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

CLASS: BTECH | **SEMESTER : V**
BRANCH: BIOTECHNOLOGY | **SESSION : MO/2025**

SUBJECT: BE304 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 hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

			CO	BL
Q.1(a)	For a reactant A (initial concentration C_{Ao}), its C_A varies according to $(1/C_A) - (1/C_{Ao}) = k\,t$. where 't' is time and 'k' is kinetic constant. Derive an expression for the rate of reaction.	[5]	1	3,4
Q.1(b)	(i) Milk is pasteurised if it is heated to 63^0C for 30 minutes, but if it is heated to 74^0C it only needs 15 seconds for the same result. Find the activation energy for this sterilisation. (ii) The pyrolysis of ethane proceeds with an activation energy of about 300 kJ/mol. How much faster is the decomposition at 650°C than at 500^0C?	[2X2.5= 5]	1	3,4
Q.2(a)	(i) What is €a in a variable density system (ii) Find €a on this reaction: $A \rightarrow 3R$.	[1+1=2]	2	2
Q.2(b)	When a concentrated urea solution is stored, it slowly condenses to biuret by the following elementary reaction: $2\ NH_2\text{-}CO\text{-}NH_2 \rightarrow NH_2\text{-}CO\text{-}NH\text{-}CO\text{-}NH_2 + NH_3$ To study the rate of condensation a sample of urea (C = 20 milliliter) is stored at 100°C and after 7 hr 40 min we find that 1 mol% has turned into biuret. Find the rate equation for this condensation reaction.	[3]	2	3,4
Q.2.(C)	In the hippopotamus, digestion occurs as an autocatalytic reaction in the stomach followed by a catalytic reaction in the intestines. This system can be modelled as a series of CSTR-PFR. The volumetric flow rate of food intake into the system can be assumed to be 100 L/day, at a concentration of 7.5 mol/L. The volume of the stomach (modelled as CSTR) is 450 L. Reciprocal rates (in moles/L-day) for the two types of reactions are provided in figures in the data sheet. If the total conversion of 50% is observed, what is the volume of the intestines? *(Note: Required data is provided separately at the end of the question paper).*	[5]	2	3,4
Q.3(a)	Assuming a stoichiometry, $A \longrightarrow R$ for a first-order gas-phase reaction, the size of the plug flow reactor for 99% conversion of pure A is calculated to be 32 litres. In fact, however, the stoichiometry is: $A \longrightarrow 3R$ (i). Will the volume of the reactor change? (ii). If so, for this corrected stoichiometry, find the required volume.	[5]	3	3,4
Q.3(b)	While being shown around Lumphead Laboratories, you stop to view a bench-top reactor used to obtain kinetic data. It consists of a 5-cm inner diameter glass column packed with an active catalyst 30 cm in height. Is this a differential or integral reactor? Explain your answer.	[5]	3	3,4

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Q.4(a)	Your company has two MFRs of unequal size for producing a specified product, following first-order kinetics. How should these reactors be connected to obtain a maximum production rate?	[5]	4	3,4
Q.4(b)	Presently, 90% of A is converted into product by a second-order reaction in a single mixed flow reactor. We propose placing a second reactor, similar to the one currently being used, in series with it. (i) For the same treatment rate as that of the first reactor, how will this addition of a reactor affect the conversion of reactant? (ii) For the same 90% conversion, by how much can the treatment rate be increased in the latter case?	[2x2.5=5]	4	3,4
Q.5(a)	In slurry reactors, pure reactant gas A is bubbled through liquid containing suspended catalyst particles. Hence, to reach the surface of the solid, the reactant must diffuse through the liquid film into the main body of the liquid and then through the film surrounding the catalyst particle. At the surface of the catalyst particle, the reactant gives the product according to first-order kinetics. Explain the above transport phenomena with the aid of a diagram and develop an expression for the rate of the reaction in terms of the film resistances.	[5]	5	3,4
Q.5(b)	Consider a porous catalyst bathed by reactant A. Explain the rate-influencing factors of this solid-catalysed reaction.	[5]	5	3,4

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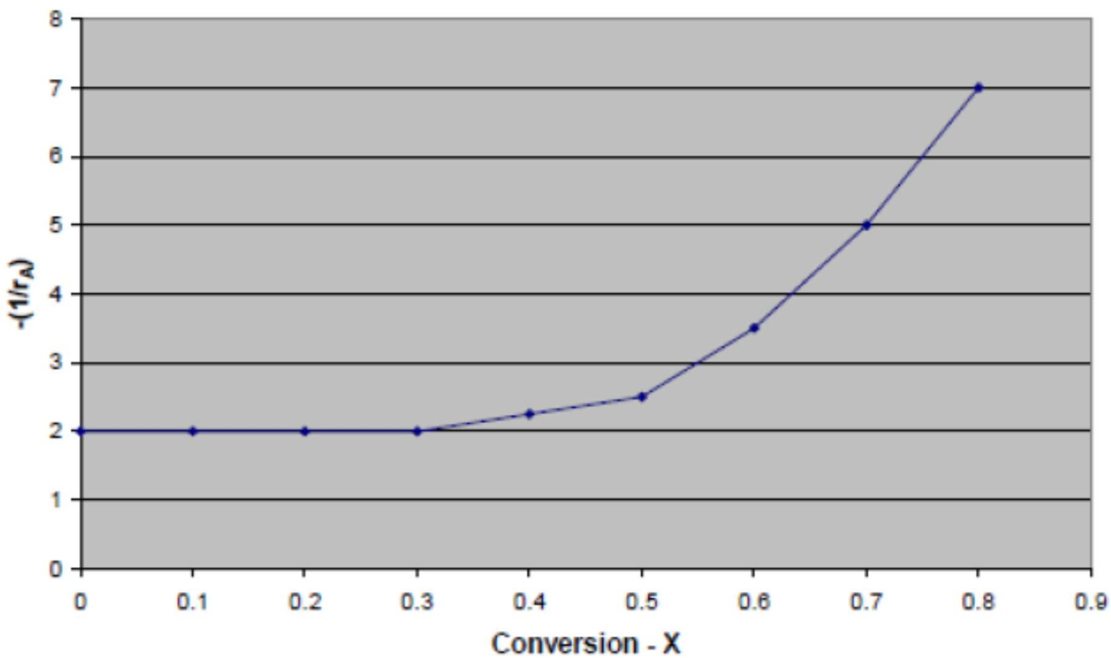
DATA SHEET

Data for Q 2 (c)

Catalytic reaction in the intestines



Autocatalytic reaction in the stomach