UNIT I

1. **Discuss the effect of air pollution.**

Effects of Air Pollution on Humans:

Even healthy people can experience health impacts from polluted air including respiratory irritation or breathing difficulties during exercise or outdoor activities. Your actual risk of adverse effects depends on your current health status, the pollutant type and concentration, and the length of your exposure to the polluted air.
High air pollution levels can cause immediate health problems including:

- Aggravated cardiovascular and respiratory illness
- Added stress to heart and lungs, which must work harder to supply the body with oxygen
- Damaged cells in the respiratory system

Long-term exposure to polluted air can have permanent health effects such as:

- Accelerated aging of the lungs
- Loss of lung capacity and decreased lung function
- Development of diseases such as asthma, bronchitis, emphysema, and possibly cancer
- Shortened life span

Those most susceptible to severe health problems from air pollution are:

- Individuals with heart disease, coronary artery disease or congestive heart failure
- Individuals with lung diseases such as asthma, emphysema or chronic obstructive pulmonary disease (COPD)
- Pregnant women
- Outdoor workers
- Older adults and the elderly
- Children under age 14
- Athletes who exercise vigorously outdoors

People in these groups may experience health impacts at lower air pollution exposure levels, or their health effects may be of greater intensity.

Effects of Air Pollution on Plants:

- Fluorine is the main air pollutant which affects the plants.
- Excess concentration of fluorine causes photo –toxicological effect.
- Reduces the yield of crop

- Reduces the photosynthesis
- Reduces the nutrients present in vegetables.

Effects of Air Pollution on Animals:

- Fluorine, Arsenic and lead affects the animals.
- Fluorine reduces milk production, lack of appetite, reduces fertility.
- Arsenic creates thirst, vomiting and respiration problems.
- Lead poisoning leads to inability to stand , diarrhoea and affects digestive track.

Effects of Air Pollution on Materials:

- Corrosion.
- Chemical attack.
- Abrasion.
- Deposit and removal.
- Sulphur dioxide, acids and gases leads to color deformation, loss of metal, reduction in tensile strength.
- Oxidants reduces tensile strength.
- Hydrogen sulphide and SPM leads to cracking.

Economic Effects of Air Pollution:

- Wastage of fuel through improper combustion.
- Reduces the economic development of a country.
- Creates non repairable damages to the monuments.
- Electronic and paper industry are affected.
- Clothes and other textile materials gets spoiled.
- Additional lighting is needed to improve the visibility.
- Glass and ceramic materials get affected.
- Affects the buildings and its components.

2. **Describe the structure and elements of atmosphere.**

Structure of Atmosphere:

The atmosphere can be divided into five layers according to the diversity of temperature and density. They are:

1. Troposphere
2. Stratosphere
3. Mesosphere
4. Thermosphere (Ionosphere)
5. Exosphere

Troposphere

- It is the lowermost layer of the atmosphere.
- The height of this layer is about 18 km on the equator and 8 km on the poles.
- The thickness of the troposphere is greatest at the equator because heat us transported to great heights by strong convectional currents.
- Troposphere contains dust particles and water vapour.
- This is the most important layer of the atmosphere because all kinds of weather changes take place only in this layer.
- The air never remains static in this layer. Therefore this layer is called ‘changing sphere’ or troposphere.
- The environmental temperature decreases with increasing height of the atmosphere. It decreases at the rate of 1 degree Celsius for every 165 m of height. This is called Normal Lapse Rate.
- The zone separating troposphere from the stratosphere is known as tropopause.
- The air temperature at the tropopause is about – 80 degree Celsius over the equator and about – 45 degree Celsius over the poles. The temperature here is nearly constant, and hence, it is called tropopause.

Stratosphere

- Stratosphere is found just above the troposphere.
- It extends up to a height of 50 km.
- The temperature remains almost the same in the lower part of this layer up to the height of 20 km. After this, the temperature increases slowly with the increase in the height. The temperature increases due to the presence of ozone gas in the upper part of this layer.
- Weather related incidents do not take place in this layer. The air blows horizontally here. Therefore this layer is considered ideal for flying of aircraft.

- The upper limit of the stratosphere is known as stratopause.
- One important feature of stratosphere is that it contains a layer of ozone gas.
- The relative thickness of the ozone layer is measured in Dobson Units.
- It is mainly found in the lower portion of the stratosphere, from approximately 20 to 30 km above the earth's surface.
- It contains a high concentration of ozone (O_3) in relation to other parts of the atmosphere.
- It is the region of the stratosphere that absorbs most of the sun's ultra-violet radiations.

Mesosphere

- It is the third layer of the atmosphere spreading over the stratosphere.
- It extends up to a height of 80 km.
- In this layer, the temperature starts decreasing with increasing altitude and reaches up to –100 degree Celsius at the height of 80 km.
- Meteors or falling stars occur in this layer.
- The upper limit of the mesosphere is known as mesopause.

Thermosphere

- This layer is located between 80 and 400 km above the mesopause.
- It contains electrically charged particles known as ions, and hence, it is known as the **ionosphere**.
- Radio waves transmitted from the earth are reflected back to the earth by this layer and due to this, radio broadcasting has become possible.
- The temperature here starts increasing with heights.

Exosphere

- The exosphere is the uppermost layer of the atmosphere.
- Gases are very sparse in this sphere due to the lack of gravitational force. Therefore, the density of air is very less here.

Composition of the atmosphere

- The atmosphere is made up of different gases, water vapour and dust particles.
- The composition of the atmosphere is not static and it changes according to the time and place.

Gases of the atmosphere

Constituent	Percent by Volume	Concentration in Parts Per Million (PPM)
Nitrogen (N_2)	78.084	780,840.0
Oxygen (O_2)	20.946	209,460.0
Argon (Ar)	0.934	9,340.0
Carbon dioxide (CO_2)	0.036	360.0
Neon (Ne)	0.00182	18.2
Helium (He)	0.000524	5.24
Methane (CH_4)	0.00015	1.5
Krypton (Kr)	0.000114	1.14
Hydrogen (H_2)	0.00005	0.5

- The atmosphere is a mixture of different types of gases.
- Nitrogen and oxygen are the two main gases in the atmosphere and 99 percentage of the atmosphere is made up of these two gases.
- Other gases like argon, carbon dioxide, neon, helium, hydrogen, etc. form the remaining part of the atmosphere.
- The portion of the gases changes in the higher layers of the atmosphere in such a way that oxygen will be almost negligible quantity at the heights of 120 km.
- Similarly, carbon dioxide (and water vapour) is found only up to 90 km from the surface of the earth.

CARBON DIOXIDE:

- Carbon dioxide is meteorologically a very important gas.
- It is transparent to the incoming solar radiation (insolation) but opaque to the outgoing terrestrial radiation.
- It absorbs a part of terrestrial radiation and reflects back some part of it towards the earth's surface.
- Carbon dioxide is largely responsible for the greenhouse effect.

- When the volume of other gases remains constant in the atmosphere, the volume of the carbon dioxide has been rising in the past few decades mainly because of the burning of fossil fuels. This rising volume of carbon dioxide is the main reason for global warming.

OZONE GAS:

- Ozone is another important component of the atmosphere found mainly between 10 and 50 km above the earth's surface.
- It acts as a filter and absorbs the ultra-violet rays radiating from the sun and prevents them from reaching the surface of the earth.
- The amount of ozone gas in the atmosphere is very little and is limited to the ozone layer found in the stratosphere.

Water Vapour

- Gases form of water present in the atmosphere is called water vapour.
- It is the source of all kinds of precipitation.
- The amount of water vapour decreases with altitude. It also decreases from the equator (or from the low latitudes) towards the poles (or towards the high latitudes).
- Its maximum amount in the atmosphere could be up to 4% which is found in the warm and wet regions.
- Water vapour reaches in the atmosphere through evaporation and transpiration. Evaporation takes place in the oceans, seas, rivers, ponds and lakes while transpiration takes place from the plants, trees and living beings.
- Water vapour absorbs part of the incoming solar radiation (insolation) from the sun and preserves the earth's radiated heat. It thus acts like a blanket allowing the earth neither to become too cold nor too hot.
- Water vapour also contributes to the stability and instability in the air.

Dust Particles

- Dust particles are generally found in the lower layers of the atmosphere.
- These particles are found in the form of sand, smoke-soot, oceanic salt, ash, pollen, etc.
- Higher concentration of dust particles is found in subtropical and temperate regions due to dry winds in comparison to equatorial and polar regions.
- These dust particles help in the condensation of water vapour. During the condensation, water vapour gets condensed in the form of droplets around these dust particles and thus clouds are formed.

3. **Explain the classification of air pollution or Gases causing air pollution.**

An air pollutant is known as a substance in the air that can cause harm to humans and the environment. Pollutants can be in the form of solid particles, liquid droplets, or gases. In addition, they may be natural or man-made. Pollutants can be classified as either primary or secondary. Usually, primary pollutants are substances directly emitted from a process, such as ash from a volcanic eruption, the carbon monoxide gas from a motor vehicle exhaust or sulphur dioxide released from factories.

Secondary pollutants are not emitted directly. Rather, they form in the air when primary pollutants react or interact. An important example of a secondary pollutant is ground level ozone — one of the many secondary pollutants that make up photochemical smog.

i. Sulphur oxides (SO_x):

SO_2 is produced by volcanoes and in various industrial processes. Since coal and petroleum often contain sulphur compounds, their combustion generates sulphur dioxide. Further oxidation of SO_2, usually in the presence of a catalyst such as NO_2, forms H_2SO_4, and thus acid rain. This is one of the causes for concern over the environmental impact of the use of these fuels as power sources.

ii. Nitrogen oxides (NO_x):

Especially nitrogen dioxide are emitted from high temperature combustion. Nitrogen dioxide is the chemical compound with the formula $N0_2$. It is responsible for photochemical smog, acid rain etc.

iii. Carbon monoxide:

It is a colourless, odourless, non-irritating but very poisonous gas. It is a product by incomplete combustion of fuel such as natural gas, coal or wood. Vehicular exhaust is a major source of carbon monoxide.

iv. Carbon dioxide (CO_2):

A greenhouse gas emitted from combustion but is also a gas vital to living organisms. It is a natural gas in the atmosphere.

v. Volatile organic compounds:

VOCs are an important outdoor air pollutant. In this field they are often divided into the separate categories of methane (CH_4) and non-methane (NMVOCs). Methane is an extremely efficient greenhouse gas which contributes to enhanced global warming.

Other hydrocarbon VOCs are also significant greenhouse gases via their role in creating ozone and in prolonging the life of methane in the atmosphere, although the effect varies depending on local air quality. Within the NMVOCs, the aromatic compounds benzene, toluene and xylene are suspected carcinogens and may lead to leukaemia through prolonged exposure. 1, 3-butadiene is another dangerous compound which is often associated with industrial uses.

vi. Particulate matter:

Particulates, alternatively referred to as particulate matter (PM) or fine particles, are tiny particles of solid or liquid suspended in a gas. In contrast, aerosol refers to particles and the gas together. Sources of particulate matter can be manmade or natural.

Some particulates occur naturally, originating from volcanoes, dust storms, forest and grassland fires, living vegetation, and sea spray. Human activities, such as the burning of fossil fuels in vehicles, power plants and various industrial processes also generate significant amounts of aerosols.

Averaged over the globe, anthropogenic aerosols—those made by human activities—currently account for about 10 per cent of the total amount of aerosols in our atmosphere. Increased levels of fine particles in the air are linked to health hazards such as heart disease, altered lung function and lung cancer.

vii. Persistent free radicals – connected to airborne fine particles could cause cardiopulmonary disease.

viii. Toxic metals – such as lead, cadmium and copper.

ix. Chlorofluorocarbons (CFCs) – harmful to the ozone layer emitted from products currently banned from use.

x. Ammonia (NH_3) – emitted from agricultural processes. Ammonia is a compound with the formula NH_3. It is normally encountered as a gas with a characteristic pungent odor. Ammonia contributes significantly to the nutritional needs of terrestrial organisms by serving as a precursor to foodstuffs and fertilizers. Ammonia, either directly or indirectly, is also a building block for the synthesis of many pharmaceuticals. Although in wide use, ammonia is both caustic and hazardous.

xi. Odours – such as from garbage, sewage, and industrial processes

xii. Radioactive pollutants – produced by nuclear explosions, war explosives, and natural processes such as the radioactive decay of radon.

Secondary pollutants include:

i. Particulate matter formed from gaseous primary pollutants and compounds in photochemical smog. Smog is a kind of air pollution; the word “smog” is a portmanteau of smoke and fog. Classic smog results from large amounts of coal burning in an area caused by a mixture of smoke and sulphur dioxide. Modern smog does not usually come from coal but from vehicular and industrial emissions that are acted on in the atmosphere by sunlight to form secondary pollutants that also combine with the primary emissions to form photochemical smog.

ii. Ground level ozone (O_3) formed from NO_x and VOCs. Ozone (O_3) is a key constituent of the troposphere (it is also an important constituent of certain regions of the stratosphere commonly known as the Ozone layer). Photochemical and chemical reactions involving it drive many of the chemical processes that occur in the atmosphere by day and by night. At abnormally high concentrations brought about by human activities (largely the combustion of fossil fuel), it is a pollutant, and a constituent of smog.
iii. Peroxyacetyl nitrate (PAN) – similarly formed from NO_x and VOCs.

4. Discuss about the various sources of air pollution.

Sources of air pollution refer to the various locations, activities or factors which are responsible for the releasing of pollutants in the atmosphere. These sources can be classified into two major categories which are:

Anthropogenic sources
Human activity mostly related to burning different kinds of fuel:

i. "Stationary Sources" include smoke stacks of power plants, manufacturing facilities (factories) and waste incinerators, as well as furnaces and other types of fuel-burning heating devices.

ii. "Mobile Sources" include motor vehicles, marine vessels, aircraft and the effect of sound etc.

iii. Chemicals, dust and controlled burn practices in agriculture and forestry management. Controlled or prescribed burning is a technique sometimes used in forest management, farming, prairie restoration or greenhouse gas abatement. Fire is a natural part of both forest and grassland ecology and controlled fire can be a tool for foresters. Controlled burning stimulates the germination of some desirable forest trees, thus renewing the forest.

iv. Fumes from paint, hair spray, varnish, aerosol sprays and other solvents.

v. Waste deposition in landfills, which generate methane. Methane is not toxic; however, it is highly flammable and may form explosive mixtures with air. Methane is also an asphyxiate and may displace oxygen in an enclosed space. Asphyxia or suffocation may result if the oxygen concentration is reduced to below 19.5% by displacement.

vi. Military, such as nuclear weapons, toxic gases, germ warfare and rocketry.

Natural sources:

i. Dust from natural sources, usually large areas of land with little or no vegetation.

ii. Methane, emitted by the digestion of food by animals, for example cattle.

iii. Radon gas from radioactive decay within the Earth's crust. Radon is a colourless, odourless, naturally occurring, radioactive noble gas that is formed from the decay of radium. It is considered to be a health hazard. Radon gas from natural sources can accumulate in buildings, especially in confined areas such as the basement and it is the second most frequent cause of lung cancer, after cigarette smoking.

iv. Smoke and carbon monoxide from wildfires.

v. Volcanic activity, which produce sulphur, chlorine, and ash particulates.

5. **Enumerate ozone layer depletion**.

This ozone layer sustains life on the earth by absorbing a great deal of UV (Ultra Violet) light radiating out of sun. If all of this light falls over the earth surface without being absorbed by the ozone layer, it will cause sunburn and will lead to death. Early 1960s scientists established that an ozone hole has occurred in the stratospheric ozone layer over Antarctica.

Ozone is a pale blue gas mainly present in the stratosphere in the form of a layer known as ozonosphere. The ozonosphere acts as an absorbent of all harmful radiations coming from the sun and space and hence behaves as a protective umbrella for the living organisms on earth. In the absence of ozone layer, all the dangerous UV rays and cosmic rays will enter into atmosphere and cause damage to living organisms.

Ozone in ozone layer is formed by the absorption of certain radiations in the upper atmosphere by oxygen. Due to such absorption, atmospheric oxygen gets dissociated and subsequently combines with molecular oxygen of upper atmosphere, thereby producing ozone.

Effects of Ozone Layer Depletion:

Ozone is a form of oxygen that is present in the earth's atmosphere in small quantity. Its presence in the lower atmosphere closer to earth contributes to air pollution and causes damage to human tissues. But its presence in the outer reaches of the earth's atmosphere is absolutely vital to life. Located 30 km above the surface of the earth, it provides a shield against the lethal ultraviolet rays of the sun. If these rays penetrate the ozone layer life would not be possible on earth.

The following are its other harmful effects:

(i) Increase in solar UV-B radiation adversely affects a number of important biological systems. Magnitude of the effects of enhanced levels of UV-B may vary among species and cultivators. Sensitive plants often show reduced photosynthesis, growth, flowering and yield.

(ii) Depletion of ozone layer has resulted in many skin related diseases. Melanoma, the particular form of skin cancer, is reported in many areas.

(iii) It reduces the crop productivity.

(iv) The depletion of ozone layer will induce eye cancer in the animals.

(v) The depletion of ozone layer leads to loss of various plants from terrestrial and aquatic habitats.

(vi) Due to it, UV radiation may cause greenhouse effect.

(vii) Ozone enters the body during breathing and thus causing lung disorders in human beings.

(viii) Ultraviolet radiation causes blood vessels near the skin's surface to carry more blood, making the skin hot, swollen or red causing sunburns.

According to the World Bank estimates, diseases attributable to ozone depletion are about 3 lakh cases of skin cancer annually and 17 million cases of catarats.

6. **What are ambient air quality standards with objectives.**

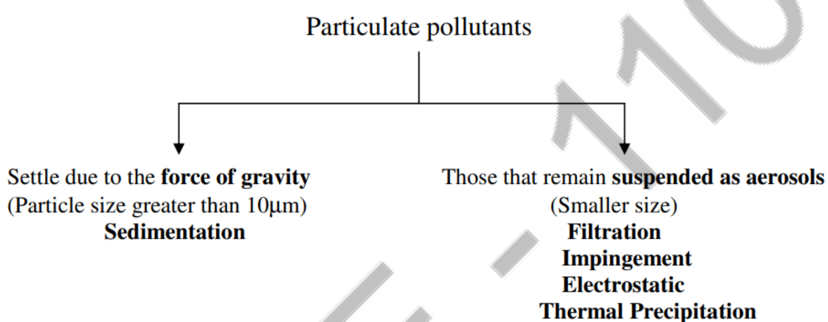
Pollutant	Time Weighted Average	Concentration in Ambient Air		Methods of Measurement
		Industrial, Residential, Rural and other Areas	Ecologically Sensitive Area (Notified by Central Government)	
Sulphur Dioxide (SO_2), µg/m^3	Annual * 24 Hours **	50 80	20 80	-Improved West and Gaeke Method -Ultraviolet Fluorescence
Nitrogendioxide (NO_2), µg/m^3	Annual * 24 Hours **	40 80	30 80	-Jacob &Hochheiser modified (NaOH-$NaAsO_2$) Method -Gas Phase Chemiluminescence
Particulate Matter (Size less than 10µm) or PM_{10}, µg/m^3	Annual * 24 Hours **	60 100	60 100	-Gravimetric -TEOM -Beta attenuation
Particulate Matter (Size less than 2.5µm) or $PM_{2.5}$, µg/m^3	Annual * 24 Hours **	40 60	40 60	-Gravimetric -TEOM -Beta attenuation
Ozone (O_3) , µg/m^3	8 Hours * 1 Hour **	100 180	100 180	-UV Photometric -Chemiluminescence -Chemical Method
Lead (Pb) , µg/m^3	Annual * 24 Hours **	0.50 1.0	0.50 1.0	-AAS/ICP Method after sampling on EPM 2000 or equivalent filter paper -ED-XRF using Teflon filter
Carbon Monoxide (CO), mg/m^3	8 Hours ** 1 Hour **	02 04	02 04	-Non dispersive Infrared (NDIR) Spectroscopy
Ammonia (NH_3), µg/m^3	Annual * 24 Hours **	100 400	100 400	-Chemiluminescence -Indophenol blue method
Benzene (C_6H_6), µg/m^3	Annual *	05	05	-Gas Chromatography (GC) based continuous analyzer -Adsorption and desorption followed by GC analysis
Benzo(a)Pyrene (BaP) Particulate phase only, ng/m^3	Annual *	01	01	-Solvent extraction followed byHPLC/GC analysis
Arsenic (As), ng/m^3	Annual *	06	06	-AAS/ICP Method after sampling on EPM 2000 or equivalent filter paper

Nickel (Ni), ng/m³	Annual *	20	20	-AAS/ICP Method after sampling on EPM 2000 or equivalent filter paper

Objectives :

- To assess the air quality.
- To guide decisions for permitting new facilities.
- To aid regulatory development.
- To develop long term management strategy.

7. Discuss any two sampling methods.



Sedimentation (Dust fall Jar):

Suitable for larger particles having a size more than 10 µ. The jar method for dust fall is based on sedimentation. Greasy slides can also be used for trapping the sedimented particles.

Dust fall jar with guard frame and stand

General considerations in site selections are:

1. The site should be free from overhead obstructions and away from inference by local sources such as an incinerator or chimney.

2. The mouth of the dust fall collector should be no less than 2.5 m and no more than 16 m above ground level, with a standard height of 6 m as recommended elevation

3. When sampling in urban areas, the dust fall collector should be set no less than 10 stack lengths from an operating smoke stack and no closer to vertical wall than the distance that provides an 300 angle from the sampler to the top of the wall or roof.

Advantages:

• Ease of procurement of 1-5 gram of weightable sample, on which a number of chemical and physical analyses can be performed.

• The method is simple and inexpensive and required no electrical power or moving parts.

It facilitates:

(a) Collection of dust that is representative of a given industry or community.

(b)Detection of process changes of a given industry

(c) Survey of a community to determine areas of high versus low levels of dust pollution

Disadvantages:

• Lack of precision and inability to distinguish episode of peak dust fall due to integration of he total sample weight over the entire sampling period (up to 30 days)

• Particles collected are more less agglomerated and may not be representative of the original from and size of particulate matter suspended

Filtration:

The particulate matter form air can be sampled by passing the air through a filter whose pore size is small enough to retain the particles. The selection of filter depends on

(1) Objectives of sampling

(2) size of the particles Membrane filter: Study of the sizes and morphology Glass fiber filter (nonhygroscopic): particles to be collected for measuring their weight.

Impaction on solid surface:

When an air stream is deflected after sticking a surface, the particles are impacted due to inertial forces. Collection efficiency is high for particle size 1 µ.

Sampler: Anderson impactor

Which has a series of plates with perforations having progressively decreasing pore sizes. Petri plates provided with some sticky substances are kept below these perforated plates.

The air passes through the larger pore size plate to smaller pore size plate. At each stage, as the air passes through the plates it strikes the sticky surface of the petri plates impacting the particles thereon.

The variation of the perforation sizes of h plates makes the velocity to vary, which the separation of particles of different sizes on different plates.

Impingement in liquid:

The particles are separated form the air by the force of inertia as the air is deflected after stricking the liquid surface. The bubbler or impingers used for collection of particles are the same those used for collection of gaseous pollutants.

Devices: (1) Green burg Smith standard (2) Midget Impingers

Limitations: Not widely used for particulates because of low sampling rates

Electrostatic Precipitation:

During operation a negative charge is imparted to wire placed axially inside a cylinder that is positively charged.

When the particle laden air stream passes through the cylinder, the particles acquire a negative charge from a corona discharge occurring on the central wire.

The particles migrate towards the inner surface of the cylinder and are removed for subsequent chemical or microscopic analysis.

Electrostatic Precipitator for collection of particulates

Thermal precipitation:

Thermal precipitators operate on the principle that small particles, under the influence of a strong temperature gradient between two surfaces, have a tendency to move towards the lower temperature and get deposited on the colder of these two surfaces.

These temperature gradients are normally of the order of 3000 0C per centimeter.

To maintain such high gradients the gas velocity through the sampling device must be maintained low; this is usually between 10 and 200 ml per minute depending on the type of device.

Efficiency: High (Small particles) & 100 % or particles in the size range form 10µm down to 0.01 µm. The particles are collected on a grid or a thin microscope cover glass for later analysis.

Centrifugal Methods:

Most centrifugal sampling devices are constructed on the principle of the cyclone.

The dust-laden gas moving at high velocity is directed tangentially into a cylindrical chamber, in which it forms a confined vortex.

The centrifugal force tends to drive the suspended particles to the wall of the cyclone body, from which they drop into a dust collection chamber.

An axial outlet is provided for the clean gas.

Advantages: procurement of a dry chemically pure sample

Disadvantages: particle size greater than 5 µ

Solution Impingers: This consists of a drawn out tube through which air containing particles flows into a solution, where the particles are trapped.

Disadvantages: unable to collect both particulate and vapor species. For this purpose oxidizing solution is used.

Application is limited because the collection solution can be operated only at low flow rate (20 lit/min).

Application: high atmospheric particulates loading exits, Simultaneous collection of particles and gases are required or alternative equipments are not available.

8. Describe the devices for sampling.

- Instruments for sampling waste gases and for atmospheric sampling
- Devices for sampling gases and vapors

Devices for general use Meters:

They are used to determine accurately the volume of the gas collected. They are fitted with manometers and thermometers to indicate the pressure and temperature of the gas stream sampled. Probes: They are tubes suitable for penetrating into the gas stream and should be constructed of material, which are non-corrosive and which can withstand special temperature conditions. They should be constructed of materials (S. S, Glass or Quartz) that do not react with the substances to be sampled. A probe should have suitable length and diameter. To ensure isokinetic sampling condition the opening of he probe should face the gas stream to be sampled. Suction Devices: Any suction device that has the required volumetric capacity can be used. Vacuum pumps driven by electric motors are very commonly used.

Devices for sampling gases and vapors Absorbers:

Effluent gases are passed through absorber (scrubbers) which contain liquid absorbents that remove one or more of the pollutants in the gas stream.

The efficiency of this process depends on

1. Amount of surface contact between gas and liquid
2. Contact time
3. Concentration of absorbing medium
4. Speed of reaction between the absorbent and gas.

Absorbent are being used to remove sulphur dioxide, hydrogen sulphide, shulphur trioxide and fluorides and oxides of nitrogen Equipments using the principle of absorption for the removal of gaseous pollutants includes

(1) Packed tower (2) Plate tower (3) bubble cap plate tower (4) Spray tower (5) Liquid jet scrubber absorber. A gas can be sampled by means of a suitable absorption reagent. For this purpose, U-shaped absorbers are used. This absorber are filled with a certain amount of reagent and fitted with a porous glass partition. So that the air or gas led into them passes through the reagent solution in the form of fine bubbles thus ensuring intimate contact Sampling is carried out at an average rate of about 100 – 150 liters per hour of gas stream Oxides of sulphur, Oxides of nitrogen, Ammonia, Hydrogen sulphide, Hydrochloric acid, Hydrofluoric acid, Hydrocynic acid, ozone, H/C, organic solvent are measured (0.1 ppm by volume) Sampling train

(i) Adsorbers: Adsorption is brought about by aspiring the air or gas to be sampled through adsorption column containing silica gel, activated charcoal or another suitable agents. After adsorption, the different pollutants can be extracted from the column in various ways. e.g. by rising the temperature Difficulties: Selecting a suitable adsorbing medium Application: used for ozone and light H/C

(ii) Condensers: The gas stream sampled is cooled in suitable containers, thus bringing about the condensation of the Volatile substances. Condensation trap can be arranged either series or parallel at decreasing temperature. Using various coolants e.g. ice, liquid air or liquid nitrogen can separate the components separated by fractional condensation. Used for the sampling of odoriferous substances.

(iii) Collector under reduced pressure: For some substances like nitric acid and aldehydes having high molecular weight, absorption in aqueous solution is sometimes incomplete. In such cases, it is to use bottles of known volume of colleting under a pressure reduced to 200 mm Hg or even less. The absorbent solution chosen is first introduced into the bottle and the pressure is thus reduced. Then the sample is admitted until the internal and external pressures are equal and the container is shaken continuously so as to ensure maximum absorption. Use for sampling the oxides on N_2

(iv) Plastics containers: Special polyethylene bags are used for collecting and transporting large volume of air. Advantages: They can be used for successive analysis of small fractions of sample taken. Polyethylene is inert with respect to many substances including SO_2, and formaldehyde Plastics bags are not suitable for collecting and storing aerosol suspensions because of the possible generation of electrostatic charges, as a result of which the aerosol tend to move towards the walls and condense on them. Used for grab sampling and sample storage before analysis

(v) Samples for Mass Spectrometric analysis Sampling for mass spectrometric analysis can be carried out by compressing the gas sample in a pressure flask so as to concentrate a large quantity of gas in a small volume or by fling evacuated containers.