and Photochemical Smog

Industrial Smog:

Under suitable condition,  $SO_2$  (produced from the burning of coal) combines with smog to produce industrial smog.

Photochemical Smog:

It is formed due to photochemical reaction of sunlight on the nitrogen oxides and hydrocarbons produced by automobile and factories. It occurs in warm, dry and sunny climate. It has high concentration of oxidants like  $O_3$  and therefore is oxidizing in nature. It causes irritation in eyes and toxic to plants.



**(ii) Primary and Secondary Pollutants.**

Primary Pollutants	Secondary Pollutants
The pollutants which are directly introduced into the environment are called primary pollutants.	The pollutants which are produced in atmosphere through various reactions of primary pollutants are called secondary pollutants.
<b>Examples:</b> Sulphur dioxide, sulphur trioxide, nitrogen oxides, carbon monoxide, hydrocarbons, ammonia, compounds of fluorine and radioactive materials.	<b>Examples:</b> Sulphuric acid, nitrogen monoxide, carbonic acid, hydrofluoric acid peroxyacetyl-nitrate (PAN), ozone, aldehydes, ketones and peroxybenzole.

**(vii) How does photochemical smog differ from reducing smog?**

Ans.

Reducing Smog (Classical Smog)	Oxidizing Smog (Photochemical Smog)
It is formed due to the build up of sulphur dioxide from combustion of coal.	It is formed due to photochemical reaction of sunlight on the nitrogen oxides and hydrocarbons produced by automobile and factories.
It mostly occurs in cool humid climate.	It occurs in warm, dry and sunny climate.
It has high concentration of $\text{SO}_2$ and is therefore reducing in character.	It has high concentration of oxidants like $\text{O}_3$ and therefore is oxidizing in nature.
It causes bronchitis and irritation i.e. problem in lungs.	It causes irritation in eyes and toxic to plants.

**(viii) What is global warming?**

Ans. Now when sunlight, consisting of ultra-violet rays, visible light and infra-red rays falls on the top of the atmosphere, the harmful ultra-violet rays are absorbed by the  $\text{O}_3$  layer and hence do not reach the earth's surface. On the other hand, the visible light and infra-red rays pass through the  $\text{CO}_2$  layer and fall on the earth. Since the infra-red radiations have heating effect, they heat the earth and its various objects. This is called global warming.

**(ix) What are the latest predictions about global warming?**

Ans. Latest predictions about global warming:

- If the atmosphere contains too much quantity of  $\text{CO}_2$ , the greenhouse effect is considerably increased.
- Thus, due to excess quantity of  $\text{CO}_2$  present in the atmosphere; the temperature of the earth is increased too much. This too much high temperature melts all the glaciers (snow-mountains) floods the low-lying areas of the earth.
- It also changes the biological activity of oceans and the patterns of cropping etc.

**(x) What gases are responsible for greenhouse effect?**

Ans. Following gases are responsible for greenhouse effect:

- $\text{CO}_2$  &  $\text{CO}$
- $\text{NO}_x$  ( $\text{NO}$  and  $\text{NO}_2$ )
- Methane ( $\text{CH}_4$ )
- CFCs

**(xi) Briefly discuss the effects of acid rain.**

Ans. Harmful effects of acid rain:

- It makes the lakes so acidic that they can no longer support fish life.
- The yield of agricultural crops is also reduced.
- $\text{HNO}_3$  acid rain gradually eats up lime stone and marble of the buildings and corrodes metals.



- (iv) It is very corrosive and attacks skin.
- (v) Acidification of soil and rocks can leach metals like Al, Hg, Pb and Ca and discharge them into water bodies. Then these heavy metals are eaten by fishes which proves very much dangerous for those animals and birds which eat these fishes.
- (vi) It also damages steel, paint, plastic, cement, masonry work and sculptural materials.

**(xii) What are different sources and Environment effects of:**

(i) VOCs                      (ii) PAN

**Ans. (i) Volatile Organic Compounds (VOCs)**

**Sources:**

- Evaporation of solvents and fuels
- Incomplete combustion of fossil fuels
- Naturally occurring compounds like terpenes from trees

**Environmental Effects:**

- Eye irritation
- Respiratory irritation
- Some are carcinogenic
- Decreased visibility due to blue-brown haze

**(ii) Peroxyacetyl Nitrates (PAN)**

**Sources:**

- Formed by the reaction of  $\text{NO}_2$  with VOCs (can be formed naturally in some environments)

**Environmental Effects**

- Eye irritation
- High toxicity to plants
- Respiratory irritation
- Damaging to proteins

**Q.2(xiii) is missing in Federal Text Book.**

**Ans. ???**

**(xiii) What are the effects of excess of  $\text{CO}_2$  present in the atmosphere.**

**Ans. Effect of excess of  $\text{CO}_2$  present in the atmosphere:**

If the atmosphere contains too much quantity of  $\text{CO}_2$ , the greenhouse effect is considerably increased i.e. the atmosphere; the temperature of the earth is increased too much. This too much high temperature melts all the glaciers (snow-mountains) floods the low-lying areas of the earth, changes the biological activity of oceans and the patterns of cropping etc. Thus we see that the presence of the excess of  $\text{CO}_2$  in the atmosphere brings about climate changes.

**(xiv) Discuss the sources and typical effects of  $\text{SO}_2$  as pollutant.**

**Ans. Sulphur dioxides ( $\text{SO}_2$ )**

**Sources:**

- Volcanic Eruption
- Burnt of oil & coal
- Sulphide ores are roasted

**Typical Effects:**

- Causes acid rain
- Respiratory irritation
- Loss of green color in plants
- Fading in color of Fabrics, leathers, paper and paints



**(xv) Briefly discuss the sources and typical effects of oxides of nitrogen (NO<sub>x</sub>).**

**Ans. Nitrogen Oxides (NO and NO<sub>2</sub>)**

**Sources:**

- Combustion of oil, coal, gas in both automobiles and industry.
- bacterial action in soil
- forest fires
- volcanic eruption
- lightning

**Typical Effects:**

- Decreased visibility due to yellowish color of NO<sub>2</sub>
- NO<sub>2</sub> contributes to heart and lung problems
- NO<sub>2</sub> can suppress plant growth.
- decreased resistance to infection
- may encourage the spread of cancer

**(xvi) What is ozone? How does it work as safeguard?**

**Ans. Ozone:**

Ozone is an allotrope of O<sub>2</sub>. It has low boiling point and present in very small concentrations throughout the atmosphere.

**Ozone as safeguard:**

The ozone layer in the stratosphere surrounds the globe and filters most of the harmful ultraviolet (UV) rays in the sunlight before they could reach on the earth. Therefore, if there is substantial reduction in the ozone layer the life on earth would be threatened.

**(xvii) How ozone is formed in stratosphere?**

**Ans.** O<sub>3</sub> is produced in the upper part of the atmosphere by the action of sunlight on O<sub>2</sub>.



Some O<sub>3</sub> is produced during various combustion processes taking place in the air around us.

**(xviii) What do you know about "ozone hole"?**

**Ans. Ozone Hole:**

The thickness of the ozone layer has been decreasing over Antarctic during the spring time. The region in which ozone depletes substantially in every year during Sep-Nov is now termed as "ozone hole".

**(xix) How is ozone layer depleting?**

**Ans.** Chlorofluorocarbons (CFCs) were invented in 1928 found many used in foams, refrigeration, air conditioners, solvent, fire extinguishers etc. these CFCs are long lived and their emissions reach stratosphere and cause ozone depletion. This has been dramatically confirmed through Antarctic ozone hole.

**(xx) What are the effects of ozone layer depletion?**

**Ans.** Any significant decrease in ozone in the atmosphere would result in an increase of UV radiation reaching the earth surface. Increase in levels of UV radiation can result in the increase in skin cancer; suppress the immune system, eye disorder including cataract and effect plants, animals and plastic materials.

**(xxi) What should we do to save ozone?**

**Ans.** In order to save the destruction of O<sub>3</sub> layer by fluoro-chloro carbons, their use should be banned. Some new types of substances should be discovered which may be used as aerosol spray propellants and should not react with O<sub>3</sub> layer.

**(xxii) What is water pollution? Write different types of water pollutants.**

**Ans. Water pollution:**

The contamination of water with the substances which have adverse effects on human beings, animal and plants is called water pollution.



**Types of water pollutants:**

Water pollutants are of following two types:

**(i) Suspended solids and sediments**

- Oil Spillage
- Live-Stock Waste
- Industrial Wastes
- Leather Tanneries

**(ii) Dissolved Solids**

- Detergents
- Pesticides
- Chemical Fertilizers

**(xxiii) Briefly discuss the effects of water pollution.****Ans. Effects of water pollution:**

- Chemical and bacterial contents in livestock waste can contaminate surface and ground water causing such infectious diseases as dysentery (پیدچس), typhoid (معیادی بخار) and hepatitis (ورم جگر).
- The spilled oil damages the marine life often causing death. The light transmission through surface of water is affected by oily layer on it thus photosynthesis of the plants and dissolved oxygen in water is decreased.
- Detergent contents of waste water mobilize the bound toxic ions of heavy metals such as Pb, Cd, and Hg from sediments into water.
- Wide spread use of pesticides for getting greater crop yields if not properly checked and controlled has associated risks of contaminating the soil, plants and water.
- When synthetic organic chemicals are ingested through food or drinking water, they can cause health problems. At high concentrations, they can cause nausea (سگی), dizziness tremors (بے ہوشی کے دورے), and blindness (انورحاپن).

**(xxiv) How preliminary treatment of waste water is done?**

Ans. In preliminary treatment most of the suspended particles are removed which are visible.

**(xxv) What is primary treatment of waste water?****Ans. Primary treatment of waste water:**

- Primary treatment involves the removal of sand particles and other particles which are visible. This is done by sedimentation and coagulation.

**(xxvi) What is secondary treatment of waste water?****Ans. Secondary treatment involves:**

- Solids removal
- Oils and greases
- Soft organics
- Hard organics
- Acid and alkalis
- Toxic materials



**(xxvii) How would you avoid from thermal pollution?**

**Ans.** The companies use water in cooling their generators. When hot water is released in water bodies, it decreases the solubility of dissolved oxygen. Thus causes serious threat to life in water. So, the companies should decrease the temperature of hot water before discharging into water bodies.



**Q.3. Give detailed answers for the following questions.**

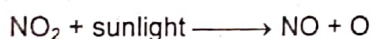
**(1) Describe different chemical reactions occurring in our atmosphere.**

**Ans. Chemical Reactions in the Atmosphere**

- Nitrogen dioxide can be formed by one of the following reactions. Notice that the nitrogen oxide (NO) acts to remove ozone (O<sub>3</sub>) from the atmosphere and this mechanism occurs naturally in an unpolluted atmosphere.



Sunlight can break down nitrogen dioxide (NO<sub>2</sub>) back into nitrogen oxide (NO).



- The atomic oxygen (O) formed in the above reaction then reacts with one of the abundant oxygen molecules (which makes up 20.94 % of the atmosphere) producing ozone (O<sub>3</sub>).



- Nitrogen dioxide (NO<sub>2</sub>) can also react with radicals produced from volatile organic compounds in a series of reactions to form toxic products such as peroxyacetyl nitrates (PAN).



**(3) How would you control air pollution? Describe different methods.**

**Ans. Controlling air pollution:**

In order to control the air pollution, the following methods are used:

- (i) By adding tetraethyl lead, TEL, Pb(C<sub>2</sub>H<sub>5</sub>)<sub>4</sub> to petrol:**

TEL, Pb(C<sub>2</sub>H<sub>5</sub>)<sub>4</sub> is added to the petrol to slow down the rate of combustion of petrol. TEL, Pb(C<sub>2</sub>H<sub>5</sub>)<sub>4</sub> provides more time to the petrol for its combustion and hence enables it to burn more completely. Due to this the quantity of unburnt hydrocarbons and CO coming out of the engine, with exhaust gases is reduced and hence air pollution is also minimized.

- (ii) Catalytic oxidation/Converter:** The pollution of air caused by unburnt hydrocarbons and CO present in the exhaust gases of the vehicle's engine can also be reduced by attaching gas device with the vehicle's engine, in which the exhaust gases can be mixed with more air and then burnt completely in the presence of platinum catalyst before they are discharged into the environment. Hydrocarbons and CO are oxidized by O<sub>2</sub> of the air in presence of platinum catalyst.

