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

CLASS: M.TECH **SEMESTER : I**
BRANCH: BIOTECH **SESSION : MO/19**

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

Q.1(a) Detail various types of heterogeneous catalysis and explain their catalytic action with suitable examples. [5]
Q.1(b) Analyse the behavior of non- catalytic and catalytic reactions using a suitable kinetic diagram. [5]

Q.2(a) Explain catalytic deactivation and mechanisms involved in deactivation. [5]
Q.2(b) Analyse the phenomena of pore diffusion resistance distorts the kinetics of reaction with deactivating catalyst. [5]

Q.3 Consider a liquid phase reaction $A \rightarrow B$, where the reaction rate is given by: [10]
$-r_{A} = kC_A / 1 + k_2 C_A^2$. The reaction is conducted at isothermal conditions and the inlet concentration of A is 1 mol/lit. The rate constants are: $k_1 = 0.01\ s^{-1}$ and $k_2 = 30\ lit^2\ mol^{-2}$. The volumetric flow rate is 10 lit s^{-1}. We want to convert 95% of A. Determine the volume of the reactor, if the reaction is to be conducted in a (i) PFR (ii) CSTR (iii) Recycle reactor with recycle ration R=1 and R=2.

Q.4(a) Mathematical analysis of heterogeneous reactions involves a technique called the shell mass balance. Discuss in detail the assumptions made in solving shell balance analysis. [5]
Q.4(b) Invertase is immobilised in ion-exchange resin of average diameter 1 mm. The amount of enzyme in the beads is measured by protein assay as 0.05 kg m^{-3}. 20 cm^3 beads are packed into a small column reactor; 75 ml sucrose solution at a concentration of 16 mM is pumped rapidly through the bed. In another reactor an identical quantity of free enzyme is mixed into the same volume of sucrose solution. Assume the kinetic parameters for free and immobilised enzyme are equal: K_m is 8.8 mM and the turnover number is 2.4×10^{-3}gmol glucose (g enzyme)$^{-1}$ s^{-1}. The effective diffusivity of sucrose in the ion-exchange resin is $2 \times 10^{-6} cm^2 s^{-1}$. What is the rate of reaction by free enzyme? [5]

Q.5(a) Analyse and discuss the strategies you will follow to minimize the negative mass transfer effects. [5]
Q.5(b) Invertase catalyses the reaction: [5]
$C_{12}H_{22}O_{11} + H_20 \rightarrow C_6H_{12}0_6 + C_6H_{12}0_6$.
Invertase from *Aspergillus oryzae* is immobilised in porous resin particles of diameter 1.6 mm at a density of 0.1 μmol enzyme g^{-1}. The effective diffusivity of sucrose in the resin is $1.3 \times 10^{-11}\ m^2\ s^{-1}$. The resin is placed in a spinning-basket reactor operated so that external mass-transfer effects are elim- inated. At a sucrose concentration of 0.85 kgm^{-3}, the observed rate of conversion is 1.25×10^{-3} kg s^{-1} m^{-3} resin. K_m for the immobilised enzyme is 3.5 kg m^{-3}.

(a) Calculate the effectiveness factor. (b) Determine the true first-order reaction constant for immobilised invertase.
Assume : $\Phi = 8.0$, $\eta_{i1} = 0.12$;$\beta = K_m / C_{AS}$
Observable Thiele moduli for Sphere as: $(R/3)^2 \times r_{Aobs} / D_{AC}.C_{AS}$

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