Enrolment No./Seat No_____________

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VII (NEW) EXAMINATION – SUMMER 2024

Subject Code:3170501 **Date:24-05-2024**

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)** Define: (i) Catalyst (ii) Promoter (iii) Inhibitor (iv) Carrier (v) Accelerator (vi) selectivity **03**

(b) Enlist the four methods of catalyst preparation. Explain anyone in detail. **04**

(c) Nitrogen was employed to determine the surface area of 1.0 g sample of silica gel and results obtained shown in table below. The sample of silica gel was maintained at the normal boiling point of liquid nitrogen (77K). One molecule of nitrogen occupies 16.2×10^{-20} m^2 area of plane surface. Calculate the specific surface area of silica gel by the BET method. The saturated vapor pressure p_0 of nitrogen at 77K is 101.3 kPa. **07**

Equilibrium Pressure, p [kPa]	5.0	6.3	7.5	9.0	11.2
Volume adsorbed, STP, V x 10^6 [m^3]	6.7	7.0	7.2	7.4	7.7

Q.2 **(a)** Write the assumption for Langmuir Hinshelwood Hougen Watson model **03**

(b) Explain the mechanism of solid catalysed reactions **04**

(c) The experimental data for the gas-phase, catalytic, irreversible reaction A + B → C is given in the table. Suggest a rate law & mechanism consistent with the data. **07**

Run	Rate (mol/g s)	P_A (atm)	P_B (atm)	P_C (atm)
1	0.073	0.1	1	2
2	3.42	1	10	2
3	0.54	10	1	2
4	6.80	1	20	2
5	2.88	1	20	10
6	0.56	20	1	2
7	0.34	1	1	2
8	4.5	1	20	5

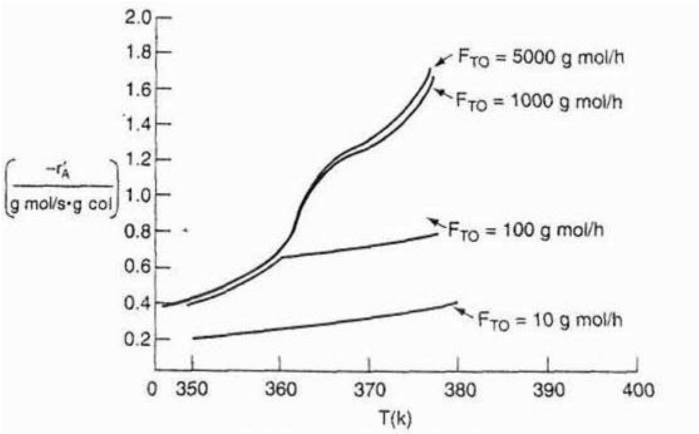
OR

(c) The catalytic reaction **07**

$$A \rightarrow B$$

takes place within a fixed bed containing spherical porous catalyst X22. Figure shows the overall rates of reaction at a point in the reactor as a function of temperature For various entering total molar flow rates F_{T0}.

(a) Is the reaction limited by external diffusion? If your answer to the question was "yes." under what conditions [of those shown (i.e., T, F_{TO})] is the reaction limited by external diffusion?



(b) is the reaction "reaction-rate-limited"? If your answer to the question was "yes," under what conditions [of those show (i.e., T, F_{TO})] is the reaction limited by the rate of the surface reactions?

(c) Is the reaction limited by internal diffusion? If your answer to the question was "yes," under what conditions [of those show (i.e., T, FTO)] is the reaction limited by internal diffusion?

(d) For a flow rate of 10 gmol/h. determine (if possible) the overall effectiveness factor, Ω, at 360 K

(e) Estimate (if possible) the internal effectiveness factor, η. at 367 K

Q.3 **(a)** Discuss the significance of Effectiveness factor for solid catalysed reaction **03**

(b) Write the significance of Thiele Modulus. **04**

(c) Cl_2 is removed from a waste stream by passing the effluent gas over a solid granular absorbent in a tubular PBR. Presently 63.2% is removed and the reaction is external diffusion limited. If the flow rate were increased by a factor of 4, the particle diameter was decreased by a factor of 3, and the tube length (z) were increased by 1.5x, what percentage of Cl_2 would be removed (assume still external diffusion limited)? What guidelines (T, C_A, u) do you propose for the efficient operation of this bed? **07**

OR

Q.3 **(a)** Write in brief about trickle bed reactor **03**

(b) Write a brief note on working of fluidized bed reactor **04**

(c) The catalytic reaction **07**

$$A \rightarrow 4R$$

is run at 3.2 atm and 117°C in a plug flow reactor which contains 0.01 kg of catalyst and uses a feed consisting of the partially converted product of 20 liters/ hr of pure unreacted A. The results are as follows:

	1	2	3	4
$C_{A,in}$, mol/lit	0.1000	0.080	0.060	0.040
$C_{A,out}$, mol/lit	0.084	0.070	0.055	0.038

Find a rate equation to represent this reaction

Q.4 **(a)** Write limitations of a shrinking core model for solid-fluid non-catalytic system **03**

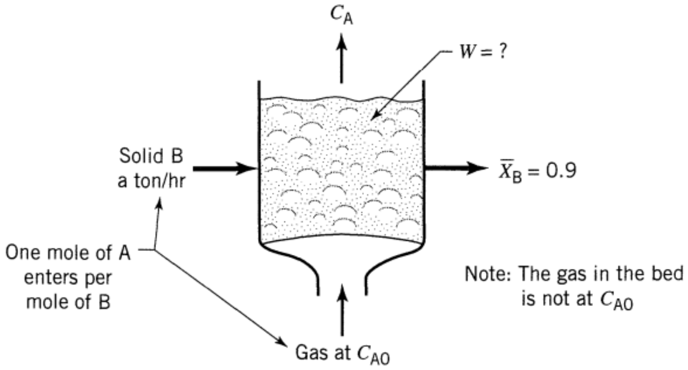
(b) Discuss with neat sketch the selection of model for fluid – particle reactions **04**

(c) In a gas-phase environment, particles of B are converted to solid product as follows: **07**

$$A_{(gas)} + B_{(solid)} \rightarrow R_{(gas)} + S_{(solid)}$$

Reaction proceeds according to the shrinking core model with reaction control and with time for complete conversion of particles of 1 hr.

A fluidized bed is to be designed to treat 1 ton/hr of solids to 90% conversion using a stoichiometric feed rate of A, fed at C_{A0},. Find the weight of solids in the reactor if gas is assumed to be in mixed flow. Note that the gas in the reactor is not at $C_{A0.}$ Below Figure sketches this problem.



OR

Q.4 **(a)** Draw a plot to show the progress of the reaction of a single spherical particle of constant size with surrounding fluid measured in terms of time for complete conversion for all the different resistances. **03**

(b) Analyze the role of temperature and particle size for experimentally determining the rate-controlling step of a fluid particle noncatalytic reaction. **04**

(c) Spherical particles of zinc blende of size R = 1 mm are roasted in an 8% oxygen stream at 900°C and 1 atm. The stoichiometry of the reaction is **07**

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

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, ρ_B, = 4.13 gm/cm^3 = 0.0425 mol/cm^3

Reaction rate constant, k'' = 2 cm/sec

For gases in the ZnO layer, D_e = 0.08 cm^2/sec

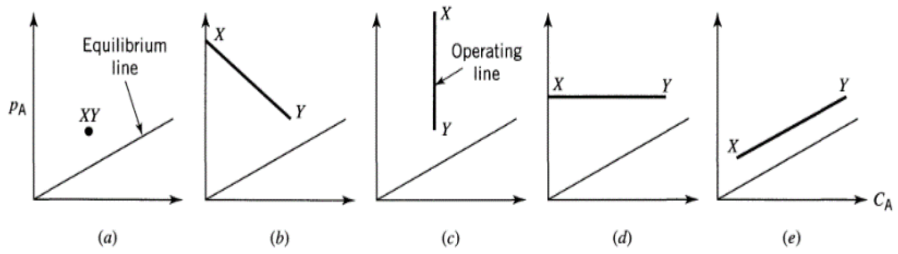
Note that film resistance can safely be neglected as long as a growing ash layer is present.

Q.5 **(a)** Write a short note on contacting patterns for two-phase systems with neat sketch **03**

(b) Dilute A diffuses through a stagnant liquid film onto a plane surface consisting of B, reacts there to produce R which diffuses back into the mainstream. Derive the overall rate expression for the L/S reaction. **04**

A(l) + B(s) →R(l).

(c) The four p_A versus C_A sketches of Fig represents various possible ideal contacting schemes of gas with liquid. Sketch the contacting scheme for straight physical absorption corresponding to the p, versus C_A operating lines XY shown in Fig. **07**



OR

Q.5 **(a)** Write in brief on how solubility data can help to predict the kinetic regime for fluid -fluid reactions **03**

(b) Derive the rate equation for fast reaction with high concentration of liquid reactant in fluid – fluid reaction **04**

(c) Air with gaseous A bubbles through a tank containing aqueous B. Reaction occurs as follows: **07**

$A_{(g\rightarrow l)} + 2B_{(l)} \rightarrow R_{(l)}$, $-r_A = kC_AC_B$, $k = 10^6\ m^6/mol^2.hr$

For this system

$k_{Ag} = 0.01$ mol/hr.m^3.Pa, f_l=0.98, k_{Al}=20 hr^{-1}, H_A=10 Pa.m^3/mol, very low solubility, $D_{al} = D_{Bl} = 10^{-6}$ m^2/hr, a = 20 m^2/m^3 for a point in the absorber-reactor where,

$p_A = 5 \times 10^3$ Pa and $C_B = 100$ mol/m^3

(a) locate the resistance to reaction (what % is in the gas film, in the liquid film, in the main body of liquid)

(b) locate the reaction zone

(c) determine the behavior in the liquid film (whether pseudo first-order reaction, instantaneous, physical transport, etc.) (d) calculate the rate of reaction (mol/m^3 .hr)

****