

ENVIRONMENTAL CHEMISTRY-I

ATMOSPHERE

Conceptual Linkage

Before reading this chapter, the student must know the:

- Definitions and differences among ion radical, atom and molecules
- Common elements their symbols and basic characters
- Introduction of acidic matter

Time Allocation

Teaching periods	= 10
Assessment periods	= 02
Weightage	= 07%

LEARNING OUTCOMES

Students will be able to:

- Define atmosphere. (Remembering)
- Explain composition of atmosphere. (Understanding)
- Differentiate between stratosphere and troposphere. (Analyzing)
- Summarize the components of stratosphere and troposphere. (Understanding)
- Describe major air pollutants. (Understanding)
- Describe sources and effects of air pollutants. (Understanding)
- Explain ozone formation. (Understanding)
- Describe acid rain and its effects. (Understanding)
- Describe ozone depletion and its effects. (Understanding)
- Describe global warming. (Understanding)

Introduction

Atmosphere is the layer of gases that covers our planet earth. The atmosphere contains almost 78% nitrogen, 20.95% oxygen, 0.93% argon, 0.04% carbon dioxide, and trace amounts of other gases. In addition to these gases about 1% water vapours also constitute an important part of this atmosphere. This mixture of gases is commonly known as air and the area where this air and some other species lie is called Atmosphere.

compared with the diameter of the earth, the atmosphere is very thin, and almost lasts for up to about 500Km. But remember that there is no definite boundary of this atmosphere and it slowly thins and finally fades into outer space.

The atmosphere is very important for maintaining life on this planet earth, as all the livings of this planet rely upon the air for their normal life processes e.g the respiration, It also serves as the thermo blanket which maintains a specific temperature for these organisms. It is the coating of the gases of atmosphere that protects the earth and life on earth from the hazardous radiation of space.

14.1 Composition of the Atmosphere

Although we live and see a little part of the earth atmosphere but in real the atmosphere of the earth is not just composed of few gases, but some other constituents are also present here. These constituents are present in the form of different layers, each having a distinct character. There is a delicate relation and effect of these layers upon the life forms of the earth. Any change in the composition of atmosphere could be fatal not only to us but also on all life forms. So we must have to maintain the composition of the earth's atmosphere as it is.

14.2 The Layers of Atmosphere

The atmosphere of earth is made up of several layers which are composed of different constituents and each layer serves in different way, which the nature has given to it.

In the subsequent section we will see the composition and functions of each of these layers separately.

14.2.1 Troposphere

The troposphere is the lowest layer of the atmosphere which begins at the surface of earth and extends to between 7 km to 14 km, with some variation due to weather factors. Most of the mass of earth atmosphere (about 75%) is present here in this layer.

The troposphere is the only atmospheric layer that can support life, where large amount of water vapour are present. The clouds develop here, and the birds fly here.

14.2.2 Stratosphere

The troposphere extends from the earth's surface up to the tropopause where the stratosphere begins. The stratosphere lasts up to the distance of almost

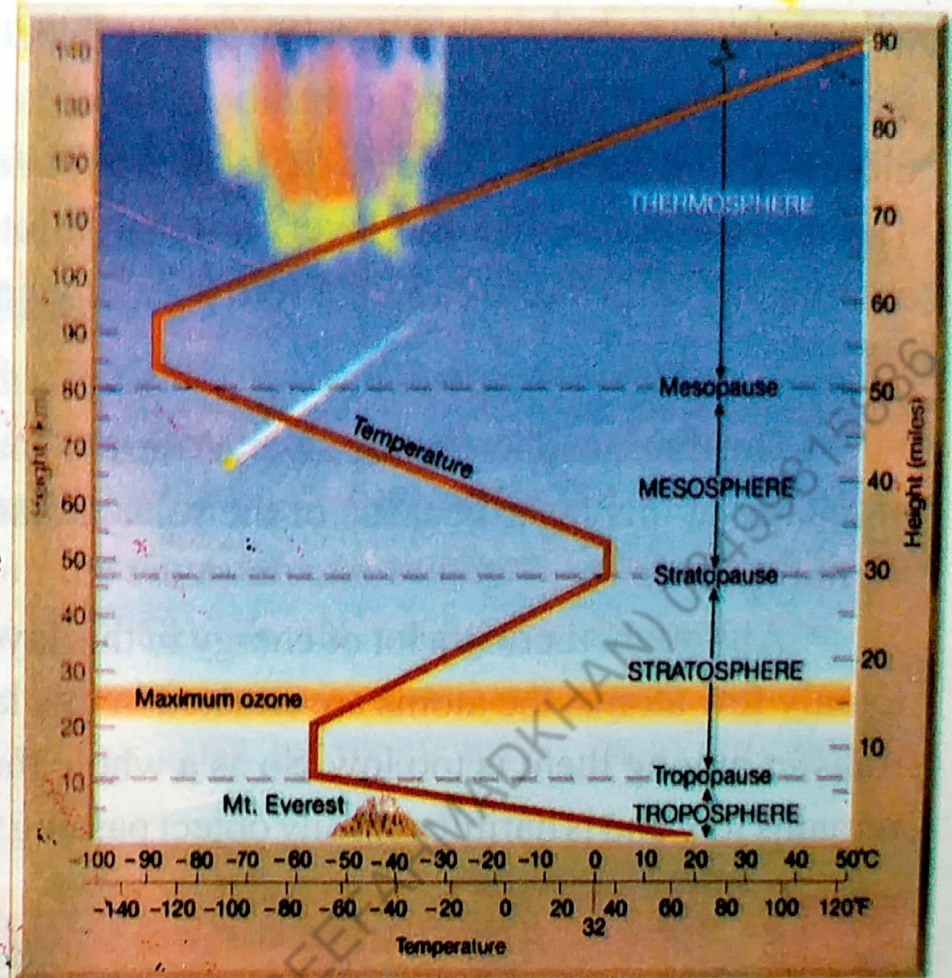


Fig. 14.1: Layers of Atmosphere

50Km from the surface of earth. The real importance of the stratosphere is the ozone layer (Some scientists classify this layer as ozonosphere). Where ozone (O_3) molecules (an allotropic form of the oxygen) absorb large amount of UV (ultra-violet) radiation of the sun. A chemical reaction takes place when an ozone molecule absorbs the UV radiation. The energy is then radiated as IR (infra-red) radiation, and that is what heats up the layer, and so this layer has relatively higher temperature than the other layers. Without the ozone, UV radiations would flood the surface of the earth causing destruction to the life.

14.2.3 Mesosphere

The mesosphere is the coldest region of atmosphere where the temperature ranges from 20°C to -80°C . The temperature falls as we move from the earth to the upper atmosphere. The mesosphere starts above from the stratosphere at about 50Km and lasts up to about 90Km. The amount of oxygen, nitrogen, and carbon dioxide in the mesosphere is almost same as that

in the levels of the earth's atmosphere immediately above the earth's surface. But the water vapour concentration here is very low, moreover the mesosphere contains higher percentages of ozone than the lower levels. The mesosphere is also the layer in which a lot of meteors burn up while entering the earth's atmosphere. From the earth they are seen as shooting stars.

14.2.4 Thermosphere

The thermosphere is the layer closest to space. There is a huge amount of energy in this layer because of the solar radiations from space hitting the thermosphere.

Although, there is a lot of energy in this layer, but this energy is limited to only few atoms, the atoms are situated in this layer at far distance and heat transfer among them is too low. So as a whole the overall heat of the system remains low and is harmless to any object passing there.

14.3 Environmental pollution and Pollutants

As the humanity grew towards the industrialization and humans discovered and made new inventions to ensure a high standard of life, they introduced into the environment such compounds which were not the part of natural environment ever before or they were present in smaller quantities. Among these additions there were also such compounds that caused a direct or indirect threat to living organisms and life forms of the planet earth. Such compounds were named **pollutants** that were affecting the natural functioning of our ecosystems and this phenomenon through which these pollutants are coming in our environment is called **environmental pollution**.

Thus a pollutant is a substance that causes contamination to the earth's environment affecting the quality of life, or the natural functioning of ecosystems.

Although some environmental pollution is a result of natural causes such as volcanic eruptions, most is caused by human activities. There are two main categories of polluting materials, or pollutants.

- **Biodegradable pollutants:**

These are materials, such as sewage, that rapidly decompose by natural

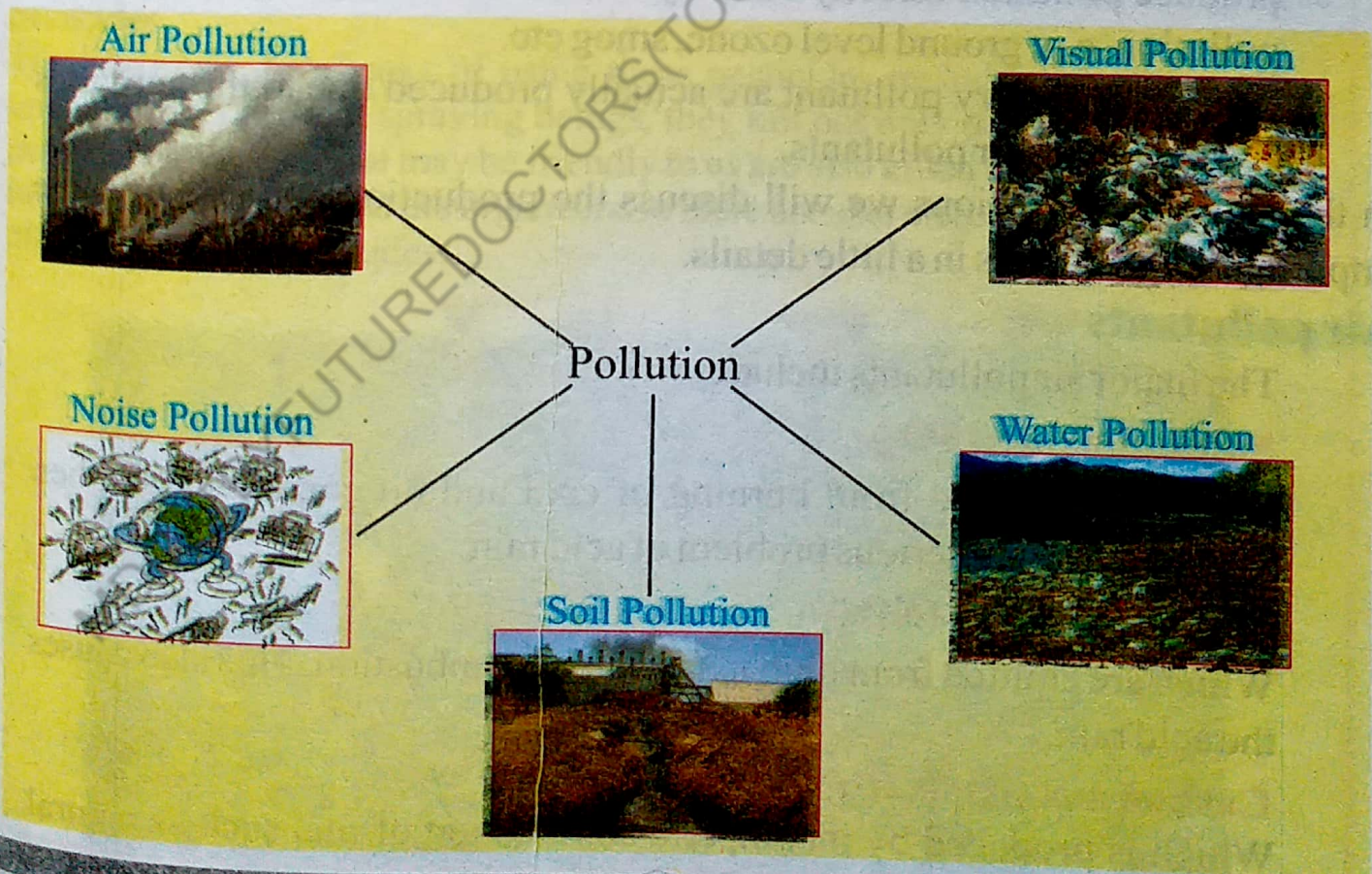
processes. These pollutants become a problem when added to the environment faster than they can decompose. Other examples of biodegradable pollutants include some gaseous substances, e.g CO , CO_2 , SO_2 , NO , NO_2 , hydrocarbon fuel vapours etc.

- **Non-degradable pollutants**

These are materials that either do not decompose or decompose slowly in the natural environment, so they cause a real danger to the livings and to the planet earth. Once such contamination occurs, it is difficult or impossible to remove these pollutants from the environment. Examples of such pollutants include chlorofluorocarbons (CFCs), dioxin pesticides, various types of plastic products, radioactive materials etc.

The pollutants pollute the earth by many ways, their pollution is classified further as:

- Air pollution
- Soil contamination
- Visual pollution
- Water pollution
- Noise pollution



Here we will discuss only the air pollution due to its greater importance, whereas the topic of water pollution has been discussed in next chapter in detail.

14.3.1 Air pollution

The air pollution is mainly caused by the release of chemicals and particulates into the atmosphere, for example by the carbon monoxide, carbon dioxide, sulfur dioxide, chlorofluorocarbons (CFCs), and nitrogen oxides produced by industry and motor vehicles, and also by some natural processes too, e.g. by the volcanic activities, which are rather uncontrollable. We are more concerned here with the man made sources of air pollution, which has grown up during industrialization.

On the basis of their role in the environment, the air pollutants have been divided into two major classes, discussed as follows,

- A. Primary air pollutants:** Which include SO_2 , NO_x , CO_x , hydrocarbons and particulate material like dust, ash, smoke etc.
- B. Secondary air pollutants:** These are the pollutants which do not produce pollution directly but they have indirect effect and thus cause pollution. e.g, ground level ozone, smog etc.

The secondary pollutant are actually produced due to the activities of primary air pollutants.

In the subsequent sections we will discuss the production and role of some important air pollutants in a little details.

Air pollutants

The major air pollutants include

- **Sulfur dioxide: (SO_2)**
Which are emitted from burning of coal and oil containing sulphur. This gas causes a serious problem of acid rain.
- **Nitrogen dioxide (NO_2)**
Which are emitted from high temperature combustion. This also causes the acid rain.
- **Carbon monoxide: (CO)**
Which is produced by incomplete combustion of fuel such as natural

gas, coal or wood. Vehicular exhaust is a major source of carbon monoxide.

- **Carbon dioxide: (CO_2)**

Which is emitted in combustion processes and has caused the green house effect (increase in the temperature of earth atmosphere).

- **Particulate materials:**

These include smoke and dust, and even more poisonous Lead. They are the suspended particles 2.5-10 micrometers in diameter. that enter the nasal cavity, and even the bronchia and lungs.

- **Chlorofluorocarbons (CFCs):**

These are the organic compounds containing 'Cl' and 'F' elements. They emit from the spray paints, Freon refrigerant, DDT insecticide etc. These are harmful to the ozone layer. The ozone layer protects the earth from the hazardous ultraviolet radiations that come from the sun and other stars.

Interesting Information

Although the pesticides and herbicides are frequently used to and herbs produce the agriculture products in large quantities by controlling the pests of crops, but on the other hand there are a number of health hazard effects of using these pesticides.

The important drawbacks of using these pesticides include their direct effect upon the dwelling and spraying beings, they kill not only the disease producing pests but other pests that may be friendly to us are also killed by these. They enter into aquatic systems and the organisms in there are also affected by the poisonous effects of these insecticides.



- **Radioactive pollutants:**

They come out from the nuclear explosions and from the hospital usages which are disinfected by radioactive radiations.

- **Ground level ozone:**

Although the upper atmosphere ozone layer is beneficial to us, but at ground it is poisonous for living beings, this is produced by the equipments that utilizes high voltages, e.g the photo state machines, where the pungent smell of ozone is often detectable.

- **Odours:**

The odour or the smell comes from garbage, sewage, and industrial processes. The bad odour also indicates that there are germs which could cause diseases.

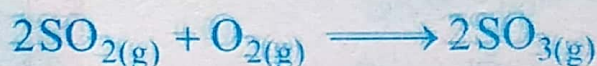
Interesting Information

A great problem that is arising in the highly populated cities of our country is the "Smog". The word Smog is the combination of smoke and fog. You may have noticed the problem of smog in many regions of the country, which usually becomes severe during winter season. The smog not only effects the health of the people of the areas but also causes the difficulties (and even accidents) in the flow of traffic.



14.4**The acid rain and its effects**

As already indicated that the acid rain is caused chiefly by two types of oxides, i.e sulphur oxides and nitrogen oxides. The term "Acid rain" is used to describe rain fall that has a pH level of less than 5.6. Acid rain is formed when oxides of sulphur or nitrogen combine with moisture in the atmosphere to make sulphuric acid and nitric acid. The sulphur dioxide reacts with the oxygen of air to give SO_3 which on combining with water forms sulphuric acid. This acid makes the water in rain acidic.



Similarly, the oxides of nitrogen, combines with water of atmosphere to form acidic products, e.g NO_2 and water.



These acids can be carried away far from their origin in clouds and then come down as rain fall. This acid rain has caused great environmental damages, and directly destroys the life forms where this acid rain falls. It has adverse impacts on forests, freshwaters and soils, killing off insect and aquatic life forms as well as causing damage to buildings and having possible impacts on human health.

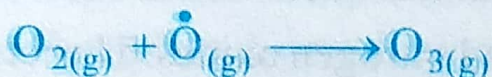
In order to prevent the acid rains a number of international treaties (e.g. montreal and Kyoto treaties) on the long range transport of atmospheric pollutants have been agreed, and this has significantly reduced the emission of hazardous gases into atmosphere, and thus has short down the acid rains.

14.5**Ozone depletion and its effects**

As described earlier that a protective layer of ozone gas is present at the upper atmosphere (Stratosphere), which protects the earth from the highly energetic and dangerous ultraviolet radiations. This process can be described by the following chemical reactions.



The O_2 produced again combines with the atomic oxygen to yield the ozone back.



In the late 1970s, scientists found that some chemicals called chlorofluorocarbons (CFCs) damage this protective layer. When chlorine of these CFCs react with the ozone there.



As it is seen above that this is a chain reaction and a single chlorine atom depletes thousands of ozone molecules, and thus the ozone is constantly depleting.

The ozone depletion is considered to have the following important effects upon the earth systems. As ozone stops the UV rays to penetrate into the earth, its depletion will allow this radiation into earth surface, which is expected to increase the skin cancer to humans. The increased UV radiations destroys the micro organisms and thus misbalancing the entire ecosystem.

The increase in UV also causes global warming directly and indirectly. Fortunately, the ozone hole yet discovered is at the antarctic region, where the

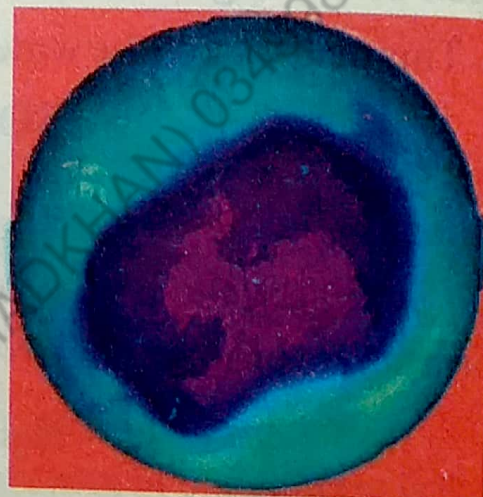


Fig. 14.2: Ozone hole (inside blue area) upon arctic region in Sep-1980

Interesting Information

Although the ozone gas is helping us to keep the planet earth safe from the destructive effects of solar and stars radiation and thus is playing a valuable role to fit the environment of earth for life, but itself the ozone is poisonous and causes undesirable effects when comes in contact. Many urban activities now a days cause the production of ground level ozone e.g sparks in electric equipments, and you may have observed this by the distinct smell of ozone near photo state machines. Thus ground level ozone is a form of air pollution.

life is not so abundant, and yet the damage to life has not been caused by this hole, but the measures are required to be taken to stop this damage.

In this consequence several steps have been taken, important of which is the ban on the usage of CFCs.

Summary of the Chapter

- ❖ Atmosphere is the layer of different gases that has covered our planet earth.
- ❖ Air is also a part or layer of the atmosphere which consists of 78% N_2 , 20.95% O_2 , 0.93% Ar, 0.04% CO_2 and some other gases in smaller amounts.
- ❖ The atmosphere is extended up to about 500km above the earth, but its concentration decreases slowly and it has no strict boundary.
- ❖ The atmosphere plays very important role in sustaining life at earth.
- ❖ The atmosphere consists of various layers of which the important are troposphere, stratosphere, mesosphere and thermosphere.
- ❖ Ozonosphere which is actually a part of stratosphere filters off the hazardous ultraviolet radiations that come from sun and stars.
- ❖ The substances that contaminate the earth environment in a manner that quality of life is disturbed are called 'pollutant', and the process of spreading such contamination is called 'pollution'.
- ❖ The pollutants are of two types, one that decomposes natural way is called bio-degradable, and the second which does not degrades by nature which is called non-biodegradable.
- ❖ The branch of chemistry which deals with the study of elements found in our environment is called environmental chemistry.
- ❖ The pollution could be of types, for example air pollution, water pollution, soil pollution, noise pollution and visual pollution etc.
- ❖ The air pollution is the contamination of injurious substances into

atmosphere which are causing danger to living organisms on planet earth.

❖ The air pollutants are basically of two types, primary and the secondary.

❖ The primary pollutants are those who themselves produce pollution and so are dangerous for living organisms.

❖ The secondary air pollutants are those that do not produce pollution directly themselves but they indirectly are dangerous and create situation or are responsible for the creation of some hazardous substance that pollute air.

❖ Chlorofluoro carbons destroy the ozone layer of atmosphere, these compounds are present in spray paints, Freon refrigerant and insecticide spray like DDT.

❖ The oxides of sulphur and nitrogen produce acid rains.

Exercise

Q1: Fill in the blanks with suitable words.

- i) The mesosphere contains the same of gases as in near the earth crust.
- ii) Thermosphere is the layer having temperature.
- iii) Biodegradable pollutants decompose by
- iv) The ozone layer protects the earth from
- v) The ozone depletion is caused primarily by
- vi) The acid rain has a pH
- vii) Smog is the combination word of and
- viii) Different oxides of and are the major primary pollutants.
- ix) The temperature of mesosphere ranges.....
- x) Percentage of O_2 in atmosphere is.....

Q2: Choose the correct answer.

- i) The atmosphere contains almost the oxygen:
(a) 20% (b) 21% (c) 78% (d) 0.04%
- ii) The troposphere is the layer of atmosphere that exists at:
(a) Uppermost level (b) Lowermost level
(c) In middle (d) Non of above
- iii) Among following the primary air pollutant is the:
(a) SO_2 (b) CFCs (c) CO (d) All of the above
- iv) The main cause of acid rain is:
(a) SO_2 (b) NO_2
(c) Both SO_2 and NO_2 (d) Ozone and smog
- v) Green house effect is causing the temperature change and results in:
(a) Increase in temperature
(b) Decrease in temperature
(c) Retains temperature constant
(d) Does not has any effect up on temperature

- vi) Plastic is the pollutant which is:
- (a) Biodegradable (b) Non-biodegradable
(c) Primary pollutant (d) Secondary pollutant
- vii) Thermosphere layer lasts up to the altitude of
- (a) 100-350 km (b) 100-150 km
(c) 50-100 km (d) 5-100 km
- viii) The ozone layer prevents:
- (a) The light that comes from sun
(b) The heat energy that comes from sun
(c) The ultra violet rays that come from sun and stars
(d) The heat energy that escapes from earth
- ix) The percentage of CO_2 in the atmosphere is:
- (a) 0.04% (b) 25% (c) 78% (d) 21%
- x) Percentage of O_2 in Thermosphere is:
- (a) 78% (b) 21% (c) 0% (d) 4%

Q3: Explain with reasoning.

- i) Smog is produced mostly in winter season.
- ii) Although ozone is a pollutant but it is also necessary for livings too.
- iii) CO_2 gas is a pollutant but its presence is essential for living organisms.
- iv) What measures should be taken to fill the hole in ozone layer?
- v) How global warming is being caused?

- Q4 Discuss how the atmosphere plays the role in sustaining life on the earth?
- Q5: What is the composition of earth atmosphere?
- Q6: What do you understand by the term pollution? How the pollution creates?
- Q7: What are pollutants? Describe the difference between primary and secondary pollutants?
- Q8: How the ozone layer affects the earth life? Discuss main causes of ozone depletion?
- Q9: Explain how ozone is produced in atmosphere?