**[ 3 Hours ]** **[ Total Marks : 80]**

**Please check whether you have got the right question paper.**

**N.B:**
1. Question No. 1 is compulsory.
2. Attempt any three questions from remaining five questions.
3. Each question carries 20 marks.
4. Figures to the right indicate full marks.
5. Assume suitable data wherever required.

**1.** **(a)** Define residence time distribution function and explain how residence time distribution is measured in a reactor. **(05)**

**(b)** Define and explain in brief what is overall effectiveness factor. **(05)**

**(c)** Define bulk density and apparent density of a solid catalyst. **(05)**

**(d)** Explain what is vessel dispersion number and Damköhler number. **(05)**

**2.** **(a)** Derive the equation for internal effectiveness factor when diffusion is occuring in a spherical catalyst pellet in the presence of an irreversible first-order reaction, $A \rightarrow B$ **(10)**

**(b)** Explain the mechanisms of catalyst deactivation. **(10)**

**3.** **(a)** Outline the construction, operation and design of a fixed bed reactor. **(10)**

**(b)** Gaseous A decomposes on a solid catalyst as per the following reaction:- **(10)**

$$A \rightarrow R, \; -r_A = k C_A^2$$

A pilot plant scale tubular reactor packed with 2 litres of catalyst is fed with 2 $m^3$/h of pure A at $300^0$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 $300^0$C consisting of 60% A and 40% diluents in a larger plant to obtain 85% conversion of A. Find the internal volume of the reactor.

**4.** **(a)** Develop a Langmuir – Hinshelwood type of rate equation for: **(10)**

$$A + B \rightleftharpoons C + D$$

where the rate of adsorption of A is the rate controlling step.

**(b)** Dispersed noncoalescing droplets ($C_{A0}$ = 2 mol/l) react as they pass through a contactor. The reaction kinetics and stoichiometry are: **(10)**

$$A \rightarrow R, \; -r_A = k C_A^2 \;\; (k = 0.5 \text{ l/mol.min})$$

Find the average concentration of reactant A remaining in the droplets leaving the contractor. Take E = 0.5 $min^{-1}$ for 1< t<3 min.

**5. (a)** Spherical particles of zinc sulphide [R = 1mm] are roasted in an 8% oxygen stream at 900$^0$C and 1 atm. The reaction that proceeds according to the Shrinking Core Model (SCM) is as follows: **(10)**

$$2ZnS + 3O_2 \rightarrow 2ZnO + 2SO_2$$

Using the data given below calculate:

i) Time required for complete conversion of a particle,

ii) Relative resistance of ash layer diffusion.

Data: $\rho_B = 4.13\ g/cm^3 = \ 0.0425\ gmol/cm^3$

$$y(n) = \frac{1}{2} y(n-1) + x(n)$$

$$D_e = 0.08\ cm^2/s$$

**(b)** Explain with help of relevant equations the following:- **(10)**

i) Segregation model for non-ideal reactors

ii) Tanks-in-series model for non-ideal reactors.

**6. (a)** A feed consisting of:- **(10)**

30% of 50 μm radius particles

40% of 100 μm radius particles

30% of 200 μm radius particles

is fed continuously in a thin layer onto a moving grate cross-current to a flow of reactant gas. For the planned operating conditions the time required for complete conversion is 5, 10 and 20 minutes for the three sizes of particles. Find the conversion of solids on the grate for a residence time of 8 minutes in the reactor.

**(b)** Write short notes on the following :- **(10)**

i) Trickle bed reactors

ii) Enzyme fermentation reactions.

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