U.S.N.										

B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

June 2025 Semester End Main Examinations

Programme: B.E.
Branch: Chemical Engineering
Course Code: 19CH6DCCR2
Course: Chemical Reaction Engineering - II

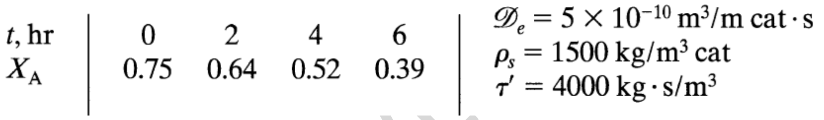
Semester: VI
Duration: 3 hrs.
Max Marks: 100

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

Important Note: Completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages. Revealing of identification, appeal to evaluator will be treated as malpractice.

<table>
<tr><th></th><th></th><th>UNIT - I</th><th>CO</th><th>PO</th><th>Marks</th></tr>
<tr><td>1</td><td>a)</td><td>What is stimulus response technique? Explain in detail about the pulse and the step input experiments.</td><td>CO1</td><td>PO 3</td><td>8</td></tr>
<tr><td></td><td>b)</td><td>First order reaction A→ Products is carried out in a PFR. The specific reaction rate is 0.9sec⁻¹. The results of the tracer experiment are as follows
<table>
<tr><td>Time (sec)</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>12</td><td>14</td></tr>
<tr><td>C_{Pulse}(g/lit)</td><td>0</td><td>0.5</td><td>3.75</td><td>6.9</td><td>9.15</td><td>7.5</td><td>4.9</td><td>3.15</td><td>2.7</td><td>1.75</td><td>1.1</td><td>0.2</td><td>0</td></tr>
</table>
Calculate the conversion of reactant A using
i) Ideal PFR
ii) Ideal CSTR
Also draw the E Curve for the data</td><td>CO2</td><td>PO4</td><td>12</td></tr>
<tr><td></td><td></td><td>OR</td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>a)</td><td>Explain the non-ideal flow patterns that may arise in the process equipment’s with the help of neat sketches.</td><td>CO2</td><td>PO4</td><td>10</td></tr>
<tr><td></td><td>b)</td><td>The concentration readings given below represent a continuous response to a pulse input into a closed vessel.
<table>
<tr><td>Time (min)</td><td>0</td><td>5</td><td>10</td><td>15</td><td>20</td><td>25</td><td>30</td><td>35</td></tr>
<tr><td>C_{Pulse} (g/lit)</td><td>0</td><td>3</td><td>5</td><td>5</td><td>4</td><td>2</td><td>1</td><td>0.001</td></tr>
</table>
This vessel is used as a reactor for the decomposition of a liquid with a rate
$– r_A=kC_A$ The value of k= 0.307min⁻¹
Estimate the fraction of the reactant that is unconverted in a real reactor and compare the results with Ideal PFR</td><td>CO2</td><td>PO4</td><td>10</td></tr>
</table>

<table>
<tr><td></td><td></td><td></td><td>UNIT - II</td><td></td><td></td><td></td></tr>
<tr><td></td><td>3</td><td>a)</td><td>Deduce a rate equation for an instantaneous reaction when the concentration of liquid is very low.</td><td><i>CO3</i></td><td><i>PO3</i></td><td>12</td></tr>
<tr><td></td><td></td><td>b)</td><td>Gaseous reactant A absorbs and reacts with the liquid B in the liquid according to the reaction
$A(g\rightarrow l) + B(l) \rightarrow R(l)$, $-r_A=kC_AC_B$ in a packed bed reactor
where p_A=100Pa and C_B=1 mol/(m^3 liquid)
i. Calculate the rate of reaction in mol/(hr. m^3 of reactor)
ii. Resistance offered by the main body of the liquid
Data Given:
$K_{Ag}.a$ = 0.10 mol/(hr. m^3 of reactor. Pa)
f_l= 0.01 (m^3 liquid/m^3 of reactor)
$K_{Al}.a$ = 100 m^3 liquid/ (m^3 reactor.hr)
a = 100m^2/m^3 reactor
$D_{Al} = D_{Bl} = 10^{-6}$ m^2/hr
k = 10m^3 liquid/(mol.hr)
H_A= 10^5 (Pa.m^3 liquid)/mol</td><td><i>CO3</i></td><td><i>PO3</i></td><td>8</td></tr>
<tr><td></td><td></td><td></td><td>OR</td><td></td><td></td><td></td></tr>
<tr><td></td><td>4</td><td>a)</td><td>Two small samples of solids are kept in a constant environment oven for a period of 1hour under the conditions prevailing in an oven the 4mm particles are 60% converted and the 2mm particles are 90% converted. Find the rate controlling mechanism for the conversion of solids.</td><td><i>CO3</i></td><td><i>PO3</i></td><td>8</td></tr>
<tr><td></td><td></td><td>b)</td><td>Derive an expression to relate between fractional conversion and the radius of unreacted core for the ash layer controlling for a spherical particle of unchanging size. State the assumptions made.</td><td><i>CO3</i></td><td><i>PO3</i></td><td>12</td></tr>
<tr><td></td><td></td><td></td><td>UNIT - III</td><td></td><td></td><td></td></tr>
<tr><td></td><td>5</td><td>a)</td><td>Discuss the various catalyst preparation methods.</td><td><i>CO3</i></td><td><i>PO3</i></td><td>8</td></tr>
<tr><td></td><td></td><td>b)</td><td>An 8.01 gm of sample is studied with nitrogen adsorption at -195.8°c. The following data are obtained.
<table>
<tr><td>P(mm hg)</td><td>Volume adsorbed (cm^3)</td></tr>
<tr><td>6</td><td>61</td></tr>
<tr><td>25</td><td>127</td></tr>
<tr><td>140</td><td>170</td></tr>
<tr><td>230</td><td>197</td></tr>
<tr><td>285</td><td>215</td></tr>
<tr><td>320</td><td>230</td></tr>
<tr><td>430</td><td>277</td></tr>
<tr><td>505</td><td>330</td></tr>
</table>
Calculate the surface area required
Data: Density of Nitrogen gas 0.808g/cc</td><td><i>CO3</i></td><td><i>PO3</i></td><td>12</td></tr>
<tr><td></td><td></td><td></td><td>OR</td><td></td><td></td><td></td></tr>
<tr><td></td><td>6</td><td>a)</td><td>Explain the properties and mechanism of catalysis.</td><td><i>CO3</i></td><td><i>PO3</i></td><td>8</td></tr>
</table>

		b)	Discuss the various estimation methods to characterize properties of the catalyst.	*CO3*	*PO3*	**6**
		c)	Explain how the surface area of catalyst particles are determined using BET method.	*CO3*	*PO3*	**6**
			UNIT - IV			
	7	a)	Derive an expression to find the effectiveness factor for diffusion through a cylindrical pore of a catalyst (pore diffusion resistance combined with surface kinetics). State the assumptions made.	*CO3*	*PO3*	**12**
		b)	How much catalyst is needed in a packed bed reactor (assume PFR & MFR) for 50% conversion for a feed rate of 2000 mol/hr at a temperature of 125^{o}C & 5atm. A →4R, $-r_A$’ = 96.55(l/(hr kg catalyst) with 20% of inerts present.	*CO3*	*PO3*	**08**
			OR			
	8	a)	Discuss the various types of catalyst deactivation.	*CO3*	*PO3*	**10**
		b)	The catalytic decomposition of reactant **(A+R)** is studied in a packed bed reactor filled with 2.4-mm pellets and using a very high recycle rate of product gases (assume mixed flow). The results of a long-time run and additional data are given below.  t, hr 0 2 4 6 X_A 0.75 0.64 0.52 0.39 $\mathscr{D}_e = 5 \times 10^{-10}\ \mathrm{m^3/m\ cat \cdot s}$ $\rho_s = 1500\ \mathrm{kg/m^3\ cat}$ $\tau' = 4000\ \mathrm{kg \cdot s/m^3}$ Find the kinetics of reaction and deactivation, both in the diffusion-free and in the strong pore diffusion resistance regime.	*CO3*	*PO3*	**10**
			UNIT - V			
	9	a)	Derive performance equations for packed bed reactor containing porous catalyst particles.	*CO4*	*PO3*	**10**
		b)	Discuss the design considerations for a three-phase fluidized bed reactor.	*CO4*	*PO3*	**10**
			OR			
	10	a)	Compare and contrast the performance characteristics of trickle bed and slurry reactors.	*CO4*	*PO3*	**10**
		b)	Explain the experimental methods used to determine the rates in reactors containing porous catalyst particles.	*CO4*	*PO3*	**10**

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