Enrolment No./Seat No_______________

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VII EXAMINATION – SUMMER 2025

Subject Code:3170501 **Date:19-05-2025**

Subject Name:Chemical Reactions Engineering II

Time:02:30 PM TO 05:00 PM **Total Marks:70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**
4. **Simple and non-programmable scientific calculators are allowed.**

			MARKS
Q.1	**(a)**	Suggest suitable heterogeneous catalyst used in Petrochemical/Petroleum Refining, Polymerisation and Bulk Chemical industries.	**03**
	(b)	List various solid catalyst synthesis methods and discuss generalized sol-gel method to synthesize solid nano-catalyst.	**04**
	(c)	What do you mean by rate controlling step for a given reaction? Derive rate equation for gas film controlled gas-liquid non-catalytic reaction.	**07**
Q.2	**(a)**	Spherical particles of zinc sulfide of size R = 1 mm are roasted in an 8% oxygen stream at 900°C and 1 atm. The stoichiometry of the reaction is $2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2$ Assuming that reaction proceeds by the shrinking-core model calculate the time needed for complete conversion of a particle and the relative resistance of ash layer diffusion during this operation. Data: Density of solid, $\rho_B = 4.13\ gm/cm^3 = 0.0425\ mol/cm^3$ Reaction rate constant, k" = 2 cm/sec For gases in the ZnO layer, De = 0.08 cm2/sec Note that film resistance can safely be neglected as long as a growing ash layer is present.	**03**
	(b)	Suggest suitable model for solid fluid reactions having following situations, 1) burning of highly porous combustible material like bunch of loose cotton, 2) burning of small thin incenses, 3) corrosion of iron plate, 4) burning of highly dense coke particle.	**04**
	(c)	A solid feed consisting of 20 wt% of 1-mm particles and smaller 30 wt% of 2-mm particles 50 wt% of 4-mm particles passes through a rotating tubular reactor somewhat like a cement kiln where it reacts with gas to give a hard nonfriable solid product (SCMI reaction control, T = 4 h for 4-mm particles). 1) Find the residence time needed for 100% conversion of solids. 2) Find the mean conversion of the solids for a residence time of 15 min.	**07**
		OR	
	(c)	1) Discuss the limitation of Shrinking Core Model. 2) With neat schematic diagram explain reactant gas and solid concentration profile for SCM and PCM models.	**07**

Q.3 (a) Suggest suitable contactor for a fluid-fluid reaction having bulk liquid resistance as a controlling resistance. Justify your recommendation. **03**

(b) With neat schematic diagram explain salient features of packed column reactor used for fluid-fluid reaction. **04**

(c) Gaseous A absorbs and reacts with B in liquid according to **07**

$A(g) + B(l) \longrightarrow R(l)$

in a packed bed under conditions where

$k_{Ag*}a = 0.1$ mol/hr.m^2 of reactor.Pa, fi = 0.01 m^3 liquid/m^3 reactor

$k_{Al*}a = 100$ m^3/liquid/m^3 reactor. hr

$D_{Al} = D_{Bl} = 10^{-6}$ m^2/hr, $k = 10^{-2}$ m^3 liquid/mol.hr

a = 100 m^2/m^3 reactor, $H_A = 1$ Pa. m^3 liquid/mol

At a point in the reactor where $p_A = 100$ Pa and $C_B = 100$ mol/m^3 liquid

(1) calculate the rate of reaction in mol/hr.m^3 of reactor.

(2) describe the following characteristics of the kinetics: location of the major resistance (gas film, liquid film, main body of liquid) behavior in the liquid film (pseudo first-order reaction, instantaneous, second-order reaction, physical transport) for the following values of reaction rate and Henry's law constant.

OR

Q.3 (a) For fluid-fluid reaction, under which circumstances high f_l value is desired? Justify with suitable example. **03**

(b) With neat schematic diagram explain salient features of tray column and agitated tank reactor used for fluid-fluid reaction. **04**

(c) The rate of CO_2 absorption into an alkaline buffered solution of K_2CO_3 and $KHCO_3$. The resulting reaction can be represented as **07**

$$\underset{(A)}{CO_2(g \rightarrow l)} + \underset{(B)}{OH^-(l)} \rightarrow HCO_3^- \quad \text{with} \quad -r_A = kC_AC_B$$

In the experiment pure CO_2 at 1 atm was bubbled into a packed column irrigated by rapidly recirculating solution kept at 20°C and close to constant C_B. Find the fraction of entering CO_2 absorbed.

Data: Column: $V_r = 0.6041$ m^3, $f_l = 0.08$, $a = 120$ m^2/m^3,

Gas: $\pi = 101325$ Pa, $H_A = 3500$ Pa. m^3/mol, $v_0 = 0.0363$ m^3/s

Liquid: $C_B = 300$ mol/m^3, $D_{Al} = D_{Bl} = 1.4 \times 10^{-9}$ m^2/s,

Rates: $k = 0.433$ m^3/mol. S, $k_{Al}a = 0.025$ s^{-1}

Q.4 (a) Discuss significance of XRD, SEM and TPD analysis in characterization of catalyst. **03**

(b) Discuss importance of surface area and thermal stability characteristics of catalyst. Also suggest suitable techniques to measure these characteristics. **04**

(c) Write short note on "Catalyst: Promoters, Inhibitors and Poisons." **07**

OR

Q.4 (a) Draw schematic diagram of three different types of industrial fixed bed catalytic reactors with heat removal arrangements for different exothermic reactions. **03**

(b) Discuss salient features of fluidized bed reactor. Also list various industrial applications of fluidized bed reactors. **04**

(c) Discuss experimental reactors for solid catalyzed reactions. **07**

Q.5 (a) Discuss significance of Thiele Modulus for heterogeneous solid catalytic reactions. **03**

(b) 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. **04**

Reaction is $A \longrightarrow R$

Dp	W	C_{A0}	v	X_A
4	1	300	60	0.8
8	3	100	160	0.6

(C) To build a packed bed reactor filled with 1.2-cm porous catalyst particles (ρ_s = 2000 kg/m3, .De = 2 x 10^{-6} m3/m cat.s) to treat 1 m^3/s of feed gas (1/3 A, 1/3 B, 1/3 inert) at 336 ^{0}C and 1 atm to 80% conversion of A. Experiments with fine catalyst particles which are free from diffusional resistance show that **07**

$A + B \rightarrow R + S$, n=2, k′ = 0.01 m^6/mol.kg.s

How much catalyst must be used?

OR

Q.5 (a) Justify role of effectiveness factor in rate expression of solid catalytic reaction. **03**

(b) Discuss salient features of LHHW model for solid catalysed reactions. **04**

(c) Gaseous A reacts ($A \rightarrow R$) in an experimental plug flow reactor. From the following conversion data at various conditions find a rate equation to represent the reaction, **07**

W, gm	0.5	1	2.5
CA,mol/m^3	30	20	10

Consider plug flow rate and C_{A0}= 60 mol/m^3, v = 3 liter/min

****