B.Tech. Eighth Semester (Food, Pulp & Paper, Oil & Paint and Petro. Tech.) (CGS)

11081 : Chemical Reaction Engineering - II (Reactor Design) : 8 CT 02

P. Pages : 3 | **AU - 3070**

Time : Three Hours | Max. Marks : 80

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Notes :
1. All question carry marks as indicted
2. Answer **three** question from section A and **three** question from section B.
3. Due credit will be given to neatness and adequate dimensions.
4. Assume suitable data wherever necessary.
5. Diagrams and Chemicals equations should be given wherever necessary.
6. Illustrate your answer necessary with the help of neat sketches.
7. Discuss the reaction, mechanism wherever necessary.
8. Use pen Blue/Black ink/refill only for writing the answer book.

SECTION - A

1. a) Dispersed non coalescing droplets $(C_{AO} = 2\,mol/\ell)$ react as per the reaction $A \rightarrow R$ with rate $-r_A = kC_A^2$, $k = 0.5\ \ell/(mol.min)$ as they pass through the contactor. Find the average concentration of A remaining in the droplets leaving the conductor. Use E = 0.5, for $1 < t < 3$ **7**

b) Explain step input method for finding exit age distribution, E. **7**

OR

2. Explain the tank in series model for RTD with pulse response experiment. **14**

3. a) Derive an expression for SCM for spherical particles of fixed size. Assume that, resistance of the ash layer controls the overall rate of reaction. **9**

b) Explain the steps occur in succession during reaction, A (Fluid) + bB (solid) $\rightarrow$ fluid product. **4**

OR

4. a) Particles of uniform size are 60% converted in a single fluidized bed as per the SCM with reaction controlling. Find the conversion if the reactor is made twice as large but containing same amount of solids with same gas environment. **8**

b) Give the diagrammatic representation of SCM of spherical particles of fixed size. **5**

5. a) Derive the rate expression for fluid-fluid heterogeneous reaction. Assume that reaction is fast and concentration of 'B' is high. **6**

b) Explain the various tower and tank contactors used for gas liquid reaction. **7**

OR

6. Explain chemical and physical absorption with suitable example and derive the rate equation for physical absorption. **13**

SECTION - B

7. a) Calculate the external surface area of non-porous spherical particles of 2 micron diameter. What size particles would be necessary if the external surface is to be 100 m^2/g? Density of particles is 2.0 g/cm3. 7

b) Explain the methods of catalyst preparation. 7

OR

8. The following data on an irreversible reaction $A \rightarrow R$ are obtained in a batch reactor (batch solids, batch fluid) using decaying catalyst. What can you say about the Kinetics? 14

C_A	1	0.802	0.675	0.532	0.422	0.368
t, h	0	0.25	0.5	1.0	02	∞

9. Gaseous A decomposes on a solid catalyst as per the following reaction: 13

$$A \rightarrow R \text{ with } -r_A = kC_A^2$$

A pilot plant scale tubular reactor packed with 2 ℓ of catalyst is fed with 2 m^3 / h of pure A at 300°C and 20 atm. 65% of A is converted.

It is desired to treat 100 m^3 / h of feed gas at 40 atm and 300°C consisting of 60% A and 40% diluent in a larger plant to obtain 85% conversion of A. Find the internal volume of the reactor.

OR

10. Consider a single cylindrical pore of length 'L' with reactant 'A' diffusing into the pore and reacting on the surface by the first order reaction taking 13

$A \rightarrow$ Product and $-r_A'' = -\frac{1}{S}\frac{dN_A}{dt} = k''C_A$ place at the walls of the pore and product diffusing out of the pore.

Show that $C_A / C_{AS} = \frac{\text{Cosh } m(L-x)}{\text{Cosh } mL}$

11. Aqueous acetone is hydrogenated to propanol by the action of pure hydrogen at 1 atm in a long column packed with porous catalyst (packed bubble column) and maintained at 14 °C. The reactants are fed at the bottom of the column. The reaction proceeds as follows: 13

$$\underset{A}{H_2(g \rightarrow \ell) +} \quad \underset{B}{CH_3COCH_3\ (\ell)} \xrightarrow[\text{catalyst}]{\text{on}} CH_3CHOHCH_3\ (\ell)$$

with rate

$-r_A' = -r_B' = k'C_A^{"2}\ C_B^{0}$, mol / (kg cat.s)

$$k' = 2.3 \times 10^{-3}\ \frac{m^3\ell}{\text{kg cat. s}} \left(\frac{\text{mol}}{m^3\ell}\right)^{1/2}$$

Find the fractional conversion of acetone to propanol.

Data :

Gas : $V_g = 4x10^{-2}$ m^3g/s, $H_A = 36850$ $(Pa, m^3\ell)/mol$

Liquid : $V_\ell = 1x10^{-4}$ m^3i/s, $C_{BO} = 1000$ $mol/m^3.\ell$

Reactor : 0.1 m^2 cross – section X 5 m high, $f_s = 0.60$

Catalyst : $d_p = 5x10^{-3}$ m, $\rho_s = 4500$ kg/m^3

$D_e = 8x10^{-10}$ $m^3\ell/(m\ Cat.s)$

Kinetics : $(k_{Ai}\, ai)_{g+L} = 0.021$ $m^3\ \ell/(m^3r.s)$

$K_{A_c}a_c = 0.051 m^3\ell/(m^3r.s)$

OR

12. a) Explain the step involve in G/L reaction on a solid catalysts. Show Graphically the resistance involved in the gas-liquid reaction on solid catalysts. **7**

b) Give the comparison between fixed bed and fluidized bed catalytic reactor. **6**

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