Enrolment No./Seat No_____

GUJARAT TECHNOLOGICAL UNIVERSITY

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

Subject Code:3170501 Date:04-12-2024

Subject Name: Chemical Reactions Engineering II

Time:10:30 AM TO 01:00 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)**	Discuss advantages and disadvantages of solid heterogeneous catalysts.	**03**
	(b)	Write four suitable industrial reactions of solid-fluid reactions.	**04**
	(c)	Derive rate expression for fluid-fluid reaction with gas film as rate controlling step.	**07**
Q.2	**(a)**	Spherical solid particles containing B are roasted isothermally in an oven with gas of constant composition. Solids are converted to a firm non-flaking product according to the SCM as follows:	**03**

$A_{(g)} + B_{(S)} \longrightarrow R_{(g)} + S_{(s)}$, C_A=0.01 kmol/m^3, ρ_B = 20 kmol/m^3

From the following conversion data (by chemical analysis) or core size data (by slicing and measuring) determine the rate controlling mechanism for the transformation of solid.

dp, mm	Xb	t, min
1	1	4
1.5	1	6

	(b)	Discuss SCM and PCM with suitable schematic diagram.	**04**
	(c)	Solids of unchanging size, R = 0.3 mm, are reacted with gas in a steady flow bench scale fluidized reactor with the following result. F_0 = 10 gm/sec, W = 1000 gm, avg. X_B = 0.75 Also, the conversion is strongly temperature-sensitive suggesting that the reaction step is rate-controlling. Design a commercial sized fluidized bed reactor (find W) to treat 4 metric tons/hr of solid feed of size R = 0.3 mm to 90% conversion	**07**
		OR	
	(c)	Derive rate expression for ash film controlled non-catalytic solid-fluid reaction.	**07**
Q.3	**(a)**	Suggest suitable justification for selection of packed tower for non-catalytic fluid-fluid redaction.	**03**
	(b)	Compare the salient features of packed column and agitator reactor for fluid-fluid heterogeneous reactions.	**04**
	(c)	Hydrogen sulfide is a absorbed by a solution of methanolamine (MEA) in a packed column. At the top of the column, gas is at 20 atm and it contains 0.1% of H_2S, while the absorbent contains 250 mol/m^3 of free MEA. The diffusivity of MEA in solution is 0.64 times that of H_2S. The reaction is normally regarded as irreversible and instantaneous.	**07**

$H_2S + RNH_2 \rightarrow HS^- + RNH^{+3}$

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(A) (B)

For the flow rates and packing used
$k_{Al}a = 0.03\ s^{-1}$
$k_{Ag}a = 60$ mol/m3.s.atm
$H_A = 10^{-4}\ m^3$atm/mol, Henry's law constant for H_2S in water.
i). Find the rate of absorption of H_2S in MEA solution.
ii). To find out whether it is worthwhile using MEA absorbent, determine how much faster is absorption with MEA compared to absorption in pure water.

OR

Q.3	**(a)**	Give three examples of heterogeneous fluid-fluid reactions.	**03**
	(b)	Discuss significance of Enhancement factor and Hatta Modulus for heterogeneous fluid-fluid reactions.	**04**
	(c)	Discuss eight special cases of non-catalytic fluid-fluid heterogeneous reactions.	**07**
Q.4	**(a)**	Discuss role of Promoters, Inhibitors and Poisons in Catalyst performance.	**03**
	(b)	Discuss sol-gel method for heterogeneous catalyst preparation.	**04**
	(c)	Discuss XRD, SEM and TPD analysis.	**07**

OR

Q.4	**(a)**	Discuss catalyst preparation through wet impregnation method.	**03**
	(b)	Draw schematic diagram of fluidized bed reactor with its salient features.	**04**
	(c)	Discuss experimental reactors for solid catalyzed reactions.	**07**
Q.5	**(a)**	Discuss concept of pore diffusion in solid catalyzed reactions.	**03**
	(b)	A first-order catalytic reaction $A_{(l)} \rightarrow R_{(l)}$ is run in a long, narrow vertical reactor with upflow of liquid through a fluidized bed of catalyst particles. Conversion is 95% at the start of operations when the catalyst particles are 5 mm in diameter. The catalyst is friable and slowly wears away, particles shrink and the fine powder produced washes out of the reactor. After a few months each of the 5-mm spheres has shrunk to 3-mm spheres. What should be the convers dion at this time? Assume plug flow of liquid. (i) Particles are porous and allow easy access for reactants (no resistance to pore diffusion). (ii) Particles are porous and at all sizes provide a strong resistance to pore diffusion.	**04**
	(C)	Explain detailed reaction mechanism on solid surface considering LHHW model.	**07**

OR

Q.5	**(a)**	Discuss salient features of trickle bed reactor.	**03**
	(b)	Define Thiele modulus and Enhancement factor and discuss its significance.	**04**
	(c)	To build a packed bed reactor filled with 1.2-cm porous catalyst particles (ρ_s = 2000 kg/m3, D_e = 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 $A + B \rightarrow R + S$, n=2, $k' = 0.01\ m^6$/mol.kg.s How much catalyst must be used?	**07**

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