BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: MTECH **SEMESTER: I**
BRANCH: BIOTECHNOLOGY **SESSION: MO/2024**

SUBJECT: BE503 ADVANCED REACTION ENGINEERING

TIME: 3 Hours **FULL MARKS: 50**

INSTRUCTIONS:
1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
***4*. Before attempting the question paper, be sure that you have got the correct question paper.**
5. Tables/Data handbook/Graph paper etc. to be supplied to the candidates in the examination hall.

			CO	BL
Q.1(a)	What are the various contacting patterns for heterogeneous reaction?	[3]	1	3
Q.1(b)	The irreversible reaction, $C(g) + B(s) \rightarrow R(g)$ first order with respect to and takes place on a flat surface. Dilute A diffuses through stagnant gas film onto a plain surface consisting of B. On the surface A reacts with B to give R which diffuses back to surface. Develop a rate expression for above reaction.	[7]	1	3,4
Q.2(a)	List the general characteristics of catalysts	[3]	2	3
Q.2(b)	Does a catalyst alter equilibrium conversion of a chemical reaction? Explain.	[4]	2	3,4
Q.2(c)	Define Effectiveness Factor of a catalyst. Can effectiveness factor of a catalyst be greater than one? Explain	[3]	2	3,4
Q.3(a)	Explain the mechanism of solid catalyzed reaction. A porous catalyst particle is soaked by reactant A. Discuss the factors influencing the rate of reaction of A.	[5]	3	3,4
Q.3(b)	A second order reaction $A \rightarrow R$, is studied in an experimental recycle reactor, with very large recycle ratio. The data recorded are as follows:	[5]	3	3,4

Data:

- Void volume of the reactor : 1 *l*
- Amount of catalyst used : 3 gms
- Feed to the reactor, v_0 = 1 *l* /hr with C_{A0} = 2 mol/ *l*
- Concentration of A in the exit stream from the recycle stream, C_{Aout} = 0.5mol/ *l*

Calculate the amount of catalyst needed in a packed bed reactor, to achieve 80% conversion, for feed to the reactor, v_0 = 1000 *l* / hr; C_{A0} 1 mol/ *l*

Q.4(a)	Explain the resistances that would be encountered during the burning of coal.	[3]	4	3,4
Q.4(b)	It is proposed to remove CO_2 from air by counter current contact with water at 25^0C.		4	3,4
	(i) Find the resistance of the gas and liquid film for this operation.	[3.5]		
	(ii) Suggest the simplest form of rate equation for tower design.	[3.5]		

Data : For CO_2 between air and water,

$$k_g a = 0.80 \text{ mol/(h·m}^3\text{·Pa)}$$

$$k_l a = 25 \text{ h}^{-1}$$

$$H = 3000 \text{ (Pa·m}^3\text{)/mol}$$

PTO

Q.5(a) Recombinant *E. coli* cells contain a plasmid derived from pBR322 incorporating genes for the enzymes *β-lactamase* and catechol 2,3-dioxygenase from *Pseudomonas putida*. To produce the desired enzymes, the organism requires aerobic conditions. The cells are immobilised in spherical beads of carrageenan gel. 5 3,4

The effective diffusivity of oxygen is: 1.4×10^{-9} m^2 s^{-1}. Oxygen uptake is zero-order with intrinsic rate constant 10^{-3} mol s^{-1} m^{-3} of particle. The concentration of oxygen at the surface of the catalyst is 8×10^{-3} kg m^{-3}. Cell growth is negligible.

(a). What is the maximum particle diameter for aerobic conditions throughout the catalyst particles? [3]

Q.5(b) For the system described above in Q.5 (a), 5 3,4

i) For particles half the diameter calculated in (a), what is the minimum oxygen concentration in the beads? [3.5]

ii) The density of cells in the gel is reduced by a factor of five. If the specific activity of the cells is independent of cell loading, what is the maximum particle size for aerobic conditions? [3.5]

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