**B.TECH/BT/8TH SEM/CHEN 4281/2019**

**CATALYTIC REACTOR DESIGN**

**(CHEN 4281)**

**Time Allotted : 3 hrs Full Marks : 70**

***Figures out of the right margin indicate full marks.***

***Candidates are required to answer Group A and***

***any 5 (five) from Group B to E, taking at least one from each group.***

***Candidates are required to give answer in their own words as far as practicable.***

**Group – A**

**(Multiple Choice Type Questions)**

1. Choose the correct alternative for the following: **10 × 1 = 10**

 (i) For a homogeneous reaction of nth order, the dimension of the rate constant is given by

(a) 1/(time)n (b) (concentration)1-n/(time)

(c) (concentration)n-1/(time) (d) 1/(concentration)1-n

 (ii) For a mixed flow reactor operating at steady state, the rate of reaction (*-rA*) is equal to

 (a) (b)

(c)  (d)

 (iii) Which of the following will give better performance for highly exothermic reaction?

(a) Fixed bed reactor

(b) Fluidized bed reactor

(c) Semi-fluidized bed reactor

(d) Plug-flow catalytic reactor.

 (iv) For an enzyme catalyzed reaction, at all CA

(a) the rate is proportional to CA (b) the rate is proportional to CE0

(c) the rate is independent of CA (d) none of the above.

 (v) For reaction under pore diffusion regime, the reaction rate

(a) varies directly with catalyst particle size

(b) varies inversely with catalyst particle size

(c) is independent of catalyst particle size

(d) none of the above.

 (vi) The plot of rate versus substrate concentration of an enzymatic reaction following Michaelis-Menten equation gives

(a) a section of rectangular hyperbola (b) a linear plot

(c) an irregular plot (d) none of the above.

 (vii) The slope of Lineweaver and Burk plot is equal to

(a) 1/Vm (b) -1 / Km (c) - Km (d) Km / Vm.

 (viii) Under strong pore diffusion regime a nth-order reaction behaves like a

(a) (n + 1) order reaction (b) $\frac{\left(n+1\right)}{2}$ order reaction

(c) $\frac{\left(n-1\right)}{2}$ order reaction (d) zero order reaction.

 (ix) The best combination of reactors to achieve the substrate concentration at the maximum cell growth rate is

(a) MFR followed by PFR (b) PFR followed by MFR

(c) two MFRs in series (d) two PFRs in series.

 (x) In order to avoid wash out of cells from a chemostat, k should be

(a) equal to unity (b) greater than unity

(c) less than unity (d) none of the above.

**Group – B**

2. Define turnover frequency. For the the irreversible reaction A + B = AB, the rate of formation of product has been found to be well correlated by the following rate equation: rAB = kC2B (independent of *CA*).What reaction mechanism is suggested by this rate expression, if the chemistry of the reaction suggests that the intermediate consists of an association of reactant molecules and that a chain reaction does not occur?

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3. (a) For the liquid phase reaction A→ D, with second-order kinetics and CA0 = 1 mol.L−1, we get 35% conversion after 1 hour in a batch reactor. What is the conversion and concentration of A after 1 hour if our raw material has a concentration of 5 mol.L−1 instead? Explain why your answer makes sense.

 (b) Define catalytic activity and selectivity of a chemical reaction.

**6 + 6 = 12**

**Group – C**

4. (a) State the procedure for evaluating rate equation of heterogeneous catalytic reaction using differential reactor.

 (b) Kinetic experiments on the solid catalyzed reaction A$\rightarrow $3R are conducted at 8 atm and 700°C in a basket type mixed reactor containing 1 gm of catalyst. Feed, consisting of pure A, is introduced at various rates into the reactor and the partial pressure of A in the exit stream is measured for each feed rate. The results are as follows:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Feed rate, liter/hr | 100 | 22 | 4 | 1 | 0.6 |
| pAout//pAin | 0.8 | 0.5 | 0.2 | 0.1 | 0.05 |

Find a rate equation to represent the rate of reaction on catalyst.

**5 + 7 = 12**

5. Sucrose is hydrolyzed in a batch bioreactor in presence of the enzyme sucrase (E) as follows:

 Sucrose (A) $→$ product

 With initial concentrations of 1 mM sucrose and 0.01 mM enzyme, the following data are obtained.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| CA, mM | 0.84 | 0.68 | 0.53 | 0.38 | 0.27 | 0.16 | 0.09 | 0.04 |
| -rA, mM/hr | 0.160 | 0.154 | 0.152 | 0.127 | 0.110 | 0.0882 | 0.0625 | 0.0400 |

Using Hanse-Woolf method, find the intrinsic kinetic parameters of Michaelis-Menten equation.

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**Group – D**

6. 5 gm sample of a porous solid catalyst is studied N2 adsorption at – 195.80C. The following data are obtained.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Pressure, mmHg | 6 | 25 | 140 | 230 | 285 | 320 | 430 | 505 |
| Volume adsorbed at 0C, 1 atm,cm3 | 61 | 127 | 170 | 197 | 215 | 230 | 277 | 330 |

The vapour pressure of N2 at – 195.80C is 1 atm. Estimate the surface area in m2/gm of the sample.

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7. Discuss in detail different methods used for catalyst preparation. Define promoters and inhibitors.

**(8 + 4) = 12**

**Group – E**

8. In his thesis, which was published as a book Monod first proposed the celebrated equation which bears his name. As experimental support for this equation form he presented results on the growth of a pure bacterial culture in a lactose solution. We reproduce one of his runs here.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| t | 0 | 0.54 | 0.90 | 1.23 | 1.58 | 1.95 | 2.33 | 2.70 |
| CA | 147 | 125 | 104 | 70 | 38 | 18 | 3.0 | 1.0 |
| CC | 15.5 | 23 | 30 | 38.8 | 48.5 | 58.3 | 61.3 | 62.5 |

Fit the Monod equation.

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9. A fermentation industry wishes to produce a valuable biochemical by maintaining maximum rate of cell growth condition as far as possible. Starting with 15.5 mg / dm3 of cells and 150 mg / dm3 of substrate, the fermentation was carried out. The yield of cell was found to be 0.65 mg cell / mg substrate. The cell growth rate was reported to be RC = 1.2 CACC / (CA + 2) mg cells formed / hr. dm3, where CA andCC are substrate and cell concentrations respectively. Find the maximum rate of cell growth that can be achieved at this condition.

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