**Important Instructions to examiners:**

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

| Q No. | Answer | Marks | Total marks |
|---|---|---|---|
| 1 A a) | **Air Pollution:** Air pollution is the introduction of particulates, biological molecules, or other harmful materials into Earth's atmosphere, causing disease, death to humans, damage to other living organisms such as food crops, or the natural or built environment.<br>**Air Pollutant:** A substance in the air that can be harmful to humans and the environment is known as an air pollutant. | 2<br>2 | 4 |
| b) | **Sources of water pollution**<br>• Industrial waste water<br>• Domestic sewage<br>• Agricultural run off<br>• Run-off from urban areas<br>**Effect of water pollution**<br>The effects of water pollution are varied and depend on what chemicals are dumped and in which locations.<br>Many water bodies near urban areas (cities and towns) are highly polluted. This is the result of both garbage dumped by individuals and dangerous chemicals legally or illegally dumped by manufacturing industries, health centers, schools and market places.<br>The main problem caused by water pollution is that it kills life that depends on these water bodies. Dead fish, crabs, birds and sea gulls, dolphins, and many other animals often wind up on beaches, killed by pollutants in their habitat (living environment).<br>Pollution disrupts the natural food chain as well. Pollutants such as lead and cadmium are eaten by tiny animals. Later, these animals are consumed by fish | 2<br>2 | 4 |

<table>
<tr><td></td><td>and shellfish, and the food chain continues to be disrupted at all higher levels. Eventually, humans are affected by this process as well. People can get diseases such as hepatitis by eating seafood that has been poisoned. In many poor nations, there is always outbreak of cholera and diseases as a result of poor drinking water treatment from contaminated waters.<br>Ecosystems (the interaction of living things in a place, depending on each other for life) can be severely changed or destroyed by water pollution. Many areas are now being affected by careless human pollution, and this pollution is coming back to hurt humans in many ways.</td><td></td><td></td></tr>
<tr><td>c)</td><td>Methods used for pollution control in fertilizer industry<br>• API separation<br>• Ammonia stripping<br>• Urea Hydrolisation<br>• Cyanide reactions<br>• Nitrification tanks<br>• Final clarification</td><td>1 mark each for any four</td><td>4</td></tr>
<tr><td>d)</td><td>Classification of solid waste<br><table><tr><th>Types</th><th>Example of sources</th></tr><tr><td>Food wastes</td><td>Animal, fruits and vegetable residues resulting from the handling and preparation, cooking and eating of foods</td></tr><tr><td>Rubbish</td><td>1.cobustible papers, plastics, leather, cardboard, wood, rubber etc. 2. Non-combustible glass, aluminium cans ,crockery, tin cans , dirt, construction wastes.</td></tr></table></td><td>1 mark each for any four</td><td>4</td></tr>
</table>

| | | | | |
|---|---|---|---|---|
| | Ashes and residue | Material remaining from the burning of wood, coal, and coke and other combustible wastes in homes, stores, industrial and municipal facilities for the purpose of heating and cooking | | |
| | Demolition and construction waste | Wastes from construction, remoulding, repairing of residential , commercial and industrial buildings | | |
| | Special waste | 1.street sweepings. 2.road side litter from municipal litter containers. 3. Dead animals | | |
| | Treatment plant waste | From water, wastes water and industrial waste treatment plants | | |
| | Hazardous wastes | Chemical<br>Biological<br>Flammable<br>explosive | | |
| | Agricultural wastes | Planting<br>Harvesting of crops, fields etc. | | |
| 1 B a) | **Dust fall jar**<br>It is a simple device used for sampling air particles larger than 10 micrometer in diameter. A typical collector consists of plastic jar of about 20-35 cm height and 10-15 cm diameter at the base with a slight tapering of the wall from top to bottom. A holder is provided to ensure safe and upright position of the collector. The sample is deposited over a period of one month and the material is dried and weighed. Usually only water insoluble dust fall is reported in 4mg/cm2. Since dust particles larger than 10 micrometer are seldom carried for the distance in excess of 1 km, dust fall station must be closely spaced for any meaningful data. | | 4 | 6 |

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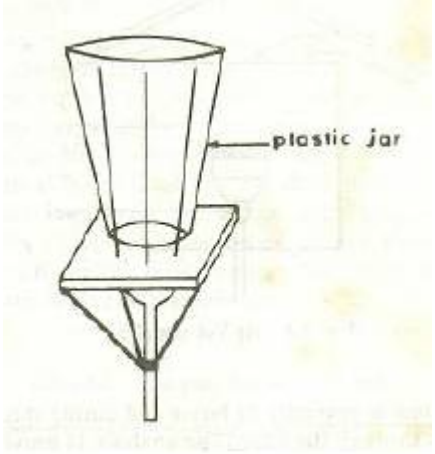
| |  | 2 | |
| b) | **Sludge treatment**<br>**Sludge treatment** describes the processes used to manage and dispose of sewage sludge produced during sewage treatment. Sludge is mostly water with lesser amounts of solid material removed from liquid sewage. Primary sludge includes settleable solids removed during primary treatment in primary clarifiers. Secondary sludge separated in secondary clarifiers includes treated sewage sludge from secondary treatment bioreactors.<br>Sludge treatment is focused on reducing sludge weight and volume to reduce disposal costs, and on reducing potential health risks of disposal options. Water removal is the primary means of weight and volume reduction, while pathogen destruction is frequently accomplished through heating during thermophilic digestion, composting, or incineration. The choice of a sludge treatment method depends on the volume of sludge generated, and comparison of treatment costs required for available disposal options. Air-drying and composting may be attractive to rural communities, while limited land availability may make aerobic digestion and mechanical dewatering preferable for cities, and economies of scale may encourage energy recovery alternatives in metropolitan areas. | 6 | 6 |

| | | | |
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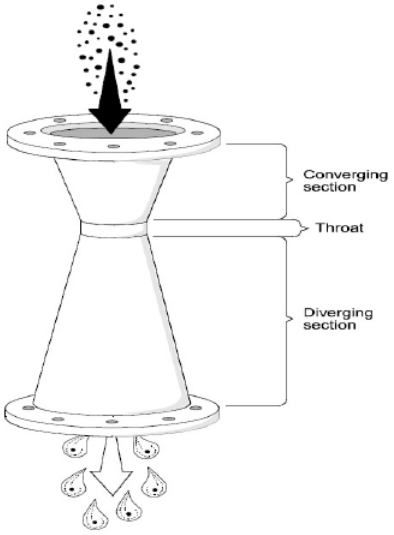
| | Energy may be recovered from sludge through methane gas production during anaerobic digestion or through incineration of dried sludge, but energy yield is often insufficient to evaporate sludge water content or to power blowers, pumps, or centrifuges required for dewatering. Coarse primary solids and secondary sewage sludge may include toxic chemicals removed from liquid sewage by sorption onto solid particles in clarifier sludge. Reducing sludge volume may increase the concentration of some of these toxic chemicals in the sludge. | | |
| 2 a) | **Gas adsorption:** Adsorption is the adhesion of atoms, ions, or molecules from a gas, liquid, or dissolved solid to a surface. This process creates a film of the adsorbate on the surface of the adsorbent<br>**Venturi scrubber**<br>  <br> | 2<br><br>2 | 4 |
| b) | **Activated sludge treatment**<br>Activated sludge plant involves:<br>1. Wastewater aeration in the presence of a microbial suspension,<br>2. Solid-liquid separation following aeration, | 2 | 4 |

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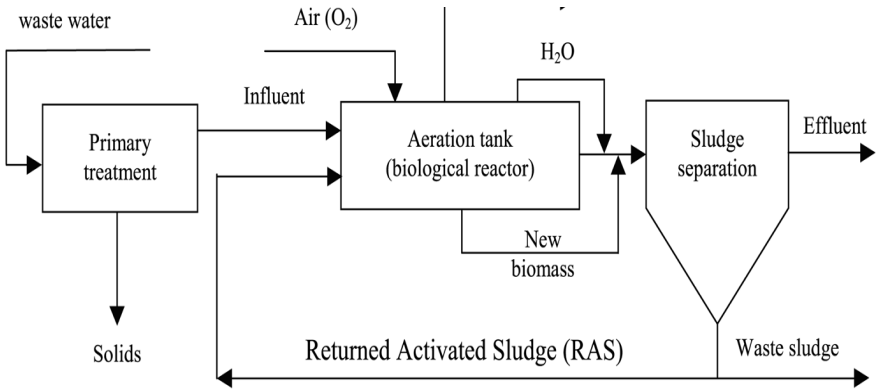
|---|---|---|---|
| | 3. Discharge of clarified effluent,<br>4. Wasting of excess biomass, and<br>5. Return of remaining biomass to the aeration tank.<br>In activated sludge process wastewater containing organic matter is aerated in an aeration basin in which micro-organisms metabolize the suspended and soluble organic matter. Part of organic matter is synthesized into new cells and part is oxidized to $CO_2$ and water to derive energy. In activated sludge systems the new cells formed in the reaction are removed from the liquid stream in the form of a flocculent sludge in settling tanks. A part of this settled biomass, described as activated sludge is returned to the aeration tank and the remaining forms waste or excess sludge.<br>  <br> | 2 | |
| c) | **Role of pollution control board**<br>• To promote cleanliness of streams and wells in different areas of the States through prevention, control and abatement of water pollution;<br>• To improve the quality of air and to prevent, control or abate air pollution in the country;<br>• Advise the Government on any matter concerning prevention and control of water and air pollution and improvement of the quality of | 1 mark each for any four | 4 |

| | | | |
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| | air;<br>• Plan and cause to be executed a nation-wide programme for the prevention, control or abatement of water and air pollution;<br>• Plan and organise training of persons engaged in programmes for prevention, control or abatement of water and air pollution;<br>• Organise through mass media, a comprehensive mass awareness programme on prevention, control or abatement of water and air pollution;<br>• Collect, compile and publish technical and statistical data relating to water and air pollution and the measures devised for their effective prevention, control and abatement;<br>• Prepare manuals, codes and guidelines relating to treatment and disposal of sewage and trade effluents as well as for stack gas cleaning devises, stacks and ducts;<br>• Disseminate information in respect of matters relating to water and air pollution and their prevention and control;<br>• Lay down, modify or annul, in consultation with the State Government concerned, the standards for stream or well, and lay down standards for quality of air;<br>• Establish or recognize laboratories to enable the Board to perform; and<br>• Perform such other functions as and when prescribed by the Government of India.<br>• To issue directions to any industry, local bodies, or other authority for violation of the notified general emission and effluent standards, and rules relating to hazardous waste, bio-medical waste, hazardous chemicals, industrial solid waste, municipal solid waste including | | |

| | | | |
|---|---|---|---|
| d) | **3R principle**<br>**Reuse:** In today's world use and through materials is increasing and hence solid waste. Instead of throwing that material or item if it is used again, energy and environment can be saved. Solid waste generation also will be reduced. In industry various boxes, cans, pallets etc are used for material handling. These can be used again for same purpose.<br>**Recycle :** Recycling is a process to change materials (waste) into new products to prevent waste of potentially useful materials, reduce the consumption of fresh raw materials, reduce energy usage, reduce air pollution (from incineration) and water pollution (from landfilling) by reducing the need for "conventional" waste disposal, and lower greenhouse gas emissions as compared to plastic production. Recycling is a key component of modern waste reduction and is the third component of the "Reduce, Reuse, and Recycle" waste hierarchy. Recyclable materials include many kinds of glass, paper, metal, plastic, textiles, and electronics. In the strictest sense, recycling of a material would produce a fresh supply of the same material-for example, used office paper would be converted into new office paper, or used foamed polystyrene into new polystyrene.<br>**Reduce:** When you avoid making garbage in the first place, you don't have to worry about disposing of waste or recycling it later. Changing your habits is the key - think about ways you can reduce your waste when you shop, work and play. There's a ton of ways for you to reduce waste, save yourself some time and money, and be good to the Earth at the same time. Buy products in bulk. Larger, economy-size products or ones in concentrated form use less packaging and usually cost less per ounce. | 1<br><br>2<br><br>1 | 4 |

| | | | |
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| e) | **Environmental audit**<br>An environmental audit is typically undertaken in three phases:<br>1. Pre-audit<br>2. On-site audit<br>3. Post-audit<br>Each of these phases comprises a number of clearly defined Objectives, with each objective to be achieved through specific Actions, and these actions yielding results in the form of Outputs at the end of each phase.<br>**Pre-Audit Activities**<br>**Objectives**<br>• To develop an audit plan for the on-site activities<br>• To make the necessary preparation and arrangements for the on-site audit.<br>**Conduct Initial Site Visit**<br>• To arrange with the site facilitator(s) for an initial visit during normal operation of audit site to:<br>• Meet with officer-in-charge to explain purpose of audit<br>• Assess whether background information gathered is up to date and accurate<br>• Follow-up on the list of preliminary audit impressions<br>• Identify and request additional site information as necessary<br>• Confirm thoroughness of audit scope<br>• Establish adequacy of resources for audit<br>**Develop On-Site Questionnaire and Audit Protocols**<br>• To develop a series of step-by-step questions and evaluation criteria to assess: | 4 | 4 |

| | | | |
|---|---|---|---|
| | • Compliance with pertinent legislative and regulatory requirements<br>• Conformance with internal environmental policies, procedures and guidelines<br>• Status of current environmental practices<br>• Staff awareness of internal environmental policies, procedures and guidelines<br>**Post audit**<br>• Implement the suggestion given during sight visit.<br>• Study the impact of implementation | | |
| 3 a) | **Absorption method for gaseous sampling**<br>Absorption sampling method for gaseous pollutants: Absorption separates the desired pollutant from air either through direct solubility in the absorbing medium or by chemical reaction. Maintaining suitable bubble size and the requisite residence time are essential for efficient sampling. The absorbent used include water (for absorbing gases e.g. HF), oils (for absorbing hydrocarbons), alkalis (for absorbing acidic gases) and acids (for absorbing alkaline gases). The absorbing devices used include glass scrubbers, packed columns, impingers and counter current scrubbing systems. | 03<br><br>01 | 4 |

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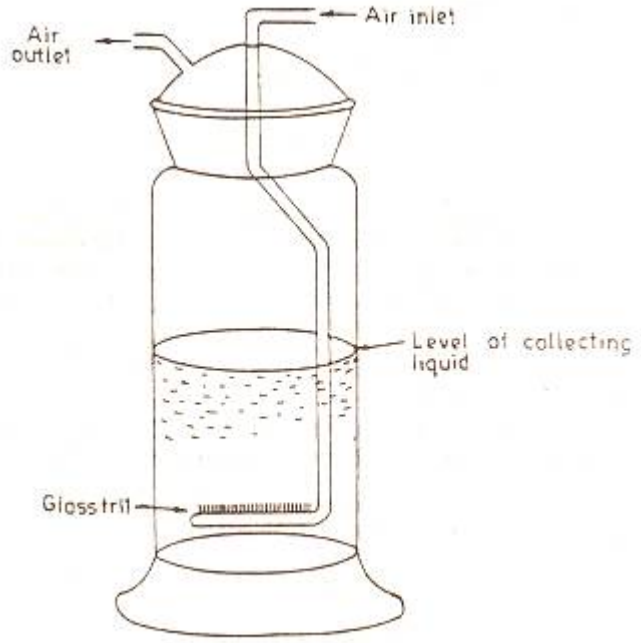
| |  Scrubbers used for sampling gaseous air pollutants. | | |
| b) | Classification of air pollutants<br>**According to origin**<br>1) Primary Pollutants: These are directly emitted to environment from sources CO, $CO_2$, $SO_2$<br>2) Secondary Pollutants: These are derived from primary pollutants. eg Ozone, PAN, smog<br>**According to chemical composition:**<br>i) Organic pollutants<br>ii)Inorganic pollutants<br>**According to State of Matter**<br>1) Gaseous pollutants: which get mixed with the air and do not normally settle out. e.g. CO, $CO_2$, $SO_2$, $NO_x$, etc<br>2) Particulate pollutants: which comprise of finely divided solids or liquids and | 1<br>1<br>2 | 4 |

often exist in colloidal state as aerosols.

a) Dust : Particle size 1 to 200 micrometer

b) Smoke : Particle size 0.01 to 1 micrometer

c) Fumes : Particle size 0.1 to 1 micrometer

d) Mist: Liquid droplets smaller than 10 micrometers condensed in air.

e) Fog: Water droplets in air.

f) Aerosols: All air born suspension either liquid or gases.

c) **CPCB air quality standards:** — 1mark each for any four point — 4

| Sr. No | Pollutant | Total Weighted Average | Concentration in Ambient Air | |
|---|---|---|---|---|
| | | | Industrial, Residential, Rural and other area | Ecologically sensitive area |
| 1 | Sulphur dioxide (SO2) µg/$m^3$ | Annual*<br>24 hours** | 50<br>80 | 20<br>80 |
| 2 | Nitrogen dioxide(NO2) µg/$m^3$ | Annual*<br>24 hours** | 40<br>80 | 30<br>80 |
| 3 | Particulate matter (size <10µm) µg/$m^3$ | Annual*<br>24 hours** | 60<br>100 | 60<br>100 |
| 4 | Particulate matter (size <2.5µm) µg/$m^3$ | Annual*<br>24 hours** | 40<br>60 | 40<br>60 |
| 5 | Ozone µg/$m^3$ | 8 hours**<br>1hours** | 100<br>180 | 100<br>180 |
| 6 | Lead µg/$m^3$ | Annual*<br>24 hours** | 0.5<br>1.0 | 0.5<br>1.0 |
| 7 | Carbon monoxide mg/$m^3$ | 8 hours**<br>1 hour** | 02<br>04 | 02<br>04 |
| 8 | Ammonia µg/$m^3$ | Annual* | 100 | 100 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | | | 24 hours** | 400 | 400 | | |
| | 9 | Benzene µg/$m^3$ | Annual* | 5 | 5 | | |
| | 10 | Arsenic | Annual* | 6 | 6 | | |
| | *Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.<br>** 24hourly or 8 hourly or 1hourly monitored values as applicable which should not exceeded more than once in year. | | | | | | |
| d) | **BOD: -** It is the amount of oxygen required to degrade organic waste present in water by purely biological means.<br>The biological oxygen demand, ie, BOD in wastewater, is a measure of the quantity of bio-organic substances in wastewater. These can be in the form of fat, oils, carbohydrates and proteins. BOD also helps determine the quantum of organic chemicals contained in wastewater that are synthetic and biodegradable<br>**COD: -** It is the amount of oxygen required to degrade organic waste present in water by purely chemical means.<br>COD can help gauge the quantum of both biodegradable and nonbiodegradable organics. It is quick method to determine strength of waste in water. | | | | | 02<br>02 | 4 |
| e) | **Chemical Characteristics of waste water**: i)Chemical oxygen demand(COD) ii) pH iii)Acidity or alkalinity iv) hardness v) Total carbon vi) Chlorine demand vii) Total dissolved solids<br>**Biological Characteristics of waste water :** i) Biological oxygen demand (BOD) ii) presence of pathogenic bacteria iii) toxicity to man iv) aquatic organisms | | | | | 1/2 mark each for any four point | 4 |
| f) | **Grab Sampling:** It is sampling of waste water is a single sample taken at specific time.It represents the conditions of the waste water at the particular time and location of sample collection. In this method Samples usually collected manually. Grab samples are more suitable when testing for chlorine | | | | | 02 | 4 |

| | | | |
|---|---|---|---|
| | residual, pH and dissolved oxygen. Grab samples are most appropriate to small plants with low flows.<br>**Composite sampling** : A composite sample, also known as an integrated sample, is a sample which consists of a mixture of several individual grab samples collected at regular and specified time periods, each sample taken in proportion to the amount of flow at that time.<br>Automatic sampling equipment is usually used for composite sampling. | 02 | |
| 4A a) | **Working Principle of Gravity settling chamber :**<br>Gravitational force may be employed to remove particulate in settling chambers when the settling velocity is greater than about 0.12m/s. Gravity settling chambers are provided with enlarged areas to minimize horizontal velocities and allow time for the vertical velocity to carry the particle to the floor.<br>The gravitational settling chambers are usually operated with velocity between 0.5 to 2.5 m/s. Some settling chambers have simply enlarged conduits and some have horizontal shelves and baffles, spaced about 2.5cm apart. The horizontal shelves shorten the sealing path of the particles and improve removal efficiency. Gravitational settling chambers are generally used to remove large, abrasive particles (usually >50 µm) from gas streams. They offer low pressure drop and require simple maintenance, but their efficiencies are quite low for particles smaller than 50 µm. Since most of the troublesome particles have much smaller sizes than 50 µm these devices are normally used as precleaners prior to passing the gas stream through high efficiency collection devices. | 4 mark | 4 |
| b) | **Preliminary treatment** consists of screening and grit removal.<br>**Large quantities of floating rubbish** such as cans, cloth, wood and other | 1 mark | 4 |

larger objects present in waste water are usually removed by metal bars, acting like strainers as the waste water moves beneath them in an open channel. — 1 mark

**Removal of gross solids** is generally accomplished by passing waste water through mixed or moving screens. The modern mechanical screens cum filters include rotary, self-cleaning, gravity type units and circular overhead fed vibratory units which are effective in reducing the suspended solid and BOD. — 1 mark

**Grit is removed** in the early stages of treatment in grit channels or tanks. Grit, being heavier than organic solids, can be separated from organic solids by careful regulation of the flow velocity in the grit tanks. — 1 mark

**If the waste water contains appreciable quantities of oil and grease,** then it is advisable to remove as much of these as possible, in the preliminary treatment itself to avoid adverse effects on the rest of plant. This is achieved by passing the waste water through skimming tanks where oil and grease are skimmed off.

c) **Drinking water quality standards specified by WHO** — 1 mark each for any four points — 4

| Sr. No. | constituent | Recommended max. concentration in mg/l | Max. permissible concentration in mg/l |
|---|---|---|---|
| | Physical: | | |
| 1 | Turbidity(units) | 5 | 25 |
| 2 | Color(units) | 5 | 50 |
| | Chemical | | |
| 3 | pH, units | 7-8.5 | 6.5 or 9.2 |
| 4 | Total solids | 500 | 1500 |
| 5 | Calcium | 75 | 200 |
| 6 | Magnesium | 50 | 150 |
| 7 | Iron | 0.3 | 1.0 |
| 8 | Copper | 1.0 | 1.5 |
| 9 | Sulphate | 200 | 400 |
| 10 | Phenols | 0.001 | 0.002 |
| | Toxic | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 11 | Arsenic | - | 0.2 | | |
| | 12 | Chromium | - | 0.05 | | |
| | 13 | Cyanide | - | 0.01 | | |
| | 14 | Lead | - | 0.1 | | |
| d) | **Business Benefits of ISO14000:**<br>1. Efficiency, discipline and operational integration with ISO 9000.<br>2. Greater employee involvement in business operations with a more motivated workforce<br>3. Easier to obtain operational permits and authorizations<br>4. Assists in developing and transferring technology within the company<br>5. Helps reduce pollution<br>6. Fewer operating costs<br>7. Savings from safer workplace conditions8. Reduction of costs associated with emissions, discharges, waste handling,<br>transport & disposal<br>9. Improvements in the product as a result of process changes<br>10. Safer products<br>11. Minimizes hazardous and non-hazardous waste<br>12. Conserves natural resources - electricity, gas, space and water with resultant cost savings<br>13. Prevents pollution and reduces wastage<br>14. Demonstrates to customers that the firm has met environmental expectations.<br>15. Meets potential national and international government purchasing requirements.<br>16. Delivers profits from marketing "green" products<br>17. Provides a competitive marketing tool<br>18. Improves international competitiveness | | | | 1 mark each for any four points | 4 |

| | | | |
|---|---|---|---|
| | 19. Improves the organization's relationship with insurance companies<br>20. Elimination of costs associated with conformance to conflicting national standards | | |
| 4 B a) | **The necessity of recovery of chemical from black liquor:**<br>i) The spent cooking liquor commonly called black liquor is treated to recover its chemical content for reuse and its organic content as heat.<br>ii) The dark color of the effluent is due to the lining compounds which are not easily biodegradable and hence it imparts persistent color to the receiving water streams and inhibits photosynthesis and other natural self-purification process of the water streams.<br>iii) The immediate oxygen demand of the effluent brings about depletion of oxygen of the receiving stream create adverse effects to aquatic life.<br>iv) The chemicals present in the effluent, e.g. sulfites, phenols, free chlorine, methyl mercaptan are harmful to fauna and flora of the receiving water.<br>v) The settleable materials present may sink to the bottom and interfere with aquatic life. | 02 mark each for any three points | 6 |
| b) | **Objective of environment management:**<br>• Endeavour to minimize use of potentially toxic materials.<br>• Aim to source materials from sustainable origins.<br>• Maximize use of recycled and recyclable materials<br>• Maximize consideration of the environment in the roll out of new recycling projects.<br>• Where packaging is used minimize pack size to future reduce waste. | 1 mark each for any three (03) | 6 |

| | | | |
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| | • Expand practice of materials segregation to allow increased recovery and recycling of waste materials.<br>• Promote appropriate waste management practices to stakeholders.<br>• Continuous research to gain a greater understanding of management mechanisms for the benefit of the company and the community.<br>• Continuously identify ways of minimizing energy consumption e.g. car share plan to control unnecessary mileage.<br>• Continually adopt fuel-efficient systems for any fleet transport and company vehicles.<br>• Promote energy management to employees.<br>• Sustainable development targets may be management or performance related.<br>• Management targets relate to the development of themanagement system, either to enhance the existing mechanism or to enlarge it to cover new areas.<br>• Performance targets are linked to inputs and outputs, aiming to improve these figures by a set percentage.<br>• To improve and develop further mechanisms for internal and external communication relating to corporate environmental issues.<br>• To report regularly on corporate environmental management issues.<br>• To research and gather more detailed data relating to the group's key impacts.<br>• Aim to increase the recycling of office waste collected<br>• To introduce a range of recycling projects across the group.<br>• The government regulations and growing public awareness over the health. | | |

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| | **Components of environmental management:**<br>• Control of atmospheric pollution and environmental degradation.<br>• Adopting technologies which ensure sustainable development.<br>• Conducting environmental impact assessment to review the existing technologies and making it mandatory for clearing major projects of environmental concern.<br>• Instilling environmental perception among people by conducting awareness programmes.<br>• Environmental education and training at school, colleges and universities.<br>• Controlling over population.<br>• Controlling over consumption and craze by inculcating sublime human values such as service to society, non-material enrichment. | 1mark each for any three (03) | |
| 5 a) | **Fabric filter** | 4 | 4 |

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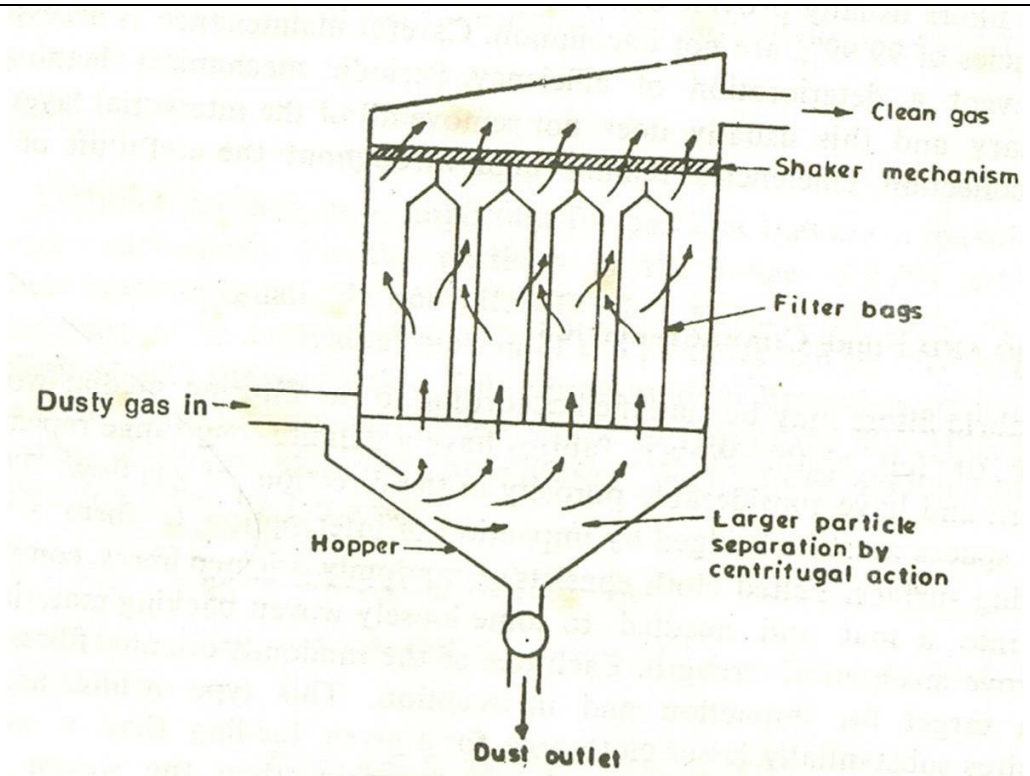
| |  | | |
| b) | **Types of water pollutants**<br>1. Oxygen demanding waste: Organic waste, sewage, food industry waste, distillery.<br>2. Disease causing waste : Pathogens<br>3. Synthetic organic compounds: Industrial waste from petrochemical Plant.<br>4. Plant nutrients: Fertilizer from farms.<br>5. Inorganic chemicals: Waste from fertilizer, acid and chloro alkali Industry.<br>6. Thermal discharge: condenser water from thermal power plant.<br>7. Oil: oil from industrial equipment, crude oil tankers. | 1 mark each for any four | 4 |
| c) | **Primary treatment**<br>Primary treatment removes material that will either float or readily settle out | 2 | 4 |

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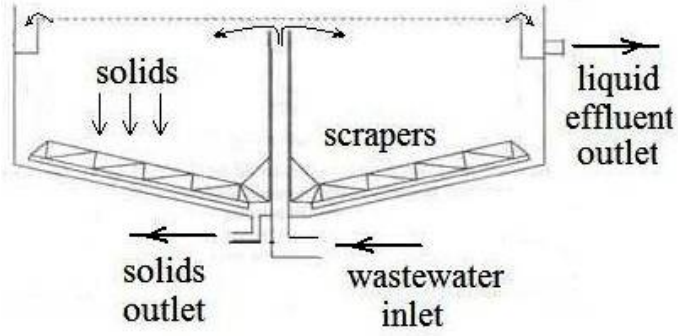
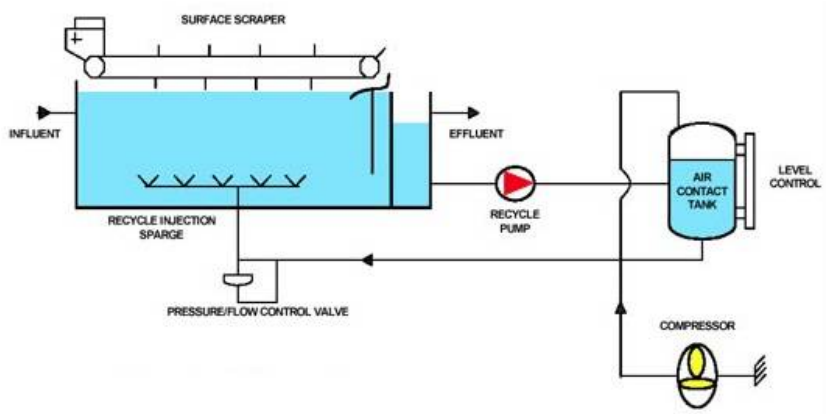
| | by gravity. It includes the physical processes of screening, comminution, grit removal, and sedimentation. Screens are made of long, closely spaced, narrow metal bars. They block floating debris such as wood, rags, and other bulky objects that could clog pipes or pumps. In modern plants the screens are cleaned mechanically, and the material is promptly disposed of by burial on the plant grounds. A comminutor may be used to grind and shred debris that passes through the screens. The shredded material is removed later by sedimentation or flotation processes. Grit chambers are long narrow tanks that are designed to slow down the flow so that solids such as sand, coffee grounds, and eggshells will settle out of the water. Grit causes excessive wear and tear on pumps and other plant equipment. Its removal is particularly important in cities with combined sewer systems, which carry a good deal of silt, sand, and gravel that wash off streets or land during a storm.<br>Suspended solids that pass through screens and grit chambers are removed from the sewage in sedimentation tanks. These tanks, also called primary clarifiers, provide about two hours of detention time for gravity settling to take place. As the sewage flows through them slowly, the solids gradually sink to the bottom. The settled solids-known as raw or primary sludge -are moved along the tank bottom by mechanical scrapers. Sludge is collected in a hopper, where it is pumped out for removal. Mechanical surface-skimming devices remove grease and other floating materials<br>**Sedimentation:** | 2 | |




**Flotation:**




d) **Sludge thickening**

Thickening is often the first step in a sludge treatment process. Sludge from primary or secondary clarifiers may be stirred (often after addition of clarifying agents) to form larger, more rapidly settling aggregates. Primary sludge may be thickened to about 8 or 10 percent solids, while secondary sludge may be thickened to about 4 percent solids. Thickeners often resemble a clarifier with the addition of a stirring mechanism. Thickened sludge with less than ten percent solids may receive additional sludge treatment while liquid thickener overflow is returned to the sewage treatment process.

**Sludge digestion**

Anaerobic digestion is a bacterial process that is carried out in the absence of

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| | oxygen. The process can either be thermophilic digestion, in which sludge is fermented in tanks at a temperature of 55 °C, or mesophilic, at a temperature of around 36 °C. Though allowing shorter retention time (and thus smaller tanks), thermophilic digestion is more expensive in terms of energy consumption for heating the sludge.<br>Aerobic digestion is a bacterial process occurring in the presence of oxygen resembling a continuation of the activated sludge process. Under aerobic conditions, bacteria rapidly consume organic matter and convert it into carbon dioxide. Once there is a lack of organic matter, bacteria die and are used as food by other bacteria. This stage of the process is known as endogenous respiration. Solids reduction occurs in this phase. Because the aerobic digestion occurs much faster than anaerobic digestion, the capital costs of aerobic digestion are lower. However, the operating costs are characteristically much greater for aerobic digestion because of energy used by the blowers, pumps and motors needed to add oxygen to the process. However, recent technological advances include non-electric aerated filter systems that use natural air currents for the aeration instead of electrically operated machinery. | 2 | |
| e) | **Characteristics of solid waste**<br>The major physical characteristics measured in waste are: (1) density, (2) size distribution of components, and (3) moisture content. Other characteristics which may be used in making decision about solid waste management are: (1) colour, (2) voids, (3) shape of components, (4) optical property, (5) magnetic properties, and (6) electric properties. Optical property can be used to segregate opaque materials from transparent substances which would predominately contain glass and plastic. Moisture content is essential for | 2 | 4 |

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| | leachate calculation and composting. Density is used to assess volume of transportation vehicle and size of the disposal facility. Shape can be used for segregation as flaky substance will behave differently compared to non-flaky substance. Important chemical properties measured for solid waste are: (1) moisture (water content can change chemical and physical properties), (2) volatile matter, (3) ash, (4) fixed carbon, (5) fusing point of ash, (6) calorific value, (7) percent of carbon, hydrogen, oxygen, sulphur and ash. Proximate analysis of waste aims to determine moisture, volatile matter, ash and fixed carbon. Ultimate analysis of waste aims to analyse percent of carbon, hydrogen, oxygen, sulphur and ash. Solid waste production is a function of land use as well as its composition is inversely proportional to the possible soil damage and bacterial contamination of the environment Wet waste will host more bacteria compared to dry waste. | 2 | |
| f) | **Need of ISO14001:**<br>i) Environmental improvements<br>ii) Regulatory compliance<br>iii) Improvement of corporate image<br>iv) Cost containment & cost saving<br>v) Competitive advantage<br>vi) Opening of international market & partners<br>vii) Improvement in employee awareness about environment<br>viii) An ethical or social commitment | 1 mark each for any four | 4 |
| 6 a) | **Cyclone separator**<br>**Construction**<br>It consists of rectangular inlet for dust laden gas. Inlet is attached to the cylinder having inverted cone at the bottom to collect dust particles. Out let is | 1 | 4 |

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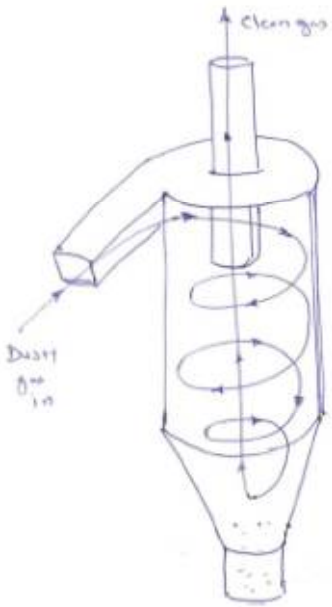
| | provided to discharge dust particles. Out let for clean gas is provided at the top. Outlet pipe is extended well below inlet of gas to avoid short circuiting of gas flows. Cyclone is not having any moving part.<br>**Working**<br>A dust laden gas enters in a cyclone separator takes spiral motion. It utilizes a centrifugal force generated by spinning gas stream to separate particle matter from the gas. The centrifugal force on a particles in spinning gas stream is much greater than gravity, there for it is effective in removing small particles. The gas spirals downwards to the bottom of the cone and at, and at the bottom the gas flow reverses to form an inner vortex which leaves through the outlet pipe. Cyclone separator is used to separate gas-solid, gas-liquid in Cement industry, Oil refinery, Petrochemical Plant, Power plants, and Metallurgical Industry etc.<br>  <br> | 2<br><br>1 | |
| b) | **Fixed bed absorber** | 2 | 4 |

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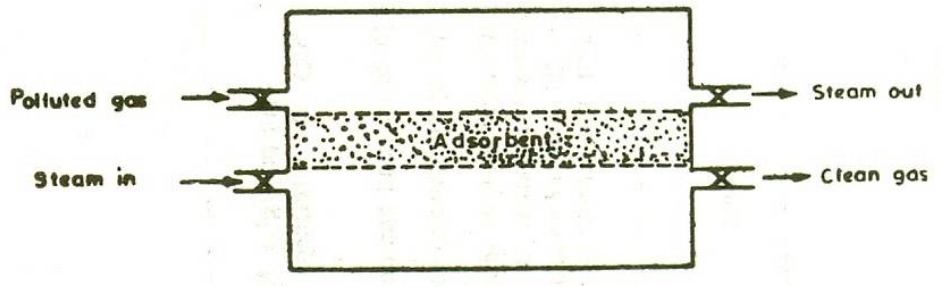
| |  <br>A polluted gas enters a bed at the top and travels downwards through the bed and leaves the bottom. Initially front portion of bed adsorb pollutants very rapidly and little amount of solute left is taken up by deeper layer of adsorber. Thus initially gas leaving bed is pollution free. After period of time layer of solid at the entrance will become saturated and active zone moves deeper in the bed. When it reaches at the bottom of bed regeneration of bed is required. | 2 | |
| c) | **Sedimentation**<br>The settleable solids are removed by gravitational settling under quiescent conditions. The sludge formed at the bottom of the tank is removed by underflow either by vacuum suction or by raking it to the discharge point at the bottom of tank for withdrawal. The clear liquid produced is known as overflow. The sedimentation operation in waste treatment plant is carried out in rectangular horizontal flow, circular radial flow and vertical flow basins.<br>In rectangular tank feed is introduced at the one end along with width of the tank and overflow is collected at the surface at different points along the length of tank. An endless conveyor scraps the floating material into a screen though while it also pushes the settled solids into sludge hopper.<br>In circular radial flow the feed is introduced through center well and the clarified effluent is collected at weirs along the periphery of the tank. Sludge removal is effected by means of rotary sludge scrapper. | 4 | 4 |

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| | In vertical flow tank feed in introduced in tank by center pipe and liquid comes in upward direction along with solid particles. A sludge blanket maintained acts as a filter and settled solid below blanket are removed from underflow. | | |
| d) | **pH** is a measure of the hydrogen ion concentration of a solution. Solutions with a high concentration of hydrogen ions have a low pH and solutions with low concentrations of H+ ions have a high pH. Solutions with a pH less than 7 are said to be acidic and solutions with a pH greater than 7 are basic or alkaline. Pure water has a pH of 7<br>**Dissolved oxygen** refers to the level of free, non-compound oxygen present in water or other liquids. It is an important parameter in assessing water quality because of its influence on the organisms living within a body of water. | 2<br>2 | 4 |
| e) | **Pollutants from urea plant**<br>• Oil and grease<br>• Ammonia<br>• Fluorides<br>• Phosphate<br>• NaOH<br>• Arsenic | 1 mark each for any four | 4 |
| f) | **Solid waste disposal processes**<br>• Open dumping<br>• Sanitary landfill<br>• Composting<br>• Incineration<br>• Anaerobic digestion | 1 mark each for any four | 4 |