Quantum Series®
ENGINEERING

QUANTUM Series

Semester - 5 Civil Engineering

Air and Noise Pollution Control

Includes MCQ

- Topic-wise coverage of entire syllabus in Question-Answer form.
- Short Questions (2 Marks)

Session 2021-22 Odd Semester

Includes solution of following AKTU Question Papers 2020-21

QUANTUM SERIES

For

B.Tech Students of Third Year
of All Engineering Colleges Affiliated to
Dr. A.P.J. Abdul Kalam Technical University,
Uttar Pradesh, Lucknow
(Formerly Uttar Pradesh Technical University)

Air and Noise Pollution Control

By

Neetendra Sahoo

Quantum
— Page —

QUANTUM PAGE PVT. LTD.
Ghaziabad ■ New Delhi

PUBLISHED BY : **Apram Singh**
Quantum Page Pvt. Ltd.
Plot No. 59/2/7, Site - 4, Industrial Area,
Sahibabad, Ghaziabad-201 010

Phone : 0120 - 4160479

Email : pagequantum@gmail.com **Website: www.quantumpage.co.in**

Delhi Office : 1/6590, East Rohtas Nagar, Sahadara, Delhi-110032

Air and Noise Pollution Control (CE : Sem-5)
1st Edition : *2020-21*
2nd Edition : *2021-22*

Price: Rs. 75/- only

Printed at : Mayank Enterprises, Delhi-110093.

CONTENTS

KCE–057 : AIR & NOISE POLLUTION CONTROL

UNIT 1

Air Pollution

CONTENTS

PART-1

Air-Pollution : Composition and Structure of Atmosphere, Global Implications of Air Pollution.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 1.1. What is air pollution ? Discuss the composition of atmosphere.

Answer

A. Air Pollution : "Pollution is an undesirable change in the physical, chemical or biological characteristic of air, water and soil that may harmfully affect the life or create a potential life hazard of any living organism especially for man."

OR

"Pollution is an unwanted alteration to the Earth's natural resources, usually with a negative impact on human health or life style."

B. Composition of Atmosphere :

1. Clean air is made up of nitrogen, oxygen and argon with traces of other gases such as carbon dioxide.
2. But natures try to balance the natural composition of environment which is disturbed by human being.
3. Plants and forests have an important contribution in it because it takes harmful carbon dioxide in respiration and releases life giving oxygen.
4. The nature accepts general exploitation but unusual exploitation harms air composition badly.

Element	Parts per Million
Nitrogen	780,800
Oxygen	209,500
Argon	9,300
Carbon dioxide	300
Neon	18.2
Helium	5.2
Krypton	1.1
Hydrogen	0.5
Nitrous oxide	0.5

5. **According to WHO (World Health Organisation) :**

"Air pollution results mainly from gaseous emissions of industry, thermal power stations automobiles domestic combustions, smoke from the fire etc. From the different sources of air pollution, a variety of pollutants are released into atmosphere."

6. Our atmosphere covers the earth as a blanket in which there is the combination of various gases which protects living beings from Ultraviolet Radiations. This atmosphere helps in spreading radio waves as a medium.

Que 1.2. **Discuss the sources of air pollution.**

Answer

Source of Environmental Pollution :

1. After starting of industrial revolution societies began to produce wastes faster than the wastes could be disposed of. These wastes accumulate in the environment and cause pollution.
2. Pollution is an undesired change in air, water, or soil that adversely affects the health, survival, or activities of humans or other organisms.

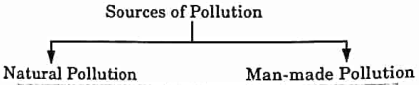


Fig. 1.2.1. Sources of environmental pollution.

1. **Natural Pollution :**

i. Such pollution takes place naturally, they cannot be stopped but they can help by management at correct time through prediction.

ii. For example-land slide, volcanic explosion, storm, etc.

According to their nature, they can be divided into three parts :

i. **Bio-degradable Pollutants :** Such pollutants which are naturally decomposed easily by temperature, air, humidity, bacteria or animals, as: the rubbish produced by human being in everyday life, the cardboard taken from the houses, vegetables, dirty water etc. They come in the series of bio-degradable pollutants.

ii. **Slow Bio-degradable Pollutants :** Such pollutants which are not naturally decomposed easily, these pollutants can stay in their original form for a long time, as: plastic can stay without decomposition up to 1500 year.

iii. **Non-degradable Pollutants :** Such pollutants living in the atmosphere for centuries spread their harmful effect. Lead (Pb), Mercury (Hg), and Aluminium (Al) atomic and nuclear waste come in this series

2. **Man-made Pollution :** Such pollution is found in milking more than necessity of natural resources unnaturally by man, urbanization and

industrialization are the chief reason, as : industrial rubbish, sewage, cutting of forests etc.

Que 1.3. **Explain the sources of man-made air pollution.**

Answer

Sources of Man-made Pollution :

1. **Transportation :**

i. Transportation is a major source of air pollutants.

ii. Vehicles are probably the largest single source of pollutants such as hydrocarbons, nitrogen dioxide and carbon monoxide.

iii. Other harmful emissions include as lead, benzene, arsenic, aldehydes, sulphates, particulate matter and the secondary creation of ozone.

iv. The lead content of petrol is 4 g/ L which is higher than the permitted levels of other parts of the world.

v. The national vehicle population has significantly increased in recent years.

2. **Industrial Processes :**

i. Major industries in India are located near in the large cities.

ii. Many industries are situated between residential areas and any pollutants emitted by the industries are dispersed and eventually deposited in the residential areas resulting in serious impacts on the health of the residents.

iii. Typical examples of industrial emissions include sulphur dioxide (SO_2), nitrogen oxides (NO_x), carbon monoxide (CO), methane (CH_4), and volatile organic compounds (VOC) and particulate matter.

iv. Most of emissions originate from industrial processes such as metallurgical plants and smelters, chemical plants and petroleum refineries, cement production, fertilizer and synthetic rubber manufacturing, pulp and paper milling.

v. Heavy metals (lead, mercury, cadmium, etc.) are emitted from smelters, brass works and secondary lead plants and coal combustion.

3. **Industrial and Non-industrial Fugitive Processes :**

i. Process fugitive particles are not emitted from a definable point such as a stack.

ii. Industrial fugitive dust emissions result from wind erosion of storage piles and unpaved roads.

iii. Fugitive emissions result from industry-related operations such as materials handling, loading and transfer operations.

iv. The mining, transportation and storage of coal are results in fugitive emission of pollutants; mainly methane.

v. Volatile hydrocarbons vaporize when fuels such as gasoline and natural gas escape from storage tanks are being transferred from one tank to another.

vi. Non-industrial fugitive emissions are caused by traffic entrainment of dust from public paved and unpaved roads, agricultural operations, construction and fires.

4. The Energy Production :

i. In India most of the energy is derived from burning carbon-based fuels such as coal, petroleum products and wood.

ii. Wood fuel is the main energy source for over 90 % of the rural population.

iii. The productive sector accounts for about 31% of energy use, the residential sector about 52 % and the transport sector about 11 %.

5. Waste Management :

i. The treatment of noxious wastes is a major source of air pollution.

ii. Dump burning is done to reduce waste volume and to destroy harmful organic materials but it can result in emissions of large quantities of particulate matter, of which consists of unburned garbage and offensive odours.

iii. Dump burning may also put significant amounts of harmful chemicals into the atmosphere, especially if the dump contains tyres, petroleum-based wastes and industrial chemicals.

iv. In addition, highly toxic emissions of particulate matter such as dioxins, hydrochloric acid and heavy metals can result during poorly managed incineration of domestic, hospital and industrial waste.

v. Burning of wastes in residential areas also contributes to the emissions.

6. Agricultural Activities :

i. Agricultural is a key sector of the economy of India and emission of pollutants occur from several sources.

ii. Burning of crop residue is a major source of hydrocarbons and particulate matter.

iii. Livestock emit methane and ammonia. Savanna burning emits large amounts of carbon monoxide (CO) and substantial amounts of nitrogen oxides (NO_x) and methane (CH_4).

iv. Manure management and enteric fermentation emit methane.

v. The spraying of the fields with pesticides, use of herbicides and dusting also contribute small amounts of pollutants.

Que 1.4. What are the causes of environmental pollution ?

Answer

Causes of Environmental Pollution : Following are the many causes of environmental pollution :

1. Urbanization causes environmental pollution.
2. Over-population causes environmental pollution.
3. Road transportation causes environmental pollution.
4. Engineering activities causes environmental pollution.
5. Mining and blasting causes environmental pollution.
6. Deforestation causes environmental pollution.
7. Industrial rubbish causes environmental pollution.
8. Over-irrigation causes environmental pollution.

Que 1.5. Describe the structure of our atmosphere.

Answer

Structure of Atmosphere : Our atmosphere can be divided into five levels. Various situations are found on various levels. They are :

1. Troposphere :

i. The troposphere is the first layer of the Earth's atmosphere.

ii. All the events related to seasons take place in this sphere, such as-formation of clouds, lightning.

iii. Its height is from 8 km to 12 km and 3/4 part of atmosphere is included in it.

2. Stratosphere :

i. The stratosphere is the second major layer of the Earth's atmosphere.

ii. The height of the stratosphere is about 50 km from the surface of the earth. We also call it protective shield.

iii. The ozone layer is also available in it which protects from harmful ultraviolet rays.

iv. This ozone layer is mostly harmed by chlorofluorocarbon (CFC).

3. Mesosphere :

i. The mesosphere is the third layer of the atmosphere, directly above the stratosphere and directly below the thermosphere.

ii. In the mesosphere, the temperature decreases as altitude increases.

iii. The height of this sphere is about 80 km from the surface of the earth.

4. Thermosphere :

i. The thermosphere is the layer in the Earth's atmosphere directly above the mesosphere and below the exosphere.

ii. The height of thermosphere is about 600 to 650 km from the Earth's surface.

iii. It checks cosmic rays of the sun and acts to reflect radio waves to the earth.

iv. Due to these radio waves we are able to talk without satellite as used by the soldiers.

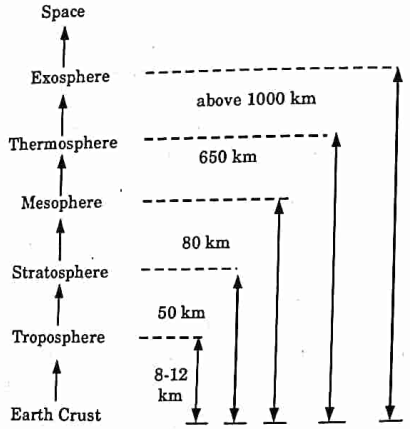


Fig. 1.5.1.

5. Exosphere :

i. The exosphere is the uppermost layer of Earth's atmosphere, where the atmosphere thins out and merges with interplanetary space.

ii. It is located directly above the thermosphere.

iii. The most common molecules within Earth's exosphere are those of the lightest atmospheric gases.

iv. Hydrogen is present throughout the exosphere, with some He, CO_2 and atomic oxygen near its base.

Que 1.6. **Discuss the effects of air pollution.**

Answer

Effects of Air Pollution : Following are the various effects of air pollution :

1. Effect on Atmosphere :

i. It is found increment in the temperature in extreme industries, motor vehicles, heat and gases emitted from AC and dense populated urban region.

ii. Gradually this temperature forms heat island on increasing.

iii. When smoke and dust covers the sky in plentiful quantity, the heat obtained from the sun goes back into the space on being reflected by smoke and dust.

iv. Due to this there is a fall in temperature and it causes the danger of snow fall.

2. Depletion of Ozone Layer :

i. In the atmosphere, 12 km above from the earth, ozone layer in stratosphere is disarranged which prevents ultraviolet rays by 99%.

ii. Generally, refrigerators, fire brigades, CFC (chlorofluorocarbon) gas used in AC, harm the ozone layer mostly.

iii. In 1985, British scientists discovered ozone hole.

iv. They find 2 % shortage in the thickness of Ozone layer; this depletion is a symbol of danger.

v. The depletion is going on, that day is not so far harmful ultraviolet rays will demolish everything. So it is quite necessary to ban CFC gases completely.

3. Green House Effect :

i. In the atmosphere, there are plenty of some gases which are heat absorber due to these, the temperature of the earth increases.

ii. In some decades, such a situation will rise, the temperature of the earth will increase from 5°C to 7°C because of which glaciers will start melting and the level of water in the sea will increase and the coastal regions will sink in the water.

iii. The average temperature of the earth is 15°C which can increase up to 30°C.

iv. So, we call these gases (CO_2, CH_4, N_2O, CFC, and SF_6) as green house gases. Green house effect places due to green house gases.

4. Acid Rain :

i. Refineries, metals-melting industries, sulphur dioxide, nitrogen dioxide produced on burning coal and petrol, SO_2 reacting with H_2O present in atmosphere in the sunlight forms sulphuric acid (H_2SO_4) and it rains as acid rain because SO_2 cannot stay in gaseous state for a long time :

$$2SO_2 + 2H_2 + O_2 \longrightarrow 2H_2SO_4$$

ii. Sulphuric acid harms the soil and plants mostly.

iii. Acid rain has bad effect on rail-lines, buildings, bridges mostly.

iv. When the value of pH is less than 5, then the rain is called acid rain.

5. **Smog :**

i. Smog is a problem in most large cities.

ii. It is caused by emissions from industry, motor vehicles, domestic wood combustion and other sources, accumulating under certain meteorological conditions.

iii. Smog is a combination of smoke and fog.

iv. The infamous London fogs about 4,000 deaths were attributed to the severe fog of 1952 were smog of this type.

There are mainly two types of smog :

1. Industrial smog.
2. **Photo-chemical Smog :**

i. Light energy (UV).

ii. Hydrocarbons/VOCs (from fossil fuel combustion).

iii. NO_x (from fossil fuel combustion).

iv. Often contains ozone (O_3).

6. **Effect of Air Pollution on Living Organisms and Non-living Organism :**

i. **Effect on Living Organisms and Plants :**

a. Sulphur-dioxide, nitrogen dioxide and carbon mono-oxide (SO_2, NO_2, CO) present in the atmosphere are very harmful.

b. These gases produce (cause) various types of diseases as: diseases related to lungs, eyes, respiration, heart, bones, teeth etc.

c. The smoothness of plants and leaves start ending. It causes the danger of cold (ice) and worms.

ii. **Effect on Non-living Organisms :**

a. Atmospheric pollution equally affects not only living organisms but also non-living organisms.

b. Due to this vehicles, building are destroyed which are in the contact of atmosphere directly.

c. The main reasons for this are acid rain and green house gases.

Que 1.7. **Discuss the various measures to monitoring and controls of air pollution.**

Answer

Measures to Monitoring and Controls of Air Pollution : To prevent air pollution, adopting following rules, the atmosphere and life can be protected. It can be prevented by a little awareness and responsibilities :

1. We should encourage people to plant new trees instead of cutting the forests.
2. Chimneys of industries should be high and purification plants should be setup.
3. Using vehicles in group, we can get rid of fuel and pollution produced by it.

4. Encouraging people to use public transport system and opposed to private vehicles.
5. Wastage obtained from industries should be destroyed properly.
6. We should focus on the fuel free from lead and full of sulphur.
7. Industrial plants should be setup away from the populated areas.
8. Walk or use a cycle for short distance or non-urgent work.
9. We should take action against the vehicles which emit smoke and harmful gases.
10. New technique should be used so that gaseous reflection may be less.
11. To cook food, equipments free from pollution, should be used as electric heater induction cooker etc.
12. Catalytic converters should be used to help control emissions of carbon monoxide and hydrocarbons.
13. Emission rates should be restricted to permissible levels by each and every industry.
14. Incorporation of air pollution control equipment in design of plant layout must be made mandatory.
15. Continuous monitoring of the atmosphere for pollutants should be carried out to know the emission levels.
16. We should plant trees near our houses because they absorb carbon dioxide and release oxygen (O_2) which is necessary to living beings.

PART-2

Classification of Air Pollutants : Particulate, Hydrocarbon, Carbon Monoxide, Oxides of Sulphur, Oxides of Nitrogen and Photo-chemical Oxidants, Indoor Air Pollution.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 1.8. **Discuss the classification of air pollutants.**

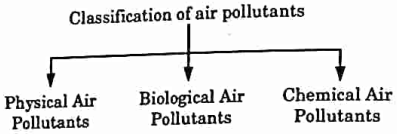
Answer

Classification of Air Pollutants :

i. Today in India, air pollution is a serious problem.

ii. It is generated due to many causes such as burning of wood, burning of biotic substance, emission of vehicles and harmful smoke from industrial workshops.

iii. The factors which cause air pollution are called air pollutants. These are of three types :



1. **Physical Air Pollutants :** There are many factors under physical air pollutants :

i. Smell of waste substances from homes.
ii. Heat emitted from radioactive radiation.
iii. Smoke produced from industrial workshop, domestic chimneys.

2. **Biological Air Pollutants :** Biological pollutants consist of decomposition of wastes from crops and the smell generated from decomposing of dead animals.
3. **Chemical Air Pollutants :** It consists of gases produced from chemical fertilizers, and harmful gases from industrial workshop as (CO_2, CO, SO_2) etc.

Que 1.9. **Discuss the form of air pollutants.**

Answer

Air pollution occurs in many forms but can generally be thought of as gaseous and particulate contaminants that are present in the Earth's atmosphere.

A. Gaseous Pollutants :

1. They include sulphur dioxide (SO_2), nitrogen oxides (NO_x), ozone (O_3), carbon monoxide (CO), volatile organic compounds (VOC), hydrogen sulphide (H_2S), hydrogen fluoride (HF), and various gaseous forms of metals.
2. These pollutants are emitted from large stationary sources such as fossil fuel fired power plants, smelters, industrial boilers, petroleum refineries, and manufacturing facilities as well as from area and mobile sources.

B. Particulates or Aerosol :

1. They come in both large and small solid forms.
2. Large particulates include substances such as dust, asbestos fibres, and lead.
3. Fine particulates include sulphates (SO_4) and nitrates (NO_3).
4. Important sources of particulates are power plants, smelters, mining operations, and automobiles.
5. Asbestos and lead affect organisms, while sulphates and nitrates not only cause health problems, but, also contribute to acid rain or acid deposition and a reduction in visibility.

C. Toxic Air Pollutants :

1. A class of chemicals which may potentially cause health problems in a significant way.

2. The sources of toxic air pollutants include power plants industries, pesticide application, and contaminated wind-blown dust.
3. Persistent toxic pollutants, such as mercury are of particular concern because of their global mobility and ability to accumulate in the food chain.

Que 1.10. **Discuss the various air pollutants and their effects.**

Answer

Following are the various air pollutants and their effects :

A. Sulphur Dioxide (SO_2) :

1. Sulphur dioxide is a colourless gas with a pungent, suffocating odour.
2. It is a dangerous air pollutant because it is corrosive to organic materials and it irritates the eyes, nose and lungs.

Effects of Sulphur Dioxide Emissions : Sulphur dioxide found in the air produces following effects :

1. Irritates eyes, nose, throat.
2. Damages lungs when inhaled.

B. Nitrogen Oxides (NO_x) :

1. Oxides of nitrogen are produced by combustion of all fossil fuels including coal and gas fired power stations and motor vehicles.
2. The two main nitrogen oxides are nitric oxide (NO), or nitrogen monoxide, and nitrogen dioxide (NO_2) the sum of which is equal to NO_x.
3. Nitric oxide (NO) is a colourless gas. Nitrogen dioxide (NO_2) is a gas of reddish-brown colour with a distinct sharp, biting odour. Combustion of fuels always produces both NO_2 and NO.
4. But almost 90 % of the NO_x combustion product is in the form of NO which is then oxidized to nitrogen dioxide (NO_2) in the air.
5. Therefore, only a small percentage of NO_2 found in the atmosphere is directly emitted there in this form.
6. The rest has been formed as a result of chemical reactions in the atmosphere itself.

Effects of Nitrogen Dioxide (NO_2) Emissions :

1. It causes acid rain which destroying fish and plant life in lakes, damaging surfaces of buildings etc.
2. It also contributes to photochemical smog.

C. Ammonia :

1. Ammonia is a colourless, pungent, hazardous caustic gas composed of nitrogen and hydrogen.
2. Ammonia emissions are also grouped as NH_y which is a sum of NH_3 and NH_4.
3. Ammonia produces from agricultural processes and production of pharmaceuticals.
4. It is characterized by a pungent odour.

Effects of Ammonia Emissions :

1. Exposure to very high concentrations of gaseous ammonia in the air may result in lung damage and even death.
2. Ammonia reacts with oxides of sulphur and nitrogen to form secondary particles in the atmosphere.
3. Ammonia is highly corrosive in nature and contaminate of surface water, negatively impacting marine life.

D. Carbon Mono-oxide (CO) :

1. Carbon mono-oxide is a colourless, odourless gas which is highly toxic to humans.
2. The combustion of carbon-based fuels produces carbon dioxide (CO_2). But not all such combustion is complete, and this leads to the production of carbon mono-oxide.
3. Motor vehicles and industry are among the largest anthropogenic sources of carbon monoxide emissions.

Effects of Carbon Mono-oxide Emissions :

1. Carbon mono-oxide is the most common type of fatal poisoning in many countries around the world.
2. Exposures to carbon monoxide may lead to toxicity of the central nervous system and heart, severe effects on the baby of a pregnant woman, headaches and dizziness.
3. Problems with getting oxygen supplied to some body parts which may be life-threatening.

E. Volatile Organic Compounds (VOCs) :

1. Volatile organic compounds (VOCs) are defined as organic compounds which easily evaporate and enter the atmosphere.
2. VOCs may include a wide range of organic air pollutants, from pure hydrocarbons to partially oxidized hydrocarbons to organic compounds containing chlorine, sulfur, or nitrogen.

Effects of Volatile Organic Compounds :

1. Some aromatic compounds such as benzene, toluene and xylene are potential carcinogens and may cause leukemia.
2. Contribute to sick building syndrome indoors.
3. As facilitators in ozone formation, VOCs may indirectly contribute to respiratory problems and other ozone-related problems.

E. Ozone (O_3) :

1. Ozone (O_3) is a colourless, poisonous gas with a sharp, cold, irritating odor.
2. Ozone which is formed in the troposphere as a result of anthropogenic emissions of primary pollutants has negative effects on humans and the natural environment, and from this point of view it is an air pollutant.
3. The tropospheric ozone is the main component of the photochemical smog.

Effects of Ozone as an Air Pollutant : Ozone in the troposphere can have the following negative effects on animals, humans and the natural environment :

1. Irritation of the respiratory system causing coughing, throat irritation and an uncomfortable sensation in the chest.
2. Compromised lung function harming the breathing process and aggravation of asthma.
3. Interference with photosynthesis and suppression of growth of some plant species. Reduction in agricultural yields.

G. Chlorofluorocarbon (CFC) :

1. This gas is most responsible for ozone depletion.
2. This gas is produced by refrigerators, AC and evaporators. CFC may stay in the atmosphere for 15 years approximately.
3. Heavily CFC emitting products should be prohibited.
4. This emitting CFC mixes with another gas of atmosphere that causes damage of human health and protective ozone layer.

Effects of Chlorofluorocarbon : CFC badly damages the protective layer of ozone which provide safety from the harmful ultraviolet rays that causes of skin, eye diseases and it damages the plants also.

Que 1.11. What are the reasons of automobile pollution in India and measures to control it ?

Answer

A. Reasons of Automobile Pollution in India :

1. Continuous increase in means of transportation in India.
2. Use of more vehicles in cities due to population growth.
3. Dependency on diesel and petrol engine only as fuel.
4. Moving old vehicles on the road freely.
5. Lack of proper pollution check of vehicles at a regular interval of time and improper condition of the roads.

B. Measures to Control Automobile Pollution : There are following measures to control it which are given below :

1. Improvement in technology of manufacturing vehicles.
2. Proper maintenance of the roads in the cities should be made and flyovers should be built.
3. Petrol should be used only for petrol engine.
4. Oil should be changed time to time.
5. Lubricant of high quality should be used.
6. Vehicles should be got service at definite interval of time.
7. Vehicles should be driven at a constant speed.
8. Quality of fuel should be improved and vehicles that run with the help of CNG and batteries should be enhanced.

PART-3

Effects of Air Pollutants on Humans, Animals, Property and Plants.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 1.12. What are the effects of air pollution on human health ?

Answer

Following are the effects of air pollution on human health :

1. **Suspended Particular Matter :**
   i. Effects on breathing and respiratory systems, aggravation of existing respiratory and cardiovascular diseases, alteration of body's defense systems against foreign materials, damage to lung tissues, carcinogenic effects, and premature mortality (still births).
   ii. Elderly people and children are most sensitive.
2. **Sulphur Dioxide (SO_2) :**
   i. Effects on breathing, respiratory illness, breakdown of lung defenses, aggravation of existing respiratory and cardiovascular diseases and death.
   ii. Asthmatics and those suffering from chronic lung and cardiovascular diseases are sensitive to SO_2 exposure.
3. **Carbon Mono-oxide (CO) :**
   i. The health threat of CO is maximum to those having cardiovascular disease, because it reduces oxygen delivery to organs and tissues.
   ii. At elevated concentrations, CO impairs visual perception, manual dexterity, and mental ability.
4. **Nitrogen Oxide (NO_x) :**
   i. NO plays a major role in tropospheric ozone formation.
   ii. NO_2 irritates the lungs, causes bronchitis and pneumonia, lowers resistance to respiratory infections.
   iii. Asthmatics are most susceptible, and increases susceptibility to viral attacks.
5. **Lead :**
   i. High lead exposures can cause seizures, mental retardation, and behavioral disorders.
   ii. Foetuses, infants and children are especially susceptible to low doses, resulting in disorders of central nervous system. Lead uptakes may be a factor in high blood pressure and heart disease.

6. **Ozone (O_3) :**
   i. Ozone reduces lung function, and is associated with coughing, sneezing, chest pain, and pulmonary congestion.
   ii. It may affect all healthy people as well as the people with impaired respiratory systems.
7. **Carbon Dioxide (CO_2) :** Increasing concentrations over the years cause green house effect, leading to global warming and climate changes.
8. **Nuclear Waste :** Causes radioactivity contaminations of areas, cancers, mutations, deaths.

Que 1.13. Discuss the effects of air pollutants on plants.

Answer

Effects of Air-pollution on Plants :

1. The adverse impacts of air pollution are not limited to human health alone, but plants and animals are also detrimentally affected by air pollutants.
2. The most prominent air pollutant, which causes severe damage to the plants is fluorine.
3. Fluorine is emitted from factories manufacturing aluminium, glass, phosphate fertilizers, etc; and in some clay baking operations.
4. The concentrations of fluorine in excess of about 0.3 $\mu g/m^3$ cause phyto-toxicological effects on plants.
5. Frequently, the plant damage is observed on the fruit or on the flower either of which significantly lowers the value of the crop.
6. The most obvious damage caused by the general air pollutants like SO_2, HF, HCl, CI_2, O_3, NO_3, NH_3, Hg, H_2S, H_2N, PAN, herbicides, smog, etc., to the plants and vegetation occurs in the leaf structure ; as the pollutants clog the stomata of the leaf, thereby reducing the intake of CO_2, which adversely affects the photosynthesis.
7. These adverse impacts may range from reduction in growth rate to the total death of the plant.
8. Plants also absorb low concentrations of pollutants like fluorine, and heavy metals like arsenic, lead, mercury, cadmium, etc; which prove very harmful to cattle and animals grazing on these vegetations, even when the plants may not even show any signs of damage.

Que 1.14. What are the effects of air pollutants on animals ?

Answer

Effects of Air-Pollutants on Live-Stock Animals :

1. The adverse health effects of air-pollutants on farm animals occur, when animals eat the plants, grasses, fodder, and other vegetation, which has been contaminated by the air pollutants.
2. Contaminates that affect the live-stock are Fluorine, Arsenic and Lead.

3. These pollutants originate either from the industries situated nearby or from dusting and spraying.
4. Out of these contaminants, fluorine proves to be the worst pollutant, since cattle and sheep are found to be more susceptible to consumption of fluorine.
5. The cattle grazing on vegetation that has been contaminated with fluorine may develop fluorosis, even when the contaminated plants do not show signs of damage.
6. Arsenic from dusts and insecticide sprays falling on the plants can similarly be accumulated by the plants, and when such contaminated vegetation is eaten by cattle, they may suffer from arsenic poisoning, with leading symptoms like salivation, thirst, vomiting, uneasiness, feeble and regular pulse and respiration.
7. Lead contamination of the atmosphere occurs on account of various industries, such as smelters, coke ovens, and other coal-based industries.
8. The lead fumes absorbed by the vegetation from the atmospheric air, contaminates the vegetation, which accumulates lead within itself.
9. The lead-contaminated vegetation when eaten by live-stock animals may cause lead poisoning, which may cause symptoms like inability to stand and staggering, prostration, etc; besides complete loss of appetite, paralysis of digestive tract, and diarrhoea.

Que 1.15. Discuss the effect of air pollutions on materials and services.

Answer

Effects of Air-Pollutants on Materials and Services :

1. Air pollutants cause deteriorating effects on metallic surfaces, glass surfaces, painted surfaces, building stones, rubber surfaces, etc. along with damaging the paper and fabric.
2. Oxides of sulphur and nitrogen react in the atmosphere with water vapour to form acidic fumes, which attack and damage the metal surfaces, a problem that has been particularly acute for the computer, switch gear, and communications industries.
3. Fluorine is highly reactive, and at high atmospheric concentrations, may even cause etching of glass on windows, etc.
4. Hydrogen sulphide (H_2S) in the ambient air reacts with lead oxide in white paint, to form lead sulphate, due to which white painted surfaces in doors, windows, walls in buildings tend to acquire brownish tint overnight.
5. Another peculiar impact of air pollution was noticed on electric cables and electricity poles, resulting in power leakage from high voltage electric cables.

6. This was caused due to deposition of particles, which are good conductors of electricity, on insulators on electrical poles, resulting in leakage from high tension lines.
7. It is extremely difficult to estimate the financial loss caused by air pollution due to accelerated deterioration of materials and aesthetic items, such as the exteriors of the buildings, statues, monuments, or horticulture plantings; or the cost of materials or service loss.

VERY IMPORTANT QUESTIONS

Following questions are very important. These questions may be asked in your SESSIONALS as well as UNIVERSITY EXAMINATION.

Q. 1. What is air pollution ? Discuss the composition of atmosphere.
Ans: Refer Q. 1.1, Unit-1.

Q. 2. Explain the sources of man-made air pollution.
Ans: Refer Q. 1.3, Unit-1.

Q. 3. Describe the structure of our atmosphere.
Ans: Refer Q. 1.5, Unit-1.

Q. 4. Discuss the effects of air pollution.
Ans: Refer Q. 1.6, Unit-1.

Q. 5. Discuss the classification of air pollutants.
Ans: Refer Q. 1.8, Unit-1.

Q. 6. Discuss the various air pollutants and their effects.
Ans: Refer Q. 1.10, Unit-1.

Q. 7. What are the effects of air pollution on human health.
Ans: Refer Q. 1.12, Unit-1.

Q. 8. Discuss the effect of air pollutions on materials and services.
Ans: Refer Q. 1.15, Unit-1.

☺☺☺

2 UNIT

Chemistry and Dispersion of Air Pollution

CONTENTS

PART-1

Air Pollution Chemistry, Meteorological Aspects of Air Pollution, Dispersion, Temperature Lapse Rate and Stability.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 2.1. **Describe the air pollution chemistry.**

Answer

Air Pollution Chemistry :

1. Some air pollutants that are released into the atmosphere by man-made activities pose environmental and health risks directly.
2. These primary pollutants include carbon monoxide, particulate matter, nitrogen oxides and lead, emitted from exhausts of road vehicles.
3. Additional impacts, however, result from the conversion of primary pollutants by a complex series of chemical reactions in the atmosphere, to secondary pollutants, many of which are potentially more harmful than their precursors.
4. Since much of the pollutant chemistry is driven by the presence of sunlight, the secondary products are commonly referred to as photochemical pollutants.
5. A well-known secondary photochemical pollutant is ozone (O_3). Its formation results from the sunlight-initiated oxidation (reaction with oxygen) of volatile organic compounds (VOCs) such as benzene (C_6H_6) in the presence of nitrogen oxides (NO_x), mostly nitric oxide (NO) and nitrogen dioxide (NO_2).
6. Once formed, ozone is scavenged by NO, and in the absence of other competing reactions, a "photostationary state" is formed where concentrations of NO, NO_2 and O_3 are all inter-related.
7. In rural areas away from major sources of NO, such as urban road transport, ozone scavenging by NO is lower, and consequently ozone concentrations in the atmosphere are higher.

Que 2.2. **Write a short note on dispersion of air pollution pollutants into the atmosphere.**

Answer

Dispersion of Air Pollutants into the Atmosphere :

1. When once a pocket of smoke, containing air pollutants, is released into the atmosphere from a source like an automobile or a factory chimney, it gets dispersed into the atmosphere into various directions depending upon the prevailing winds and temperature and pressure conditions in the environment.
2. From our knowledge of meteorology and hydrology, we know that the temperature conditions of the environment are defined by a technical term, called lapse rate. For easier understanding, we will discuss lapse rate here before discussing its effects on the dispersion of the pocket of polluted smoke (called plume).

Que 2.3. Describe the atmospheric temperature lapse rate and stability.

Answer

Atmospheric Temperature Lapse Rate :

1. When the air has minimum velocity or more or less motionless, the accumulation of the pollution will be maximum.
2. When the air is in turbulence, the pollution will be low.
3. The turbulence is not measured by the observatories but is calculated on the basis of vertical temperature profile.
4. It has been noted that the stability of the atmosphere is its tendency to resist or enhance the vertical motion, in other words to suppress or augment existing turbulence.
5. As the atmosphere is cooler at higher altitudes, normally the temperature reduces at a rate of 1°C per 100 m height.
6. This decrease in temperature is known as adiabatic lapse rate.
7. But in most of the cases, there is decrease in temperature, but is less than adiabatic lapse rate.
8. Such change is known as sub adiabatic rate and the atmosphere is known to be under stable.
9. Under such conditions, the mixing of the pollutants and their dilution takes place slowly.
10. When the rate of decrease of temperature with height is more than the adiabatic rate, is known as super-adiabatic lapse rate and the atmosphere is under unstable condition.
11. Such conditions are very good for mixing and dilution of the pollutants.
12. The adiabatic lapse rate known as neutral condition is characterised by winds, cloudy days and night.

13. Sometimes the temperature increases with height, which is known as inversion.
14. Under condition the diffusion of the pollutants cannot take place and it forms a blanket layer at the tops.
15. The emission of pollutants occurs at or near surface of the earth. But the depth of the layer into which they made turbulent or diffused varies both in space and time.
16. The height above the surface of the atmosphere, where the adiabatic lapse rate intersects the observed vertical temperature profile is known as maximum mixing depth (MMD).
17. When the mixing height is low, but still above plume height, ground level concentration will be relatively high, because in this state the pollutants are prevented from dispersing in the upward atmosphere.

PART-2

Wind Velocity and Turbulence, Plume Behavior.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 2.4. Write down the effect of wind velocity on air pollution.

Answer

A. Wind Velocity :

1. Wind carries air contaminants away from their source, causing them to disperse.
2. In general, the higher the wind speed, the more contaminants are dispersed and the lower their concentration.
3. However, high wind can also generate dust - a problem in dry windy rural areas.

B. Direct Effects of Weather on Air Quality : Following are the factors that can direct affect the amount of air pollution :

1. **Sunshine :** Makes some pollutants undergo chemical reactions, producing smog.
2. **Rain :** Washes out water-soluble pollutants and particulate matter.
3. **Higher Air Temperatures :** Speed up chemical reactions in the air.
4. Wind speed, atmospheric turbulence/stability, and mixing depth - affect the dispersal and dilution of pollutants.

Que 2.5. Describe turbulence effects on air pollutions.

Answer

1. There are basically two different causes of turbulent eddies :

i. Mechanical turbulence.

ii. Convective turbulence.

2. While both of them are usually present in any given atmospheric condition, either mechanical or convective turbulence prevails over the other.

3. **Mechanical Turbulence :**

i. It is caused by physical obstructions to normal flow such as mountains, building, trees, etc.

ii. The degree of mechanical turbulence depends on wind speed and roughness of the obstructions.

4. **Convective Turbulence :**

i. It results from different heating-cooling of surfaces and air masses.

ii. Higher the atmospheric temperature difference makes the greater turbulence in air pollution.

5. Atmospheric eddies cause a breaking apart of atmospheric parcels polluted air at lower and lower concentrations to occupy successively larger volumes of air.

6. Thus the level of turbulence in the atmosphere determines its dispersive ability.

Que 2.6. Describe the plume behaviour on air pollutions.

Answer

Plume Behaviour on Air Pollutions :

The manner in which the emitted plume behaves under each of these seven conditions are also shown in these figures, and explained below :

A. Looping Plume :

1. Looping plume [Fig. 2.6.1(*a*)] has a wavy character and occurs in super adiabatic environment; which produces highly unstable atmosphere, because of rapid mixing.

2. During the high degree of turbulence, the dispersion of plume would be rapid, yet higher concentrations near the ground may occur due to turbulence, before the dispersion is finally completed.

3. Hence, in areas where environment is generally super-adiabatic, higher stacks may be needed to prevent premature contact of pollutants with the ground.

4. Such conditions will then ensure a very good dispersion of pollutants; but automobile exhausts cannot be dispersed well, because they are released at lower levels.

B. Neutral Plume :

1. Neutral plume is the upward vertical rise of the plume from the stack, as shown in Fig. 2.6.1(*b*), which occurs when the environmental lapse rate is equal to or very near to the adiabatic lapse rate.

2. The upward lifting of the plume will continue till it reaches an air of density similar to that of the plume itself.

C. Coning Plume :

1. The neutral plume tends to cone as shown in Fig. 2.6.1(*c*), when the wind velocity is greater than 32 km/hr, and when cloud cover blocks the solar radiation by day and terrestrial radiation by night.

2. Coning plume also occurs under subadiabatic conditions (*i.e.*, when environmental lapse rate is less than the adiabatic lapse rate).

3. Under such conditions, the environment is slightly stable, and there is a limited vertical mixing, thereby increasing the probability of air pollution in the area.

4. The plume dispersion is known as coning, because the plume makes a cone like shape about the plume line, as shown in Fig. 2.6.1(*c*).

D. Fanning Plume :

1. Under extreme inversion conditions, caused by negative environmental lapse rate, from the ground and upto a considerable height, extending even above the top of the stack, the emission will spread only horizontally, as it cannot lift due to extremely stable environment.

2. In such a case, there will be no vertical mixing, and the plume will simply extend horizontally over large distances, as shown in Fig. 2.6.1(*d*). Such a plume pattern is called a fanning plume.

E. Lofting Plume :

1. When there exists a strong super adiabatic lapse rate above a surface inversion, then the plume is said to be lofting.

2. Such a plume has minimum downward mixing, as its downward motion is prevented by inversion, but the upward mixing will be quite turbulent and rapid.

3. The dispersion of pollutants will therefore, be rapid, and no concentrations will touch the ground.

4. Hence, this would be the most ideal case for dispersion of emissions.

F. Fumigating Plume :

1. When an inversion layer occurs at a short distance above the top of the stack, and super adiabatic conditions prevail below the stack, then the plume is said to be fumigating (Fig. 2.6.1(*f*)).

2. In such a case, the pollutants cannot escape above the top of the stack because of inversion layer, and they will be brought down near the ground due to turbulence in the region above the ground and below the inversion, caused by strong lapse rate.
3. This represents quite a bad case of atmospheric conditions for dispersion.

G. Trapping Plume :

1. When inversion layers exist above the emission source, as well as below the source, then naturally, the emitted plume will neither go up, nor will it go down, and would remain confined between the two inversions, as shown in Fig. 2.6.1(*g*).
2. Such a plume is called a trapping plume, and is considered a bad condition for dispersion, as the dispersion cannot go above a certain height.

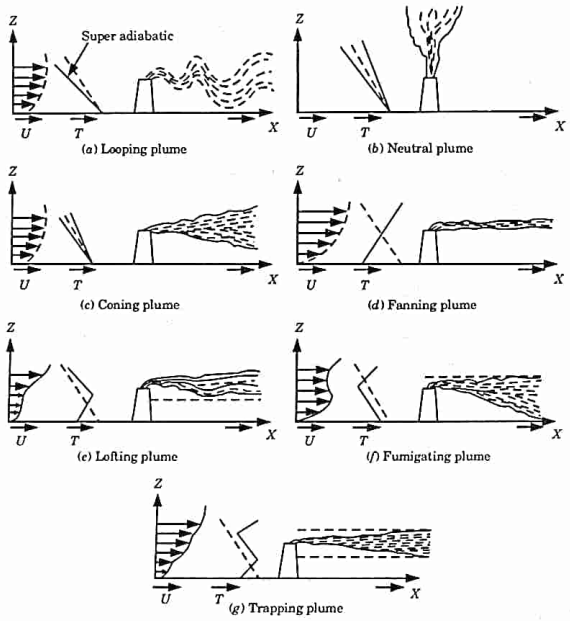


Fig. 2.6.1. Different types of plume behaviours.

PART-3

Dispersion of Air Pollutants, the Gaussian Plume Model, Stack Height and Dispersion.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 2.7. **What are the impact of atmospheric pressure on dispersion of air pollutants ?**

Answer

Impact of Atmospheric Pressure on Dispersion of Air Pollutants :

1. While the formation of high pressure system over an area, if continues for several days, could buildup serious air pollution problems, due to formation of inversion conditions.
2. Hence, high pressure systems (anticyclones), which are accom anied by clear skies, light winds, and atmospheric stability, may pro to be bad for dispersion of pollutants.
3. On the other hand, low pressure systems (cyclones), which are as ated with highly unstable atmospheric conditions, generally lead good mixing and rapid dispersion of pollutants.
4. Hence, such cyclonic atmospheric conditions, which ar ly accompanied by rains and storms, prove to be better for dis of pollutants.
5. However when a warm front overtakes a low pressure cell, ing influences are produced.
6. Initially, warm front will reduce the pollutant load mainly rm activity along its leading edge; but as the warm front de re stable conditions will form with an accompanying incre di pollution potential.

Que 2.8. **Discuss the impact of moisture and pre pitation on dispersion of air pollutants.**

Answer

Impact of Moisture and Precipitation on Dispersion of Air Pollutants :

1. The moisture content, and the form in which it is present in the atmosphere, may considerably affect the stability of air at a particular region.

2. The presence of water vapour (humidity) in the air affects the air quality, primarily by blocking and obstructing the solar radiation reaching the ground, and also the heat radiation reflected from the surface.
3. Humidity also leads to formation of fogs, and increases the Earth's corrosive action of air pollutants.
4. Excessive moisture in the atmosphere will finally lead to rains, which are helpful in improving the quality of the ambient air, because they wash down the pollutants to the Earth, to be ultimately drained out with rain-run off.
5. The process of removal of atmospheric SO_2 through rain, may, however, cause problems due to reaction of SO_2 with water, forming H_2SO_3 or H_2SO_4 leading to fall of acid rain, which increases the rate of corrosion where air pollutants are present and in addition, decreases the pH of rivers and streams, adversely influencing the algae and plant life of such water bodies.

Que 2.9. How do winds impact the dispersion of pollutants into the ambient air environment ?

Answer

Impact of Winds on Dispersion of Pollutants :

1. The moving air is known as wind. Such a movement in the air is caused by the unequal distribution of atmospheric temperature and pressure over the Earth's surface, and is largely influenced by the rotation of the earth.
2. The direction of winds is always from high pressure areas to low pressure areas, but the coriolis force tends to deflect the air currents out of these expected patterns.
3. Regional and local geographical and topographical features may also affect the direction and speed of winds.
4. The quicker heating and cooling of the Earth as compared to the neighbouring sea may also cause the flow of sea breezes from sea to land during day time, and flow of land breezes from land to sea during nights after sun set, respectively.
5. Such a wind pattern may also contribute to air pollution problems.
6. In the friction layer at the Earth's surface, winds are generally gusty and changeable, primarily due to locally generated mechanical or thermal turbulence.
7. Wind speed is usually measured by an anemometer at a height, say Z_0. Knowing the wind velocity (u_0) at anemometer height (Z_0), we can work out the velocity u at any other height Z by using the formula

$$u = u_0 \left[\frac{Z}{Z_0}\right]^k \qquad ...(2.9.1)$$

Where, k is a constant ≈ 1/9 for large lapse rates, and 1/3 for marked inversions, average normal value being 1/7.

8. The direction and speed of surface winds primarily govern the drift and diffusion of polluted gases and particulate emissions from automobiles and factories, etc. emitted near the ground levels.
9. The higher the wind speed at or near the point of emission, the more rapidly the pollutants would be carried away from the source.
10. The pollutants so dispersed, will not exist at the same concentration, but will rapidly be diluted with greater and greater volumes of air.

Que 2.10. Write down the Gaussian distribution equation which is commonly used to predict the concentration of an air pollutant evolving from a source (factory) at any downward point, and the location of the maximum pollution.

Answer

Gaussian Distribution Equation :

1. The Gaussian plume model is the most common air pollution model for estimating concentrations from point sources downwind.
2. Employing a three-dimensional axis of downwind (x), crosswind (y), and vertical (z) with the origin at the effective height of emission, it assumes that the time-averaged plume concentrations from a continuously emitting plume, at each downwind distance, have independent Gaussian distributions both in the horizontal and the vertical.
3. Following are the assumptions of Gaussian model :

i. Concentrations are proportional to the emission rate.

ii. Pollutants are diluted by the wind at the point of the emission at a rate inversely proportional to the wind speed, which is constant both in time and height

iii. They do not undergo chemical reactions or other removal processes.

iv. Pollutant material reaching the ground or the top of the mixing height as the plume grows is reflected back to the plume centerline.

4. The equation, known as Gaussian distribution equation, is given as :

$$C_{x,y} = \frac{Q}{\pi u \sigma_z \sigma_y} (e)^{-\frac{1}{2}\left(\frac{H^2}{\sigma_z^2} + \frac{y^2}{\sigma_y^2}\right)}$$

or

$$C_{x,y} = \frac{Q}{\pi u \sigma_z \sigma_y} (e)^{-\frac{1}{2}\frac{H^2}{\sigma_z^2}} \cdot (e)^{-\frac{1}{2}\frac{y^2}{\sigma_y^2}} \qquad ...(2.10.1)$$

where, C = The concentration of pollutant in gm/m^3.

Q = The pollutant emission rate in gm/sec.

u = Mean wind velocity in m/sec.

x and y = Downwind and cross wind horizontal distances, respectively in m.

σ_y = Plume's standard deviation in cross-wind direction in m.

σ_z = Plume's standard deviation in vertical direction in m.

H = Effective height of stack.

5. When concentration is required only along x-direction, *i.e.*, in the downwind horizontal direction along the centre line of the plume, then naturally, $y = 0$. Then eq. (2.10.1) becomes

$$C_{x,0} = \frac{Q}{\pi u \sigma_z \sigma_y} (e)^{-\frac{1}{2}\left(\frac{H^2}{\sigma_z^2}\right)} \quad ...(2.10.2)$$

6. When the smokes are emitted at ground level, the effective stack height (H) is zero, then the above eq. (2.10.2) gets further simplified, as

$$C_{x,0} = \frac{Q}{\pi u \sigma_z \sigma_y} \quad ...(2.10.3)$$

7. Values of σ_y and σ_x are not only a function of downwind distance (x) but are also a function of atmospheric stability.

Que 2.11. **A coal-fired thermal power plant burns 6.25 tonnes of coal per hour, and discharges the combustion products through a stack having an effective height of 80 m. The coal has a sulphur content of 4.7 %, and the wind velocity at the top of the stack is 8.0 m/sec. Atmospheric conditions are moderately to slightly unstable. Determine the maximum ground-level concentration of SO_2 and the distance from the stack at which this maximum occurs.**

Answer

Given : Coal burnt per hour = 6.25 t = 6250 kg, Sulphur content of coal = 4.7 %, H = 80 m, u = 8 m/sec

To Find : $C_{(x,\,0)max}$ of SO_2 and x_{max}

1. Emission rate for SO_2 :

Sulphur produced per hr = $6250 \times \frac{4.7}{100}$ kg = 293.75 kg

Now, $S + O_2 = SO_2$

the molecular mass of both S and O_2 is 32, and they combine on a one to one mass basis.

$\therefore$ 293.75 kg of S + 293.75 kg of O_2 = 587.5 kg of SO_2 per hour

Emission rate of SO_2 in gm/sec = $\frac{587.5 \times 1000}{60 \times 60}$ gm/sec

= 163.19 gm/sec.

2. The maximum ground level concentration occurs where $\sigma_z = 0.707\,H$, provided $\frac{\sigma_z}{\sigma_y}$ is constant with x.

For the given atmospheric conditions of moderately to slightly unstable, we have the stability class as B to C. For conservative designs, let us assume it to be class C.

The maximum ground level concentration would occur where

$$\sigma_z = 0.707\,H = 0.707 \times 80 = 56.6 \text{ m}.$$

From we can find that az will reach a value of 56.6 m at x = 850 m (for C class of course).

Hence, maximum concentration would occur at x = 850 m, provided $\frac{\sigma_z}{\sigma_y}$ is constant upto this distance. It can be confirmed from that for class C conditions, $\frac{\sigma_z}{\sigma_y}$ is constant for distances (x) up to 1 km from the stack.

Hence, x_{max} = 850 m.

3. Now, to determine concentration at x = 850 m, we use Gaussian Distribution Equation (2.10.2), as

$$C_{(x,\,0)} = \frac{Q}{\pi u \sigma_z \sigma_y} (e)^{-\frac{1}{2}\left(\frac{H^2}{\sigma_z^2}\right)} \quad ...(2.11.1)$$

Form eq. (2.11.1), σ_y = 88 m at x = 850 (C class)

$$\therefore \quad C_{max} = \frac{163.19}{3.14 \times 8 \times 56.6 \times 88} (e)^{-\frac{80^2}{2(56.6)^2}} \text{ gm/m}^3$$

$$= 4.8 \times 10^{-4} \text{ gm/m}^3 = 480\ \mu \text{ gm/m}^3.$$

Que 2.12. **From the above question, determine the ground level concentrations at a distance of 2 km downwind at :**

a. The centre line of the plume, and

b. At a crosswind distance of 0.5 km on either side of the centre line.

Answer

Given : $x = 2$ km

To Find : $C_{(x,y)}$ at

i. $y = 0$, ii. $y = 0.5$ km

1. Concentration at $x = 2$ km along centre line of plume, means $y = 0$ and $x = 2$ km. The ground level concentration is given as,

$$C_{(x,0)} = \frac{Q}{\pi u \sigma_z \sigma_y} (e)^{-\frac{1}{2}\frac{H^2}{\sigma_z^2}}$$

where, $\sigma_z = 130$ (from σ_z *Vs* x graph, for $x = 2$ km and C class)

$\sigma_y = 220$ (from σ_y *Vs* x graph, for $x = 2$ km and C class)

$$\therefore \quad C_{(2,0)} = \frac{163.19}{3.14 \times 8 \times 130 \times 220} (e)^{-\frac{80^2}{2 \times (130)^2}} \text{ gm/m}^3$$

$$= 1.878 \times 10^{-4} \text{ gm/m}^3 = 1878 \, \mu \text{ gm/m}^3.$$

2. Concentration at $x = 2$ km and $y = 0.5$ km (*i.e.*, 500 m) is given by,

$$C_{(x,y)} = \frac{Q}{\pi u \sigma_z \sigma_y} (e)^{-\frac{H^2}{2\sigma_z^2}} (e)^{-\frac{y^2}{2\sigma_y^2}}$$

$$= \frac{163.19}{3.14 \times 8 \times 130 \times 220} (e)^{-\frac{80^2}{2 \times 130^2}} \times (e)^{-\frac{(0.5)^2}{2 \times 220^2}} \text{ gm/m}^3$$

$$= 0.142 \times 10^{-4} \text{ gm/m}^3 = 14.2 \, \mu \text{ gm/m}^3.$$

Que 2.13. What is meant by the effective height of a stack (chimney) and how is it computed ?

Answer

Effective Height of a Stack :

1. The value of H used in Gaussian Distribution Equation is the effective height of the stack (chimney) and not its actual height.
2. This effective height consists of actual height (h) plus the height (Δh) to which the plume rises above the stack before levelling out, as shown in Fig. 2.13.1.

$$\therefore \quad H = h + \Delta h \qquad \ldots(2.13.1)$$

where, h = Actual height of stack in m.

Δh = Plume height in m.

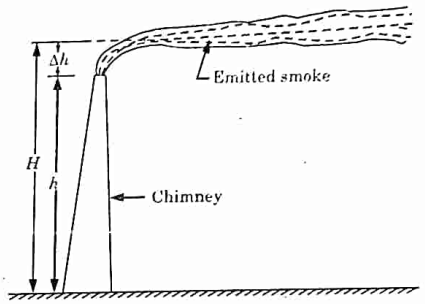


Fig. 2.13.1.

3. There exists several equations for calculating the plume height Δh; out of which, Holland's equation is often used and is given by,

$$\Delta h = \frac{v_s D}{u} \left[15 + 2.68 \times 10^{-3} \, PD \left(\frac{T_s - T_a}{T_s} \right) \right] \qquad \ldots(2.13.2)$$

where, Δh = Rise of plume above the stack in m.

v_s = Stack gas velocity *i.e.*, efflux emission velocity from the stack in m/sec.

D = Inside exit diameter of stack in m.

u = Wind speed in m/sec.

P = Atmospheric pressure in mill-bars.

T_s = Stack gas temperature in K.

T_a = Air temperature in K.

4. Eq. (2.13.2) is quite suitable for computing Δh from neutral conditions. For unstable conditions, the above value of Δh should be increased by 10 to 20 %, and for stable conditions, it should be decreased by 20 to 10 %.
5. Another frequently used equation for computing Δh is given by Davidson and Bryant, as :

$$\Delta h = \left(\frac{v_s}{u} \right)^{1.4} \left(1 + \frac{T_s - T_a}{T_s} \right) \qquad \ldots(2.13.3)$$

6. All the terms used in this equation have the same meaning, as for eq. (2.13.2).

7. The Bureau of Indian Standards (BIS), earlier known as ISI, has through their code No. IS : 8829—1978 suggested the following empirical formulas for computing plume rise (Δh) :

i. For hot effluents with heat release of the order of 10^6 cal/sec or more :

$$\Delta h = 0.84\,(12.4 + 0.09\,h)\,\frac{Q_H^{1/4}}{u} \qquad ...(2.13.4)$$

where, Q_H = Heat release in calories per second.
h = Height of the chimney in m.
u = Wind velocity in m/sec.

ii. For not very hot releases, and which can be counted as momentum sources above :

$$\Delta h = \frac{3 v_s D}{u} \qquad ...(2.13.5)$$

where, v_s and D have the same meaning as in eq. (2.13.2).

Que 2.14. Determine the effective height of a stack, with the following given data :
1. **Physical stack is 180 m tall with 0.95 m inside diameter.**
2. **Wind velocity is 2.75 m/sec.**
3. **Air temperature is 20 °C.**
4. **Barometric pressure is 1000 millibars.**
5. **Stack gas velocity is 11.12 m/sec.**
6. **Stack gas temperature is 160 °C.**

Answer

Given : $h = 180$, $D = 0.95$ m, $u = 2.75$ m/sec,
$T_a = 20$ °C $= 20 + 273 = 293$ K, $P = 1000$ millibars, $v_s = 11.12$ m/sec
$T_s = 160$ °C $= 160 + 273 = 433$ K
To Find : Effective height of a stack (H).

1. Using Holland's equation, we get

$$\Delta h = \frac{v_s \times D}{u}\left[1.5 + 2.68 \times 10^{-3}\, PD\left(\frac{T_s - T_a}{T_s}\right)\right]$$

$$= \frac{11.12 \times 0.95}{2.75}\left[1.5 + 2.68 \times 10^{-3} \times 1000 \times 0.95 \times \frac{433 - 293}{433}\right]$$

$$= \frac{11.12 \times 0.95}{2.75}\left[1.5 + \frac{2.68 \times 0.95 \times 140}{433}\right]$$

$\Delta h = 8.92$ m

2. Effective height of stack, $H = h + \Delta h$
$= 180 + 8.92 = 188.92$ m

VERY IMPORTANT QUESTIONS

Following questions are very important. These questions may be asked in your SESSIONALS as well as UNIVERSITY EXAMINATION.

Q. 1. Describe the air pollution chemistry.
Ans. Refer Q. 2.1, Unit-2.

Q. 2. Describe the atmospheric temperature lapse rate and stability.
Ans. Refer Q. 2.3, Unit-2.

Q. 3. Describe the plume behaviour on air pollutions.
Ans. Refer Q. 2.6, Unit-2.

Q. 4. Discuss the impact of moisture and precipitation on dispersion of air pollutants.
Ans. Refer Q. 2.8, Unit-2.

Q. 5. Write down the Gaussian distribution equation which is commonly used to predict the concentration of an air pollutant evolving from a source (factory) at any downward point, and the location of the maximum pollution.
Ans. Refer Q. 2.10, Unit-2.

Q. 6. What is meant by the effective height of a stack (chimney) and how is it computed ?
Ans. Refer Q. 2.13, Unit-2.

Q. 7. Determine the effective height of a stack, with the following given data :
1. **Physical stack is 180 m tall with 0.95 m inside diameter.**
2. **Wind velocity is 2.75 m/sec.**
3. **Air temperature is 20 °C.**
4. **Barometric pressure is 1000 millibars.**
5. **Stack gas velocity is 11.12 m/sec.**
6. **Stack gas temperature is 160 °C.**

Ans. Refer Q. 2.14, Unit-2.

3

UNIT

Air Pollution Control

CONTENTS

PART-1

Ambient Air Quality and Standards, Air Sampling and Measurements.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 3.1. What do you mean by ambient air quality measurement and their standards of air pollution ?

Answer

Ambient Air Quality Measurement and their Standards :

1. The first Indian emission regulations came into existence in 1989. Further in 1991 and 1992 these regulations were soon replaced by gasoline and diesel vehicles.
2. Since 2000 India had been starting European Emissions and Fuel Regulations for light duty and heavy duty vehicles.
3. The automotive emission India is working on the two reports from planning commission established expert committee for Auto fuel Policy, Auto fuel vision and policy 2025.
4. The implementation schedule of EU emission in India is tabulated as given below :

Standard	Reference	Year	Region
India 2000	Euro 1	2000	All over the country
Bharat Stage II	Euro 2	2001	NCR, Mumbai, Kolkata, Chennai
		2003	NCR, 11 other cities
		2005	All over the country
Bharat Stage III	Euro 3	2005	NCR, 11 other cities
		2010	All over the country
Bharat Stage IV	Euro 4	2010	NCR, 13 other cities
		2015	29 cities mainly in the states of Uttar Pradesh, Rajasthan, Haryana and Maharashtra
Bharat Stage V	Euro 5	2019	All over the country
Bharat Stage VI	Euro 6	2021	All over the country

5. The above standards are for 4-wheel vehicles are suggested in different regions of the country.
6. For 2 and 3 wheelers, Bharat stage II applied from April 2005 and Bharat stage III from April 2010.
7. In May 2014 the expert committee recommended Bharat stage V from April 2017 all over the country. It is proposed up to 2025.

Que 3.2. What are the objectives of stack sampling at origin of pollution ?

Answer

Objectives of Stack Sampling :

1. The most important work is to collect the samples of the emission of gases at source. This collection of samples is also known as stack sampling at origin of pollutants.
2. The emission inventories data are systematically collected to have the detailed information regarding the air pollution emission in the particular area.
3. The main objects of the sampling at source are :

i. To measure the quality and quantity of pollutant produce by the source.
ii. To determine the quality and efficiency of control equipments under various conditions.
iii. To determine the emission due to changes in raw materials and the processes in the industry.
iv. For the application of the local control system at the place.
v. To collect data from a single pollutant or multiple pollutant source.
vi. To know the nature of the pollutant source.
vii. To determine the effect on the emission of the pollutant source in different weather of the year.
viii. To determine the effect in the emission in different zones/areas of the country.

Que 3.3. Write the steps of procedure for particular matter sampling.

Answer

Procedure for Particular Matter Sampling : The NEERI (National Environmental Engineering Research Institute) has given the procedure for the collection of particular matter sampling :

1. Determine the gas composition and correct to moisture content.
2. Determine the temperature and velocity at each traverse point.
3. Determine the empty weight thimble (W_1).
4. Mark out the traverse points on the probe. The marks are properly fixed by typing with asbestos thread.
5. Check all points for leakages.
6. Determine the flow rate to be sampled under isokinetic conditions.

7. Insert the probe at the traverse points 1, very close to the stack. Start the pump and adjust the flow so that the rotameter reads the predetermined value.
8. Switch off the pump at the end of sampling time.
9. Read the vacuum at the dry gas meter (DGM) and temperature.
10. Move the probe to the subsequent traverse points by repeating the steps 5 to 8.
11. After completion of collection of sample, remove the probe and allow it to cool.
12. Remove the thimble carefully. Some of the dust would be adhered to the nozzle. These should be removed by tapping and transfer to the thimble.
13. Weigh the thimble with sample. The difference in weight gives the dust collected.
14. The volume of sample collected either given by dry gas meter or by sampling rate given by rotameter multiplied by the sampling time.
15. Hence from (12) and (13) the emission rate can be calculated. This will give DGM conditions. This is to be corrected for temperature and pressure so as to obtain for standard conditions.

PART-2

Control of Particulate Air Pollutants using Gravitational Settling Chambers, Cyclone Separators, Wet Collectors, Fabric Filters (Bag-house filter), Electrostatic Precipitations (ESP).

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 3.4. Describe the gravitational settling chamber with its advantages and disadvantages.

Answer

A. Gravity Settling Chamber :

1. It consists of a cylindrical body with multiple dust hoppers as shown in the Fig. 3.4.1.
2. The dirty air enters into the chamber from one end. During this process the dense particles present in the air settled down into the hoppers and the clean air escaped out from another end.
3. This technique is based on the gravity phenomenon.
4. The emitted smokes, when made to pass through a settling chamber Fig. 3.4.1, drop some of their larger sized particles in the chamber, under Stoke's law.

5. The largest size particle (d) that can be removed with 100 % efficiency in such a chamber of length L and height H is given by,

$$d = \sqrt{\frac{18\mu\, v_h\, H}{g\, L\, \rho_p}}$$

where, v_h = Horizontal velocity of gas passing through the chamber, between 0.5 to 2.5 m/sec.
ρ_p = Density of particles removed.
μ = Viscosity of air, at the given temperature in kg/m. sec.
C = Correction factor for existing non-quiescent conditions in the gas flow through the chamber, generally taken at equal to 2.

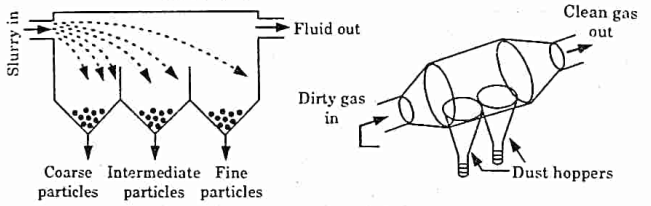


Fig. 3.4.1. Gravity settling chamber.

B. Advantages of Settling Chamber : Following are the advantages of settling chamber :

1. It has very low energy cost.
2. It has low capital cost.
3. It has low pressure drop through device.
4. It has excellent reliability.
5. It provides incidental cooling of gas stream.

C. Disadvantages of Settling Chamber : Following are the disadvantages of settling chamber :

1. It has large physical size.
2. It cannot handle sticky dust.
3. Its cost increases as the cost of material increases.

Que 3.5. Explain in detail "Cyclones Equipments" which is used to control air pollutants.

Answer

Cyclones Equipments :

1. It consists of a cylinder with inverted cone at the bottom.
2. The gas particles enter the cylinder from top in tangential manner.
3. Then it passes through vertex separators. The rotational effect and the gravity are used to separate mixture of solids and fluids.
4. A centrifugal force rotates the particles at very high speed which is called a cyclone in industrial and professional kitchens for separating grease from the exhaust air.

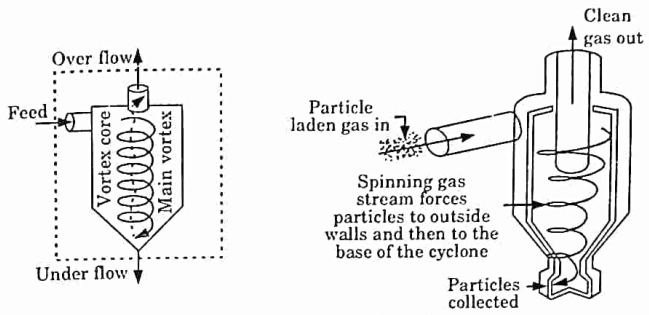


Fig. 3.5.1. Cyclone method.

5. A cyclone works on the principle of creating high-speed spiral air flow to remove particles. This spiral motion applies a centrifugal force on the particles.
6. The inertia of the particles forces them to the outside walls of the cyclone, where they fall to the bottom and are collected.
7. The speed of the air flow and the width of the cyclone influence particle removal the smaller the diameter, the more efficient is the particle removal.
8. The conical section at the base of the cyclone gradually decreases the diameter of the spinning gas stream, resulting in better removal of smaller particles.
9. However, in practice, reducing the diameter increases the pressure drop across the cyclone. Combining several units together as a 'multi-cyclone' can prevent this.
10. Its efficiency depends on the generated centrifugal force (F_c), which in turn, depends on mass of the particles (M_p), inlet gas velocity (v_i) and radius of cyclone (R), and is given by,

$$F_c = M_p \frac{v_i^2}{R}$$

11. A dynamic precipitator Fig. 3.5.1 imparts centrifugal force to the entering gas with the help of rotating vanes, and is, thus, about 7 times more effective than an ordinary cyclone.
12. Such a unit can work as an exhaust fan as well as a dust collector.
13. They are widely used in ceramics, food and pharmaceutical and wood working industries.
14. They cannot, however, handle wet fibrous material, which tend to accumulate on the moving vanes.

Que 3.6. What are the advantages and disadvantages of cyclone collector or separator ?

Answer

A. Advantages of Cyclone Collector :

1. Relatively inexpensive, simple to design and maintain.
2. Requires less floor area.
3. Ensures dry continuous disposal of collected dusts.
4. Low to moderate pressure loss (2.5 to 20 cm).
5. It can handle large volumes of gases at temperatures upto 90°C. Cyclones are widely used in industries producing larger quantities of gas containing larger sized particles, like, Cement and Fertilizer plants, Petroleum refineries, Asphalt mixing plants, Grain mills, Cotton gins, etc.

B. Disadvantages of Cyclone Collector :

1. Requires much head room.
2. Collection efficiency is low for smaller particles.
3. Quite sensitive to variable dust loadings and flow rates.

Que 3.7. Describe the "Wet Scrubber" which is used to control air pollution.

Answer

Wet Scrubber :

1. Wet scrubbers are effective air pollution control devices for removing particles and gases from industrial exhausts.
2. In this device polluted air passes through absorbent liquid or water sprayed on the polluted air.
3. So these dirty particles of air stream contacts the liquid, the liquid absorbs the pollutants, in much the same way that rain droplets wash away strong odours on hot summer days.

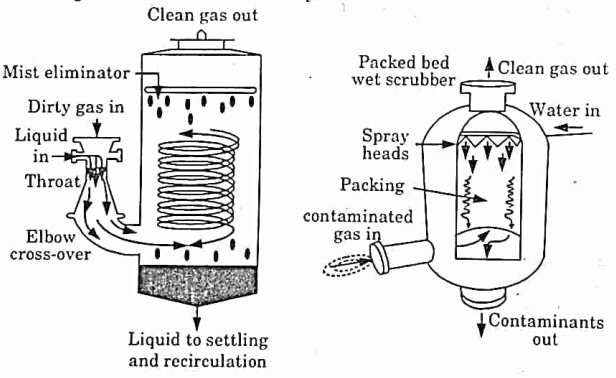


Fig. 3.7.1. Wet scrubber.

i. A packed bed wet scrubber removes gaseous and particle contaminants from a gas stream.
ii. It works by bringing the gas stream into contact with a scrubbing liquid (usually water).
iii. The scrubbing liquid absorbs the gaseous pollutants, and the spray droplets physically capture the particles.
iv. The packed bed of non-reactive material gives a greater gas-to-liquid contact which improves the removal of particle pollutants.
v. Using certain scrubbing liquids can increase gaseous pollutant removal, e.g., using an alkaline liquid to remove acidic pollutants.
vi. Trapping and treating droplets of the scrubbing liquid can allow it to be recycled.

4. Wet scrubber produce wet sludge in the air purification process, it holds in the pond temporarily and after that it will be treated before reuse or disposed.
5. Wet scrubbers can be highly effective in removing particles, with removal efficiencies of up to 99%; however, their efficiency for very small particles can be much lower.
6. However, scrubbers suffer from high levels of corrosion and produce slurry waste streams which are less convenient for recycling and disposal.
7. Scrubbers remove 80-95 % of the SO_x. Certain types do not remove NO_x.
8. They are costly to retrofit to existing power plants. They increase the electric generating costs by 10-15 %.
9. Scrubbers are like liquid filters for the gases resulting from combustion.
10. The exhaust gases are forced through a spray of water containing calcium hydroxide, $Ca(OH)_2$.
11. The SO_2 gas reacts with the lime to produce a solid of calcium sulphate, $CaSO_4$.
12. There are some problems in getting rid of the liquid sludge that is produced. It can be pumped into a pond for temporary storage.

Que 3.8. What are the advantages and disadvantages of scrubber equipments ?

Answer

A. Advantages of Scrubbers : Following are the advantages of scrubbers :

1. It is a very efficient process to separate dirt from ambient air.
2. It can handle flammable and explosive dusts with little risk.
3. It provides gas absorption and dust collection in a single unit.
4. It provides cooling which is produced of hot gases.
5. It can be neutralized the corrosive and dusts.

B. Disadvantages of Scrubbers : Following are the disadvantages of scrubbers :

1. High potential for corrosion problems.
2. Disposal of waste sludge can be very expensive.

3. Collected particulate may be contaminated and unrecyclable.
4. Requires make up water to replace purged liquid and disposed sludge.

Que 3.9. Explain the bag house or fabric filters, used to control air pollution.

Answer

Bag House or Fabric Filters :

1. In such a system, the flue gas is allowed to pass through a woven or felted fabric, which filters out the particulate matter and allows the gas to pass.
2. Small particles are retained on the fabric, initially through interception and electro static attraction; and later on, when a dust mat is formed, the fabric starts collecting particles more efficiently.
3. A bag house filter unit, Fig. 3.9.1, provided in an ordinary room of the factory, contains several vertically hanging fabric cylindrical bags (1.8 to 9 m long); the upper ends of the bags are closed, and lower ends are attached to a hopper, where also, the inlet of the flue gas is located.

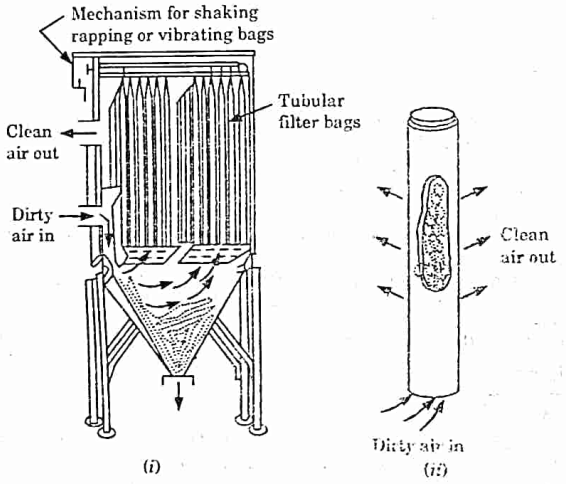


Fig. 3.9.1. Bag house fabric filter unit.

4. The upward moving gas drops out particulate matter in these bags, which settles down into the hopper, and cleaner gas goes out through the fabric filters.
5. The framework, housing the hanging bags, is provided with an automatic shaking device for cleaning the bags of the collected dust.

6. Compared to other types of air pollution control equipment, bag houses are incredibly versatile and can be engineered for almost any dust producing application by varying size and bag types.
7. They are very efficient when properly maintained and are also rugged enough to handle rough applications.
8. However, they typically require a lot of maintenance and a relatively dry environment to operate effectively.
9. Their use is also limited to certain operating temperatures and chemical conditions.

Que 3.10. What are the advantages and disadvantages of bag house filter ?

Answer

A. Advantages : Following are the advantages of bag house filters :

1. Versatile and flexible for many applications.
2. It is very high for collection and removal of very small particles.
3. It is cost-effective when properly designed and maintained.
4. It is modular design for convenient assembly.
5. It can collect other pollutants with certain fabric coating additions.

B. Disadvantages : Following are the disadvantages of bag house filters :

1. It is limited by high temperatures and corrosive chemicals.
2. It is requires a lot of maintenance.
3. It is not well suited for very high dust loads.
4. It is large footprint requiring large floor areas.
5. It is potential for fire or explosion.

Que 3.11. Describe the electrostatic precipitator equipment.

OR

What are the equipments used to control air pollution in industries ? Describe any one of them.

Answer

Air Pollution Controlling Equipments :

Following are the equipments used to control air pollution in industries :

1. Gravity settling chamber.
2. Scrubbers.
3. Cyclones.
4. Bag house filters.
5. Electrostatic precipitator.

Electrostatic Precipitator Equipment :

1. The electrostatic precipitator works by removing particles and smoke from a gas stream using an electrostatic charge.
2. Electrostatic precipitator generally large size low velocity dust collection devices.
3. In this transformers are used to develop extremely high voltage given between charging electrodes and collecting plates

4. Electrostatic precipitators have two parts one is the charging and another is the collecting sections.
5. In the charging section, the incoming smoke, grease, mist, and other particulates pass by ionizer wires which impart a positive electrical charge to these contaminants.
6. The positively charged contaminants are then drawn through the collection section which contains a secondary electrical field with negatively charged aluminium plates.
7. Since opposite charges attract, the positively charged contaminants collect on the negatively charged aluminium plates, periodically the collected dust is removed from the collecting plates by a hammer device, which falls to a bottom hopper for removal.
8. The removal efficiencies for ESPs are highly variable, however, for very small particles alone, the removal efficiency is about 99 percent.
9. ESPs are used in boilers, furnaces, and many other units of thermal power plants, cement factories, steel plants, etc.

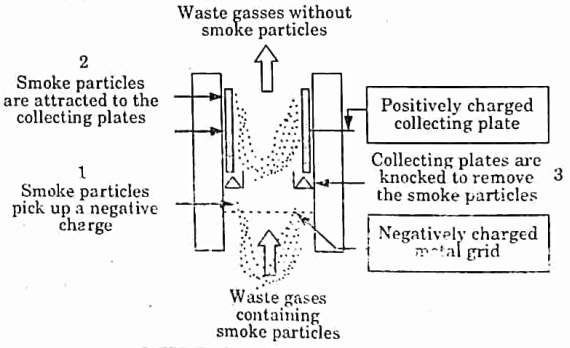


Fig. 3.11.1. Electrostatic precipitator.

Que 3.12. What are the advantages and disadvantages of electrostatic precipitator ?

Answer

A. Advantages of Electrostatic Precipitator : Following are the advantages of electrostatic precipitator :

1. Particles may be collected wet or dry.
2. 99 % and plus efficiency can be obtained.
3. Even small particles can be removed.
4. Maintenance is nominal, unless corrosive and adhesive materials are present in flue gases.

5. They contain a few moving parts.
6. They can be operated at high temperatures upto 300–450 °C.

B. Disadvantages of Electrostatic Precipitator : Following are the disadvantages of electrostatic precipitator :

1. Higher initial costs.
2. Sensitive to variable dust loadings and flow rates.
3. They use high voltage, and hence may pose risk to personal safety of the staff.
4. Collection efficiency reduces with time.

VERY IMPORTANT QUESTIONS

Following questions are very important. These questions may be asked in your SESSIONALS as well as UNIVERSITY EXAMINATION.

Q. 1. What are the objectives of stack sampling at origin of pollution ?
Ans: Refer Q. 3.2, Unit-3.

Q. 2. Write the steps of procedure for particular matter sampling.
Ans: Refer Q. 3.3, Unit-3.

Q. 3. Explain in detail "Cyclones Equipments" which is used to control air pollutants.
Ans: Refer Q. 3.5, Unit-3.

Q. 4. Describe the "Wet Scrubber" which is used to control air pollution.
Ans: Refer Q. 3.7, Unit-3.

Q. 5. Explain the bag house fabric filters, used to control air pollution.
Ans: Refer Q. 3.9, Unit-3.

Q. 6. Describe the electrostatic precipitator equipment.
Ans: Refer Q. 3.11, Unit-3.

☺☺☺

4

UNIT

Control of Gaseous Contaminants

CONTENTS

PART-1

Absorption, Adsorption, Condensation and Combustion.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 4.1. **Enumerate the various engineering devices that are used to control the emission of gaseous air pollution from industries. Describe any one.**

Answer

Following are the devices used to control the emission of gaseous air pollution from industries :

1. Absorption units.
2. Adsorption units.
3. Combustion or incineration equipments.

Absorption Units : Absorption units includes spray towers, plate towers, packed towers, and venturi scrubbers.

1. Out of these devices, spray towers and venturi-scrubbers can simultaneously be used for removing particulate pollutants.
2. Scrubbers are generally less effective in removing gaseous pollutants than towers, but then, towers get frequently clogged by particulate matter.
3. Other effective devices for removing gaseous pollutants, *i.e.*, plate towers and packed towers, are shown in Fig. 4.1.1 and Fig. 4.1.2, respectively.
4. These absorption units work on the principle of transfer of the pollutants from the gas phase to the liquid phase.
5. In other words, the pollutants from the dirty gas get absorbed in the liquid, through which the gas is made to pass, in these units.
6. Such absorption takes place by diffusion as well as dissolution.
7. The effectiveness of these devices, naturally, depends upon the solvent (liquid), through which the gas is made to pass.
8. When water is used as the solute, the removal is restricted only to a few inorganic gases, such as NH_3, Cl_2, and SO_2.
9. All such absorbent units must be properly designed for the given conditions, before one of them is adopted.

10. Care should also be taken to ensure that the pollutants transferred from air to water, may not cause heavy and uncontrollable water pollution.

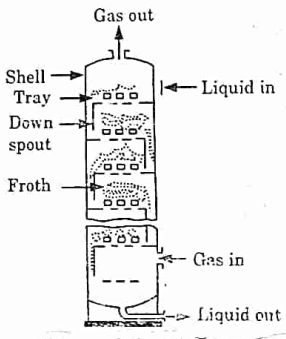


Fig. 4.1.1. Plate tower.

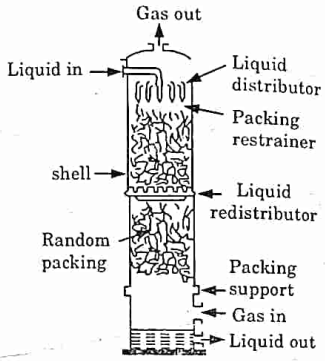


Fig. 4.1.2. Packed tower.

Que 4.2. Describe the adsorption units used to control gaseous air pollutions.

Answer

Adsorption Units :

1. Absorption units use adsorbents like activated carbon, molecular sieves (dehydrated zeolites, *i.e.*, alkali or metal silicates), activated alumina, silica gel, etc.
2. In adsorption units, the dirty gases are made to pass through the beds of such adsorbent materials, wherein the pollutants are effectively caught and removed.
3. Activated carbon beds can very effectively catch hydrocarbons, H_2S, and SO_2.
4. One special form of molecular sieve can also capture NO_x. A schematic sketch of such a unit is shown in Fig. 4.2.1.
5. The above adsorbents, except activated carbon, have the drawbacks of preferably capturing water, before catching any of the gaseous pollutants; and hence, water may have to be removed from the gas, before it is treated in such units.
6. Moreover, almost all the adsorbents are subject to destruction at moderately high temperatures (150 °C for active carbon, 600 °C for molecular sieves, 400 °C for silica gel, and 500 °C for activated alumina).
7. Hence, they prove to be very inefficient for purifying industrial gases at such high temperatures.

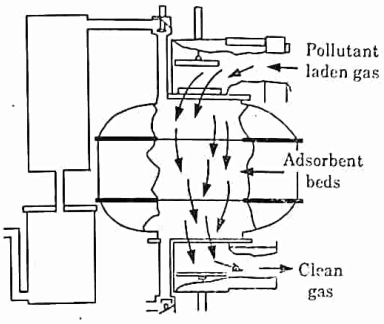


Fig. 4.2.1. Schematic sketch of an adsorption tower unit.

Que 4.3. Explain in detail about condensation and combustion equipments which are used as pollution control device.

Answer

Combustion or Incineration Equipments :

1. It may be used to purify polluted gases, when the pollutants in the gas streams are oxidizable to an inert gas.
2. Pollutants, like hydrocarbons and carbon monoxide (CO) can be easily burnt, oxidized, and removed in such equipments.
3. Both, Direct flame combustion by burners Fig. 4.3.1, and catalytic combustion Fig. 4.3.2, have been used in commercial applications.

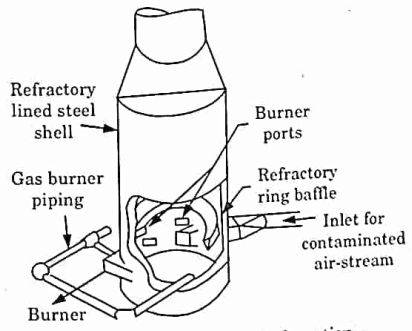


Fig. 4.3.1. Direct flame incineration.

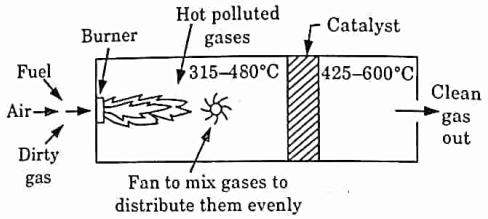


Fig. 4.3.2. Catalytic incineration.

4. Catalytic incineration can be used when combustible materials in the waste polluted gas, are too low to make direct-flame incineration feasible.
5. This generally happens when the energy of the polluted gas is lesser than 3.7 MJ/m^3.
6. At all such energy contents, the gas burning becomes self supporting after initial ignition, thereby making possible the use of direct flame incinerators. Secondary supporting fuel may also sometimes be used to make such a method feasible.
7. It has also to be ensured that the final combustion product from the incinerator is easily disposable, and less toxic than the original gas pollutants, being removed.
8. Direct flame incineration has been successfully used to purify the industrial gases in Varnish cooking, Meat smoke houses, and Paint bake oven industries,
9. When the combustible fuel value of the polluted gases are lower, some catalytic materials have been found to accelerate the rate of oxidation, without themselves undergoing a chemical change, thus reducing the incineration time, or making the incineration feasible even with low-energy polluted gases.
10. Costly Platinum (Pt) or Palladium (Pd) compounds have often been used as catalysts. Conventionally, such a catalytic compound is placed in a bed similar to absorption beds, and the supporting lattice is made of ceramic.
11. The old catalytic systems were effective only when the hot gases were being passed through them; and hence, pre-heating by heaters (as shown in Fig. 4.3.2) was an absolute necessity. But in modern days, even cold catalytic systems, which work at ambient temperatures, have been designed, thus eliminating the necessity of pre-heating.
12. Catalytic incinerators have often been successfully used to control SO_2, NO_x, CO, hydrocarbons, etc. Besides being costly, their major drawback is their susceptibility to poisoning by sulphur and lead compounds, even in trace amounts.
13. Catalytic combustion has successfully been used in purifying emissions like, varnish cooking, asphalt oxidation, printing press, etc.

PART-2

Control of Sulphur Oxides, Nitrogen Oxides, Carbon Monoxide, and Hydrocarbons, Automotive Emission.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 4.4. Describe the air pollution caused by automobiles and its control.

Answer

Air Pollution from Automobiles :

1. Automobiles chiefly emit carbon monoxide (CO), hydrocarbons (HC), and nitrogen oxides (NO_x).
2. The contents of these pollutants in the smoke, emitted by the automobiles, may usually vary, as :

CO	—	0.5 to 6.4 %
HC	—	300 to 1000 ppm
NO_x	—	500 to 3000 ppm,

depending upon the type and condition of the engine of the automobile.
3. An ideal internal combustion engine (IC engine), when gets stoichiometric mixture of air and fuel (14.7 : 1 ratio) burns them up completely to CO_2, water and nitrogen, without producing any CO.
4. But in actual practice, two and three wheeler petrol engines receive high fuel content mixture (12 : 1 ratio), during cold start, idling, acceleration, and high speed cruising; and similarly diesel engines receive low fuel content mixture (16 : 1 ratio) when running at a medium speed. So in practice, the combustion of fuel in automobiles is never complete.
5. Naturally then, the exhaust gases from such engines, invariably contain products of incomplete combustion; *i.e.*, CO, HC, H_2, hundreds of oxygenated hydrocarbons, as well as small fractions of nitrogen oxides.
6. These pollutants are highly dangerous to the overall environment and to the life in general; and hence the automobiles are now a days seen as a symbol of technological menace.
7. The emissions from petrol engines of two, three and four wheelers (including cars, having 4 stroke engines), contain heavier concentrations of HC and CO; whereas, the four stroke diesel engines of diesel vehicles (buses and trucks) contain heavier concentrations of NO along with thick smoke and particles.

8. The auto emissions also contain gaseous pollutants, like SO_2, and lead compounds, especially when lead containing fuel is used in India.

Controlling of Automobiles Pollution :

1. In order to reduce lead menace, efforts are now on, in India, to reduce lead content in the gasoline, as it will take quite some time before we are able to switch over completely to lead-free gasoline.
2. Similarly, SO_2 emissions are caused in auto exhausts, because sulphur, or 'compounds of sulphur' are invariably present in the mineral oil.
3. Efforts are also on, to reduce sulphur content, to as low a level as possible, in the gasoline.
4. Besides the above improvements required in the gasoline, the upkeep and maintenance of the auto engines, is also of utmost importance.
5. The proper tuning of the engine and carburettor is very essential, in order to control pollutant emissions.
6. Central Motor Vehicles Rules 1989, framed under Motor Vehicles Act, 1988, has therefore, stipulated permissible auto-emission levels.
7. The maximum permissible CO emission, while idling is limited to 3.0% for cars, and 4.5% for two and three wheelers.

PART-3

Control Catalytic Convertor Euro-I, Euro-II and Euro-III Specifications, Indian Specifications.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 4.5. Write a short note on catalytic convertor, which is used to control the air pollution from automobiles.

Answer

Catalytic Convertor :

1. The catalytic convertors are usually made of noble metals, like platinum, palladium, etc., and help in oxidising CO and HC into their final end product of CO_2, and also to reduce NO into nitrogen.
2. These noble metal catalysts are highly active, and resist sulphur poisoning.
3. They may be made in pellets, or may be in the form of a monolithic one piece metal.

4. A catalytic convertor is generally placed inside the tail exhaust pipe of the automobile, so as to pass through it the 'partially oxidised emissions, before they are let out into the atmosphere.
5. In earlier years, two different catalytic metal beds were being used for oxidizing CO and HC, and for reducing NO ; but in modern days, catalysts have been designed, which catalyse both sets of reactions.
6. These catalysts, popularly called three way catalysts, (P_t, P_d and R_h), have simplified the dual bed to a single bed catalytic converter.
7. Presently, installation of such three way catalytic converters is compulsory for all automobiles plying on the roads of USA and Japan.
8. The auto manufacturers in India, have however, been avoiding the incorporation of catalytic convertors in the vehicles, primarily due to the high cost of noble metals.
9. These convertors will also necessitate certain changes in the basic design of the engines, as they tend to reduce the engine efficiency.
10. Efforts are also being made at Indian Institute of Petroleum - Dehradun, Regional Research Laboratory - Bhubaneswar, and Projects and Development India Ltd. - Sindri, to develop an efficient catalytic system, using cheaper metals, like Mn, Cu, Cr-Cu, composite oxides.
11. Be that as it may, the Indian car manufacturers have now started fitting catalytic converters in the new cars being released in our metro cities and the lead free petrol required to run such vehicles has been available in all the metropolitan cities of India, since about the year 1996.
12. Whereas, there had been an improvement in the designs of petrol run cars, there had been a tendency on the part of auto manufactures to change over to diesel run cars, due to lesser unit cost of diesel as compared to petrol.
13. The diesel fumes have, however, been found to be more polluting than those of petro, particularly in respect of toxic carcinogenic particulate matter being released by diesel vehicles.
14. The ban on diesel cars has also been recommended by the environmental Pollution (Prevention and Control) Authority (EPCA).

Que 4.6. Write down the specifications of Euro-I, Euro-II and Euro-III.

Answer

Table 4.6.1 Existing as well as notified Euro-I, Euro-II and Euro-III Emission Norms

	CO (g/km)		HC + NO (g/km)		PM (g/km)	
	Petrol	Diesel	Petrol	Diesel	Petrol	Diesel
India 1996	8.68-12.40	5-9	3-4.36	2-4	–	–
India 2000	2.72	2.72-6.90	0.97	0.97-1.70	–	0.14-0.25
Euro I : (Enforced in Europe in 1993) Enforced in National Capital Region (NCR) of India from June 1, 1999	2.72	2.72	0.97	0.97	–	0.14
Euro II : (Enforced in Europe in 1996) Enforced in NCR India) from April 1, 2000	2.20	1.00	0.50	0.70-0.90	–	0.08-0.10
Euro III : (Enforced in Europe in 2000	2.30	0.60	0.2-0.15	0.56	–	0.05

Que 4.7. What are the Indian specifications of pollution control from automobiles ?

Answer

Indian Specifications of Pollution Control from Automobiles :

1. The first Indian emission regulations were idle emission limits which became effective in 1989.
2. These idle emission regulations were soon replaced by mass emission limits for both gasoline (1991) and diesel (1992) vehicles, which were gradually tightened during the 1990s.
3. Since the year 2000, India started adopting European emission and fuel regulations for four-wheeled light-duty and for heavy-duty vehicles.
4. India's own emission regulations still apply to two- and three-wheeled vehicles.

5. The foundation for automotive emission standards in India since the early 2000s is contained in two reports from the Indian Planning Commission.
6. The National Auto Fuel Policy, announced on October 6, 2003, envisioned a phased program for introducing Euro 2-4 emission and fuel regulations by 2010.
7. In order to establish limits beyond Bharat Stage IV, the Indian Planning Commission established an Expert Committee in 2013 to draft an updated Auto Fuel Policy, Auto Fuel Vision and Policy 2025, that was published in May 2014.

Indian Specification :

Standard	Reference	Date	Region
India 2000	Euro 1	2000	Nationwide
Bharat Stage II	Euro 2	2001	NCR, Mumbai, Kolkata, Chennai
		2003-04	NCR, 11 other cities
		2005-04	Nationwide
Bharat Stage III	Euro 3	2005-04	NCR, 11 other cities
		2010-04	Nationwide
Bharat Stage IV	Euro 4	2010-04	NCR, 13 other cities
		2015-07	Above plus 29 cities mainly in the states of Haryana, Uttar Pradesh, Rajasthan and Maharashtra
		2015-10	North India plus bordering districts of Rajasthan (9 States)
		2016-04	Western India plus parts of South and East India (10 States and Territories)
		2017-04	Nationwide
Bharat Stage V	Euro 5	NO	—
Bharat Stage VI	Euro 6	2020-04	Nationwide

Que 4.8. What are the application of adsorption for control of gaseous and odour emission at source ?

Answer

Application of Adsorption : following are the application of adsorption for control of gaseous and odour emission at source :

1. **Vapor Recovery in Process Industries :**

i. Major applications are in the recovery of solvents from air stream that are free from particulate matter and whose vapor concentrations are above 700 ppm.

ii. Activated carbon has been found very effective in adsorption of various organic compounds.

2. **Deodorization of Odours Emissions :** Many odorants in low concentrations such as 100 ppb or less are detectable and objectionable and deodorization of such gas stream by solid adsorption is in many instances an effective and economical procedure.

3. **Adsorption of H_2S and Carbon disulphide from Waste Gases of Viscose Production Plants :** Typical pollutants in the waste gases of Viscose rayon industries are hydrogen sulphide and carbon disulphide and these gases can be separated from waste gas stream in single adsorption plant using activated carbon.

4. **Adsorption of Sulphur Containing Gases :**

i. Adsorptive separation of various sulphur compounds like H_2S, SO_2, can be achieved by physical adsorption catalysis.

ii. Activated carbon serves as a contact catalyst for various reactions of sulphur compounds including air oxidation of H_2S to sulphur of SO_2, to SO_3 or to sulphuric acid and reduction of SO_2, or sulphuric acid by H_2S to produce sulphur.

5. **Adsorption of NO_x :** The methods applied for removal of NO_x from waste gases are trusted on physical and catalized adsorption.

6. **Adsorption of Mercury Vapours :** Mercury vapours can be removed by use of adsorbent like activated carbon and ion-exchange resin.

7. **Control of Gaseous Radio Active Emission :** Activated carbon adsorption can be used to prevent emission of radioactive gases from nuclear reactors or other source. Radon and radio-iodine are examples of adsorbable radioactive gases.

8. **Gas Masks :** Activated carbon or charcoal is used almost universally in gas because they are best all round adsorbent for toxic gases.

VERY IMPORTANT QUESTIONS

Following questions are very important. These questions may be asked in your SESSIONALS as well as UNIVERSITY EXAMINATION.

Q. 1. Enumerate the various engineering devices that are used to control the emission of gaseous air pollution from industries. Describe any one.

Ans. Refer Q. 4.1, Unit-4.

Q. 2. Explain in detail about condensation and combustion equipments which are used as pollution control device.

Ans. Refer Q. 4.3, Unit-4.

Q. 3. Write a short note on catalytic convertor, which is used to control the air pollution from automobiles.

Ans. Refer Q. 4.5, Unit-4.

Q. 4. What are the application of adsorption for control of gaseous and odour emission at source ?

Ans. Refer Q. 4.8, Unit-4.

☺☺☺

5
UNIT

Noise Pollution

CONTENTS

PART-1

Noise Pollution : Basics of Acoustics and Specification of Sound, Sound Power, Sound Intensity and Sound Pressure Levels.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 5.1. Define noise and explain as to how and why it should be regarded as an environmental pollutant ?

Answer

1. Sound in the environment is caused by vibrations in the air (or some, other medium) that reach human ears and stimulate a sensation of hearing.
2. When the sound becomes loud, or disagreeable, or unwanted, it becomes noise.
3. Since the unwanted sound (*i.e.*, noise) certainly produces several undesirable effects on our body health, it can be termed as an environmental pollutant.
4. The Air (Prevention and Control of Pollution) Act 1981 of India includes noise as one of the air pollutant.
5. Noise can, therefore, also be defined as that unwanted sound pollutant, which produces undesirable physiological and psychological effects in an individual, by interfering with one's social activities like work, rest, recreation, sleep, etc.
6. It may also be noted that when noise is defined as unwanted sound, then certainly it becomes a subjective definition, independent of the loudness of the sound, since a particular loudness may not be liked by one person, whereas the same loudness may be quite pleasant to another person.
7. A particular sound being enjoyed by one person can, thus, become a noise pollution to another person.
8. The noise, as an air pollutant, in fact, differs from other pollutants in the sense that it is transient in nature, and is not a continuing or persisting phenomenon.
9. When once the noise pollution stops, the environment becomes free of this pollutant, unlike other pollutants like gases and particulate matter which continue to linger on, after once entering into the air atmosphere.

Que 5.2. **What do you understand by noise pollution and what are the factors of noise pollution ?**

Answer

Noise Pollution :

1. Noise pollution is caused when noise which is an unpleasant sound affects our ears and leads to psychological problems like stress, hypertension, hearing impairment, etc. It is caused by machines in industries, loud music, etc.
2. Sound levels beyond 100 dB can cause permanent hearing loss, and noise of around 90 dB causes auditory weakness. The industrial sound limit according to the world health organization (WHO) is 75 dB.

Factors of Noise Pollution : There will be various factors of noise pollution. Some human made noise pollutions are as follows :

1. Road Traffic Noise :

i. Noise pollution arises due to several transportations means like : Scooters, motorcycles, cars, buses, and trucks etc. Measures must be taken to reduce road traffic noise pollution.

ii. Increased traffic has brought about traffic jams and automobile congestion that produce noise via repeated hooting.

iii. Road traffic is one of the most widespread sources of noise, and unfortunately, the most difficult to control.

iv. Research shows that over 40 % of the populations are bothered by noise from road traffic.

2. Pet Noise :

i. As owners of pets such as dogs, birds and cats, you must prevent them from causing any noise nuisance to your neighbours.

ii. Don't let your dog bark or whine or leave it alone for long periods.

3. Neighbour's Noise :

i. Neighbour's noise can be part of a more serious neighbour problem.

ii. Under the Housing Act social landlords can take action against tenants for anti-social behaviour.

iii. The Noise-Pollution (Regulation and Control Rules-2000 gives councils the power to issue an anti-social behaviour order to anyone causing "harassment, alarm or distress" this can include noise.

4. Aircraft Noise :

i. Many people regularly hear aircraft noise. Those living near civil and military airports are severely affected by takeoff and landing noise.

ii. The impact is greatest the perimeter of the airport and below flight paths.

iii. Loud aircraft noise can cause insomnia, concentration disorders and learning difficulties in children.

5. Railway Noise :

i. Railways are another major source of environmental noise in India.

ii. The authorities take measures to reduce this form of noise pollution.

iii. This becomes the dominant source of noise for most people living near railways only at a relatively high level.

6. Construction Site Noise :

i. This covers inherently noisy operations building works, road-works, demolition, dredging etc.

ii. They often take place in areas which were quiet beforehand and are expected to be quite again when the work is complete.

iii. Do not leave powered tools running idly switch it off when you are not using it. Complete the work as quickly as possible do not let it drag on for months.

7. Fireworks Noise :

i. Recently fireworks have become an increasing noise problem for people and pets.

ii. They are let off not only for traditional celebrations such as Marriage, Deepawali Night, but year round to mark public and private celebration.

8. Musical Instrument Noise :

i. Keep the volume as low as possible, especially late at night. Use headphones, or listen to music on a personal stereo.

ii. If you play a musical instrument, avoid practice early in the morning or during the late evening/night.

iii. If the instrument has an amplifier, turn the volume down or preferably use personal headphones.

9. Household appliances Noise :

i. Household appliances are produce lots of noise are which disturb home members and neighbours also.

ii. There are various home-made noise pollutants including domestic gadgets such as pressure cookers, washing machines, mixer-grinders, desert coolers, air conditioners, sewing machines and vacuum cleaners.

iii. Electrical transistors, TVs, musical instruments, telephones, and loudspeakers, Doors bell, crying of infants etc.

Que 5.3. **Write down the specifications of acceptable noise level for different areas as per BIS code 4954-1968 pollution.**

Answer

Following are the specifications of acceptable noise level for areas as per BIS code 4954-1968 pollution :

Table 5.3.1.

Area Code	Category of Area/Zone	Limits in dB (A) L_{eq}	
		Day Time	Night Time
(A)	Industrial Area	75	70
(B)	Commercial Area	65	55
(C)	Residential Area	55	45
(D)	Silence Zone	50	40

Note :

1. Day time shall mean from 6.00 am to 10.00 pm.
2. Night time shall mean from 10.00 pm to 6.00 am.
3. Silence zone is an area comprising not less than 100 metres around hospitals, educational institutions, courts, religious places or any other area which is declared as such by the competent authority.
4. Mixed categories of areas may be declared as one of the four above mentioned categories by the competent authority.

Que 5.4. Write down the major highlights of the provisions of noise pollution (Regulation and control Rules, 2000).

Answer

The major highlights of the provisions of this Noise Pollution (Regulation and Control Rules, 2000) are indicated below :

1. The State Government shall take measures for abatement of noise including noise emanating from vehicular movements and ensure that the existing noise levels do not exceed the ambient air quality standards (see Table 5.3.1) specified under these rules.
2. All development authorities, local bodies and other concerned authorities while planning developmental activity or carrying out functions relating to town and country planning shall take into consideration all aspects of noise pollution as a parameter of quality life to avoid noise menace and to achieve the objective of maintaining the ambient air quality standards in respect of noise.
3. The noise levels in any area/zone shall not exceed the ambient air quality standards in respect of noise as specified in the Schedule (see Table 5.3.1).

4. The authority shall be responsible for the enforcement of noise pollution control measures and the due compliance of the ambient air quality standards in respect of noise.
5. A person may, if the noise level exceeds the ambient noise standards by 10 dB(A) or more given in the corresponding columns against any area / zone, make a complaint to the authority.
6. The authority shall act on the complaint and take action against the violator in accordance with the provisions of these rules and any other law in force.

Que 5.5. Write a short note on :

1. **Sound power.**
2. **Sound pressure.**
3. **Sound intensity.**

Answer

A. Sound Power :

1. The power of sound (W) is defined as the rate of doing work by a travelling sound wave in the direction of the propagation of the wave.
2. The energy transmitted by a sound wave in the direction of its propagation in thus, defined as its power, and is represented in Watts in SI units.

B. Sound Pressure :

1. The equivalent pressure of such a sine wave is represented by root mean square pressure (p_{rms}) as :

$$p_{rms} = \sqrt{p_{(t)}^2} = \sqrt{\frac{1}{T} \cdot \int_0^T p_{(t)}^2 \, dt} \qquad ...(5.5.1)$$

where, $p_{(t)}$ = Pressure at any time t.

2. The rms sound pressure is, thus obtained by adding the squares of amplitude values at small time intervals, and dividing the total by the averaging time, and finally taking the square root of the total.
3. This works out equal to $\frac{A}{\sqrt{2}}$ for a regular sine wave.
4. The sound pressure (p_{rms}) is further related to atmospheric pressure and barometric pressure by the equation.
5. Sound pressure = Total atmospheric pressure – Barometric pressure.

C. Sound Intensity :

1. In addition to sound pressure (P_{rms}), the sound intensity (I) is another important term which is used to measure sound.
2. It is defined as the sound power averaged over the time, per unit area normal to the direction of propagation of the sound wave.

3. Intensity and power of a sound wave are related by the equation

$$I = \frac{W}{a} \quad ...(5.5.2)$$

where, I = Intensity of sound wave in Watt/m^2.

W = Power of sound wave in Watts (averaged over the time.

a = A unit area $\perp$ to the direction of wave motion.

4. Sound intensity (I) is further related to rms sound pressure by the equation,

$$I = \frac{p_{rms}^2}{\rho C} \quad ...(5.5.3)$$

where, p_{rms} = rms sound pressure in pascals (Pa) .

ρ = Density of air or medium in which sound wave is travelling in kg/m^3.

C = Velocity of sound wave in m/sec.

5. The density of air (ρ) and the speed of sound (C) used in the above equation can be known if the temperature of air is known.

6. In other words, given the temperature and pressure of air, the density of air can be determined from the standard tables; and the speed of sound determined by the equation

$$C = 20.05\sqrt{T} \quad ...(5.5.4)$$

where, T = Absolute temperature in Kelvin (K).

C = Speed of sound in m/sec.

Que 5.6. Explain in detail "level of noise".

Answer

Levels of Noise :

1. The sound pressure of the faintest sound that can be heard by a normal healthy individual is about 20 micro-pascal (μ-Pa).
2. On the other hand, the loudest sound produced by a Saturn rocket at the lift off stage is about 200 Pa.
3. This astronomical variation in sound pressure (varying from 20 μ-Pa to 200 Pa) is usually avoided by expressing sound pressure on a scale based on the log of the ratio of the measured sound pressure and a reference standard pressure. Measurements on this scale are called levels.
4. The sound level (L) is, thus, represented as :

$$L = \log_{10}\frac{Q}{Q_0} \quad ...(5.6.1)$$

where, Q = Measured quantity of sound pressure, or sound intensity.

Q_0 = Reference standard quantity of sound pressure, or sound intensity.

L = Sound level in bels (B).

5. The unit of sound level obtained in eq. (5.6.1) is bels (B), and since it turns out to be a rather large unit, a smaller unit of decibels (dB) is generally used.
6. Hence, when sound level is expressed in decibels, the eq. (5.6.1) reduces to

$$L \text{ in dB} = 10\ \log_{10}\frac{Q}{Q_0} \quad ...(5.6.2)$$

i. The reference standard quantity Q_0 in the above equation is taken is to be equal to 20 μPa, when should pressure is measured. In that eventuality, eq. (5.6.2) reduces to sound pressure level (L_p) in dB

$$L_p = 10\log_{10}\left(\frac{p_{rms}}{20\ \mu Pa}\right)^2$$

or

$$L_p = 20\log 10\left(\frac{p_{rms}}{20\ \mu Pa}\right) \quad ...(5.6.3)$$

where, p_{rms} = Root mean square pressure in μPa.

ii. Similarly, the reference standard quantity Q_0 in eq. (5.6.2) is taken to the equal to 10^{-12} W/m^2, when sound intensity level is measured. The sound intensity level is thus given as :

7. **Sound intensity level (L_i) in dB**

$$L_i \text{ in } dB = 10\log_{10}\left(\frac{I}{10^{-12}}\right)$$

where, I = Measured sound intensity is W/m^2 ...(5.6.4)

8. Out of these two terms, *i.e.*, sound pressure and sound intensity, sound pressure level on reference scale of 20 μPa, is usually adopted to express sound levels in decibels.

PART-2

Plane, Point and Line Sources, Multiple Sources, Outdoor and Indoor Noise Propagation, Psychoacoustics and Noise Criteria, Effects of Noise on Health, Annoyance Rating Schemes.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 5.7. Discuss the behaviour of point, line and plane sound sources.

Answer

A. Point Sources :

1. The SPL from an ideal point source radiator falls at the rate of 6 dB per doubling of distance.
2. The Intensity of sound from the point source falls off as the inverse square of the distance. This is known as the inverse square law.
3. The energy radiated from the point source is evenly distributed over the surface of an expanding sphere.
4. The surface area of the sphere is inversely proportional to the distance (radius of the sphere) squared.

B. Line Sources :

1. The SPL from an infinitely long line source falls off at a rate of 3 dB per doubling of distance.
2. This is because the energy distribution is now over the surface of a cylinder, rather than a sphere as in the case of the point source.
3. Because the surface area of the expanding cylinder is inversely proportional to distance, not distance squared, it follows that the energy density falls simply with distance from the source, rather than distance squared.

C. Plane Sources :

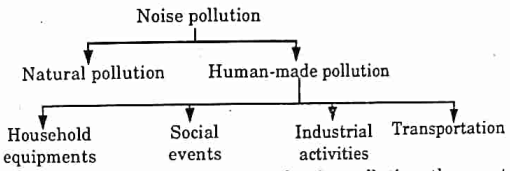
1. Imagine an infinitely large flat surface that radiates sound.
2. The SPL from an infinitely large plane sound source is constant with distance from the source.
3. The energy distribution from the source is now over the surface of another plane some distance from the source.
4. As the wave propagates it does not expand but rather continues to pass through precisely the same area as the source itself.
5. Therefore the energy density at any point in space is equal to the energy density at the source plane itself.
6. The SPL is constant everywhere in the vicinity of a plane radiator.

Que 5.8. Discuss the various sources of noise pollution.

Answer

Sources of Noise Pollution :

The occurrence of noise will dependent or independent in nature. According to their source of generation, noise pollution can be classified into two categories :



A. Natural Sources : Under natural noise pollution, the events take place naturally as heavy rain, lightening, volcanic explosion, thundering of clouds etc. but their effect remains upto particular time and area and they do not harm most.

B. Human-made Sources : This type of noise pollution affects vast. Loud music, sound of vehicles, noise produced by industries is under it. Some causes of these are as follows :

1. **From Household Equipments :** In our daily life, household equipments such as mixers, vacuum cleaner, washing machine, cooler, music system, dog barking etc., cause noise pollution.
2. **From Social Events :** Such social group programs in which mostly people make a noise. Its examples are following: group worshiping, disco, parties, market areas marriage functions etc.
3. **From Industrial Activities :** The noise produced by industrial units is very dangerous and loud e.g., manufacturing industries, printing machines, site of building construction, etc.
4. **From Transportation Means :** Now-a-days, where we see, we will hear loud noise of vehicles which produce maximum noise, e.g., trains, buses, aeroplanes, taxies, agricultural machines (tractors, crashers) etc.

Que 5.9. Explain the outdoor and indoor noise propagation.

Answer

A. Outdoors Noise Propagation :

1. Sound waves travel in a continuously extending spherical wave-front from the source.

2. For a point source that emits a certain sound energy, this energy is concentrated in a single point at the source.
3. At a distance from the source, the same energy is distributed over a sphere.
4. The greater the distance from the source, larger the surface over which the energy is dispersed.
5. The sound energy is dispersed over an imaginary sphere with a surface that grows in proportion to the square of the distance from a point source.
6. The surface of the sphere grows 4 times with each doubling of the distance from the source.
7. The sound hence rapidly declines with the distance from the source.
8. Each doubling of the distance from the point source yields a 6 dB reduction of the sound level.

B. Indoor Noise Propagation :

1. The sound wave hits building construction surfaces before it is significantly attenuated.
2. The sound field indoors is not spherical but depends on the geometry and the acoustical properties of these surfaces.
3. The volume of the room and the distances between the sound source, the building construction surfaces and the listening point are also important.
4. The sound in a certain listening point in a room is composed of the direct sound and the reflected sound.
5. The direct sound is the sound that has not yet been reflected in a surface.
6. The sum of all reflected sound is called the reverberant sound field.
7. It consists of all sound that has been reflected once, twice or more in the building construction surfaces.
8. The sound reflected one time is called 1st reflections, two times 2nd reflections etc.
9. If the surfaces were perfectly absorptive, there would be no reflections at all.
10. In reality, there is always a loss of energy when a sound wave hits a wall.
11. The air also absorbs some of the sound wave's energy.
12. The sound absorption is frequency dependent. High frequency sound is often more easily absorbed than low frequency sound.

Que 5.10. Write a short not on :

A. Psychoacoustic of noise pollution.

B. Noise criteria of noise pollution.

Answer

A. Psychoacoustics of Noise Pollution :

1. Psychoacoustics is the scientific study of sound perception, *i.e.*, the branch of science studying the psychological and physiological responses associated with sound including speech and music.
2. Hearing includes the mechanical wave propagation and a sensory and perceptual event.
3. When sound arrives at the ear, it is transformed in to neural action potential.
4. The ear has a non-linear response to sounds of different intensity levels: this non-linear response is called loudness

B. Noise Criteria of Noise Pollution :

1. The human ear can nominally hear sounds in the range 20 Hz (0.02 kHz) to 20,000 Hz (20 kHz).
2. The upper limit tends to decrease with age; most adults are unable to hear above 16 kHz.
3. Tones between 4 and 16 Hz can be perceived by the body's sense of touch.
4. The minimum threshold at which a sound can be heard is frequency dependent. By measuring this minimum intensity for testing tones of various frequencies, a frequency dependent absolute threshold of hearing (ATH) curve may be derived and can be used to find the lower limits.

Que 5.11. What are effects of noise on health ?

Answer

Effects on Noise Pollution on Human Health :

1. **Hearing Problems :**

i. Hearing is one of the five senses that human beings have. As such, it is an essential part of the life of any person.

ii. But in as much as the ear serves the purpose of receiving sound waves, it can also do so to a certain limit.

iii. When it gets to the point termed as noise, it means it is undesirable because it interferes with one's hearing capacity.

iv. This is the reason people cover their years when there is really loud noise.

v. Such loud noise can cause hearing impairment, which can even result in permanent hearing loss.

vi. Hearing loss due to noise pollution is attributed to prolonged exposure of noise levels above 85 decibels.

2. **Difficulty in Sleeping :**

i. Noise can deter sleep because of its psychological effect. Having noise around can distort peaceful sleep as it causes stress.

ii. Moreover, being in a noisy place means there is almost no chance of having any sleep.

iii. Inadequacy of sleep in turn interrupts the normal functioning of the body, leading to discomfort, fatigue, and general moodiness.

3. **Reduced Cognitive Functioning :**

i. The ear is connected to the brain, which coordinates the body's stimulus responses.

ii. For this reason, all the sound waves that hit the ear are sent to the brain for interpretation.

iii. This means too much noise also gets to the brain and according to scientific reports, such kind of noise dulls the brain and contributes to a lower response rate by the brain.

iv. Due to this, cognitive functioning reduces and so is the ability to solve problems normally.

v. Individuals who live in areas with too much noise, for instance, adjacent to busy highways, railway lines, airports or near loud night clubs tend to have lower cognitive power compared to those who live in quieter environments.

4. **Cardiovascular Problems :**

i. Noise 'excites' the heart. Too much noise means that the heart is also disturbed and ends up beating faster; increasing blood pressure.

ii. In loud noise, stress hormones such as adrenaline and cortisol are also released.

iii. Therefore, blood pressure will definitely increase in noisy environments thus prompting faster flow of blood which in turn leads to secretion of catecholamine, a hormone that further magnifies the number of times the heart pumps blood.

iv. As much as there is no harm in this, regular exposure will keep the body getting higher impulses leading to increased blood pressure.

v. If blood pressure keeps rising, it may open up chances for heart related diseases such as high blood pressure and stroke.

vi. Other cardiovascular diseases include hypertension and arteriolosclerosis and are caused by the dilation of the pupil and constriction of blood vessels.

5. **Emotion and Behavioral Change :**

i. This is different from cognitive thinking. Too much noise means disturbance of peace which may lead to annoyance or anger.

ii. People in this state tend to have constant headaches which may even intensify if the noise is continuous.

iii. This may lead to an amplified stress levels and thus, emotions take over and violence may ensue.

iv. This type of behavior is reported to be due to anxiety. With such behavior, it becomes hard to concentrate on work and achieve set goals owing to reduced work efficiency.

6. **Reproduction Problems :**

i. Varying studies have been conducted to estimate the effect of noise pollution on reproduction in human beings and surprisingly, most of these studies have posited that pregnant women exposed to noise pollution during the course of their expectancy tend to give birth to children with less body weight.

ii. The stress levels experienced by the expectant mother equally disturbs the unborn child.

Que 5.12. Discuss the annoyance rating schemes of noise pollution.

Answer

Annoyance Rating Schemes of Noise Pollution :

1. Noise levels in general have increased over the years.
2. Sound pressure level represents the magnitude of noise and is one of the characteristics that can verify whether a given noise is above its "pollution level".
3. There are other characteristics of noise that dictate whether people will react adversely to it or not. These are :

i. Spectral composition or frequency content.

ii. Duration.

iii. Presence of pure tones.

iv. Suddenness.

v. Variability.

vi. Information content.

4. The above factors introduce much subjectivity into noise pollution characterization, and various rating schemes have been devised that are meant to correlate with the annoyance related characteristics of a noise signal.

5. Noise levels are commonly measured by a hand-held instrument called a sound-level meter that gives either a single-number evaluation of the time-varying pressure in decibels or a spectral breakdown of the signal.
6. The annoyance is accessed using the noise annoyance rating scale as shown in Fig. 5.12.1.

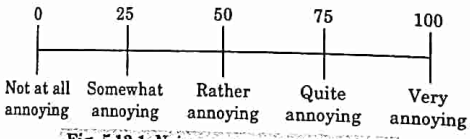


Fig. 5.12.1. Noise annoyance rating scale.

7. Annoyance is strongly dependent on dB level in each frequency band, and noise control techniques are equally dependent on the decibel level in each frequency band.
8. Thus, identifying noise problems with regard to both magnitude and frequency is an important step toward intelligent noise control.

PART-3

Special Noise Environments : Infrasound, Ultrasound, Impulsive Sound and Sonic Boom, Noise Standards and Limit Values, Noise of Instrumentation and Monitoring Procedure, Noise Indices, Noise Control Methods.

Questions-Answers

Long Answer Type and Medium Answer Type Questions

Que 5.13. **Write a short note on :**

1. **Ultrasound.**
2. **Infrasound.**
3. **Sonic Boom.**
4. **Impulsive sound.**

Answer

1. **Ultrasound :**

i. Ultrasound is sound waves with frequencies higher than the upper audible limit of human hearing.

ii. Ultrasound is not different from "normal" (audible) sound in its physical properties, except that humans cannot hear it.

iii. This limit varies from person to person and is approximately 20 kilohertz (20,000 hertz) in healthy young adults.

iv. Ultrasound devices operate with frequencies from 20 kHz upto several gigahertz.

v. Ultrasound is used in many different fields. Ultrasonic devices are used to detect objects and measure distances.

vi. Ultrasound imaging or sonography is often used in medicine.

vii. In the nondestructive testing of products and structures, ultrasound is used to detect invisible flaws.

viii. Industrially, ultrasound is used for cleaning, mixing, and accelerating chemical processes.

x. Animals such as bats and porpoises use ultrasound for locating prey and obstacles.

2. **Infrasound :**

i. Infrasound, sometimes referred to as low-frequency sound, describes sound waves with a frequency below the lower limit of audibility (generally 20 Hz).

ii. Hearing becomes gradually less sensitive as frequency decreases, so for humans to perceive infrasound, the sound pressure must be sufficiently high.

iii. The ear is the primary organ for sensing infrasound, but at higher intensities it is possible to feel infrasound vibrations in various parts of the body.

iv. The study of such sound waves is sometimes referred to as infrasonics, covering sounds beneath 20 Hz down to 0.1 Hz. and rarely to 0.001 Hz.

v. People use this frequency range for monitoring earthquakes and volcanoes, charting rock and petroleum formations below the earth, and also in ballistocardiography and seismocardiography to study the mechanics of the heart.

3. **Sonic Boom :**

i. A sonic boom is the sound associated with the shock waves created whenever an object travels through the air faster than the speed of sound.

ii. Sonic booms generate enormous amounts of sound energy, sounding similar to an explosion or a thunderclap to the human ear.

iii. The crack of a supersonic bullet passing overhead or the crack of a bullwhip are examples of a sonic boom in miniature.

iv. Sonic booms due to large supersonic aircraft can be particularly loud and startling, tend to awaken people, and may cause minor damage to some structures.

v. They led to prohibition of routine supersonic flight over land.

vi. Although they cannot be completely prevented, research suggests that with careful shaping of the vehicle the nuisance due to the sonic booms may be reduced to the point that overland supersonic flight may become a practical option.

4. Impulsive Sound :

i. It is a category of (acoustic) noise which includes unwanted, almost instantaneous (thus impulse like) sharp sound (like clicks and pops).

ii. Noises of the kind are usually caused by electromagnetic interference, scratchers on the recording disks, gunfire, explosions and ill synchronization in digital recording and communication.

iii. High levels of such a noise (200 dB) may damage internal organs, while 180 decibels are enough to destroy or damage human ears.

Que 5.14. Write down the acceptable outdoor noise levels for various type of building as per BIS code 4954-1968.

Answer

S. No.	Acceptable Outdoor Noise Levels in-Residential Areas	
	Location	Noise levels dB(A)
1.	Radio and TV studios	25-30
2.	Music rooms	30-35
3.	Hospitals, class rooms, auditorium	35-40
4.	Apartments, hotels, homes conference-rooms, small offices	35-40
5.	Court rooms, private libraries offices	40-45
6.	Large public offices, banks, stores, etc.	45-50
7.	Restaurants	50-55

Que 5.15. Discuss the noise pollution from road. Discuss the methods to prevent noise pollution from road.

Answer

A. Noise pollution from roads :

1. One of the main sources of environmental noise in India is road traffic.

2. Traffic noise is a major concern because it affects every person directly or indirectly.
3. There are basically two sources of traffic noise. One is from new roads, the other from existing roads.
4. Noise from existing roads is more difficult to tackle.
5. Some roads traffic generates noise greater than 70 decibels. Barrier could be applied to some 40 identified road sections for implementation under the Public Works Programme.
6. Other solutions are being investigated for the remainder, such as traffic management and alternate motor vehicles.
7. To protect residents affected by traffic noise from new roads, the Environmental Protection Department liaises with other departments during the planning stage to minimize the impacts.

B. Method to Prevent Noise Pollution from Road :

1. Avoid slamming car doors.
2. Keep the silencer in good order.
3. Do not start engine unnecessarily.
4. Use the horn only in an emergency.
5. Carry out noisy repairs during the day.
6. Use noise barriers and take proper traffic measures.
7. Service the vehicle regularly for quietness and economy.
8. Check the brakes are properly adjusted and do not squeal.
9. Quieter vehicles, tyres and road surfaces should be used.
10. Keep the volume of in car music reasonable loud music reduce, boost noise on road.

Que 5.16. Explain the methods of reducing noise at home.

Answer

Reducing Noise at Home : The following simple measures can be taken for reducing noise at home :

1. Keep noisy household equipment (e.g., washing machines) away from partition walls.
2. When buying a new household appliance, ask how noisy it is.
3. Perform noisy jobs during normal waking hours.
4. Apologise to neighbours in advance for disturbance.
5. Keep the volume of TV, radio and music as low as possible, especially late at night.
6. If you want to turn the volume up, use headphones.

7. If your dog barks when left alone, arrange to leave it with a friend.
8. If you have an old or faulty burglar alarm, replace it with one complying with standard.
9. If you have a party, tell your neighbours in advance and keep the noise to a minimum.
10. If using fireworks for a celebration, tell neighbours especially if they have pets and don't let fireworks off after 11:00 pm.

Que 5.17. Discuss the different techniques used to control the noise pollution in industries.

Answer

Noise Reduction (Control) in Industries : Following are different techniques used to control the noise pollution in industries :

1. Reducing noise from process exhaust stacks.
2. Controlling high pressure steam, natural gas and other vent noises.
3. Acoustic blankets/warps attenuate noise from the equipment casing.
4. Acoustically treating roof exhausters, ventilating equipment and cooling towers.
5. Closing openings in enclosures and barrier walls required for utilities.
6. Damping method of reducing noise in chutes, hoppers, machine guards, conveyors, panels and more.
7. Selecting efficient equipment like selecting fans, compressors, PD blowers and engines that operate efficiently contribute significantly to noise attenuation.
8. Adjusting fan speed is in direct correlation with fan speed, so simple adjustments can produce significant results.
9. Duct lining ventilation systems with acoustic absorbent material such as foam or fiberglass will effectively decrease airborne noise.
10. Reducing noise pollution by muffling the sounds at the source is one of the best methods in industry and for urban living.
11. Protective equipment is generally mandatory when noise levels exceed 85 dB(A) in industry.

Que 5.18. Explain the different noise problems control approaches by Government.

Answer

Noise Problems Control Approaches :

A four-pronged approach is adopted by the Government to tackle environmental noise in India. The four prongs are as follows :

1. **Planning :**

i. Planning is better than cure. The government has prescribed standards with due regards to noise in planning new development or redevelopment projects.

ii. Considerable efforts have been devoted to pre-empting noise problems that may arise from land use and public work planning activities.

iii. These efforts ensure that new noise-sensitive receivers such as homes and schools will not be exposed to excessive noise and new infrastructure will not cause insurmountable noise problems.

iv. Further, whenever an opportunity for urban redevelopment arises, these opportunities will be seized to improve the noise environment through environmentally friendly urban design.

2. **Abatement :**

i. Abatement is one of the means to resolve existing noise problems, which are caused by busy highway running through populated areas and schools affected by noise from aircraft or road traffic.

ii. A large number of schools in India have been badly affected by noise from road traffic, and from aircraft noise when the airport was still in operation.

iii. So in noise abatement zones road surfaces are made from noise absorptive materials which help to traffic noise upto 5 dB(A).

iv. A policy has been implemented to address the noise impact of existing roads. The following measures will be adopted at excessively noisy road sections where practicable :
   a. Erect road-side noise barriers or enclosures.
   b. Pave roads with low-noise resurfacing materials.
   c. Implement traffic management scheme, such as restricting or diverting traffic at certain sensitive hours.

3. **Control :**

i. Many forms of environmental noise are under statutory control.

ii. A key instrument for control is the Noise Control Ordinance. The Ordinance controls construction, noise from commercial and industrial premises, neighbourhood noise and noise from newly-registered motor vehicles.

iii. In addition to the Noise Control Ordinance, Road Traffic Ordinance also provides control over noise generated from motor vehicles.

iv. The Aircraft Noise Ordinance also controls environmental noise. It requires aircrafts flying in and out of the city.

v. International Airport to be certified for the most stringent noise standards.

vi. This is controlled under the factories and Industrial Undertakings Ordinance, the enforcement of which is carried out by the Labour Department.

4. Partnership :

i. Apart from controlling pollution through law enforcement, the Environmental Protection Department (EPD) also encourages compliance by developing partnership programmes with various trades and industries affected by pollution control laws.

ii. These include the construction industry, restaurant trade, vehicle repair workshops and property management sector which are the subject of most public complaints over the past decade.

Que 5.19. Discuss the various noise control equipments.

Answer

Noise control Equipment : Following are the various equipments used to control noise :

A. Fan Silencers :

1. A wide variety of fans and blowers are used in today's industrial facilities in a variety of applications.
2. They may be stand alone or included as components in OEM equipment such as dust collectors and air handling units.
3. Rotating mechanical equipment such as fan is a common noise source in manufacturing plants.
4. The noise generated by fans can quickly become a significant problem, requiring the use of silencers and wraps.
5. Specific fan/silencer needs and facility requirements including issues such as :

i. Space restrictions.

ii. Maintaining air flow by minimizing pressure loss through the silencer.

iii. Meeting environmental noise regulations and industrial health and safety requirements.

iv. Using construction materials specific to the application.

v. Providing accessories including rain hoods, transitions, support brackets and flow measuring devices.

B. Sound Enclosures :

1. A highly effective means for controlling localized industrial noise is to install an encapsulating sound enclosure to contain and absorb noise where reduced sound levels are required.
2. Because almost every in-place noise issue is in a different environment, each application is a custom design.

i. Noise Control Curtains :

a. Adapting flexible curtains to sound enclosure assembly provides efficient noise control.

b. The sound proofing curtain systems are an economical, high performance, noise control product possessing high mechanical strength.

c. They are fire safe, easily cleanable, resistant to dust, dirt, oils and most chemicals, and give a long service life.

d. Curtains reduce reverberant noise energy and offer a 7-10 dB reduction.

ii. Rigid Metal Noise Enclosures :

a. Another effective type of sound enclosure is a rigid metal enclosure.

b. The standard wall is constructed of an 18 GA solid exterior skin with a 22 GA interior perforated liner, and a 4 lb/ft^3 density acoustic fill core.

c. Options for other types of wall construction are available. With an STC of upto 41, metal enclosures are designed to both contain and absorb noise, and to act as a barrier between noisy and quiet areas.

iii. Acoustic Flexible Connectors :

a. Acoustic flexible connectors are manufactured using a unique combination of materials to control airstream breakout noise.

b. Depending on the application, the flexible inner wall is manufactured from high-temperature or rugged; acoustic media is then sandwiched between this inner wall and a tough outer acoustic barrier.

c. Finally, everything is secured in place with two sets of heavy duty backing bars.

C. Industrial Process Silencers :

1. Industrial process silencers are the equipments which are used for attenuate noise.
2. Silencer design, with an understanding of the application, equipment, and process, is critical when it comes to meeting specific noise attenuation requirements.
3. There are three basic types of silencers :

i. **Absorptive and Dissipative Silencers :** These are lined with sound absorbing materials such as mineral wool or fiberglass to attenuate sound waves. They are most effective with mid and high frequency noise.

ii. **Reactive Chamber Silencers :** They have target with low frequency noise. Multiple chambers with differing internal cross sections are used to reflect noise energy back to the source.

iii. **Absorptive/Reactive :** It is a combination of both the absorptive and reactive designs. Design covers a broader range of frequencies to meet stricter attenuation requirements.

D. Acoustic Building Ventilation Systems :

1. Successful acoustic building ventilation systems are a combination of noise attenuation solutions coupled with good ventilation practices.

2. High volume acoustic ventilation systems remove high internal heat loads from "hot" sources such as large compressors, engines, generators and motors while minimizing noise impact on surrounding communities by the rotating equipment and necessary supply/exhaust fans.

VERY IMPORTANT QUESTIONS

Following questions are very important. These questions may be asked in your SESSIONALS as well as UNIVERSITY EXAMINATION.

Q. 1. Define noise and explain as to how and why it should be regarded as an environmental pollutant ?
Ans: Refer Q. 5.1, Unit-5.

Q. 2. Write down the specifications of acceptable noise level for areas as per BIS code 4954-1968 pollution.
Ans: Refer Q. 5.3, Unit-5.

Q. 3. Write down the major highlights of the provisions of noise pollution (Regulation and control Rules, 2000).
Ans: Refer Q. 5.4, Unit-5.

Q. 4. Discuss the various sources of noise pollution.
Ans: Refer Q. 5.8, Unit-5.

Q. 5. Write a short not on :
A. Psychoacoustic of noise pollution.
B. Noise criteria of noise pollution.
Ans: Refer Q. 5.10, Unit-5.

Q. 6. What are effects of noise on health ?
Ans: Refer Q. 5.11, Unit-5.

Q. 7. Write down the acceptable indoor noise levels for various type of building as per BIS code 4954-1968.
Ans: Refer Q. 5.14, Unit-5.

Q. 8. Discuss the different techniques used to control the noise pollution in industries.
Ans: Refer Q. 5.17, Unit-5.

Q. 7. Discuss the various noise control equipments.
Ans: Refer Q. 5.19, Unit-5.

☺☺☺

Air Pollution (2 Marks Questions)

1.1. Define air pollution.
Ans: Air pollution is define as the presence in or introduction into the air of one or more contaminants, which are injurious to human beings.

1.2. What are the compositions of gases in air ?
Ans: Composition of atmospheric air :
$N_2 = 78\ \%$, $O_2 = 21.93\ \%$, $Ar = 0.93\ \%$, $CO_2 = 0.03\ \%$, etc.

1.3. Discuss in short structure of atmosphere.
Ans:

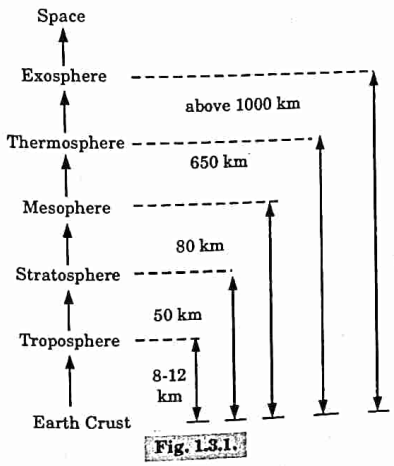


Fig. 1.3.1.

1.4. What is the green house effect ?

Ans. The green house effect is a natural process that warms the Earth's surface. When the Sun's energy reaches the Earth's atmosphere, some of it is reflected back to space and the rest is absorbed and re-radiated by green house gases such as water vapour, CO_2 CH_4, nitrous oxide, O_3 and some artificial chemicals (e.g., CFCs).

1.5. What are the sources of air pollution ?

Ans. Mainly there are two sources of air pollution :
i. Natural sources ii. Man-made sources

1.6. Write down the classification of pollutants.

Ans. Following are the various types of pollutants :
i. Degradable. ii. Slowly degradable.
iii. Non-degradable.

1.7. What do you mean by acid rain ?

Ans. Acid rain, or acid deposition, is a broad term that includes any form of precipitation with acidic components, such as sulphuric or nitric acid that fall to the ground from the atmosphere in wet or dry forms.

1.8. Define the term smog.

Ans. Smog is a kind of air pollution, originally named for the mixture of smoke and fog in the air.

1.9. What are the effects of air pollution on atmosphere ?

Ans. Following are the effects of air pollution on atmosphere :
i. It is found increment in the temperature in extreme industries, motor vehicles, heat and gases emitted from AC and dense populated urban region. Gradually this temperature forms heat island and on increasing.
ii. When smoke and dust covers the sky in plentiful quantity, the heat obtained from the sun goes back into the space on being reflected by smoke and dust. Due to this there is a fall in temperature and it causes the danger of snow fall.

1.10. What are the effects of air pollutant on human ?

Ans. **Impact on Human :** Air pollution invites many diseases such as asthma, irritation of eyes, headache, dizziness, heart diseases etc.

1.11. What are the effects of air pollutant on animal ?

Ans. **Impact on Animal :** It destroys the life of aquatic as fish when acid rain is formed in air. It may cause skin cancer in wildlife.

1.12. What are the effects of acid rain on plants ?

Ans. **Impact on Plants :** Acid rain destroys the leaves of the plants and ozone prevents the growth of plants.

☺☺☺

2 UNIT

Chemistry and Dispersion of Air Pollution (2 Marks Questions)

2.1. How do air pollution occurs ?

Ans. Air pollution occurs when certain gases and particles build up in the atmosphere to such levels that they can cause harm to our health, causing breathing and respiratory problems, and even resulting in premature death, as well as damaging the environment around us.

2.2. Why temperature inversion is necessary ?

Ans. Temperature inversions are important because they suppress vertical dispersion of pollution and often trap pollution near the surface where we live.

2.3. Define atmospheric stability.

Ans. Atmospheric stability is associated with how air parcels behave once they are displaced vertically from their initial positions.

2.4. What are the types of atmospheric stability ?

Ans. There are three types of atmospheric stability :
i. **Positive Stability :** It implies that a displaced air parcel will return to its initial position; associated with high pollution.
ii. **Neutral Stability :** Neutral stability implies that a displaced air parcel will remain at its new position; associated with moderate pollution.
iii. **Negative Stability or Instability :** It means that a displaced air parcel will continue to accelerate away from its rest position; associated with low pollution.

2.5. How does temperature affect air quality ?

Ans.
i. Temperature inversions affect air pollution because they change the dynamics of air movement.
ii. Warm air rises in the atmosphere because it is less dense and, therefore, more buoyant than the cooler air above it.
iii. This smothering effect traps air pollutants and allows their concentrations to increase.

2.6. How does air pollution affect our health ?

Ans. Pollution affect our health in the following ways :

i. Respiratory diseases.
ii. Cardiovascular damage.
iii. Fatigue, headaches and anxiety.
iv. Irritation of the eyes, nose and throat.
v. Damage to reproductive organs.
vi. Harm to the liver, spleen and blood.

2.7. Define the mechanical turbulence.

Ans.

i. Random fluctuation of wind velocity (speed and direction).
ii. Wind is zero at ground surface and rise with elevation to near the speed imposed by the pressure gradient.
iii. The greater the mean wind speed, greater the turbulence.
iv. The more the mechanical turbulence, the easier it is to disperse the spread the atmospheric pollutants.

2.8. Define the thermal turbulence.

Ans.

i. Different of air circulation during day time and nights.
ii. During clear nights when the ground radiates its heat away to the cold night sky and the cold air above it causing a sinking density current.

2.9. What are the effects of wind on air pollution ?

Ans. Following are the effects of wind on air pollution :

i. Wind diffuses pollutants by stretching them along the wind direction.
ii. Wind speed also enhances turbulence, and thus vertical and horizontal diffusion.
iii. Variations in wind direction are also important as they lead to sinuous plumes.
iv. The greatest potential for pollution is in low wind situations because horizontal transport and turbulent diffusion are both curtailed.

2.10. Define the mixing depth.

Ans.

i. The vertical distance between Earth's surface and the height to which convectional movements extend is called the mixing depth.
ii. Generally, greater the mixing depth, better the air quality.

2.11. What are the classes of air quality model ?

Ans. **Classes of Air Quality Model :** The air quality modeling procedures can be categorized into four generic classes Gaussian, numerical, statistical or empirical and physical.

2.12. What are the uses of Gaussian model ?

Ans. Gaussian models are the most widely used techniques for estimating the impact of nonreactive pollutants.

2.13. What are the plume types ?

Ans. Following are the types of plume :

i. Looping plume.
ii. Neutral plume.
iii. Coning plume.
iv. Fanning plume.
v. Lofting plume.
vi. Fumigating plume.
vii. Trapping plume.

2.14. Discuss the looping plume.

Ans.

i. High degree of convective turbulence.
ii. Superadiabatic lapse rate that means strong instabilities.
iii. Associated with clear daytime conditions accompanied by strong solar heating and light winds.
iv. High probability of high concentrations sporadically at ground level close to stack.
v. Occurs in unstable atmospheric conditions.

2.15. Discuss the fanning plume.

Ans.

i. Occurs under large negative lapse rate.
ii. Strong inversion at a considerable distance above the stack.
iii. Extremely stable atmosphere.
iv. Little turbulence.
v. If plume density is similar to air, travels downwind at approximately same elevation.

☺☺☺

3 UNIT

Air Pollution Control (2 Marks Questions)

3.1. Write short note on air quality measurement.

Ans. Following are the ambient air quality measurement and their standard :

1. The first Indian emission regulations came into existence in 1989. Further in 1992 and 1991 these regulations were soon replaced by gasoline and diesel vehicles.
2. Since 2000 India had been starting European Emissions and fuel regulations for light duty and heavy duty vehicles.
3. The automotive emission India is working on the two reports from planning commission established expert committee for Auto-fuel Policy, Auto fuel vision and policy 2025.

3.2. Define the stack sampling of air pollutant.

Ans.

i. For deciding the techniques to be adopted for removing the pollution from the gaseous emission of the industries, automobile, vehicles etc.

ii. The most important work is to collect the sample of the emission of gases at source. This collection of samples is also known as stack sampling at origin of pollutants.

3.3. Write short note on sampling study planning.

Ans. For the stack sampling, proper planning is required. The proper survey is done before planning. For the planning following points should be considered :

i. The planner should be familiar with the process and operation to determine the cycle operation.
ii. All methods of the sampling should be well known.
iii. Sample time because some sample undergoes cyclic changes.
iv. Amount of sample required.
v. The site should be well surveyed before taking the sample because the source point must located clearly.

3.4. Discuss the selection of sampling location of air pollutant.

Ans.

i. The selection of the sampling site is an individual judgment and requires the well experience of the field.

ii. The sampling point should be as far as possible from the disturbing influence such as elbows, bends, transition pieces, baffles or other obstructions.

iii. Researcher have shown that sampling point should be at a distance of 5 to 10 times diameters downstream from any obstructions and 3 to 5 times diameter upstream from similar disturbance.

3.5. List the major equipments used to control air pollution.

Ans. Following are the major equipments used to control the air pollution :

i. Cyclones.
ii. Scrubbers.
iii. Bag house-filters.
iv. Electro-static precipitator.
v. Gravity settling chamber.

3.6. Write note on gravity settling chamber.

Ans.

i. It consists of a cylindrical body with multiple dust hoppers.
ii. The dirty air enters into the chamber from one end.
iii. During this process the dense particles present in the air settled down into the hoppers and the clean air escaped out from another end.
iv. This technique is based on the gravity phenomenon.

3.7. Write note on scrubbers.

Ans.

i. Scrubbers are designed to remove gases pollutants from the air.
ii. In this device polluted air passes through a chamber.
iii. In this chamber water is sprayed on the air.
iv. Particles are made wet and removed from the air.
v. It is a very efficient process to separate from ambient air.

3.8. What are the advantages of bag house filters ?

Ans.

i. Versatile and flexible for many applications.
ii. Very high for collection and removal of very small particles.
iii. Cost-effective when properly designed and maintained.
iv. Modular design for convenient assembly.

3.9. Write down the types of scrubbers.

Ans. Following are the types of scrubbers :

i. Spray towers.
ii. Cyclone spray chambers.
iii. Venturi scrubbers.
iv. Orifice scrubbers.
v. Impingement scrubbers.
vi. Packed bed scrubbers.
vii. Dry scrubbers.

☺☺☺

4 UNIT

Control of Gaseous Contaminants (2 Marks Questions)

4.1. Write a short note on absorption units.

Ans:

i. Absorption units work on the principle of transfer of the pollutants from the gas phase to the liquid phase.

ii. In other words, the pollutants from the dirty gas get absorbed in the liquid, through which the gas is made to pass, in these units. Such absorption takes place by diffusion as well as dissolution.

4.2. Write a note on adsorption units.

Ans:

i. Adsorption units use adsorbents like activated carbon, molecular sieves (dehydrated zeolites, *i.e.*, alkali or metal silicates), activated alumina, silica gel, etc.

ii. In adsorption units, the dirty gases are made to pass through the beds of such adsorbent materials, wherein the pollutants are effectively caught and removed.

iii. Activated carbon beds can very effectively catch hydrocarbons, H_2S, and SO_2.

4.3. What are the classifications of adsorbent ?

Ans: Potential adsorbent can be classified into three groups :

i. Non polar solids - where the adsorption is mainly physical e.g., activated carbon.

ii. Polar solids - where the adsorption is chemical and no change in the chemical structure of the molecules or the surface occurs e.g. silica and aluminium oxides. These materials adsorb both polar and nonpolar molecules, but they exhibit preference or polar molecules.

iii. Chemical Adsorbing surfaces which adsorb the molecules and then release them after reaction, which may be either catalytic, leaving the surface unchanged or noncatalytic requiring replacement of the surface atoms.

4.4. Discuss activated carbon.

Ans:

i. Among the various adsorbent mentioned above activated carbon is most commonly used adsorbent because it has large surface area per unit weight or volume of solid.

ii. Activated carbon is the residue obtained from various carbonaceous materials like coal, nut shells, wood, paper mill sludge, petroleum sludge, which are subjected to various steps like drying, carbonizing and activating.

iii. Activated carbon is effective in adsorbing molecules or organic substances with less selectivity than is exhibited by other more polar adsorbents.

4.5. What are the characteristics of adsorbents ?

Ans:

i. Some of the important parameters for characterization of adsorbents are particle size, surface area, pore size, pore volume and pore volume distribution, density, adsorption capacity, iodine number and molasses number, hardness and abrasion resistance.

ii. The total adsorptive capacity of a sample of activated carbon or any adsorbent may be measured by its activity or relativity for a standard vapour.

4.6. What are the applications of adsorption for control of gaseous and odour emission at source ?

Ans: Following are the applications of adsorption process :

i. Vapour Recovery in Process Industries.

ii. Deodorization of Odours Emissions.

iii. Adsorption of H_2S and carbon disulphide (CS_2) from waste gases of viscose production plants.

iv. Adsorption of sulphur containing gases.

4.7. Write down the effects of sulphur dioxide (SO_2).

Ans: Sulphur dioxide found in the air produces following effects :

i. Irritates eyes, nose, throat.

ii. Damages lungs when inhaled.

4.8. What are the effects of nitrogen dioxide (NO_2) ?

Ans:

i. When inhaled, nitrogen dioxide becomes a serious air pollutant which may cause pulmonary edema (accumulation of excessive fluid in the lungs).

ii. It causes acid rain which destroying fish and plant life in lakes, damaging surfaces of building etc.

iii. It also contributes to photochemical smog.

4.9. What are the effects of carbon mono-oxide (CO) emission on human health ?

Ans. Following are the effects of carbon mono-oxides emission on human health :

i. Carbon mono-oxide is the most common type of fatal poisoning in many countries around the world.
ii. Exposures to carbon monoxide may lead to toxicity of the central nervous systems and heart, severe effects on the body of a pregnant woman, headaches and dizziness.
iii. Problems with getting oxygen supplied to some body parts which may be life-threatening.

4.10. Write down the effects of volatile organic compounds (VOCs).

Ans. Following are the effects of VOCs :

i. Some aromatic compounds such as benzene, toluene and xylene are potential carcinogens and may cause leukemia.
ii. Contribute to sick building syndrome indoors.
iii. As facilitators in ozone formation, VOCs may indirectly contribute to respiratory problems and other ozone-related problems.

4.11. What are the effects of ozone (O_3) as an air pollutant ?

Ans. Following are the effects of ozone :

i. Ozone in the troposphere can have the following negative effects on animals, humans and the natural environment.
ii. Irritation of the respiratory system causing coughing, throat irritation and an uncomfortable sensation in the chest.
iii. Compromised lung function harming the breathing process and aggravation of asthma.

4.12. What are the reasons of automobiles pollution in India ?

Ans. Following are the reasons of automobiles pollution :

i. Continuous increase in means of transportation in India.
ii. Use of more vehicles in cities due to population growth.
iii. Dependency on diesel and petrol engine only as fuel.
iv. Moving old vehicles on the road freely.

4.13. What are the measures to control the automobile pollution ?

Ans. There are following measures to control the automobile pollution :

i. Improvement in technology of manufacturing vehicles.
ii. Proper maintenance of the roads in the cities should be made and flyovers should be built.
iii. Petrol should be used only for petrol engine.
iv. Oil should be changed time to time.
v. Lubricant of high quality should be used.

4.14. Which Euro standard is currently in use in India ?

Ans. Euro VI - since 1st April 2020.

☺☺☺

UNIT 5

Noise Pollution (2 Marks Questions)

5.1. Define noise pollution.

Ans. The unwanted unpleasant sound that causes discomfort for all living beings is known as noise pollution.

5.2. List out the sources of noise pollution.

Ans. Industrial noise, transport noise and neighborhood noise are the sources of noise pollution.

5.3. What are the control measures of noise pollution ?

Ans. Source control, transmission path intervention, receptor control, oiling, etc., are the control measures of noise pollution.

5.4. What are the effects of noise pollution ?

Ans. The impacts of noise pollution are :

1. Hearing capability.
2. General health.
3. In communication.

5.5. What is Echo ?

Ans. A sound that reflected from a surface to the listener's ear is called echo.

5.6. Explain 'Intensity of Sound'.

Ans. The rate of sound per unit area is called intensity of sound. Intensity of sound is measured in decibel (dB). Human ears can generally hear the sound between 20 Hz to 20,000 Hz. The sound between 60-65 Hz is quite suitable for human ears. The sound more than above level it can cause loss of hearing capacity.

5.7. What are psychological effects of air pollution ?

Ans. **Psychological Effects :**

i. High noise pollution affects the proper sleep of everybody which will be one of the causes of insomnia. It affects the emotional balance of persons.
ii. It also affects working capabilities and arouses the fatigue in short period of time.

iii. Sometimes it will be the cause of depression, means person does not use his mind properly or positive sense.

5.8. Discuss degree of noise.

Ans: Following are the various degrees of noise :

i. Painful : 120 – 140 dB
ii. Extremely Loud : 90 dB
iii. Very Loud : 60 – 80 dB
iv. Moderate : 40 – 50 dB
v. Faint : 30 dB

5.9. Define the power of sound.

Ans:

i. The power of sound (W) is define as the rate of doing work by a travelling sound wave in the direction of the propagation of the wave.
ii. The energy transmitted by a sound wave in the direction of its propagation is thus, defined as its power, and is represented in Watts in SI units.

5.10. What are the effects of noise pollution on human health ?

Ans: Following are the effects of noise pollution on human health :

i. Noise pollution causes various mental, physical, and physiological disorders in human beings and animals.
ii. Health effects of noise include anxiety and stress reaction and in extreme cases fright.
iii. The physiological manifestations are headaches, irritability and nervousness, feeling of fatigue and decreases work efficiency.

5.11. How to control and prevent the noise pollution ?

Ans: **Control and Prevention of Noise Pollution :**

Noise pollution invites many kinds of physical and mental depressions. It is compulsory to check them. Many suitable step must be taken to check them :

i. People should be aware of it.
ii. Vehicles and generators should have silencers.
iii. We should listen to music and TV in low volume.
iv. Generators and motors should have sound proofing.

5.12. Write down the noise control equipments.

Ans: Following are the noise control equipments :

i. Fan silencers.
ii. Sound enclosures.
iii. Industrial process silencers.
iv. Acoustic building ventilation systems.

☺☺☺

B.Tech.

(SEM. V) ODD SEMESTER THEORY EXAMINATION, 2020-21

AIR AND NOISE POLLUTION CONTROL

Time : 3 Hours **Max. Marks : 100**

Note: 1. Attempt **all** Sections. If require any missing data; then choose suitably.

SECTION – A

1. Attempt **all** questions in brief. **(2 × 10 = 20)**

a. What do you understand by Gustiness ?

Ans: Gustiness is the characteristic of surface winds and determines the extent to which the pollutants are mixed and diluted with the ambient air. It is directly proportional to the wind speed.

b. List four major zones of atmosphere with their average distance from Earth's surface.

Ans: Refer Q. 1.3, 2 Marks Questions, Page SQ–1N, Unit-1.

c. What is the minimum particle size removed by gravitational settling chambers ?

Ans: Particle size greater than 50μ are effectively remove by gravitational settling chambers.

d. Name some of the special noise environment.

Ans: Following are some of the special noise environment:

i. Ultrasound
ii. Infrasound
iii. Impulse Noise
iv. Sonic Booms

e. Differentiate between: Dust, Smoke and Fumes.

Ans:

1. Dust :

i. It is a commonly used term applied to solid particles larger than colloidal particles and capable of temporary suspension in air or other gases.
ii. These are formed by natural disintegration of rock and soil or by mechanical process grinding and spraying with their size varying from 1 to 200 μ.

2. Smoke :

i. It consists of finely divided particles resulting from incomplete combustion or other chemical process.
ii. They consist of predominantly of carbon particles and other combustion material with their size less than 1μ.

3. **Fumes :**

i. Fumes are solid particles generated by condensation from gaseous state, generally after volatilisation from melted substance and after accompanied by a chemical reaction such as oxidation.
ii. The particle size varies from 0.1 to 1 μ.

f. What do you mean by the term acoustic ?

Ans: Acoustic is a branch of physics that study the sound, acoustics concerned with the production, control, transmission, reception and effect of sound, knowledge of this science is used to design and construction of theaters, cinemas etc with proper acoustic conditions.

g. Define radiation inversion.

Ans: Radiation inversion is a phenomenon occurring from the unequal cooling rates for the Earth and the air above the Earth. In other words when the Earth cools rapidly and more quickly than the air above it, then naturally the temperature in the environment will be less at the Earth and will increase above it, causing negative lapse rate and inversion condition.

h. Enumerate any two merits of fabric filters.

Ans: Refer Q. 3.10, Page 3–10N, Unit-3.

i. Write down the Indian Specifications of Euro-II.

Ans: Refer Q. 4.6, Page 4–9N, Unit-4.

j. Name all absorption units which are used to control of gaseous pollutants.

Ans: Refer Q. 4.1, Page 4–2N, Unit-4.

SECTION – B

2. Attempt any **three** of the following : **(3 × 10 = 30)**

a. A coal fired power plant releases from the stack SPM at the rate of 2.3 g/s. The stack height is 60 m while the temperature of the stack gases is 1600°C and the ambient air temperature is 30°C. The wind velocity at the stack height is 2.5 m/s, while the stack gas velocity is 5.0 m/s. The stack diameter is 3.5 m. The atmosphere pressure is 1.005 bar. The wind speed at 10 m height from the ground is 1.95 m/s. Estimate the ground level concentration for land 2 km downwind distance take the standard deviations for 1 km as $\sigma_y = 34$, $\sigma_z = 14$; for 2 km $\sigma_y = 63$, $\sigma_z = 22$ respectively.

Ans:

Given : Rate = 2.3 g/s, Stack height, h = 60 m, Temperature of stack gases = 160 °C, Ambient air temperatures = 30°, Wind velocity of height of stack, u = 2.5 m/s, Stack gas velocity, v_s = 5 m/s, Stack diameter, D = 3.5 m, Atmospheric pressure, P = 1.005 bar, Wind speed at height 10 m = 1.95 m/s, $\sigma_{y1} = 34$, $\sigma_{z1} = 14$, $\sigma_{y2} = 63$, $\sigma_{z2} = 22$.
To Find : Ground level concentration for 1 and 2 km downwind distance.

1. Plume height (Δh) is given by,

$$\Delta h = \frac{V_s D}{u}\left[1.5 + 2.68 \times 10^{-3} P D\left(\frac{T_s - T_a}{T_s}\right)\right]$$

$$T_a = 30° + 273 = 303 \text{ K}$$
$$P = 1.005 \text{ bar} = 1005 \text{ millibar}$$
$$T_s = 160°\text{C} + 273 = 433 \text{ K}$$

$$\Delta h = \frac{5 \times 3.5}{2.5}\left[1.5 + 2.68 \times 10^{-3} \times 1005 \times 3.5\left(\frac{433 - 303}{433}\right)\right]$$

$$\Delta h = 30.31 \text{ m}$$

2. Effective height of stack, $H = h + \Delta h = 60 + 30.31 = 90.31$ m
3. The concentration of pollutant in gm/m^3 is given by,

$$c_{(x,y)} = \frac{Q}{\pi u \sigma_z \sigma_y} e^{-\frac{1}{2}\left(\frac{H^2}{\sigma_z^2} + \frac{y^2}{\sigma_y^2}\right)}$$

i. Ground level concentration at 1000 m downwind,

$$c_y = \frac{Q}{\pi u \sigma_z \sigma_y} e^{-\frac{H^2}{2\sigma_z^2}} = \frac{2.3}{3.14 \times 2.5 \times 34 \times 14} \times e^{-\frac{90.31^2}{2 \times 14^2}}$$
$$= 5.6674 \times 10^{-13} \text{ gm/m}^3$$

ii. Ground level concentration at 2000 m downwind,

$$c = \frac{2.3}{3.14 \times 2.5 \times 63 \times 22} \times e^{-\frac{90.31^2}{2 \times 22^2}} = 4.634 \times 10^{-8} \text{ gm/ m}^3$$

b. Define Air (Prevention and Control of Pollution) Act. Discuss its salient features.

Ans:

A. The Air (Prevention and Control of Pollution) Act, 1981 :

1. The air (prevention and control of pollution) act, 1981 is a central act of parliament, which provides for the prevention and control of air pollution and maintaining the good quality of air.
2. It also provided for the establishment of the central and state boards for the prevention and control of air pollution.

B. The Main Functions of the Central Pollution Control Board are as Follows :

1. To advise the Central Government on any matter concerning the improvement of the quality of the air and the prevention, control and abatement of air pollution.
2. To plan and cause to be executed a nation-wide programme for the prevention, control and abatement of air pollution.
3. To provide technical assistance and guidance to the State Pollution Control Board.
4. To carry out and sponsor investigations and research related to prevention, control and abatement of air pollution.
5. To collect, compile and publish technical and statistical data related to air pollution; and
6. To lay down standards for the quality of air and emission quantities.

C. The Main Functions of the State Pollution Control Boards are as Follows :

1. To plan a comprehensive programme for prevention, control and abatement of air pollution and to secure the execution thereof;
2. To advise the State Government on any matter concerning prevention, control and abatement of air pollution.
3. To collect and disseminate information related to air pollution.
4. To collaborate with Central Pollution Control Board in programme related to prevention, control and abatement of air pollution; and
5. To inspect air pollution control areas, assess quality of air and to take steps for prevention, control and abatement of air pollution in such areas.

c. Describe the catalytic converter. Also, explain how it can be used to reduce the automobile emissions with the help of reactions ?

Ans:

A. Catalytic Converter :

1. A catalytic converter is a device used to reduce the emissions from an internal combustion engine (used in most modern day automobiles and vehicles).
2. Not enough oxygen is available to oxidize the carbon fuel in these engines completely into carbon dioxide and water; thus toxic by-products are produced.
3. Catalytic converters are used in exhaust systems to provide a site for the oxidation and reduction of toxic by-products (like nitrogen oxides, carbon monoxide, and hydrocarbons) of fuel into less hazardous substances such as carbon dioxide, water vapor, and nitrogen gas.
4. A catalytic converter uses basic redox reactions to reduce the pollutants a car makes. It converts around 98 % of the harmful fumes produced by a car engine into less harmful gases.

5. It is composed of a metal housing with a ceramic honeycomb-like interior with insulating layers.
6. This honeycomb interior has thin wall channels that are coated with a washcoat of aluminum oxide.
7. This coating is porous and increases the surface area, allowing more reactions to take place and containing precious metals such as platinum, rhodium, and palladium.
8. No more than 4-9 grams of these precious metals are used in a single converter.
9. The converter uses simple oxidation and reduction reactions to convert the unwanted fumes.

B. Reactions : Catalytic converters use reduction and oxidation (redox) reactions to reduce harmful emissions.

1. Reduction Reactions :

i. Converters use a reduction catalyst composed of platinum and rhodium.

ii. It helps reduce nitrogen oxides (NO_x) by removing nitrogen atoms from nitrogen oxide molecules (NO and NO_2).

iii. This lets the free oxygen form oxygen gas (O_2). Then, the nitrogen atoms attached to the catalyst react with each other.

iv. This reaction creates nitrogen gas (N_2).

Nitric acid $2NO \longrightarrow N_2 + O_2$

Nitrogen dioxide $2NO_2 \longrightarrow N_2 + 2O_2$

2. Oxidation Reactions :

i. Catalytic converters also use an oxidative catalyst composed of platinum or palladium.

ii. It helps reduce hydrocarbons (HC) and carbon monoxide (CO).

iii. Carbon monoxide and oxygen combine to form carbon dioxide (CO_2).

iv. Unburnt hydrocarbons and oxygen combine to form carbon dioxide and water.

$$2CO + O_2 \longrightarrow 2CO_2$$

$$HC + O_2 \longrightarrow CO_2 + H_2O$$

d. Briefly explain the effects of varying concentrations of CO, SO_2, H_2S, NO and NO_2 in air.

Ans: Refer Q. 1.10, Page 1–12N, Unit-1.

Effects of H_2S :

i. Atmospheric concentration of hydrogen sulphide and other reduced forms of sulphur can create objectionable odour and cause direct effect on materials, plants, animal and human.

ii. The repeated exposures to even low concentrations have irritating effects on the mucous membrane, eye and respiratory tract.

e. What are the effects of the noise pollution on health ?

Ans: Refer Q. 5.11, Page 5–12N, Unit-5.

SECTION – C

3. Attempt any **one** part of the following : **(1 × 10 = 10)**

a. Describe various types of pollutants emitted from petrol-driven and diesel driven motor vehicles. Also write Euro-1, Euro-II and Euro-III specifications for pollution control in petrol driven passenger cars.

Ans: **Pollutants :** Refer Q. 4.4, Page 4–6N, Unit-4.
Euro Specifications : Refer Q. 4.6, Page 4–8N, Unit-4.

b. Differentiate between absorption and adsorption process in detail with examples.

Ans:

Parameter	Absorption	Adsorption
Definition	It is a process in which any substance (atoms, ions, or molecules) is taken by or absorbed by another substance, especially in the solid or liquid material.	The substances like gas, liquids or dissolved solids loosely adhere or stick to the surface of another substance which can be solid or liquid.
Type of phenomenon	It is a bulk phenomenon.	It is a surface phenomenon.
Type of process	Endothermic process.	Exothermic process.
Rate of reaction	Uniform rate.	The reaction rate increases slowly and attains equilibrium.
Concentration	The concentration of the absorbate in the absorbent is uniform after absorption.	The adsorbate is more concentrated on the surface then the other part of the adsorbent.
Temperature effect	No effect of temperature.	Works at the lower temperature.
Application	Cold storage, ice production, turbine inlet cooling, refrigerants, etc.	Air conditioning, water purification, synthetic resin, chillers, etc.

4. Attempt any **one** part of the following : **(1 × 10 = 10)**

a. Explain Gaussian plume in detail. What is prefeasibility report? Mention salient points of EIA notification, 2006.

Ans:

A. Gaussian Plume : Refer Q. 2.10, Page 2–10N, Unit-2.

B. Prefeasibility Report : An environmental pre-feasibility study allows to evaluate the environmental impacts caused by the project already in the preliminary planning stage, thus anticipating suitable solution regarding the critical issues detected.

C. Features : The salient features of EIA Notification, 2006 include :

1. The EIA Notification, 2006 has categorized the projects into two categories namely; Category 'A' and Category 'B' based on their impact potential.
2. Category 'A' projects will be appraised at the Central level while Category 'B' project at the State level.
3. State level Environment Impact Assessment Authorities and Committees (SEIAAs and SEACs) have been constituted for the purpose of appraisal of Category 'B' projects.
4. The stage of scoping for prescribing terms of reference by the Regulatory Agency for the EIA studies has been incorporated in accordance with the International practice. It is expected to improve the quality of EIA thereby improving the quality of decision making and minimizing the delays.
5. The public consultation process has been made more structured. It has two components *i.e.* comments through correspondence and by public hearing at site. Provision to videograph the proceedings of the public hearing has been made.
6. NOCs from other regulatory agencies such as SPCB etc. are not a pre-requisite for considering application for environmental clearance.

b. Enumerate the impacts of atmospheric pressure, moisture, and precipitation on dispersion of air pollutants.

Ans: **Impact of Atmospheric Pressure :** Refer Q. 2.7, Page 2–8N, Unit-2.

Impact of Moisture and Precipitation : Refer Q. 2.8, Page 2–8N, Unit-2.

5. Attempt any **one** part of the following : **(1 × 10 = 10)**

a. Differentiate between L_N, L_{eq} and L_{dn} in relation to expression of sound levels.

Ans.

1. The L_N Concept :

i. The parameter L_N is a statistical measure indicating how frequently a particular sound level is exceeded.

ii. The value of L_N will represent the sound pressure level that will exceed for N % of the gauging time.

iii. Say for example, the given 70 dB value of L_{60} will mean that 70 dB for 60 % of the measuring time.

2. The L_{eq} Concept :

i. L_{eq} is that statistical value of sound pressure level that can be equated to any fluctuating noise level.

ii. L_{eq} is defined as the constant noise level, which, over a given time expands the same amount of energy, as is expanded by the fluctuating levels over the same time.

iii. This value is expressed by the equation :

$$L_{eq} = 10 \log \sum_{i=1}^{i=n} (10)^{\frac{L_i}{10}} \times t_i$$

where, n = Total number of sound samples.

L_i = The noise level of any i^{th} sample.

t_i = Time duration of i^{th} sample, expressed as fraction of total sample time.

3. The equivalent noise level (Weighted on A Network) during 24 hour time period with + 10 dB (A) correction applied to measurement recorded during night time of 22 hr to 07 hr is usually represented by L_{dn}.

b. Explain in brief the major factors and actions that may help in noise abatement in a modern society.

Ans. Noise Abatement and Control :

1. Certain noises can be kept under control by legal laws and ordinances, while others have to be dampened and attenuated by then use of good technology and town planning.

2. For example, the noises produced by motor vehicles can be controlled to some extent by proper maintenance of vehicles, which can be ensured by prescribing and implementing the maximum permissible noise levels for different types of automobiles, through, Motor Vehicles Act.

3. Similarly, industrial noises can be brought under the control of factories Act by specifying maximum permissible noise levels and other checks.

4. Public blaring of loudspeakers and playing of television sets at loud levels can be prevented by general legal laws of public nuisance or laws specifically made for noise pollution.

5. Other noises are to be reduced by better design technology to be used in the modern day gadgets like fans, air-conditioners, washing machines, refrigerators, mixers and grinders, etc.

6. Another method for abating noise effects is to use proper town planning techniques, for construction of houses and offices away from the major sources of noise.

7. Proper segregation, zoning and separation of residential complexes from the commercial and industrial ones, by means of physical barriers, roads, railway lines, parks or green belts, do constitute good town planning.

8. Raising the thick and high vegetation and growing of trees along the sides of roads and railway lines, offer cheaper barriers to cause some noise reduction.

9. Locating the noisy sources on the downwind side of the residences, may be another important consideration in good town planning, because noise will then travel farther in the downwind direction away from the residences.

10. The control of noise can be achieved by adopting following approaches :

i. **Reducing the Sound Produced :** Noise producing sources should be rectified so that intensity of noise is reduced at the source of itself.

ii. **Interrupting the Path of the Sound :** Some barrier is made or the path of the sound is channelised so that desired location can be segregated from the effect of the noise.

iii. **Protecting the Recipient :** The application of personal protection by using ear muff or cotton plug.

(1 × 10 = 10)

6. Attempt any **one** part of the following :

a. Describe the principle of operation, advantages, and limitations of gravitational settling chamber for particulate contaminants.

Ans. Refer Q. 3.4, Page 3–4N, Unit-3.

b. Enumerate and describe the various natural properties which clean the ambient air over time by removing the various air pollutants.

Ans. Following are the various natural phenomenon given below :

1. Dispersion :

i. Dispersion of pollutants by winds reduces the concentration of air pollutants at one place, although in the strict sense, it does not remove them from the environment as a whole. This mechanism is therefore, a diluting mechanism only.

ii. The dispersion through long chimneys, helps us in diluting the air pollutants near their sources only, and does not reduce their long term undesirable effects on the community as a whole.

2. Rainout : It is the process involving precipitation above the cloud level, where submicron particles present in the atmosphere in the clouds, serve as condensation nuclei, around which drops of water may from and fall out as raindrops.

3. Gravitational Settling :

i. It is the most important natural mechanism, under which large heavy particles from the ambient air settle down on buildings, trees and other objects.

ii. This generally happens for the particles which are larger than 20 μm in size.

iii. This process also helps in removing flocculated particles formed by uniting of smaller particles over larger particles, till a floc particle, large and heavy enough to settle out under gravity, is formed.

4. Absorption :

i. In the natural absorption process, the gaseous as well as particulate pollutants from the air get collected in the rain or mist, and may settle out with that moisture.

ii. This phenomenon takes place below the cloud level, when falling raindrops absorb pollutants, and is also known as washout or scavenging.

iii. The process, however, does not help in removing particles smaller than 1 μm in size.

5. Adsorption :

i. It is the phenomenon in which the gaseous, liquid, or solid pollutants present in the ambient air are kept attracted, generally

electrostatically, by a surface, where they are concentrated and retained.

ii. Natural surfaces, such as soils, rocks, leaves, blades of grass, buildings, and other objects can adsorb and retain pollutants.

7. Attempt any **one** part of the following : **(1 × 10 = 10)**

a. Enumerate the effects of the air pollution on humans, animals, property, and plants.

Ans. **Effect of Air Pollution on Human Health :** Refer Q. 1.12, Page 1–15N, Unit-1.

Effect of Air Pollution on Plant : Refer Q. 1.13, Page 1–16N, Unit-1.

Effect of Air Pollution on Animal : Refer Q. 1.14, Page 1–16N, Unit-1.

Effect of Air Pollution on Property : Refer Q. 1.15, Page 1–17N, Unit-1.

b. What is photochemical smog and how is it formed ? Explain in detail.

Ans. **Photochemical Smog :**

1. Photochemical smog is a mixture of pollutants that are formed when nitrogen oxides and volatile organic compounds (VOCs) react to sunlight, creating a brown haze above cities.

2. It tends to occur more often in summer, because that is when we have the most sunlight.

Chemistry of Smog Formation :

i. Nitrogen dioxide (NO_2) can be broken down by sunlight to form nitric oxide (NO) and an oxygen radical (O) :

$$NO_2 + \text{sunlight} \longrightarrow NO + O$$

ii. Oxygen radicals can then react with atmospheric oxygen (O_2) to form ozone (O_3) :

$$O + O_2 \longrightarrow O_3$$

iii. Ozone is consumed by nitric oxide to produce nitrogen dioxide and oxygen :

$$O_3 + NO \longrightarrow NO_2 + O_2$$

iv. Harmful products, such as PAN, are produced by reactions of nitrogen dioxide with various hydrocarbons (R), which are compounds made from carbon, hydrogen and other substances :

$$NO_2 + R \longrightarrow \text{Products such as PAN}$$

v. The main source of these hydrocarbons is the VOCs. Similarly, oxygenated organic and inorganic compounds (RO_x) react with nitric oxide to produce more nitrogen oxides :

$$NO + RO_x \longrightarrow NO_2 + \text{other products}$$

☺☺☺

Air Pollution
(Multiple Choice Questions)

1. What concentration of Neon (in PPM) generally present in the atmosphere ?

A. 5.2 B. 1.1
C. 18.2 D. 300
Explanation : Refer Q. 1.1, Page 1–2N, Unit-1.

2. _____ is an unwanted alteration to the Earth's natural resources, usually with the negative impact on human health or life style.

A. Contamination **B. Pollution**
C. Adulteration D. Waste
Explanation : Refer Q. 1.1, Page 1–2N, Unit-1.

3. Air pollution arises from the pollutants sources like,

A. Industry B. Thermal power stations
C. Automobiles **D. All of the above**
Explanation : Refer Q. 1.1, Page 1–2N, Unit-1.

4. The type(s) of natural pollutants includes,

A. Bio-degradable pollutants
B. Slow bio-degradable pollutants
C. Non-degradable pollutants
D. All of the above
Explanation : Refer Q. 1.2, Page 1–3N, Unit-1.

5. Non-degradable pollutants includes,

A. Lead B. Mercury
C. Aluminium **D. All of the above**
Explanation : Refer Q. 1.2, Page 1–3N, Unit-1.

6. The lead content in petrol is _____ .

A. 0.004 g/L B. 0.04 g/L
C. 0.4 g/L **D. 4 g/L**
Explanation : Refer Q. 1.3, Page 1–4N, Unit-1.

7. Heavy metals like lead and mercury are emitted from,

A. Smelters B. Coal combustion
C. Secondary lead plants **D. All of the above**
Explanation : Refer Q. 1.3, Page 1–4N, Unit-1.

8. Which of the following is/are the cause(s) of environmental pollution ?
A. Urbanization B. Overpopulation
C. Deforestation **D. All of the above**
Explanation : Refer Q. 1.4, Page 1–5N, Unit-1.

9. In which layer of atmosphere the events related to season takes place, such as formation of clouds and lightening ?
A. Troposphere B. Stratosphere
C. Mesosphere D. Thermosphere
Explanation : Refer Q. 1.5, Page 1–6N, Unit-1.

10. In which layer of atmosphere, ozone layer is available ?
A. Troposphere **B. Stratosphere**
C. Mesosphere D. Thermosphere
Explanation : Refer Q. 1.5, Page 1–6N, Unit-1.

11. The height of mesosphere is about _____ from the surface of earth.
A. 12 km B. 50 km
C. 80 km D. 650 km
Explanation : Refer Q. 1.5, Page 1–6N, Unit-1.

12. Which layer of atmosphere, checks cosmic rays of the sun and reflects radio waves to the earth ?
A. Troposphere B. Stratosphere
C. Mesosphere **D. Thermosphere**
Explanation : Refer Q. 1.5, Page 1–6N, Unit-1.

13. In which layer of atmosphere, light gases like Hydrogen and Helium are present ?
A. Troposphere B. Stratosphere
C. Mesosphere **D. Exosphere**
Explanation : Refer Q. 1.5, Page 1–6N, Unit-1.

14. Adverse effect(s) caused by air pollution is/are,
A. Depletion of ozone layer B. Green house effect
C. Acid rain **D. All of the above**
Explanation : Refer Q. 1.6, Page 1–7N, Unit-1.

15. At what distance from the earth ozone layer is situated which protects earth from harmful UV rays ?
A. 12 km B. 50 km
C. 80 km D. 650 km
Explanation : Refer Q. 1.6, Page 1–7N, Unit-1.

16. Which of the following is not a green house gas ?
A. CO_2 B. CH_4
C. N_2O **D.** N_2
Explanation : Refer Q. 1.6, Page 1–7N, Unit-1.

17. Which of the following is not a component of photo-chemical smog ?
A. Hydrocarbons B. UV rays
C. Ozone **D. Sulphur dioxide**
Explanation : Refer Q. 1.6, Page 1–7N, Unit-1.

18. Match the following according to classification of air pollutants :

1. Physical air pollutants	i. Harmful industrial gases
2. Biological air pollutants	ii. Smell and heat emitting waste
3. Chemical air pollutants	iii. Plants and animals waste

A. 1 – i, 2 – iii, 3 – ii **B. 1 – ii, 2 – iii, 3 – i**
C. 1 – iii, 2 – ii, 3 – i D. 1 – ii, 2 – i, 3 – iii
Explanation : Refer Q. 1.8, Page 1–10N, Unit-1.

19. _____ consists of gases produced from chemical fertilizers and harmful industrial gases.
A. Physical air pollutants **B. Chemical air pollutants**
C. Biological air pollutants D. Gaseous pollutants
Explanation : Refer Q. 1.8, Page 1–10N, Unit-1.

20. Substance(s) include in large particulates is/are
A. Asbestos fibres B. Dust
C. Lead **D. All of the above**
Explanation : Refer Q. 1.9, Page 1–11N, Unit-1.

21. Which of the following gas is not an air pollutant ?
A. Sulphur dioxide **B. Argon**
C. Ammonia D. Ozone
Explanation : Refer Q. 1.10, Page 1–12N, Unit-1.

22. We can control automobile pollution as a rider by
A. Using high quality lubricant
B. Changing engine oil time to time
C. Using CNG or electric vehicle
D. All of the above
Explanation : Refer Q. 1.11, Page 1–14N, Unit-1.

23. Which of the following gas plays a major role in tropospheric ozone formation ?
A. NO B. NO_2
C. N_2 D. CO_2
Explanation : Refer Q. 1.12, Page 1–15N, Unit-1.

24. Which of the following gas/gases causes respiratory problems ?

A. SO_2 B. CO
C. NO_2 **D. All of the above**
Explanation : Refer Q. 1.12, Page 1–15N, Unit-1.

25. Most harmful gas for the plants, which cause phytotoxicological effect on plant, is
A. Sulphur Dioxide **B. Fluorine**
C. Nitrogen Oxide D. Ammonia
Explanation : Refer Q. 1.13, Page 1–16N, Unit-1.

26. The concentration of fluorine in excess of about _____ causes phytotoxicological effect on plant.
A. 0.2 $\mu g/m^3$ **B. 0.3 $\mu g/m^3$**
C. 0.4 $\mu g/m^3$ D. 0.5 $\mu g/m^3$
Explanation : Refer Q. 1.13, Page 1–16N, Unit-1.

27. When lead-contaminated vegetation is eaten by the live-stock animals, then they may have
A. Inability to stand
B. Paralysis of digestive tract
C. Prostration
D. All of the above
Explanation : Refer Q. 1.14, Page 1–16N, Unit-1.

28. The effect of air pollution on materials and services includes
A. Deterioration of metallic surface
B. Etching of glass on windows
C. Leakage from high voltage electric cables
D. All of the above
Explanation : Refer Q. 1.15, Page 1–17N, Unit-1.

29. 'Smog' is a kind of air pollution, originally named after
A. Mixture of smoke and fog in air.
B. Mixture of smoke and dust.
C. Mixture of smoke and liquid.
D. None of these
Explanation : Refer Q. 1.8, 2 Marks, Page SQ–2N, Unit-1.

Chemistry and Dispersion of Air Pollution
(Multiple Choice Questions)

1. Which of the following is primary air pollutant ?
A. NO_2 B. Carbon dioxide
C. Sulphur dioxide D. None of these
Explanation : Refer Q. 2.1, Page 2–2N, Unit-2.

2. The secondary products formed in the presence of sunlight and primary air pollutant are referred as
A. Physical air pollutants **B. Photochemical pollutants**
C. Chemical air pollutants D. Gaseous pollutants
Explanation : Refer Q. 2.1, Page 2–2N, Unit-2.

3. In remote areas concentration of ozone is higher in the atmosphere because
A. There are more vegetation
B. Wind velocity is higher
C. The presence of NO is lower
D. None of these
Explanation : Refer Q. 2.1, Page 2–2N, Unit-2.

4. The temperature conditions of the environment are defined by
A. Atmospheric diffusion **B. Lapse Rate**
C. Climate dynamics D. Saturated Adiabatic Lapse rate
Explanation : Refer Q. 2.2, Page 2–3N, Unit-2.

5. The pocket of polluted smoke is known as,
A. Smoke plume B. Smoke stack
C. Chimney D. None of these
Explanation : Refer Q. 2.2, Page 2–3N, Unit-2.

6. The accumulation of the pollution is maximum when,
A. The air is in turbulence
B. The air is motionless
C. The temperature is lower
D. None of these
Explanation : Refer Q. 2.3, Page 2–3N, Unit-2.

7. The gradual decrease in temperature with the higher altitude is known as,

A. Climate dynamics B. Atmosphere diffusion
C. Adiabatic lapse rate D. Sub-adiabatic rate
Explanation : Refer Q. 2.3, Page 2–3N, Unit-2.

8. The height above the surface of atmosphere, where adiabatic lapse rate intersects the observed vertical temperature profile is known as
A. Maximum mixing depth B. Maximum mixing height
C. Ventilation coefficient **D. Both (A) and (B)**
Explanation : Refer Q. 2.3, Page 2–3N, Unit-2.

9. How does wind affects the air pollution ?
A. Wind disperse the contaminants
B. Wind generate dust in air
C. Wind affects temperature, which indirectly contributes in pollution
D. All of the above
Explanation : Refer Q. 2.4, Page 2–4N, Unit-2.

10. Which cf the following weather factor makes pollutants undergo chemical reactions ?
A. Sunshine B. Rain
C. High velocity wind D. Humidity
Explanation : Refer Q. 2.4, Page 2–4N, Unit-2.

11. Which type of air turbulence is caused by physical obstruction to normal flow such as mountain, building, etc ?
A. Convective turbulence **B. Mechanical turbulence**
C. Frontal turbulence D. Wind shear
Explanation : Refer Q. 2.5, Page 2–5N, Unit-2.

12. The convective turbulence
A. Increase with increase of temperature difference
B. Decrease with increase in temperature difference
C. Does not depend on the temperature
D. Increase with decrease in temperature difference
Explanation : Refer Q. 2.5, Page 2–5N, Unit-2.

13. When there exists a strong super adiabatic lapse rate above a surface inversion, then plume is said to be
A. Fanning plume **B. Lofting plume**
C. Neutral plume D. Trapping plume
Explanation : Refer Q. 2.6, Page 2–5N, Unit-2.

14. Looping plume occurs in
A. Super adiabatic environment
B. Atmosphere where environmental and adiabatic lapse rate is equal
C. Atmosphere where environmental lapse rate is less than adiabatic lapse rate
D. Sub adiabatic environment with high temperature
Explanation : Refer Q. 2.6, Page 2–5N, Unit-2.

15. The neutral plume tends to become coning plume, when the wind velocity is greater than
A. 24 km/h B. 30 km/h
C. 32 km/h D. 40 km/h
Explanation : Refer Q. 2.6, Page 2–5N, Unit-2.

16. When inversion layer occurs at short distance above the stack and superadiabatic condition prevail below stack, then plume is said to be
A. Fumigating plume B. Lofting plume
C. Coning plume D. Trapping plume
Explanation : Refer Q. 2.6, Page 2–5N, Unit-2.

17. High pressure system (anticyclones) may prove to be bad for dispersion of pollutants, if it is accompanied with
A. Clear sky B. Light winds
C. Stable atmosphere **D. All of the above**
Explanation : Refer Q. 2.7, Page 2–8N, Unit-2.

18. What type of atmospheric condition(s) is/are better for dispersion of pollutants ?
A. Low pressure system (cyclone)
B. High pressure system
C. Clear sky
D. Stable atmosphere
Explanation : Refer Q. 2.7, Page 2–8N, Unit-2.

19. How the presence of humidity in the air affects the air quality ?
A. By blocking and obstructing solar radiation
B. By reflecting heat radiation from surface.
C. By leading formation of fog
D. All of the above
Explanation : Refer Q. 2.8, Page 2–8N, Unit-2.

20. Acid rain adversely influence the water-body by,
A. Decaying vegetation
B. Increasing pH of water
C. Increasing level of water
D. None of these
Explanation : Refer Q. 2.8, Page 2–8N, Unit-2.

21. The movement of air is caused by
i. Unequal distribution of temperature
ii. Unequal distribution of pressure
iii. Rotation of the earth
A. (i) and (ii) only B. (iii) only
C. (ii) and (iii) only **D. All of the above**
Explanation : Refer Q. 2.9, Page 2–9N, Unit-2.

22. The force which tends to deflect the air currents out of their expected pattern is called,
A. Gravitational force **B. Coriolis force**
C. Frictional force D. Centrifugal force
Explanation : Refer Q. 2.9, Page 2–9N, Unit-2.

23. In the friction layer at the Earth's surface, winds are generally gusty and changeable due to
A. High pressure
B. Superadiabatic environment
C. Locally generated mechanical or thermal turbulence
D. Sub adiabatic environment
Explanation : Refer Q. 2.9, Page 2–9N, Unit-2.

24. Wind velocity is measured by,
A. Speedometer B. Tachometer
C. Pyranometer **D. Anemometer**
Explanation : Refer Q. 2.9, Page 2–9N, Unit-2.

25. Wind velocity measured by Anemometer is given by
A. $k\left[\frac{Z}{Z_0}\right]^{n_0}$ **B.** $u_0\left[\frac{Z}{Z_0}\right]^{k}$
C. $u_0\left[\frac{Z_0}{Z}\right]^{k}$ D. $k\left[\frac{Z_0}{Z}\right]^{n_0}$
Explanation : Refer Q. 2.9, Page 2–9N, Unit-2.

26. Which equation is used to predict the concentration of an air pollutant evolving from a source at any downward point ?
A. Equation of turbulent diffusion
B. Diffusivity equation
C. Gaussian distribution equation
D. Equation of hydrostatic equilibrium
Explanation : Refer Q. 2.10, Page 2–10N, Unit-2.

27. At zero effective height of stack, Gaussian distribution equation will be,
A. $C_{x,0} = \frac{Q}{\pi u \sigma_z \sigma_y}$ B. $C_{x,0} = \frac{\sigma_z \sigma_y}{Q \pi u}$
C. $C_{x,0} = \frac{Q \pi u}{\sigma_z \sigma_y}$ D. $C_{x,0} = \frac{Qu}{\pi \sigma_z \sigma_y}$
Explanation : Refer Q. 2.10, Page 2–10N, Unit-2.

28. Calculate sulphur emission (sulphur produced per hour) if 6.25 tonnes of coal having 4.7% of sulphur content burnt at power plant.

A. 187.45 kg **B. 293.75 kg**
C. 354.85 kg D. 387.65 kg
Explanation : Refer Q. 2.11, Page 2–11N, Unit-2.

29. Effective height of stack is equal to,
A. Actual height of stack – Plume height
B. Actual height of stack + Plume height
C. Actual height of stack + Inversion point
D. Actual height of stack – Inversion point
Explanation : Refer Q. 2.13, Page 2–13N, Unit-2.

30. According to Bureau of Indian Standards, the plume rise for not very hot release is given by
A. $\frac{4 v_s D}{u}$ B. $\frac{3 v_s u}{D}$
C. $\frac{3 v_s D}{u}$ D. $\frac{4 v_s u}{D}$
Explanation : Refer Q. 2.13, Page 2–13N, Unit-2.

☺☺☺

3 UNIT

Air Pollution Control (Multiple Choice Questions)

1. The first Indian emission regulations come into existence in
A. 1989 B. 1991
C. 1992 D. 2000
Explanation : Refer Q. 3.1, Page 3–2N, Unit-3.

2. Since 2000, India has started European emission and fuel regulations for
A. Light duty vehicles B. Heavy duty vehicles
C. Medium goods vehicles **D. Both (A) and (B)**
Explanation : Refer Q. 3.1, Page 3–2N, Unit-3.

3. From April 2005, Bharat Stage II emission standards are applied for
A. Heavy duty vehicles B. Medium goods vehicles
C. 2 and 3 wheelers D. None of the above
Explanation : Refer Q. 3.1, Page 3–2N, Unit-3.

4. The expert committee recommended Bharat Stage V all over the country from
A. April 2010 **B. April 2017**
C. April 2018 D. May 2019
Explanation : Refer Q. 3.1, Page 3–2N, Unit-3.

5. In the year 2001 Bharat Stage II is implemented in the region of
A. NCR B. Mumbai
C. Kolkata **D. All of the above**
Explanation : Refer Q. 3.1, Page 3–2N, Unit-3.

6. The collection of samples of the gases emitted from the source is called
A. Stack sampling at origin of pollution
B. Pollution under control check
C. Particular matter sampling
D. Dry gas meter check
Explanation : Refer Q. 3.2, Page 3–3N, Unit-3.

7. The main objective(s) of the sampling at source is/are

A. To know the nature of pollution source.
B. To measure quality and quantity of pollutants produce by source.
C. For application of the local control system at the place.
D. All of the above.
Explanation : Refer Q. 3.2, Page 3–3N, Unit-3.

8. NEERI stands for
A. National Environmental Economics Research Institute
B. National Energy and Ecology Research Institute
C. National Environmental Engineering Research Institute
D. National Environmental and Ecology Research Institute
Explanation : Refer Q. 3.3, Page 3–3N, Unit-3.

9. The procedure for the collection of particulates matter sampling includes in determining
A. Gas composition and correct moisture content.
B. Temperature and velocity at each traverse point.
C. The flow rate to be sampled under isokinetic condition.
D. All of the above.
Explanation : Refer Q. 3.3, Page 3–3N, Unit-3.

10. Flow rate of the fluid is measured by
A. Anemometer **B. Rotameter**
C. Mass flow meter D. Venturimeter
Explanation : Refer Q. 3.3, Page 3–3N, Unit-3.

11. Gravitational settling chamber is not helpful against
A. Large particulates B. Micro particulates
C. Sticky dust D. None of these
Explanation : Refer Q. 3.4, Page 3–4N, Unit-3.

12. Gravity settling chambers technique is based on
A. Principle of gravity B. Principle of aeration
C. Bernoulli's principle D. Pascal principle
Explanation : Refer Q. 3.4, Page 3–4N, Unit-3.

13. Gravity settling chambers are used
A. To remove smog
B. To remove suspended particulates matter
C. To remove smoke
D. To remove volatile organic compounds
Explanation : Refer Q. 3.4, Page 3–4N, Unit-3.

14. Cyclones equipments are not helpful against
A. Sticky dust B. Large particulates
C. Micro particulates **D. Wet fibrous materials**
Explanation : Refer Q. 3.5, Page 3–5N, Unit-3.

15. Dynamic precipitators are widely used in

A. Ceramic industries
B. Wood working industries
C. Pharmaceutical industries
D. All of the above
Explanation : Refer Q. 3.5, Page 3–5N, Unit-3.

16. Cyclone collector is more effective against
A. Sticky dust **B. Large particles**
C. Small particles D. Wet fibrous materials
Explanation : Refer Q. 3.6, Page 3–6N, Unit-3.

17. Cyclone collectors are used in industries like,
A. Asphalt mixing plants B. Grain mills
C. Petroleum refineries **D. All of the above**
Explanation : Refer Q. 3.6, Page 3–6N, Unit-3.

18. Disadvantage(s) of the cyclone collector includes,
A. Low efficiency for smaller particle.
B. High potential of corrosion problems.
C. It requires lot of maintenance.
D. All of the above.
Explanation : Refer Q. 3.6, Page 3–6N, Unit-3.

19. Wet scrubbers can be highly effective in removing particles, with removed efficiency upto,
A. 80% B. 84%
C. 95% **D. 99%**
Explanation : Refer Q. 3.7, Page 3–7N, Unit-3.

20. Scrubbers suffer from high level of the corrosion due to
A. Corrosive sludge B. Hot gases
C. Inadequate liquid flow D. High pressure
Explanation : Refer Q. 3.7, Page 3–7N, Unit-3.

21. If the gaseous pollutants are acidic in nature, then the scrubbing liquid used will be _____ in nature.
A. Alkaline B. Acidic
C. Corrosive D. Organic
Explanation : Refer Q. 3.7, Page 3–7N, Unit-3.

22. Limitation of the wet scrubber includes,
A. Low efficiency for smaller particles.
B. Disposal of waste sludge is difficult.
C. Collection efficiency reduces with time.
D. It requires lot of maintenance.
Explanation : Refer Q. 3.8, Page 3–8N, Unit-3.

23. Which of the following air pollution control equipment is most versatile and can be engineered for almost any dust producing application ?

A. Cyclone collectors
B. Dynamic precipitators
C. Wet scrubbers
D. Bag house filters
Explanation : Refer Q. 3.9, Page 3–9N, Unit-3.

24. Under what type of environment, Bag house filters can operate more effectively ?
A. High temperature environment
B. Dry environment
C. Cold environment
D. Humid environment
Explanation : Refer Q. 3.9, Page 3–9N, Unit-3.

25. The advantage(s) of using Bag house filters includes,
A. Versatile and flexible
B. Effective for small dust particles
C. Cost effective
D. All of the above
Explanation : Refer Q. 3.10, Page 3–10N, Unit-3.

26. The limitation(s) of using Bag house filter includes,
A. Limited operation against high temperature and corrosive chemicals.
B. Low efficiency for smaller particles.
C. Collection efficiency reduces with time.
D. All of the above.
Explanation : Refer Q. 3.10, Page 3–10N, Unit-3.

27. Electrostatic precipitators are mainly used in industries like,
A. Thermal power plants
B. Cement factories
C. Steel plants
D. All of the above
Explanation : Refer Q. 3.11, Page 3–10N, Unit-3.

28. The electrostatic precipitator works by removing particles and smoke from gas stream using
A. Electrostatic charge
B. Centrifugal force
C. Absorbent materials
D. Gravity phenomenon
Explanation : Refer Q. 3.11, Page 3–10N, Unit-3.

29. Which of the following pollution control equipment is effective on both wet and dry particles ?
A. Electrostatic precipitator
B. Dynamic precipitator
C. Gravity settling chamber
D. Cyclone collector

Explanation : Refer Q. 3.12, Page 3–11N, Unit-3.

30. The main disadvantage(s) of using electrostatic precipitator is/are,

A. Low efficiency for larger particles
B. Collection efficiency reduces with time
C. Requires lot of maintenance
D. All of the above

Explanation : Refer Q. 3.12, Page 3–11N, Unit-3.

Control of Gaseous Contaminants (Multiple Choice Questions)

1. Type(s) of device(s) used to control the emission of gaseous air pollution from industries is/are

A. Absorption units
B. Adsorption units
C. Combustion equipments
D. All of the above

Explanation : Refer Q. 4.1, Page 4–2N, Unit-4.

2. Which devices out of these can simultaneously be used for removing particulate pollutants ?

i. Spray towers ii. Plate towers
iii. Packed towers iv. Venturi scrubbers
A. (i) and (ii) only **B. (i) only (iv) only**
C. (ii) and (iii) only D. All of the above

Explanation : Refer Q. 4.1, Page 4–2N, Unit-4.

3. Which of the following device is relatively less effective in removing gaseous pollutants ?

A. Spray towers B. Packed towers
C. Venturi scrubbers D. Plate towers

Explanation : Refer Q. 4.1, Page 4–2N, Unit-4.

4. The functioning of the absorption unit is based on,

A. Principle of gravity
B. Static charge
C. Principle of transfer of the pollutants from gas phase to liquid phase
D. Principle of aeration

Explanation : Refer Q. 4.1, Page 4–2N, Unit-4.

5. Water can be only used as solute in absorption units, if the removal is restricted to inorganic gases like,

A. NH_3 B. SO_2
C. Cl_2 **D. All of the above**

Explanation : Refer Q. 4.1, Page 4–2N, Unit-4.

6. Adsorption units are highly inefficient in purifying,

A. Sticky dust
B. Acidic gases
C. Micro particulates
D. Industrial gases at high temperature
Explanation : Refer Q. 4.2, Page 4–3N, Unit-4.

7. Match the following as per maximum operating temperature for the adsorbents,

i. Active carbon	1. 600°C
ii. Molecular sieves	2. 150°C
iii. Silica gel	3. 500°C
iv. Activated alumina	4. 400°C

A. i – 3, ii – 1, iii – 1, iv – 4 **B. i – 2, ii – 1, iii – 4, iv – 3**
C. i – 1, ii – 4, iii – 2, iv – 2 D. i – 4, ii – 3, iii – 2, iv – i
Explanation : Refer Q. 4.2, Page 4–3N, Unit-4.

8. Which of the following adsorbent is capable of capturing water before any pollutant gases ?
A. Activated carbon B. Dehydrated zeolites
C. Silica gel D. Activated alumina
Explanation : Refer Q. 4.2, Page 4–3N, Unit-4.

9. Activated carbon is effective on gaseous pollutant(s) like,
A. Hydrocarbons B. H_2S
C. SO_2 **D. All of the above**
Explanation : Refer Q. 4.2, Page 4–3N, Unit-4.

10. Adsorption units use adsorbents like,
A. Activated carbon B. Molecular sieves
C. Silica gel **D. All of the above**
Explanation : Refer Q. 4.2, Page 4–3N, Unit-4.

11. The major drawback of catalytic incinerators is,
A. Inability to treat acidic gases.
B. Inefficient in purifying gases under high temperature.
C. Susceptibility to poisoning by sulphur and lead compounds.
D. Inefficiency towards micro particulates.
Explanation : Refer Q. 4.3, Page 4–4N, Unit-4.

12. Catalytic incineration is used when the energy of the polluted gas is less than,
A. 2 MJ/m^3 B. 3 MJ/m^3
C. 3.7 MJ/m^3 D. 4.2 MJ/m^3
Explanation : Refer Q. 4.3, Page 4–4N, Unit-4.

13. Direct flame incineration has been used to purify industrial gases from,
A. Varnish cooking B. Paint bake oven industries
C. Meat smoke houses **D. All of the above**
Explanation : Refer Q. 4.3, Page 4–4N, Unit-4.

14. Catalytic combustion has successfully been used in purifying emission like,
A. Meat smoke houses B. Varnish cooking
C. Asphalt oxidation D. Paper mills
Explanation : Refer Q. 4.3, Page 4–4N, Unit-4.

15. Catalytic incinerators are used to control which of the following gases ?
A. Sulphur dioxide B. Carbon monoxide
C. Hydrocarbons **D. All of the above**
Explanation : Refer Q. 4.3, Page 4–4N, Unit-4.

16. The emission from four stroke diesel engine contain heavier concentration of _____ gas.
A. HC B. CO
C. NO D. H_2
Explanation : Refer Q. 4.4, Page 4–6N, Unit-4.

17. The emission from four stroke petrol engine contain heavier concentration of

i. HC	ii. NO
iii. CO	iv. H_2
v. CO_2	

A. (ii) and (iii) only **B. (i) and (iii) only**
C. (iv) and (v) only D. All of the above
Explanation : Refer Q. 4.4, Page 4–6N, Unit-4.

18. The maximum permissible CO emission for the cars while idling is
A. 2.8% **B. 3.0%**
C. 5.2% D. 6.4%
Explanation : Refer Q. 4.4, Page 4–6N, Unit-4.

19. The emission from the automobiles mainly contains
A. Carbon monoxide B. Hydrocarbons
C. Nitrogen oxides **D. All of the above**
Explanation : Refer Q. 4.4, Page 4–6N, Unit-4.

20. The pollution emitted by the automobiles can be controlled by
A. Reducing lead content in gasoline.
B. Reducing sulphur content in gasoline.
C. Keeping good maintenance of automobiles engine.
D. All of the above
Explanation : Refer Q. 4.4, Page 4–6N, Unit-4.

21. EPCA stands for
A. Energy Policy and Conservation ACT
B. Electro Plated Copper Alloy
C. Environment Pollution (Prevention & Control) Authority.
D. Enhanced Partnership and Cooperation Agreement
Explanation : Refer Q. 4.5, Page 4–7N, Unit-4.

22. The catalytic convertors made of noble metals like platinum and palladium helps in
A. Oxidising CO to CO_2 B. Reducing NO to N_2
C. Oxidising HC to CO_2 **D. All of the above**
Explanation : Refer Q. 4.5, Page 4–7N, Unit-4.

23. A catalytic convertor is generally placed inside which part of automobiles ?
A. Engine B. Carburetor
C. Tail exhaust pipe D. Fuel tank
Explanation : Refer Q. 4.5, Page 4–7N, Unit-4.

24. The auto manufacturers in India have been avoiding the incorporation of catalytic convertor in the vehicle due to
A. Susceptibility to poisoning by sulphur and lead compounds.
B. High cost of noble metals.
C. Ineffectiveness towards hydrocarbons.
D. Frequent maintenance requirement.
Explanation : Refer Q. 4.5, Page 4–7N, Unit-4.

25. The diesel fumes found to be more polluting than those of petrol, in respect of
A. Lead concentration
B. Acidic gases
C. Volatile organic compounds
D. Toxic carcinogenic particulate matter
Explanation : Refer Q. 4.5, Page 4–7N, Unit-4.

26. The emission standard Euro III was enforced in Europe in the year
A. 1993 B. 1996
C. 1999 **D. 2000**
Explanation : Refer Q. 4.6, Page 4–8N, Unit-4.

27. According to Euro III, the emission of CO gas in petrol vehicle should be limited to
A. 2.20 g/km **B. 2.30 g/km**
C. 2.72 g/km D. 4.36 g/km
Explanation : Refer Q. 4.6, Page 4–8N, Unit-4.

28. Which policy envisioned a phased program for introducing Euro 2–4 emission and fuel regulations?
A. National Auto Fuel Policy
B. Pollution Prevention Act
C. Vehicular Pollution Control Policy
D. Clean Air Policy
Explanation : Refer Q. 4.7, Page 4–9N, Unit-4.

29. The application of adsorption, for control of gaseous emission at source includes

A. Vapor recovery in process industries
B. Gas masks
C. Control of gaseous radioactive emission
D. All of the above
Explanation : Refer Q. 4.8, Page 4–10N, Unit-4.

30. Mercury vapours can be removed by use of adsorbent like
A. Molecular sieves B. Silica gel
C. Activated carbon D. Activated alumina
Explanation : Refer Q. 4.8, Page 4–10N, Unit-4.

5 UNIT

Noise Pollution
(Multiple Choice Questions)

1. The sound becomes noise when it is
A. Loud B. Disagreeable
C. Unwanted **D. All of the above**
Explanation : Refer Q. 5.1, Page 5–2N, Unit-5.

2. Which act of India includes noise as one of the air pollutant ?
A. Air (Prevention and Control of Pollution) Act, 1981
B. The Environment Protection Act, 1986
C. Air Pollution Control Act 1987
D. Clean Air Act 1970
Explanation : Refer Q. 5.1, Page 5–2N, Unit-5.

3. The industrial sound limit according to WHO is
A. 60 dB **B. 75 dB**
C. 90 dB D. 100 dB
Explanation : Refer Q. 5.2, Page 5–3N, Unit-5.

4. Noise pollution may affect our ears and leads to psychological problems like
A. Stress B. Hypertension
C. Hearing impairment **D. All of the above**
Explanation : Refer Q. 5.2, Page 5–3N, Unit-5.

5. Which rule give council the power to issue an anti-social behaviour order to anyone causing noise ?
A. Noise-Pollution (Regulation and Control) Rules-2000
B. Noise Reduction Rule-1987
C. Noise Control Rule-1998
D. Noise Control Act-1972
Explanation : Refer Q. 5.2, Page 5–3N, Unit-5.

6. Match the following as per acceptable day time noise according to BIS code :

i. Industrial area	1. 65 dB
ii. Commercial area	2. 50 dB
iii. Residential area	3. 55 dB
iv. Silence zone	4. 75 dB

A. i–1, ii–2, iii–3, iv–4 B. i–3, ii–1, iii–2, iv–4
C. i–4, ii–1, iii–3, iv–2 D. i–1, ii–4, iii–3, iv–2
Explanation : Refer Q. 5.3, Page 5–4N, Unit-5.

7. Silence zone is an area comprising not less than _____ meters around hospitals, institutions, courts, etc.
A. 200 B. 150
C. 100 D. 80
Explanation : Refer Q. 5.3, Page 5–4N, Unit-5.

8. _____ is defined as the rate of doing work by a travelling sound wave in the direction of propagation of wave.
A. Sound power B. Sound pressure
C. Sound intensity D. Sound propagation
Explanation : Refer Q. 5.5, Page 5–6N, Unit-5.

9. Sound pressure is equals to,
A. Total atmospheric pressure + Barometric pressure
B. Total atmospheric pressure – Barometric pressure
C. Wind pressure – Barometric pressure
D. Wind pressure + Barometric pressure
Explanation : Refer Q. 5.5, Page 5–6N, Unit-5.

10. _____ is defined as the sound power averaged over the time per unit area, normal to the direction of propagation of sound wave.
A. Sound power B. Sound pressure
C. Sound intensity D. Sound propagation
Explanation : Refer Q. 5.5, Page 5–6N, Unit-5.

11. The sound pressure of the faintest sound that can be heard by a normal healthy individual is
A. 10 μ-Pa B. 15 μ-Pa
C. 20 μ-Pa D. 40 μ-Pa
Explanation : Refer Q. 5.6, Page 5–7N, Unit-5.

12. SPL stands for
A. Sound Power Limit **B. Sound Pressure Level**
C. Sound Path Line D. Sound Power Level
Explanation : Refer Q. 5.7, Page 5–9N, Unit-5.

13. The SPL from an ideal point source radiator falls at the rate of
A. 2 dB per doubling distance
B. 3 dB per doubling distance
C. 4 dB per doubling distance
D. 6 dB per doubling distance
Explanation : Refer Q. 5.7, Page 5–9N, Unit-5.

14. In line sources, the fall of SPL is

A. Directly proportional to the distance
B. Directly proportional to the square of distance
C. Inversely proportional to the distance
D. Inversely proportional to the square of distance.
Explanation : Refer Q. 5.7, Page 5–9N, Unit-5.

15. The energy density at any point in space is equal to the
A. Energy density at the source plane
B. Half of energy density at the source plane
C. Energy density at line source
D. Energy density at point lies on line surface
Explanation : Refer Q. 5.7, Page 5–9N, Unit-5.

16. Sources of natural noise pollution does not includes,
A. Heavy rain noise
B. Volcanic explosion noise
C. Pet animal noise
D. Thundering of clouds
Explanation : Refer Q. 5.8, Page 5–10N, Unit-5.

17. The study of scientific perception of the sound is known as,
A. Acoustics **B. Psychoacoustics**
C. Audiology D. Otology
Explanation : Refer Q. 5.10, Page 5–11N, Unit-5.

18. The human ear can hear sound in the frequency range of
A. 40 Hz – 20 kHz B. 20 Hz – 16 kHz
C. 2 Hz – 16 kHz **D. 20 Hz – 20 kHz**
Explanation : Refer Q. 5.10, Page 5–11N, Unit-5.

19. Hearing loss due to noise pollution is attributed to prolonged exposure of noise level above
A. 100 dB **B. 85 dB**
C. 80 dB D. 75 dB
Explanation : Refer Q. 5.11, Page 5–12N, Unit-5.

20. Noise levels are commonly measured by hand-held instrument called,
A. Barometer B. Otometer
C. Sound-level meter D. Audiometer
Explanation : Refer Q. 5.12, Page 5–14N, Unit-5.

21. The characteric(s) of noise that dictate whether people will react adversely to it or not is/are
A. Spectral composition B. Duration
C. Variability **D. All of the above**
Explanation : Refer Q. 5.12, Page 5–14N, Unit-5.

22. Ultrasound is a sound wave with frequency higher than

A. 16,000 Hz B. 18,000 Hz
C. 20,000 Hz D. 22,000 Hz
Explanation : Refer Q. 5.13, Page 5–15N, Unit-5.

23. Ultrasound is used in many different fields like,
A. Sonography in medical
B. Non destructive testing of materials
C. For accelerating chemical process
D. All of the above
Explanation : Refer Q. 5.13, Page 5–15N, Unit-5.

24. The study of sound waves covering sound beneath 20 Hz is called
A. Infrasonics B. Ultrasonics
C. Otology D. Acoustics
Explanation : Refer Q. 5.13, Page 5–15N, Unit-5.

25. Infrasound is used in monitoring
A. Earthquakes
B. Volcanoes
C. Petroleum formations below earth
D. All of the above
Explanation : Refer Q. 5.13, Page 5–15N, Unit-5.

26. _____ is the sound associated with the shockwaves created whenever an objects travels through the air faster than speed of sound.
A. Impulsive sound **B. Sonic boom**
C. Ultrasound D. Infrasound
Explanation : Refer Q. 5.13, Page 5–15N, Unit-5.

27. Impulsive sounds are usually caused by
A. Electromagnetic interference
B. Scratchers on the recording disks
C. Gun fires
D. All of the above
Explanation : Refer Q. 5.13, Page 5–15N, Unit-5.

28. Match the following according to acceptable outdoor noise level in residential areas :

i. Radio and TV studios	1. 50 – 50 dB
ii. Music rooms	2. 25 – 30 dB
iii. Court rooms	3. 40 – 45 dB
iv. Restaurants	4. 30 – 35 dB

A. i–4, ii–3, iii–2, iv–1 **B. i–2, ii–4, iii–3, iv–1**
C. i–3, ii–4, iii–1, iv–2 D. i–1, ii–4, iii–3, iv–2
Explanation : Refer Q. 5.14, Page 5–17N, Unit-5.

29. EPD stands for
A. Environmental Protection Department
B. Environmental Protection Division

C. Environmental Product Declaration
D. Environmental Pollution Department
Explanation : Refer Q. 5.18, Page 5–19N, Unit-5.

30. The equipment(s) used to control noise is/are
A. Sound enclosures
B. Fan silencers
C. Acoustic building ventilation system
D. All of the above
Explanation : Refer Q. 5.19, Page 5–21N, Unit-5.