B.Tech. Eighth Semester (Chemical Engineering) (CGS)

11675 : Chemical Reaction Engineering-II : 8 CH 02

P. Pages : 4 **AW - 3493**

Time : Three Hours Max. Marks : 80

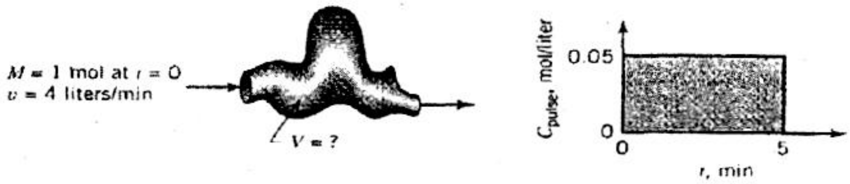
Notes :
1. Answer **three** question from Section A and **three** question from Section B.
2. Due credit will be given to neatness and adequate dimensions.
3. Assume suitable data wherever necessary.
4. Diagrams and chemical equations should be given wherever necessary.
5. Illustrate your answer necessary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

SECTION - A

1. a) A pulse input to a vessel gives the results shown in Fig. **7**

   a) Check the material balance with the tracer curve to see whether the results are consistent.

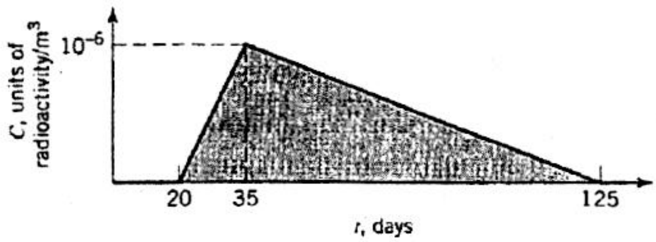
   b) If the result is consistent, determine $\bar{t}$, V and sketch the E curve.



b) A batch of radioactive material is dumped into the Columbia River at Hanford, Washington. At Bonneville Dam, about 400 km downstream the flowing waters (6000 m^3/s) are monitored for a particular radioisotope $\left(t_{1/2} > 10 \text{ yr}\right)$ and the data of Fig. are obtained. **7**

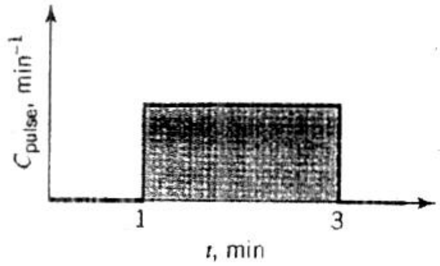
   a) How many units of this tracer were introduced into the river?

   b) What is the volume of Columbia River waters between Bonneville Dam and the point of introduction of tracer?



OR

2. a) Dispersed noncoalescing droplets ($C_{A0} = 2\,\text{mol/liter}$) react ($A \rightarrow R, -r_A = kC_A^2, k = 0.5\,\text{liter/mol.min}$) as they pass through a contractor. Find the average concentration of A remaining in the droplets leaving the contactor if their RTD is given by the curve in Fig. **7**



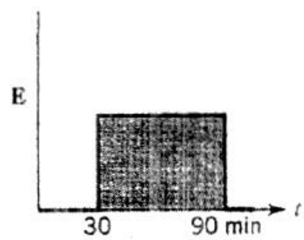
b) Explain the fitting the Dispersion model for small Extents of dispersion, D/uL < 0.01 and large deviation from plug flow, D/uL > 0.01. **7**

3. The concentration of reactants and products for the reaction A (g) + aB(s) = solid product for a particle of unchanging size, use SHRINKING-CORE MODEL FOR SPHERICAL PARTICLES OF UNCHANGING SIZE. Obtain the relationship of time with radius and with conversion in which the **13**

a) Chemical Reaction controls. b) Ash layer controls.

OR

4. Hydrogen sulfide is removed from coal gas by passing the gas through a moving bed or iron oxide particles. In the coal gas environment (Consider uniform) the solids are converted from Fe_2O_3 to FeS by the SCM/reaction control, $\tau = 1$ hr. Find the fractional conversion of oxide to iron sulfide if the RTD of solids in the reactor is approximated by the E curves of **13**



5. In a Fluid-Fluid Reactions discuss the eight special cases, that is from infinitely fast to very slow reaction. Obtain the rate equation for case. **13**
B. (Infinitely fast reaction with high C_B.)

OR

6. We wish to lower the concentration of B in the liquid ($V_l = 1.62\,m^3, C_u = 55555.6\,mol/m^3$) of an agitated tank reactor by bubbling gas ($F_g = 9000\,mol/hr, \pi = 10^5\,Pa$) containing A ($P_{Ain} = 1000\,Pa$) through it. A and B react as follows: **13**

$A(g \rightarrow l) + B(l), \rightarrow \text{product}(l) - r_A''' = kC_AC_B.$

a) How long must we bubble gas through the vessel to lower the concentration from $C_{B0} = 555.6$ to $C_{Bf} = 55.6\,mol/m^3$?

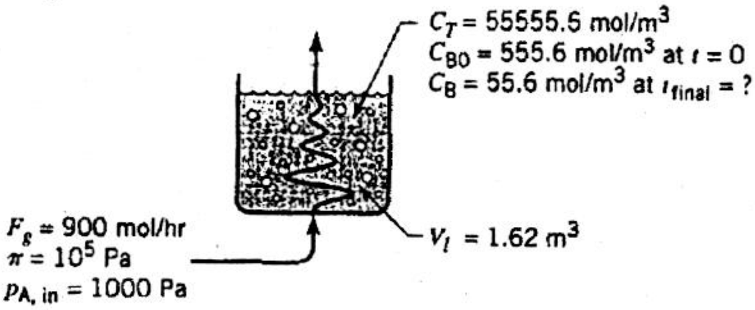
b) What percent of entering unreacted?

Additional data

$K_{Ag}a = 0.72\,mol/hr \cdot m^3 \cdot Pa$ $f_l = 0.9 m^3\ liquid/m^3\ total$

$K_{Al}a = 144\,hr^{-1}$ $D_A = D_B = 3.6 \times 10^{-6}\,m^2/hr$, $a = 100\ m^2/m^3$

$H_A = 10^3\,Pa \cdot m^3/mol$ $k = 2.6 \times 10^5\,m^3/mol \cdot hr$



SECTION – B

7. a) Explain the method for determination of Surface Area of catalyst. **14**

b) Explain the concept of catalyst deactivation.

c) Define Promoters & Inhibitors in solid catalysts.

OR

8. a) Explain the method for determination of pore volume of a catalyst particle. **7**

b) A hydrogenation catalyst is prepared by soaking alumina particles (100 to 150 mesh size) in aqueous $NiNO_3$ Solution. After drying and reduction the particles contain about 7 wt % NiO. This catalyst is then made into large cylindrical pellets for rate studies. The gross measurements for one pellet are **7**

Mass = 3.15 g
Diameter = 1.00 in
Thickness = 1 in
Volume = 3.22 cm^3

The Al_2O_3 particles contain micropores, and the pelleting process introduces macropores surrounding the particles. From the experimental methods already described the macropore volume of the pellet is 0.645 cm^3 and the micropore volume is 0.40 cm^3/g of particles. From this information calculate:

a) The density of the pellet.
b) The macropore volume in cubic centimeters per gram.
c) The macropore void fraction in the pellet.
d) The micropore void fraction in the pellet.

9. The following kinetic data are obtained in an experimental Carberry type basket reactor using 100gm of catalyst in the paddles and different flow rates from run to run : **13**

$A \to R$	F_{A0}, mol/ min	0.14	0.42	1.67	2.5	1.25
$C_{A0} = 10\,mol/m^3$	C_A, mol/ m^3	8	6	4	2	1

Determine the amount of catalyst needed in a packed bed reactor for 75% conversion of 1000 mol A/min of a $C_{A0} = 8\ mol/m^3$ feed.

OR

10. The catalytic reaction **13**

$$A \rightarrow 4R$$

is studied in a plug flow reactor using various amounts of catalyst and 20 liters/hr of pure A feed at 3.2 atm and 117°C. The concentrations of A in the effluent stream is recorded for the various runs as follows.

Run	1	2	3	4
Catalyst used, kg	0.020	0.040	0.080	0.160
C_{Aout}, mol/ liter	0.074	0.060	0.044	0.029

Find the rate equation for this reaction, using the integral method of analysis

11. The first-order decomposition of A is run in an experimental mixed flow reactor. Find the role played by pore diffusion in these runs; in effect determine whether the runs were made under diffusion-free, strong resistance, or intermediate conditions. **13**

d_p	W	C_{A0}	v	X_A	
2	4	75	10	0.2	$A \rightarrow R$
1	6	100	5	0.6	

OR

12. The following kinetic data on the reaction $A \rightarrow R$ are obtained in an experimental packed bed reactor using various amounts of catalyst and a fixed feed rate $F_{A0} = 10k\ mol/hr$. **13**

W, kg cat	1	2	3	4	5	6	7
X_A	0.12	0.20	0.27	0.33	0.37	0.41	0.44

Find the reaction rate at 40% conversion.

In designing a large packed bed reactor with feed rate $F_{A0} = 400$ k mol/hr how much catalyst would be needed for 40% conversion.

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