Name:

Enrolment No:

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2018

Programme Name: M. Tech CE + PD **Semester : I**
Course Name : Chemical Reactor Engineering and Design **Time : 03 hrs**
Course Code : CHPD7004 **Max. Marks: 100**
Nos. of page(s) : 02

Instructions: 1) Answer the questions section wise in the answer booklet. 2) Assume suitable data wherever necessary. The notations used here have the usual meanings.

SECTION A (Total Marks: 3 x 10 = 30)

- Attempt ***all*** the questions. All questions carry equal marks.

<table>
<tr><th>S. No.</th><th></th><th>Marks</th><th>CO</th></tr>
<tr><td>Q 1</td><td>Enzyme E catalyses the fermentation of substrate A (the reactant) to product R. Find the size of mixed flow reactor needed for 95% conversion of reactant in a feed stream (25 liter/min) of reactant (2 mol/liter) and enzyme. The kinetics of the fermentation at this enzyme concentration are given by
$$A \xrightarrow{\text{enzyme}} R, \qquad -r_A = \frac{0.1\,C_A}{1+0.5\,C_A} \quad \frac{\text{mol}}{\text{liter}\cdot\text{min}}$$</td><td>10</td><td>CO1</td></tr>
<tr><td>Q 2</td><td>The first-order isomerization A → B is being carried out isothermally in a batch reactor on a catalyst that is decaying as a result of aging. Derive an equation for conversion as a function of time.</td><td>10</td><td>CO3</td></tr>
<tr><td>Q 3</td><td>Explain about Geldart classification of solids in bubbling fluidized bed (BFB) with a neat sketch.</td><td>10</td><td>CO5</td></tr>
<tr><td colspan="4">SECTION B (Total Marks: 3 x 15 = 45)
➢ Attempt <i>all</i> the questions. All questions carry equal marks.</td></tr>
<tr><td>Q 4</td><td>What is a fixed bed reactor? Establish the mathematical equations in fluid and solid phases to design a fixed bed reactor along with boundary conditions. State the assumptions clearly.</td><td>15</td><td>CO4</td></tr>
<tr><td>Q 5</td><td>From a pulse input into a vessel, the following output signal is obtained
<table><tr><td>Time, min</td><td>1</td><td>3</td><td>5</td><td>7</td><td>9</td><td>11</td><td>13</td><td>15</td></tr><tr><td>Concentration (arbitrary)</td><td>0</td><td>0</td><td>10</td><td>10</td><td>10</td><td>10</td><td>0</td><td>0</td></tr></table>If the flow through the vessel is represented with the tanks-in-series model, determine the number of tanks to use.</td><td>15</td><td>CO2</td></tr>
<tr><td rowspan="2">Q 6</td><td>i) Develop an expression for the conversion of nonisothermal continuos-flow reactor operated at steady state from the general energy balance equation.</td><td>05</td><td rowspan="2">CO2,
CO3,
CO5</td></tr>
<tr><td>ii) What are the steps involved in a heterogeneous catalyst reaction?</td><td>05</td></tr>
</table>

	iii) Explain in brief about slurry reactor with a neat sketch.	**05**	
	SECTION-C (Total Marks: 1 x 25 = 25)		
Q 7	The second order decomposition reaction A → B + 2C; is carried out in a tubular reactor packed with catalysts pellets 0.4 cm in diameter. The reaction is internal-diffusion limited. Pure A enters the reactor at a superficial velocity of 3 m/s, a temperature of 250^{0}C and a pressure of 500 kPa. Experiments carried out on smaller pellets where surface reaction is limiting yielded a specific reaction rate of 50 m^6/mol.gcat.s. Obtain an expression for the length of bed and calculate its value necessary to achieve 80% conversion. Neglect axial diffusion with respect to forced axial convection. Data: Effective diffusivity: 2.66 x 10^{-8} m^2/s Bed porosity: 0.4 Bulk density of bed: 2 x 10^6 g/m^3 Internal surface area: 400 m^2/g For large values of Thiele modulus, $\eta=\left(\frac{2}{n+1}\right)^{1/2}\frac{3}{\phi_n}$; n is order of reaction.	**25**	**CO3**