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

N.B. (i) Question number 1 is compulsory.
(ii) Answer any three questions from rest.
(iii) Assume suitable data wherever necessary.

Q. 1. A) Explain Pulse input experiment for RTD measurement [5]

B) In an experiment to determine the pore volume and catalyst particle porosity the following data were obtained on a sample of activated silica
Mass of catalyst sample placed in chamber = 101.5 gm
Volume of helium displayed by the sample = 45.1 cm^3
Volume of mercury displayed by sample = 82.7 cm^3
Calculate the required properties [5]

C) Explain the following terms [5]

(i) Hatta number (ii) Effectiveness factor

D) What is tracer and what are the properties of tracer? [5]

Q. 2. A) The concentration readings given below represent a continuous response to pulse input into a closed vessel. [15]

Time t (sec)	10	20	30	40	50	60	70	80
Tracer conc., gm/lit	0	3	5	5	4	2	1	0

i) Tabulate and plot E & F curve
ii) Calculate mean residence time
iii) Variance of response to pulse input
Determine the fraction of material leaving the reactor that has spent between 20 & 60 sec in the reactor.

B) Explain dispersion model [5]

Q. 3. A) Calculate the time required for complete burning of particles of graphite (*size: Ro = 5 mm, density:* ρ_B *= 2.2 gm/cc*) in an *8%* oxygen stream at *900°C and 1 atm.*
For the high gas velocity used assume that film diffusion does not offer any resistance to transfer and reaction. Data: *Rate constant = k" = 20 cm/sec* [10]

B) An ore of uniform size particles is to be roasted in a fluidized bed reactor. The time required for complete conversion of solid particles is 20 min and the mean residence time of particles in the bed is 48 min. the solids remain unchanged in size during reaction. Calculate the fraction of the original ore remaining unconverted assuming (i) the chemical reaction step to be rate controlling (ii) the ash diffusion step to be rate controlling [10]

Q. 4. A) Ethanol can be produced by catalytic vapour phase hydration of hydration of ethylene at 135 atm and 573 K.

$C_2H4 + H_2O \longleftrightarrow C_2H_5OH$

$A + B \longleftrightarrow R$

The rate expression for this reaction is

$(-r_A) = zk_Ak_B(p_Ap_B-p_R/K) / (1 + k_Ap_A + k_Bp_B)^2$, *mol/(gm.cat.h)*

Where $z = 0.018$, $k_A = k_B = 0.003$

The equilibrium constant is given by

$RT\ lnK = 30T - 9730$ *where* $R = 1.987$ *cal/(mol.K)*

The total feed rate to *PFR is 10 kg/h* with equimolar amounts of ethylene and steam. Find the weight of catalyst needed to achieve *20%* conversion of ethylene. [12]

B) 10 m3/h of a gaseous feed containing *A & B* passes through an experimental reactor packed with 4 kg of catalyst.

The stoichiometry and rate are given by

$A + B \longrightarrow R + S$

$(-r_A) = 0.6\ C_A\ C_B$, *mol/kg.h*

Find the conversion of reactants if the feed to the reactor contains *0.1 mol A/m^3 and 10 mol B/m^3* [8]

Q. 5. A) Develop Langmuir Hinshelwood model for the following reaction when adsorption of A is rate limiting step [12]

$A + B \longleftrightarrow R + S$

B) Explain BET method for determination of surface area of solid catalyst [8]

Q. 6. A) Explain contacting patterns (schemes) for two phase systems [5]

B) Explain helium mercury method to determine void volume & solid density [5]

C) Derive an expression of time required for complete conversion of spherical particle when diffusion through gas film control the overall reaction rate. [10]