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

Time : Three Hours

AW - 3514

Max. Marks : 80

Notes :
1. All question carry marks as indicated.
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 chemical 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 of pen Blue/Black ink/refill only for writing the answer book.

SECTION - A

1. The concentration readings given below represent a continuous response to a pulse input into a closed vessel. **14**

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

This vessel is to be used as a reactor for decomposition of a liquid A,
A → Product with rate $-r_A = k C_A$,

$k = 0.307\ min^{-1}$

Estimate the fraction of the reactant unconverted in the real reactor and compare this with the fraction unconverted in a plug flow reactor of same size.

OR

2. Explain pulse input experiment for finding RTD. **14**

3. Derive the conversion equation for SCM for spherical particle of fixed size, assume that, resistance of the gas film controls the overall rate. **13**

OR

4. The reduction of iron ore of size R = 5 mm and density $\rho_B = 4.6 g/cm^3$ by hydrogen can be represented by the shrinking core model (SCM). With no water vapour present, the reaction stoichiometry is $4H_2 + Fe_3O_4 \rightarrow 4H_2O + 3Fe$. The rate approximately proportional to concentration of hydrogen. **13**

The first order rate constant is given by $K'' = 1.93 \times 10^5 e^{-24000/RT}$, cm/s. Taking $D_e = 0.03$ cm^2/s for hydrogen penetration in product layer, calculate the time needed for complete conversion of a particle of oxide to metal of temperature of 600°C and pressure of 1 atm. Take At. wt. of Fe = 56, and O = 16. Film resistance can safely be neglected in presence of ash layer.

An undesired impurity is to be removed from air by absorption in pure water in a counter current tower. 13

Impurity in inlet air = 0.5% (500 Pa)
Impurity in outlet air = 0.1% (100 Pa)
Flow rates of gas and liquid are :

$F_g/A_{cs} = 1\times10^5 \text{ mol}/(\text{h.m}^2)$

$F_l/A_{cs} = 10.6\times10^5 \text{ mol}/(\text{h.m}^2)$

$F_{Ag}\,a = 0.6 \text{ mol}/(\text{h.m}^3\text{.Pa})$

$K_{A\ell}\,a = 0.5 \text{ h}^{-1}$

Molar density of liquid, assumed constant, is C_T =56000 mol/m^3 and H_A = 15 (Pa. m^3)/mol. Calculate the height of tower required.

OR

6. a) Explain the use of solubility data to determine the Kinetic regime. 7

b) Explain chemical and physical absorption with suitable example. 6

SECTION - B

7. Derive an expression for conversion (X_A) as a function of time for irreversible first order reaction $A \rightarrow R$, which is carried out isothermally in a batch reactor on a catalyst that is decaying as per following decay law $\frac{-da}{dt} = k\,da$ 14

OR

8. a) Explain the methods of catalyst preparation in detail. 6

b) Explain the mechanisms of catalyst deactivation. 8

9. Derive an expression for the effectiveness factor of a rectangular slab of porous catalyst. 13

OR

10. For the catalytic reaction $A \rightarrow 4R$, following rate-concentration data are available: 13

C_A, mol/l	0.039	0.0575	0.075	0.092
$-r'_A$, mol A/(h.kg cat)	3.4	5.4	7.6	9.1

Determine the size of packed bed (W) to treat 2500 mol/h of pure A at 3.2 atm. and 117°C to 35% conversion directly from the data given.

11. The hydrogenation of 2 - butyne -1, 4 - diol to butenediol is to be carried out in a slurry reactor using a palladium based catalyst. 13

$$H_2(g \rightarrow L) + \text{butynediol}(l) \xrightarrow[\text{cat}]{\text{solid}} \text{butenediol}$$

The reaction is first order in hydrogen and in butynediol. The initial concentration of butynediol $\left(C_{B_0}\right)$ is 2500 mol/m^3. Pure hydrogen is bubbled through the reactor. Unsed

hydrogen is recompressed and recirculated, and the whole operation takes place at 14.6 atm.

Find the time required to achieve 90% conversion of reactant to butenediol

Data:

Reactor : Mechanically agitated slurry reactor (semibatch)

Vol^m of reactor $= V_r = 2\,m^3 \cdot r$,

$Fs = 0.0055\,m^3 cat / m^3 r$

Catalyst: $dp = 5 \times 10^{-5}\,m$, $\rho_s = 1450 kg / m^3$

$De = 5 \times 10^{-10}\,m^3 l / (m.cat.s)$

Liquid: $C_{B_0} = 2500\,mol / m^3$, $V_l = V_r$

Gas: · Pure H_2 at 14.6 atm, H_A= 148000 (Pa. m^3. l/mol)

Kinetics: $(K_{Ai}\ ai)_{g+l} = 0.277 m^3 l / (m^3 r.s)$

Sum of the gas and liquid film conductance's

$K_{A_c} = 4.4 \times 10^{-4}\,m^3 l / (m^2.cat.s)$

Rate constant $K' = 5 \times 10^{-5}\,m^6 \ell / (mol.kg\ cat.s)$ at 35° C

OR

12. a) Explain any two reactors use to carrying out G/L reaction catalysed by solids. **8**

b) Explain the step involve in G/L reaction on a solid catalyst. **5**

****