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

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

SUBJECT: CL503 ADVANCED REACTION ENGINEERING

TIME:3:00 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) Determine rate constant and orders of reaction for the following kinetic data observed for a reaction between $HgCl_2$ and $C_2O_4^{2-}$ [5]

Experiment	$[HgCl_2]$, M	$[C_2O_4^{2-}]$, M	Initial rate, M min^{-1}
1	$[HgCl_2]_1 = 0.105$	$[C_2O_4^{2-}]_1 = 0.15$	1.8×10^{-5}
2	$[HgCl_2]_2 = 0.105$	$[C_2O_4^{2-}]_2 = 0.30$	7.1×10^{-5}
3	$[HgCl_2]_3 = 0.052$	$[C_2O_4^{2-}]_3 = 0.30$	3.5×10^{-5}

$$\text{rate of reaction} = k[HgCl_2]^m[C_2O_4^{2-}]^n$$

Q.1(b) Compute the concentration of enzyme-substrate complex [ES] in Michaelis-Menten Equation using the two methods. [5]

Q.2(a) Explain the principles of Membrane, Slurry and Trcikle bed reactors with neat diagrams. [5]

Q.2(b) Describe the factors to considered for designing a polymerization reactor in an algorithmic order along with a neat sketch. [5]

Q.3(a) Prove that conversion of a first order reaction by Tanks-in-series model and segregation model are equal by deriving relevant expressions. [5]

Q.3(b) Compare and contrast zero, one and two parameter models used for describing non-ideal reactors. [5]

Q.4(a) Derive an expression for rate of change of core radius (r_c) with time using Shrinking Core model considering diffusion through gas film is rate limiting. [5]

Q.4(b) Determine the effectiveness factor and true rate constant for a solid-gas reaction with a reaction rate of 10^5 mole/hr m^3 and concentration of gas is 20 mole/m^3. The catalyst particle diameter is 2.4 mm. Assume effective diffusivity as 5×10^{-5} m^2/hr. [5]

Q.5(a) Predict the nature of the reaction in terms of spontaneity for the following reaction: $CaCO_3 \longrightarrow Ca^{2+} + CO_3^{2-}$ at 25 ^{0}C, by solving for dG_r , Q and K. Given, G^0 at std. states of Ca^{2+} = -132 Kcal/mol; CO_3^{2-} = -126 Kcal/mol ; $CaCO_3$ = -270 Kcal/mol. Activity coefficients and concentrations of Ca^{2+} , CO_3^{2-} and $CaCO_3$ are 0.28 & 0.01 mol/L ; 0.21 & 45 μmol/L ; 1 & 1 mol/L respectively. Assume an appropriate value for ideal gas constant [5]

Q.5(b) Derive the expressions relating reaction co-ordinate and number of moles for single and multiple reactions [5]

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