V SEMESTER B.TECH. EXAMINATIONS MARCH 2021

SUBJECT: CHEMICAL REACTION ENGINEERING [CHE 3102]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitable assumed.
- Use graphs wherever relevant.

1A.	Briefly discuss various theories of temperature dependency of a rate equation.	**06**
1B.	Develop the performance equation for an ideal CSTR.	**04**
2A.	A continuous reactor is to be designed for a homogenous **liquid phase reaction** for the production of chloro ethane $HCl + C_2H_4 \rightarrow C_2H_5Cl$ It is first order with respect to HCl with k = 0.002 s^{-1}. With a flow rate of 0.02 m^3/s. The feed concentration is 1 $kmol/m^3$. **i)** What is the volume of a plug flow required to achieve 90% conversion? **ii)** Had this reaction been performed in a continuous flow stirred tank reactor would it be better? Justify.	**03+03**
2B.	**i)** Prove that for an autocatalytic reaction A+R-> R+R where $-r_A = k\ C_A\ C_R$, the rate of disappearance of A is maximum when $C_A=C_R$ **ii)** What are the applications of recycle reactor?	**03+01**
3A.	The elementary **liquid phase reversible** reaction 2A+B === R has k_{1A} = 10 l^2/mol^2. min and k_{2A} = 0.5 min^{-1}. The feed consists of 1.4 mol A/liter and 0.8 mol B/liter. **i)** Choose the best flow reactor scheme to carry out this reaction for 70% conversion of **A**. **ii)** Find the size of the best scheme of reactor/s when entering flow rate is 10 liter/min.	**04+02**
3B.	Chemical A reacts to give R (k_1 = 5 hr^{-1}) and R reacts to form S (k_2 = 2hr^{-1}). In addition, R decomposes to give T (k_3 = 1hr^{-1}), all reactions being elementary. If a solution containing 2 mol/liter of A is introduced into a CSTR, a space time of 46.4 minutes is required to obtain maximum of the desired product R. What is the maximum concentration of R?	**04**

<table>
<tr><td>4A.</td><td>Derive an expression for conversion for a first order reaction, in a real CSTR modeled using bypass and dead space. (Evaluation of model parameters not required).</td><td>04</td></tr>
<tr><td>4B.</td><td>Discuss the various non ideal flow patterns which exist in process equipment.</td><td>03</td></tr>
<tr><td>4C.</td><td>Calculate the mean conversion in a non-ideal reactor we have characterized by RTD measurements for a first order, liquid phase, irreversible reaction in a completely segregated fluid: A-> products. The specific reaction rate is 0.1 min^{-1} at 320 K. (Please turn over for full table)
<table>
<tr><th>t min</th><th>E(t) 1/min</th><th>X(t)</th></tr>
<tr><td>0</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>0.02</td><td>0.095</td></tr>
<tr><td>2</td><td>0.1</td><td>0.181</td></tr>
<tr><td>3</td><td>0.16</td><td>0.259</td></tr>
<tr><td>4</td><td>0.2</td><td>0.33</td></tr>
<tr><td>5</td><td>0.16</td><td>0.393</td></tr>
<tr><td>6</td><td>0.12</td><td>0.451</td></tr>
<tr><td>7</td><td>0.08</td><td>0.503</td></tr>
<tr><td>8</td><td>0.06</td><td>0.551</td></tr>
<tr><td>9</td><td>0.044</td><td>0.593</td></tr>
<tr><td>10</td><td>0.03</td><td>0.632</td></tr>
<tr><td>12</td><td>0.012</td><td>0.699</td></tr>
<tr><td>14</td><td>0</td><td>0.75</td></tr>
</table></td><td>03</td></tr>
<tr><td>5A</td><td>Aqueous A at a concentration C_{A0} = 1000 mol/m^3 is introduced into a batch reactor where it reacts away to form product R according to stoichiometry A-> R. The concentration of A in the reactor is monitored at various times, as shown below:
<table>
<tr><td>C_A mol/m^3</td><td>1000</td><td>500</td><td>333</td><td>250</td><td>200</td></tr>
<tr><td>t min</td><td>0</td><td>100</td><td>200</td><td>300</td><td>400</td></tr>
</table>
i) Find rate of this reaction? Use any method.
ii) Find size of a PFR required for a conversion of 75% when volumetric flow rate is 100 liter/hr?</td><td>04+04</td></tr>
<tr><td>5B</td><td>Derive a mechanism for this elementary reaction A+B-> R with a rate expression $-r_A = k C_A C_B$</td><td>02</td></tr>
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