**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 constantvalues 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 | **Attempt any three** | | 12 |
| 1 A i) | **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>**Classification of Air Pollutant:**<br>Gaseous pollutants :- SOx, NOx, CO<br>Particulate matter :- Cement dust, metal dust<br>Fumes :-Acid fumes, Welding fumes<br>Smoke : Smoke after burning fuel, Smoke after burning waste | 2<br>2 | 4 |
| ii) | **Chemical Characteristics Physical Characteristics and 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 vii) Temperature viii) Turbidity ix) Odor x) Color<br>**Biological Characteristics of waste water :** i) Biological oxygen demand (BOD) ii) presence of pathogenic bacteria iii) toxicity to man iv) aquatic organisms | ½ mark each for any 8 | 4 |
| iii) | **Pollutants from urea plant**<br>• Oil and grease<br>• Ammonia<br>• Fluorides<br>• Phosphate | 1 mark each for any four | 4 |

<table>
<tr><td></td><td>

- NaOH
- Arsenic

</td><td></td><td></td></tr>
<tr><td>iv)</td><td>

**Solid waste:** Solid waste means any garbage, refuse, sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facility and other discarded materials including solid, liquid, semi-solid, or contained gaseous material, resulting from industrial, commercial, mining and agricultural operations, and from community activities, but does not include solid or dissolved materials in domestic sewage, or solid or dissolved materials in irrigation return flows or industrial discharges that are point sources.

**Classification of solid waste**

<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>
<tr><td>Ashes and residue</td><td>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</td></tr>
<tr><td>Demolition and construction waste</td><td>Wastes from construction, remoulding, repairing of residential , commercial and</td></tr>
</table>

</td><td>1<br><br>3</td><td>4</td></tr>
</table>

| | | | | |
|---|---|---|---|---|
| | | 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. | | |
| **1b** | **Attempt any one** | | | **6** |
| 1 B i) | **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 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 | 2<br><br>2 | 6 |

| | | | |
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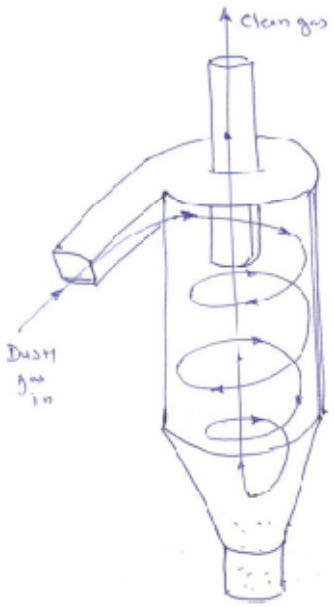
| | pipe. Cyclone separator is used to separate gas-solid, gas-liquid in Cement industry, Oil refinery, Petrochemical Plant, Power plants, and Metallurgical Industry etc.<br>  <br> | 2 | |
| ii) | **3R principle**<br>**Reuse:** In today's world use and through materials is increasing and hence solid 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>e.g. Catalyst drums can be used again to fill catalyst.<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 | 2<br><br>2 | 6 |

<table>
<tr><td></td><td>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>e.g. Plastic water bottles can be recycled to get plastic again.<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.<br>e.g. Unnecessary use of plastic and paper can be avoided in packing.</td><td>2</td><td></td></tr>
<tr><td>2</td><td>Attempt any four</td><td></td><td>16</td></tr>
<tr><td>2 a)</td><td>CPCB air quality standards:<br><table><tr><th rowspan="2">Sr. No</th><th rowspan="2">Pollutant</th><th rowspan="2">Total Weighted Average</th><th colspan="2">Concentration in Ambient Air</th></tr><tr><th>Industrial, Residential, Rural and other area</th><th>Ecologically sensitive area</th></tr><tr><td>1</td><td>Sulphur dioxide (SO2) µg/m$^3$</td><td>Annual*<br>24 hours**</td><td>50<br>80</td><td>20<br>80</td></tr><tr><td>2</td><td>Nitrogen dioxide(NO2) µg/m$^3$</td><td>Annual*<br>24 hours**</td><td>40<br>80</td><td>30<br>80</td></tr></table></td><td>1 mark each</td><td>4</td></tr>
</table>

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | 3 | Particulate matter (size <10µm) µg/$m^3$ | Annual* 24 hours** | 60 100 | 60 100 | | |
| | 4 | Particulate matter (size <2.5µm) µg/$m^3$ | Annual* 24 hours** | 40 60 | 40 60 | | |
| | 7 | Carbon monoxide mg/$m^3$ | 8 hours** 1 hour** | 02 04 | 02 04 | | |

b) **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 |

c) **Sludge thickening** — 2 — 4

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

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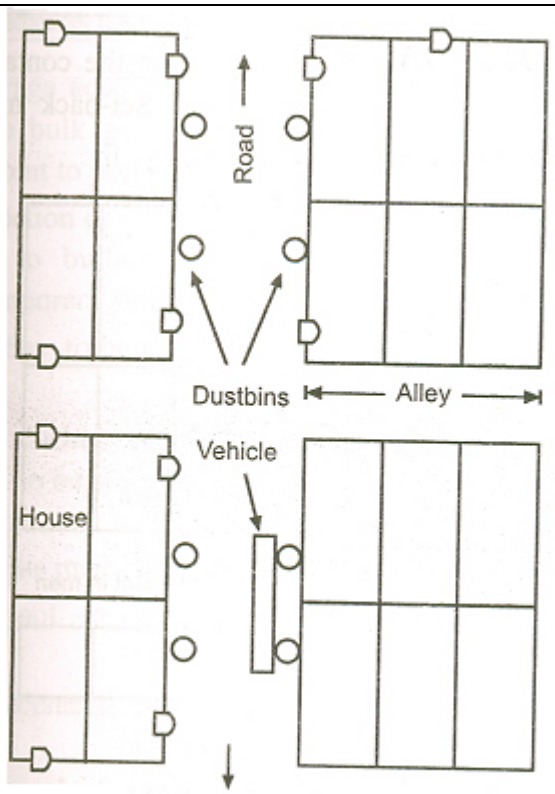
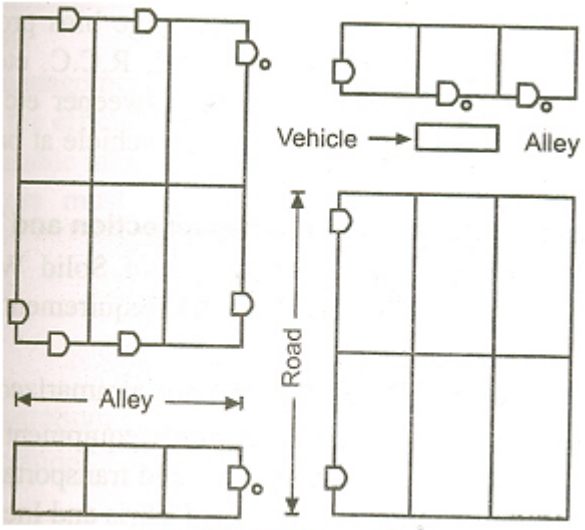
| | a clarifier with the addition of a stirring mechanism. Thickened sludge with less than ten percent solids may receive additional sludge treatment while liquid thickener overflow is returned to the sewage treatment process.<br>**Sludge dewatering**<br>Water removal is the primary means of weight and volume reduction, 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. Sludge dewatering is the separation of a liquid and solid phase whereby, generally, the least possible residual moisture is required in the solid phase and the lowest possible solid particle residues are required in the separated liquid phase.<br>**Importance of dewatering of sludge in sludge management:**<br>1. The costs for trucking sludge to the ultimate disposal site become substantially lower when the volume is reduced by dewatering<br>2. Dewatered sludge is generally easier to handle than thickened or liquid sludge.<br>3. Dewatering is required normally prior to the incineration of the sludge to increase the calorific value by removal of excess moisture.<br>4. Dewatering is required before composting to reduce the requirements for supplemental bulking agents.<br>5. In some cases removal of excess moisture may be required to render sludge odorless and non putrescible<br>6. Dewatering is required prior to land filling sludge to reduce leachate production of the landfill site. | 2 | |
| d) | **Solid waste collection from house to house** : | 4 | 4 |

| | | | |
|---|---|---|---|
| | Types:<br>• Curb service<br>• Alley service<br>• Set-out service<br>• Set-out set-back service<br>• Back-yard service<br><br>i) Curb service: the refuse containers placed at the curb on the scheduled day by house-owner are collected by workers from refuse vehicle and emptied into vehicle.<br>ii) Alley service: this method is similar to the previous one, except that the containers are placed at the alley line instead of curb.<br>iii) Set-out service: the workers with refuse vehicles collect the containers from individual houses and empty them in refuse vehicles. The empty containers are collected by the house – owners.<br>iv) Set-out set-back service: set-out men collect the containers from individual houses and empty them in refuse vehicle. Set- back men return the empty containers to house owner.<br>v) Back-yard service: the workers with refuse vehicle carry bin, wheel barrow etc. to the back yard and empty the refuse containers in it. | 2<br><br>1 | |




Curb service




Alley service

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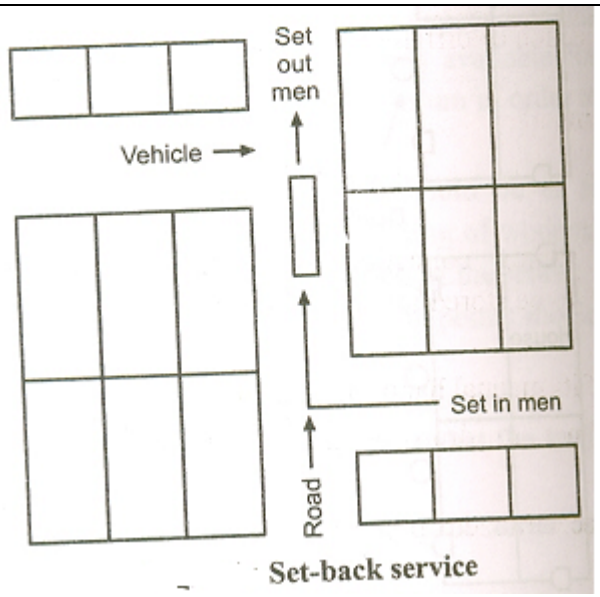
| |  | | |
| e) | **Need of ISO14001:**<br>i) Environmental improvements<br>ii) Regulatory compliance<br>iii) Improvement of corporate image<br>iv) Cost containment & cost saving<br>v) Competitive advantage<br>vi) Opening of international market & partners<br>vii) Improvement in employee awareness about environment<br>viii) An ethical or social commitment | 1 mark each for any four | 4 |
| **3** | **Attempt any four** | | **16** |
| 3 a) | **Catalytic Incinerator**<br>The catalysts used for effective pollution control are the precious metals, primarily platinum and palladium or their alloys. These are arranged in such a way as to provide the maximum possible surface area for contact with the gas. | 02 | 04 |

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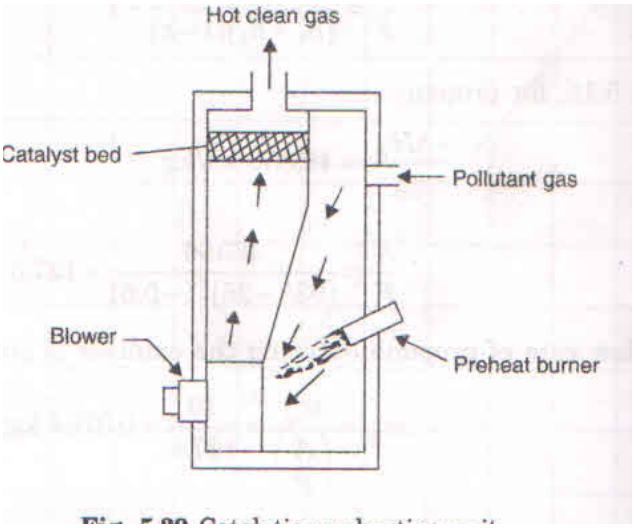
| | The catalyst is coated onto suitable elements such as metal ribbons, ceramic rods or alumina pellets. These elements are then packed into the Catalyst bed. A catalytic combustion unit consists of a reaction vessel or converter in which the catalyst is arranged in single or multiple fixed beds proceeded by a preheat section, if necessary.<br>In the preheat section, only the gas stream is heated to the temperature required to support catalytic combustion. The preheated gas is then passed through the catalyst bed where the combustion occurs. To maintain the catalyst in an active state and to achieve complete combustion about 1% excess oxygen is required.<br>  <br> | 02 | |
| 3 b) | **Sources of air pollution** :<br>i) **Natural sources**: The natural sources of air pollution are volcanic eruptions releasing poisonous gases such as SO2, H2s and CO etc. forest fires, natural organic and inorganic decays marsh gases, deflation of sand and dust, extra-terrestrial bodies, cosmic dust, pollen grains of flowers, soil debris, comets and fungal spores. | 1 mark each for any four | 04 |

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| | Manmade sources such as<br>ii) **Rapid Industrialization**: The industries such as pulp and paper, chemical, petroleum refineries, mining iron and steel works are responsible for nearly 2o% of air pollution.<br>iii) **Transportation:** Automobile exhaust release smoke and to a little extent leads particles. The chief sources from automobiles are a) exhaust system b) fuel tank c) Carburetor, d) crank case.<br>iv**) Burning of fossil fuel and fires**: The conventional sources of energy are wood, coal and fossil fuels. The byproducts of burning of fossil fuel, wood, and coal are nothing but poisonous gases such as CO, $CH_4$, $SO_2$, NO etc.<br>v) **Deforestation:** The deforestation by man for his own needs has disturbed the balance of O2 and $CO_2$ in atmosphere.<br>v) **Increase in population:** An increase in population leads to global warming and emission of greenhouse gases.<br>vi) **Agricultural activities**: Various biocides used for agricultural purposes cause air pollution as it poisonous substances are carried away by wind.<br>vi) **Solid waste disposal** : Backyard burning and open burning of heaps of solid wastes results in the emission of smoke and pollutants like NO, CO,$CO_2$ etc<br>vii) **Radioactive fallout:** Nuclear reactions, nuclear weapon testing, chemical processing plants, hospitals, research laboratories contribute radio nuclides into air.<br>viii) **Construction activities**: During construction activity various pollutants are emitted into the atmosphere. | | |
| 3 c) | **Concept of BOD and COD**<br>**BOD: -** It is the amount of oxygen required to degrade organic waste present | 02 | 04 |

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| | 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 to 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 | |
| 3 d) | **Electrostatic Precipitator** is the equipment that can be used for the control of dust fibers particles from process industries.<br>**Working Principle:** Electrostatic precipitation is a method of dust collection that uses electrostatic forces, and consists of discharge wires and collecting plates. A high voltage is applied to the discharge wires to form an electrical field between the wires and the collecting plates, and also ionizes the gas around the discharge wires to supply ions. When gas that contains an aerosol (dust, mist) flows between the collecting plates and the discharge wires, the aerosol particles in the gas are charged by the ions. The Coulomb force caused by the electric field causes the charged particles to be collected on the collecting plates, and the gas is purified. | 01<br>03 | 04 |
| 3 e) | **Role of pollution control board (MPCB)**<br>i)To promote cleanliness of streams and wells in different areas of theStates through prevention, control and abatement of water pollution;<br>ii)To improve the quality of air and to prevent, control or abate airpollution in the country; | 1 mark each for any four | 04 |

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| | iii)Advise the Government on any matter concerning prevention andcontrol of water and air pollution and improvement of the quality ofair;<br>iv)Plan and cause to be executed a nation-wide programme for theprevention, control or abatement of water and air pollution;<br>v)Plan and organize training of persons engaged in programmes for prevention, control or abatement of water and air pollution;<br>vi)Organize through mass media, a comprehensive mass awarenessprogramme on prevention, control or abatement of water and airpollution;<br>vii)Collect, compile and publish technical and statistical data relating towater and air pollution and the measures devised for their effectiveprevention, control and abatement;<br>viii) Prepare manuals, codes and guidelines relating to treatment anddisposal of sewage and trade effluents as well as for stack gas cleaningdevises, stacks and ducts;<br>ix)Disseminate information in respect of matters relating to water and airpollution and their prevention and control;<br>x)Lay down, modify or annul, in consultation with the State Governmentconcerned, the standards for stream or well, and lay down standards forquality of air;<br>xi)Establish or recognize laboratories to enable the Board to perform;<br>xii)Perform such other functions as and when prescribed by theGovernment of India.<br>xiii)To issue directions to any industry, local bodies, or other authority forviolation of the notified general emission and effluent standards, andrules relating to hazardous waste, bio-medical waste, hazardouschemicals, industrial solid waste, municipal solid waste including plastic waste under the | | |

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| | Environment (Protection) Rules, 1986. . | | |
| 3 f) | **Methods used for water sampling are:**<br>**Grab Sampling**<br>**Composite sampling**<br>**Grab Sampling:** It is sampling of waste water is a single sample taken at specific time.<br>*Advantages:* It is useful to determine effects of extreme conditions. Grabsamples do provide an immediate sample, and are thus to be preferred for some tests.<br>*Disadvantages:* It is showing only prevailing conditions at the time of sampling. 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>*Advantages:* It takes into account changes in flow and other characteristics of the water over time. Hence provide meaningful data.<br>*Disadvantages:* Composite samples cannot be used for tests of water Characteristics which change during storage (such as dissolved gases) or of water characteristics which change when samples are mixed together (such as pH.) | 1<br>1<br>2 | 04 |
| **4a** | **Attempt any three** | | **12** |
| 4.a)(i) | **Trickling filter**<br>A trickling filter is used for treatment of waste water. It consists of a bed of highly permeable media on whose surface a mixed population of microorganisms is developed as a slime layer. Passage of wastewater through the filter causes the development of a gelatinous coating of bacteria, protozoa | 02 | 04 |

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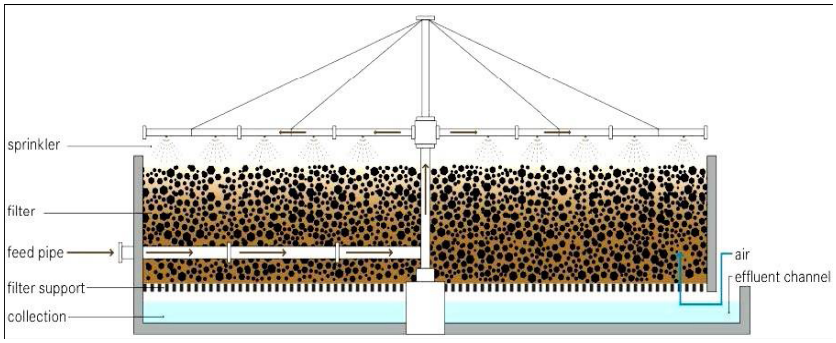
| | and other organisms on the media. With time, the thickness of the slime layer increases preventing oxygen from penetrating the full depth of the slime layer. In the absence of oxygen, anaerobic decomposition becomes active near the surface of the media<br>  <br><br>Sprinkler : To sprinkle waste water on filter<br>Filter: To hold biological slime<br>Feed pipe : Inlet for waste water<br>Filter support: To hold filter media<br>Effluent channel: to take out treated waste water | 02 | |
| 4.a)(ii) | **Disposal method of solid waste are** i) open dumping ii) Sanitary land filling iii) Incineration iv) Composting<br>**Explanation of any one method (Incineration and composting is explained else where in the solution. Sanitary Landfill explain as follows)**<br>Sanitary landfilling is an engineered operation, designed and operated according to acceptable standards. It may be defined as a method of disposing refuse on land without creating nuisances or hazards to public health or safety. The operation is carried out without environmental damage and in areas | 1<br>2 | 4 |

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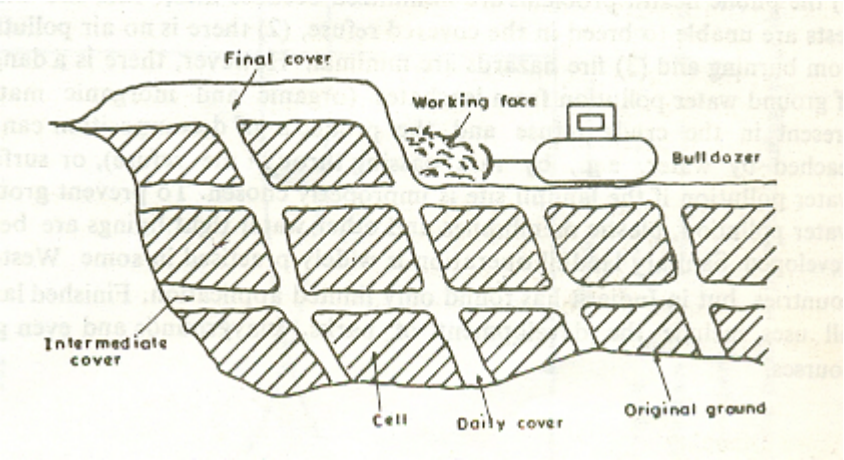
| | already spoiled or in need of restoration.<br>In sanitary landfill operation, refuse is spread and compacted in this layers within a small area. This layered structure is usually referred to as a cell. To allow for proper compaction, the cell depth should not exceed about 2 meters. The cell is then covered with a layer of soil which is spread uniformly and then compacted. To provide as adequate seal the 'cover' should normally be at least 20 cm thick. If the refuse includes large irregular objects it may be necessary to increase the thickness of the cover. On the other hand , a cover thickness of less than 15 cm may be satisfactory if the refuse has been pulverized. When a number of cells reach the final desired elevation, a final cover of about one meters of earth is placed and it is again compacted. This final cover is necessary to prevent rodents from burrowing into the refuse. The following figure is shows the cross-sectional area of a typical sanitary landfill.<br>  <br> | 1 | |
| 4.a)(iii) | **Working of fabric filter**<br>Dust-laden gas or air enters the fabric filter through hoppers (large funnel-shaped containers used for storing and dispensing particulate) and is directed into the fabric filter compartment. The gas is drawn through the bags, either on | 02 | 04 |

| | | | |
|---|---|---|---|
| | the inside or the outside depending on cleaning method, and a layer of dust accumulates on the filter media surface until air can no longer move through it. When sufficient pressure drop (delta P) occurs, the cleaning process begins. Cleaning can take place while the fabric filter is online (filtering) or is offline (in isolation).<br>When the compartment is clean, normal filtering resumes.<br>Fabric filter are very efficient particulate collectors because of the dust cake formed on the surface of the bags.<br>The fabric provides a surface on which dust collects through the following four mechanisms:<br>Inertial collection - Dust particles strike the fibers placed perpendicular to the gas-flow direction instead of changing direction with the gas stream.<br>Interception - Particles that do not cross the fluid streamlines come in contact with fibers because of the fiber size.<br>Brownian movement- Sub micrometer particles are diffused, increasing the probability of contact between the particles and collecting surfaces.<br>Electrostatic forces - The presence of an electrostatic charge on the particles and the filter can increase dust capture.<br>A combination of these mechanisms results in formation of the dust cake on the filter, which eventually increases the resistance to gas flow. The filter must be cleaned periodically. | 02 | |

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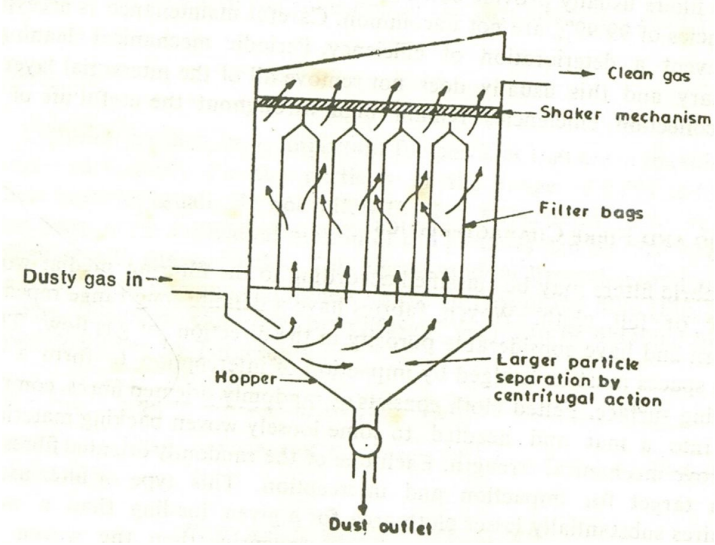
| |  | | |
| 4.a)(iv) | **Business Benefits of ISO14000:**<br>1. Efficiency, discipline and operational integration with ISO 9000<br>2. Greater employee involvement in business operations with a more motivated workforce<br>3. Easier to obtain operational permits and authorizations<br>4. Assists in developing and transferring technology within the company<br>5. Helps reduce pollution<br>6. Fewer operating costs<br>7. Savings from safer workplace conditions<br>8. Reduction of costs associated with emissions, discharges, waste handling, 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 | ½ mark each for any 8 | 04 |

| | | | |
|---|---|---|---|
| | 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<br>19. Improves the organization's relationship with insurance companies<br>20. Elimination of costs associated with conformance to conflicting national standards<br>21. Process cost savings by reduction of material and energy input<br>22. Satisfying investor / shareholder criteria<br>23. Helps reduce liability and risk<br>24. Improved access to capital | | |
| **4b** | **Attempt any one** | | **6** |
| 4.b)(i) | **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, | 02 mark each for any three | 06 |

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| | 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. | | |
| 4.b)(ii) | **Environment Audit Procedure:**<br>The generalapproach followed for environmental audit overs three main phases, namely collection of information, evaluation of information collected and formulation of conclusions, including identification of aspects needing improvement. These phases cover pre audit preparation, a site visit normally involving interviews with personnel and inspection of facilities and post-visit activities.<br>Environmental Audit procedure involve following activities viz., the pre-audit, at site and post-audit phases.<br>**Pre AuditActivities**: The activities in the pre audit phase cover the nomination of the audit team, setting out of terms of reference and priorities, making all concerned aware of the objectives and scope of environmental audit and preparation of a background note.<br>**On site Audit Activities**: In the on site phase, it is ensured the audit team and interact staff interact throughout, a thorough inspection is made in the field, sampling and tests are made as necessary, relevant records are reviewed, various persons are interviewed and tentative findings are discussed with the management.<br>**Post Audit Activities:** In the post audit phase, the draft report is circulated for review and comments based on which the final report is prepared, and action plan is evolved. The feedback from the follow up action is provided for the next audit. | 02<br>02<br>02 | 06 |
| **5** | **Attempt any four** | | **16** |
| 5 a) | **Effecty of air pollution on health:** | | 4 |

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| | 1) **Sulfur dioxide (SO2)** :<br>$SO_2$ is an irritant gas which can easily get oxidized to sulfur trioxide and in the presence of water, these can form sulfurous and sulfuric acid. The health problems related to the mucous membrane and respiratory tract are due to sulfate aerosols. Chronic effects of $SO_2$ include increased probabilities of bronchitis, "colds" of long duration and suppression of immune system.<br>2) **Hydrocarbons :**<br>The health effects of hydrocarbons have been noted in occupational exposures to tetra methyl lead, benzene, etc. Hydrocarbon vapors can cause health effects. Inhaling formaldehyde can cause irritation. It is a major contributor to eye and respiratory irritation caused by photochemical smog.<br>3) **Carbon monoxide :**<br>Carbon monoxide has a great affinity for the hemoglobin in the blood and combines with blood to form carboxyhemoglobin. This reduces the ability of hemoglobin to carry oxygen to the body tissues.<br>4) **Oxide of Nitrogen:**<br>NO reduces the oxygen carrying capacity of blood.<br>**Effecty of air pollution on material:**<br>1) Five mechanism of deterioration have been attribbuted to air poliiution<br>2) Solid partical of large enough size that are travelling at a hgh enough speed can cause deterioration by abrasion.<br>3) Small liquid and solid partical that settle on exposed surface do not cause more than aesthetic deterioration.<br>4) In presence of water as a medium the pollutant react with the surface | 2<br><br>2 | |

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| | by solubilization and oxidation / reduction reaction. | | |
| b) | ***Incineration***<br>• Incineration destroys harmful microorganisms and toxic substances often contained in biomedical waste. It is also the method for destroying recognizable human anatomical remains, reports Environmental Health and Safety at the University of California. The disadvantage of this method is that it releases persistent pollutants to the air, including dioxin and toxic metals such as mercury, reports the Center for Environmental Studies at Virginia Commonwealth University. Medical waste incinerators are a major contributor of dioxin pollution to the environment<br>***Steam Sterilization***<br>• Steam sterilization is a process of submitting biomedical waste to high pressure saturated steam at a minimum temperature of 249.8 degrees F for at least 20 minutes before its disposal. This treatment uses a machine called an autoclave. Although most pathogens such as bacteria and viruses are destroyed at high temperatures and pressures, some resistant strains of the microorganism that causes Creutzfeldt-Jakob disease, a brain degenerative disorder, can survive steam sterilization<br>***Chemical Decontamination***<br>• According to Environmental Health and Safety at University of California, chlorine, quaternary ammonium and phenolic compounds can treat liquid or semi-liquid biomedical waste. However, this method brings environmental disadvantages when used in excess to treat bio-contaminated waste water. Quaternary ammonium compounds, or quats, are hazardous to most wildlife, especially fish and other aquatic | 4 marks for any one | 4 |

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| | creatures. | | |
| c) | **Activated sludge process**<br><br>**Principle** - a biological wastewater treatment process which speeds up waste decomposition. Activated sludge is added to wastewater, and the mixture is aerat-ed and agitated. After a certain amount oftime, the activated sludge is allowed to settleout by sedimentation and is disposed of (wasted) or reused (returned to the aeration tank)<br>**Working**<br>A basic activated sludge process consists of several interrelated components:<br>• An aeration tank where the biological reactions occur<br>• An aeration source that provides oxygen and mixing<br>• A tank, known as the clari-fier, where the solids settle and are separated from treated wastewater<br>• A means of collecting the solids either to return them to the aeration tank, (return activated sludge [RAS]), or to remove them from the process (waste activated sludge [WAS]).<br>Aerobic bacteria thrive as they travel through the aera- tion tank. They multiply rapidly with sufficient food and oxygen. By the time the waste reaches the end of the tank (between four to eight hours), the bacteria has used most of the organic matter to produce new cells. The organisms settle to the bottom of the clarifier tank, separating from the clearer water. This sludge is pumped back to the aeration tank where it is mixed with the incoming wastewater or removed from the system as excess, a process called wasting. The relatively clear liquid above the sludge,the supernatant, is sent on for further treatment as required | 02<br><br>02 | 4 |

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| d) | **Principle:**<br>Environmental management refers to those activities which enhance beneficial links and minimise adverse links among resources systems and their environments, and which seek to attain desirable environmental system states, in response to community perceptions and desires, under prevailing socio-economic and technological conditions.<br>**Objectives :**<br>(1) Reduction of wastes and improvement of recycling rate<br>(2) Promotion of energy and resource conservation<br>(3) Proper control of chemical substances<br>(4) Development of environmentally benign products | 02<br><br>02 | 4 |
| e) | ***Sewage*** - Sewage pollutants include domestic and hospital wastes, animal and human excreta etc. The sewage let off causes oxygen depletion, spread of diseases/epidemics.<br><br>***Metals*** - Metals like mercury are let off into water bodies from industries. Heavy metals like mercury cause poisoning and affect health causing numbness of tongue, lips, limbs,deafness, blurred vision and mental disorders.<br><br>***Lead*** - Industrial wastes also lead to Lead pollution. If lead enters the human body system in higher quantities it affects RBCs, bone, brain, liver, kidney and the nervous system. Severe lead poisoning can also lead to coma and death.<br><br>***Cadmium*** - Source for cadmium pollution is industries, fertilizers. Cadmium gets deposited in visceral organs like liver, pancreas, kidney, intestinal | 1 mark each for any four | 4 |

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| | mucosa etc. Cadmium poisoning causes vomiting, headache, bronchial pneumonia, kidney necrosis, etc.<br><br>***Arsenic*** - Fertilizers are source for arsenic pollution. Arsenic poisoning causes renal failure and death. It also causes liver and kidney disorders, nervous disorders and muscular atrophy, etc.<br><br>***Agrochemicals like DDT*** - It is a pesticide. Accumulation of these pesticides in bodies of fishes, birds, mammals and man affects nervous system, fertility and causes thinning of egg shells in birds.<br><br>***Bacteria, Viruses and Parasites*** - These are sourced from human and animal excreta, they are infectious agents.<br><br>***Plastics, Detergents, Oil and Gasoline*** - They are a waste from industries, household and farms. They trigger organic pollution and is harmful to health.<br><br>***Inorganic Chemicals*** - Inorganic chemicals like acids, salts, metals are a result of industrial effluents, household cleansers, and surface run-off and are injurious to health.<br><br>***Radioactive Materials*** - Mining and ores processing, power plants, weapons production and natural give rise to radioactive pollution like that of uranium, thorium, cesium, iodine and radon. Radioactive pollution causes serious health diseases to all organisms. | | |

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| | ***Sediments*** - Sedimentation of soil, silt due to land erosion and deposition causes disruption in ecosystem.<br><br>***Plant Nutrients*** - Nutrients like nitrates, phosphates, and ammonium are let off from agricultural and urban fertilizers, sewage and manure. Excess of nutrients cause eutrophication and affect the ecosystem.<br><br>***Animal Manure and Plant Residues*** - These substances in water causes increased algal blooms and microorganism population. This increases oxygen demand of water, affecting aquatic ecosystem. This is introduced into water due to sewage, agricultural run-off, paper mills, food processing etc.<br><br>***Thermal Pollution*** - Temperature changes of water caused due to using water as cooling agent in power plants and industries causes increase in water temperature affecting the aquatic life. | | |
| f) | Characteristics of waste water:<br>**Physical characteristics:**<br>1.Total Solids (TS): All the matter that remains as residue upon evaporation at 103$^{o}$C to 105$^{o}$C.<br>2. Settleable solids: Settleable solids are measured as ml/L, which is an approximate measure of the sludge that can be removed by primary sedimentation.<br>3. Suspended solids (SS) and Filterable solids (FS).<br>**Chemical Characteristics:**<br>Points of concern regarding the chemical characteristics of wastewater are: | 01<br><br>02 | 4 |

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| | -Organic matter<br>-Measurements of organic matter<br>-Inorganic matter<br>-Gases<br>-pH<br>**Biological Characteristics:**<br>The main microorganisms of concern in wastewater treatment are Bacteria, Fungi, Algae, Protozoa, Viruses, and pathogenic microorganisms groups. | 01 | |
| **56** | **Attempt any four** | | **16** |
| 6 a) | **Grab Sampling**:<br>Wastewater sampling is generally performed by one of two methods, grab sampling or composite sampling. Grab sampling is just what it sounds like; all of the test material is collected at one time. As such, a grab sample reflects performance only at the point in time that the sample was collected, and then only if the sample was properly collected. Composite sampling consists of a collection of numerous individual discrete samples taken at regular intervals over a period of time, usually 24 hours. The material being sampled is collected in a common container over the sampling period. The analysis of this material, collected over a period of time, will therefore represent the average performance of a wastewater treatment plant during the collection period.<br>**Freez out Sampling**:<br>The vapours and gases that condensed at low temprature are removed from sample airstream by passage through a vessel immersed in a refrigeration liquid.<br>Usually forming a sampling train in which two or three coolent liquid progressively lower the air temprature in its passage through the system | 02<br>02 | 4 |
| b) | **Fixed bed absorber** | | 4 |

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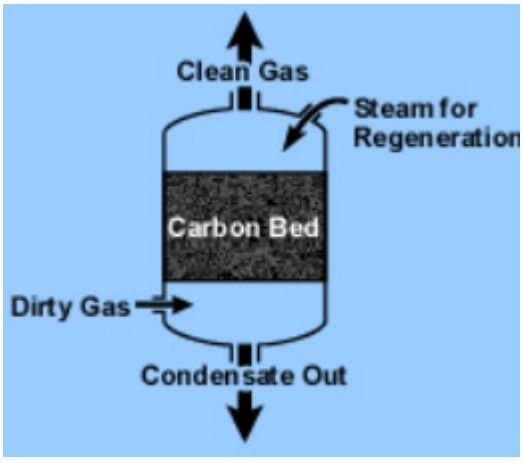
| | 1. When a gas or vapor is brought into contact with a solid, part of it is taken up by the solid. The molecules that disappear from the gas either enter the inside of the solid, or remain on the outside attached to the surface. The former phenomenon is termed absorption (or dissolution) and the latter adsorption.<br>2. The most common industrial adsorbents are activated carbon, silica gel, and alumina, because they have enormous surface areas per unit weight.<br>3. Activated carbon is the universal standard for purification and removal of trace organic contaminants from liquid and vapor streams. Carbon adsorption systems are either regenerative or non-regenerative.<br>**- Regenerative system** usually contains more than one carbon bed. As one bed actively removes pollutants, another bed is being regenerated for future use.<br>**- Non-regenerative systems** have thinner beds of activated carbon. In a non-regenerative adsorber, the spent carbon is disposed of when it becomes saturated with the pollutant.<br>  <br> | 02<br><br>02 | |

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| c) | The objective of primary treatment is the removal of settleable organic and inorganic solids by sedimentation, and the removal of materials that will float (scum) by skimming. Approximately 25 to 50% of the incoming biochemical oxygen demand ($BOD_5$), 50 to 70% of the total suspended solids (SS), and 65% of the oil and grease are removed during primary treatment. Some organic nitrogen, organic phosphorus, and heavy metals associated with solids are also removed during primary sedimentation but colloidal and dissolved constituents are not affected.<br>The primary method include:<br>1. Screening<br>2. Comminutin<br>3. Grit removal<br>4. Sedimentation<br><br>**Sedimentation:**<br>Primary sedimentation tanks or clarifiers may be round or rectangular basins, typically 3 to 5 m deep, with hydraulic retention time between 2 and 3 hours. Settled solids (primary sludge) are normally removed from the bottom of tanks by sludge rakes that scrape the sludge to a central well from which it is pumped to sludge processing units. Scum is swept across the tank surface by water jets or mechanical means from which it is also pumped to sludge processing units. | 02<br><br>02 | 4 |
| d) | **Pollutants from urea plant**<br>• Oil and grease<br>• Ammonia<br>• Fluorides | 2 | 4 |

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| | • Phosphate<br>• NaOH<br>• Urea<br>From above pollutants urea and ammonia are causing serious health effects of human.<br>1. Urea can be irritating to skin, eyes, and the respiratory tract. Repeated or prolonged contact with urea in fertilizer form on the skin may cause dermatitis.<br>2. The substance decomposes on heating above melting point, producing toxic gases, and reacts violently with strong oxidants, nitrites, inorganic chlorides, chlorites and perchlorates, causing fire and explosion.<br>3. Ammonia is irritating and corrosive. Exposure to high concentrations of ammonia in air causes immediate burning of the nose, throat and respiratory tract. This can cause bronchiolar and alveolar edema, and airway destruction resulting in respiratory distress or failure. | 2 | |
| e) | **Total dissolved solids (TDS)**<br>TDS is a measure of the combined content of all inorganic and organic substances contained in a liquid in molecular, ionized or micro-granular (colloidal sol) suspended form. Generally the operational definition is that the solids must be small enough to survive filtration through a filter with two-micrometer (nominal size, or smaller) pores. Total dissolved solids are normally discussed only for freshwater systems, as salinity includes some of the ions constituting the definition of TDS. The principal application of TDS is in the study of water quality for streams, rivers and lakes, although TDS is not generally considered a primary pollutant (e.g. it is not deemed to be associated with health effects) it is used as an indication of aesthetic characteristics of drinking water and as an aggregate indicator of the presence of a broad array | 02<br><br>02 | 4 |

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| | of chemical contaminants.<br>**Total suspended solids (TSS)**<br>TSS is a water quality parameter used for example to assess the quality of wastewater after treatment in a wastewater treatment plant. It is listed as a conventional pollutant in the U.S. Clean Water Act.[1] This parameter was at one time called non-filterable residue (**NFR**), a term that refers to the identical measurement: the dry-weight of particles trapped by a filter, typically of a specified pore size. However, the term "non-filterable" suffered from an odd (for science) condition of usage: in some circles (Oceanography, for example) "filterable" meant the material retained on a filter, so non-filterable would be the water and particulates that passed through the filter. In other disciplines (Chemistry and Microbiology for examples) and dictionary definitions, "filterable" means just the opposite: the material passed by a filter, usually called "Total dissolved solids" or **TDS**. Thus in chemistry the non-filterable solids are the retained material called the **residue**. | | |
| f) | Component<br>1- Waste generation.<br>Solid wastes include all solid or semisolid material that has no longer considered of sufficient value to be retained.<br>2- On-site handling, storage and processing.<br>***On-site handling*** refers to the activities associated with the handling of solid wastes until they are placed in the containers used for their storage before collection. It may also be required to move loaded containers to the collection point and to return the empty containers to the point where they are stored between collections.<br>**The factors that mast be considered in the on-site storage of solid** | 1 mark each for any four | 4 |

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| | **wastes include** 1- Type of containers. 2- The container location. 3- Public health and aesthetics. 4- The collection method.<br><br>3- Collection.:collection is presented in four parts:<br>1- The types of collection services.<br>2- The types of collection systems.<br>3- An analysis of collection system.<br>4- The general methodology involved in setting up collection routs.<br><br>4- Transfer and transport.<br>It is the collection systems in which the containers used for the storage of wastes remain at the point of waste generation except when moved for collection. There are two types of stationary container systems: 1) self-loading collection vehicles equipped with compactors. 2) Manually loaded vehicles.<br>5- Processing and recovery.<br>- Separation of solid waste could be at the source or at the final stage before disposal of the solid waste.<br>- Chemical and biological transformation processes are used to reduce the volume and weight of waste requiring disposal.<br>- It is very important to separate the recyclable materials to reduce the volume of the waste disposal.<br><br>6- Disposal.<br>- **Disposal** on or in the earth mantel is the viable method for the long-term handling solid wastes. Sanitary lanfilling is the method of disposal | | |

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| | used most commonly for municipal wastes. | | |