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UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, December 2017

Program: M.Tech CE+PD | **Semester –I**

Subject (Course): Chemical Engineering Research and Design | **Max. Marks : 100**

Course Code : CHPD7004 | **Duration : 3 Hrs**

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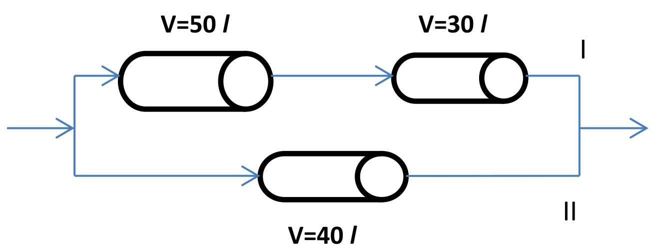
NOTE: i) Attempt ALL from Section A and any TWO from Section B
ii) Make necessary assumption in case of data missing.
iii) Exchange of calculators NOT allowed.

SECTION A [10×6=60]

1. (a) The reactor setup as shown in Fig. below consists of three PFR in two parallel branches. Branch I has a PFA of volume 50 liters followed by a PFR of volume 30 liters. Branch II has a single PFR of 40 liters. What fraction of feed should go to the branch I? *[5M]*



(b) Derive the expression for time required for reactant concentration to drop to the half of initial concentration. *[5M]*

2. The elementary liquid phase reaction (A+B-→ R+S) is carried out in a PFR. For equimolar amounts of A and B (C_{Ao}=C_{Bo}=0.9 mol/l), 94% conversion is achieved in it. If a CSTR, 10 times as large as PFR, were arranged in series with the existing unit, which unit needs to be arranged first (in series) to enhance the production rate?
3. Define space time and space velocity. Develop the performance equations of single batch as well CSTR reactor with neat schematics as well as graphical representation of performance equation.
4. (a) The desired liquid phase reaction, $A+B \rightarrow R+T$ $\quad \frac{dC_R}{dt}=\frac{dC_T}{dt}=k_1 C_A^{1.5} C_B^{0.3}$ is accompanied by the unwanted side reaction, $A+B \rightarrow S+U$ $\quad \frac{dC_S}{dt}=\frac{dC_U}{dt}=k_1 C_A^{0.5} C_B^{1.8}$. From the standpoint of favorable product

distribution, describe the different possible contacting schemes with neat schematics. Also suggest the best or least desirable scheme. [*5M*]

(b) Write a note on the basics of non-ideal flow including various terms as RTD, state of aggregation and earliness and lateness of mixing. Draw figure for showing different non-ideal flow patterns. [5M]

5. Assuming a stoichiometry A-→ R for a first order gas reaction, the size of PFR required to achieve 99% conversion of pure A is 32*l*. However, the stoichiometry of the reaction is A-→ 4R. For this corrected stoichiometry, find the required size (volume) of same type reactor.
6. Liquid reactant A decomposes in parallel path as follows:

$$A \to R,\ r_R = 0.4\left(\frac{m^3}{mol.\min}\right)C_A^2$$

$$A \to S,\ r_S = 2\left(\frac{1}{\min}\right)C_A$$

With aqueous feed of 40 mol/m^3 enters a PFR, decomposes and gives mixture of A, R and S. Find exit concentration of R and S, space time for X_A=0.9 in PFR.

SECTION B [20×2=40]

7. At 500K, the rate of a bimolecular reaction is ten times the rate at 400K. Find the activation energy for this reaction from (a) Arrhenius theory, (b) collision theory. (c) Also find the percentage difference in the rate of reaction at 600K predicted by these methods?
8. A homogenous liquid phase reaction, $A \to S\ (-r_A = kC_A^2)$ takes place in a MFR and results in 50% conversion. (a) Find the conversion if this reactor is replaced by another MFR having reactor volume 6 times the original one (all other parameters are same), (ii) Find the conversion if original MFR is replaced by a PFR of same size (all other parameters are same).
9. The data given below represent a continuous response to a pulse input into a closed vessel which is to be used as chemical reactor. Calculate mean residence time ($\bar{t}$) of the fluid in the vessel. Tabulate and construct E curve.

t, min	0	5	10	15	20	25	30	35
C_{pulse}, g/l	0	3	5	5	4	2	1	0