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# MANIPAL INSTITUTE OF TECHNOLOGY

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## V SEMESTER B.TECH. (BIOTECHNOLOGY / CHEMICAL ENGINEERING)

## END SEMESTER EXAMINATIONS, NOV/DEC 2016

SUBJECT: MICROBIAL TREATMENT OF WASTEWATER [BIO 4003]

**REVISED CREDIT SYSTEM**
**(01/12/2016)**

Time: 3 Hours MAX. MARKS: 50

**Instructions to Candidates:**

- Answer **ALL** the questions.
- Missing data may be suitable assumed.

**1A.** The following test results were obtained for a treated wastewater sample. Using the value of the activity coefficient for a divalent ion, estimate the equilibrium concentration of calcium in solution needed to satisfy the solubility product for calcium carbonate ($CaCO_3$) at 25°C. The value of the solubility product constant $K_{sp}$ at 25°C is 5 X $10^{-9}$. **5**

| Cation | Concentration(ppm) | Anion | Concentration(ppm) |
|---|---|---|---|
| $Ca^{2+}$ | 121.3 | $HCO_3^-$ | 280 |
| $Mg^{2+}$ | 36.2 | $SO_4^{2-}$ | 116 |
| $Na^+$ | 8.1 | $Cl^-$ | 61 |
| $K^+$ | 12 | $NO_3^-$ | 15.6 |

**1B.** The following test results were obtained for a wastewater sample taken at an industrial facility. All of the tests were performed using a sample size of 100 mL. Determine the concentration of total solids, total volatile solids, suspended solids, volatile suspended solids, total dissolved solids and total volatile dissolved solids in mg/L. The samples used in the solids analyses were all either, dried, or ignited to constant weight **5**

Tare mass of evaporating dish = 54.6422 g
Mass of evaporating dish plus residue after evaporation at 105°C = 54.7022 g
Mass of evaporating dish plus residue after ignition at 550°C = 54.6722 g
Tare mass of Whatman GF/C filter and reside after drying at 105°C = 1.5348 g
Mass of Whatman GF/C filter and residue after drying at 105°C = 1.5553 g
Mass of Whatman GF/C filter and residue ignition at 550°C = 1.5453 g

**2A.** Using Least square method, Compute *k* and *UBOD* for the following data reported for a stream receiving some treated effluent. **5**

| *Time (d)* | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *BOD (mg/L)* | 0 | 65 | 109 | 138 | 158 | 178 | 190 | 200 | 205 | 210 | 212 |

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<table>
<tr><td>2B.</td><td>What do you mean by TOC in municipal wastewater? How is it measured?</td><td>2</td></tr>
<tr><td>2C.</td><td>Determine the ThOD for Tryptophan ($C_{11}H_{12}N_2O_2$).</td><td>3</td></tr>
<tr><td>3A.</td><td>Explain the Most probable number (MPN) analysis for the quantification of total coliform bacteria using Presumptive, Confirmed, and Completed test.</td><td>3</td></tr>
<tr><td>3B.</td><td>Determine graphically the 96-h $LC_{50}$ values in percent by volume for the following toxicity test data obtained using flathead minnows.
<table>
<tr><th>Concentration of waste, % by volume</th><th>No. of Test animals</th><th>No. of Test animals dead after 96 h</th></tr>
<tr><td>60</td><td>20</td><td>20</td></tr>
<tr><td>40</td><td>20</td><td>18</td></tr>
<tr><td>20</td><td>20</td><td>16</td></tr>
<tr><td>10</td><td>20</td><td>12</td></tr>
<tr><td>5</td><td>20</td><td>6</td></tr>
<tr><td>2</td><td>20</td><td>2</td></tr>
</table></td><td>3</td></tr>
<tr><td>3C.</td><td>Estimate the amount of heat, surplus sludge and biogas formed during aerobic degradation of 1 mol of glucose (in an activated sludge system at a high BOD loading rate. Write the mass and energy balance for the over all process.</td><td>4</td></tr>
<tr><td>4A.</td><td>Briefly explain the role of inorganic acceptor during biomass degradation.</td><td>2</td></tr>
<tr><td>4B.</td><td>The kinetics of a cellulose degradation followed Ekenstam's relationship, given below.
$$\ln\left(1-\frac{1}{DP^0}\right)-\ln\left(1-\frac{1}{DP}\right)=kt$$
The time course of cellulose degradation is as follows:
<table>
<tr><td>Time (h)</td><td>0</td><td>0.3</td><td>1.2</td><td>2.3</td><td>2.9</td><td>3.4</td><td>4</td></tr>
<tr><td>DP</td><td>1265</td><td>714</td><td>323</td><td>180</td><td>167</td><td>143</td><td>123</td></tr>
</table>
Determine rate constant for the degradation of cellulose.</td><td>4</td></tr>
<tr><td>4C.</td><td>For glutamine ($C_5H_{10}N_2O_3$), use the Buswell equation and determine theoretically:<br>a) the gas composition (% carbon dioxide and % methane) produced and<br>b) the volume of methane produced from 1 kg of the biomolecules at NTP.</td><td>4</td></tr>
<tr><td>5A.</td><td>Explain the autotrophic and heterotrophic nitrification of municipal wastewater. Give reaction scheme for both the processes. What are the major microbial genera involved in each of the processes? Discuss about the nitrification process with both types of microorganisms in the same treatment system.</td><td>5</td></tr>
<tr><td>5B.</td><td>Discuss in detail about the design considerations for Upflow anaerobic sludge blanket (UASB) process involving volumetric organic loading, upflow velocity, reactor volume, physical features and gas collection system.</td><td>5</td></tr>
</table>