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

N.B. (1) Question No.1 is compulsory.
(2) Attempt any **three** questions from remaining.
(3) Assume suitable data wherever necessary with proper justification

Q.1 a) The Thiele modulus for a first order isothermal reaction for a flat plate geometry catalyst is found to be 2. Calculate the catalyst effectiveness factor. **(05)**

b) Calculate the time required for complete burning of particles of graphite (size: Ro= 5 mm, density: $\rho_B = 2.2$ gm/cm^3) in an 8 % oxygen stream at 900 deg C and 1 atm. For the high gas velocity assume that film diffusion does not offer any resistance to transfer and reaction. Rate constant : k" = 20 cm/sec **(05)**

c) Sketch the concentration profile for fluid fluid reaction if it is slow reaction (Assume reaction is between gaseous A and liquid B. Show the concentration profile for 1) High C_B 2) Low C_B **(05)**

d) A liquid macrofluid ,as it flows through a vessel , reacts as per following reaction and kinetics: **(05)**
$A \rightarrow R$ $-r_A = k$ mol/l min; k=3 mol/l min and C_{A0}= 6 mol/l
For the flow pattern with E=0.333 for 0<t< 3 min, determine the conversion of A.

Q.2. Develop Langmuir-Hinshelwood type of rate equation for **(20)**

$$P + Q \rightleftarrows R + S$$

a) When the rate of desorption of R is rate controlling step.
b) When the surface reaction between Adsorbed P and gaseous Q is rate controlling step.

Q.3 a) In a fluidized bed reactor, particles of iron sulphide of uniform size are to be roasted. The time required for complete conversion is 20 min. The mean residence time of particles in the fluidized bed is 60 min. the particles remained as hard solids during reaction. The time required for complete conversion is a function of size of particle ($\tau \alpha R^{1.5}$). Calculate the fraction of the original iron sulphide that remains unreacted. **(10)**

b) Develop conversion time relationship for spherical particles of unchanging size using Shrinking core model for the case when chemical reaction step is offering controlling resistance. **(10)**

Q.4. We plan to remove 90% of the reactant A present in a gas stream by absorption in pure water in a packed tower. Find the volume of tower required for countercurrent operation. **(20)**
For the gas stream : Fg = 9 x10^4 mol/h at $\pi = 10^5$ Pa
$p_{A\,in}$ =1000 Pa, p_{Aout} =100 Pa
For liquid stream : $F_l = 9x10^5$ mol/h
For the packing used
$k_{Ag}.a = 0.36$ mol / (h.m^3.pa); $k_{Al}.a = 72$ h^{-1}
The molar density of liquid under all conditions is
C_T= 55556 mol/m^3
k = 0 m^3 liquid / (mol.h); H_A=18 (Pa.m^3 liquid) / mol

Q.5.a) A first order decomposition reaction where k= 0.05 min^{-1} was carried out in a reactor with a number of dividing baffles .The results of tracer test are given in table below **(20)**

t, min	0	10	20	30	40	50	60	70
C_{pulse}, *g/l* (tracer output concentration)	35	38	40	40	39	37	36	35

i) Calculate mean residence time
ii) Estimate the conversion assuming a) plug flow ; b) mixed flow
iii) How many tanks in series would you suggest to model this reactor.

Q.6.a) Oxidation of NO is catalyzed by an active carbon according to following rate: **(10)**

$$-r' = \frac{p_{NO}^2 . p_{O2}}{a + b\, p_{NO}^2 + c\, p_{NO2}} \left(\frac{mol}{h.g\ cat}\right)$$

a = 1.619 x 10^{-4} , b = 4.812, c = 1.352 x 10^{-3}
p = partial pressure in atm
Find the volume of a reactor for converting 50 metric tonnes per day of NO to NO_2 when using an air-No mixture containing 15 mole % of NO. The conversion of No is 90%. The bulk specific gravity of catalyst is 0.48 and the total pressure is 3 atm.

b) Write short note on Slurry Reactor **(10)**
