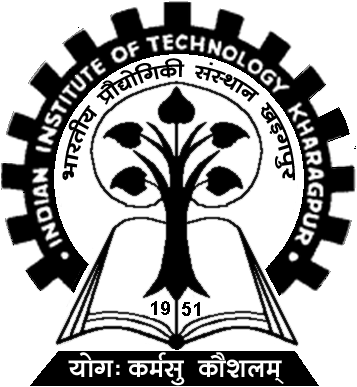
**INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR**



**End-Autumn Semester 2018-19**

**Date of Examination : 15.11.2018 Session (AN) Duration 3 hrs Full Marks: 50**

**Subject No. :**  **CH31009 Subject : REACTION ENGINEERING   
Department/Center/School : CHEMICAL ENGINEERING**

**Specific charts, graph paper, log book etc., required:**  **Graph sheets**

**Special Instructions (if any) :** attempt all questions. Assume the missing parameters.

**PART- A**

**Q1.** The following kinetic data on the reaction A→ R are obtained in an experimental packed-bed reactor using various amount of catalyst and a fixed feed rate FA0=10 kg-mol/hr**.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Catalyst wt.(W), kg | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Conversion(XA) | 0.12 | 0.20 | 0.27 | 0.33 | 0.37 | 0.41 | 0.44 |

1. Find the reaction rate at 35% conversion.
2. In designing a large packed bed reactor with a feed rate FA0= 500 kmol/hr how much catalyst would be needed for 35% conversion.
3. Find the amount of catalyst that would be needed in part (b) if the reactor employed a very large recycle of product stream. [4+2+2]

**Q2.** (a) Derive an expression for the concentration of reactant in the exit stream from a series of three mixed flow reactors of different sizes. Assume that the reaction follows first order kinetics as –rA= k CA and the holding times are τ1, τ2 and τ3 for the first, second and third reactor respectively. The volumetric flow rate is v0.

(b) A second order reaction carried out in a single CSTR results in 80% conversion of reactant A. It is proposed to put another similar CSTR in series with the first one. For all other parameters remain identical (i) how will this addition affect the conversion of reactant (ii) if the same 80% conversion is to be obtained from reactors in series by how much can the treatment rate be increased? [4+6]

**Q3.** Reactant A in a liquid produces R and S by the following reactions:

A→ R

A→ S ( )

A feed with CA0 = 1 mol/L, CR0 = 0 and CS0=0 enters in two mixed reactors in series (τ1 = 2 min; τ2 = 4 min). The composition in the first reactor is CA1=0.40, CR1=0.4 and CS1= 0.2 . Find the composition leaving the second reactor.

[6]

**PART-B**

**Q4.** a) What do you understand by effective diffusivity of a porous solid catalyst? Discuss each factor associated with its expression. [1+2=3]

b) How do the diffusion, pore length and rate of the reaction influence on the values of Thiele modulus and effectiveness factor? [1+1+1=3]

c) How does the shape of the catalyst particle play role in the relation between Thiele modulus and effectiveness factor? [1]

d) Write the physical significance of Thiele modulus. [2]

e) At which condition the value of effectiveness factor goes beyond unity and why? [1+2=3]

**Q.5.** Which type of reaction has higher Thiele modulus ─ Reversible or Irreversible? Explain your answer with proper justification. [1+3=4]

**Q.6.** What is the significance of Weisz-Prater criterion? [2]

**Q.7.** Low temperature (-195.80C) nitrogen adsorption data were obtained for Fe-alumina catalyst. The results for a 50.4 g sample are:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Pressure, mm Hg | 8 | 30 | 50 | 102 | 130 | 148 |
| Vol. Adsorbed, cm3 (at 0C and 1 atm) | 103 | 116 | 130 | 148 | 159 | 163 |

Estimate the surface area (area/g) of the catalyst. [4]

**Q.8.** Two samples of silica-alumina catalysts have particle densities of 1.126 and 0.962 g/cc respectively, as determined by mercury displacement. The true density of the solid material in each case is 2.37 g/cc. The surface area of the first sample is 467 m2/g and that of second is 372m2/g. Which sample has the larger mean pore radius? [3]