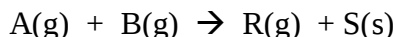


GUJARAT TECHNOLOGICAL UNIVERSITY
M. E. - SEMESTER – I • EXAMINATION – WINTER • 2014

Subject code: 2713008**Date: 07-01-2015****Subject Name: Advanced Reaction Engineering****Time: 02:30 pm - 05:00 pm****Total Marks: 70****Instructions:**

1. Attempt all questions.
2. Make suitable assumptions wherever necessary.
3. Figures to the right indicate full marks.

Q.1 a) Gas containing A contacts and reacts with a semi infinite slab of solid B as follows **07**



As reaction progresses, a sharp reaction plane advances slowly into the solid leaving behind it a layer of product through which gaseous A and R must diffuse. Overall then three resistances act in series that of the gas film, the ash layer, and reaction. Noting that the rate of thickening of the ash layer is proportional to the rate of reaction at that instant $dl/dt = M (-r_A)$. Show that the time to reach any thickness l is the sum of the time required if each resistance acted alone i.e.

$$t_{\text{actual}} = t_{\text{film alone}} + t_{\text{ash alone}} + t_{\text{reaction alone}}$$

b) Discuss fluidized bed reactor and also derive the performance equation for the same. **07**

Q.2 a) Derive the rate equation for a first order reaction in slurry reactor. **07**

b) Derive design equations for moving bed reactors with the help of neat diagram. Also discuss the heat effects in moving beds. **07**

OR

b) Discuss the characteristics and uses of trickle bed reactor. Also develop the equation for rate of transport of each step involved in trickle bed reactor. **07**

Q.3 a) Discuss in brief about the choice of reactors and various conditions to minimize unwanted products in case of parallel reactions with two reactants. **07**

b) Oxidation of ethanol to form acetaldehyde is carried out on a catalyst of 4 wt % Cu and 2 wt % Cr on Al_2O_3 . Unfortunately, acetaldehyde is also oxidized on this catalyst to form carbon dioxide. The reaction is carried out in a threefold excess of oxygen and in dilute concentration [0.1 % ethanol, 1 % O_2 and 98.9 % N_2]. The volume change with reaction can be neglected. Derive the expression in terms of concentration of acetaldehyde as a function of space time. The reactions are irreversible and of first order in ethanol and acetaldehyde. **07**

OR

Q.3 a) Reactant A decomposes by three simultaneous reactions to form three products, in which B is desired. **10**

$$A \rightarrow X \text{ with } -r_{1A} = r_X = k_1 = 0.0001 \text{ mol/dm}^3 \cdot \text{s}$$

$$A \rightarrow B \text{ with } \tilde{n}r_{2A} = r_B = k_2 C_A = (0.0015 \text{ s}^{-1}) C_A$$

$$A \rightarrow Y \text{ with } \tilde{n}r_{3A} = r_Y = k_3 C_A^2 = (0.008 \text{ dm}^3/\text{mol} \cdot \text{s}) C_A^2$$

Specific reaction rates are given at 300 K and activation energies for the reactions are $E_1 = 10,000 \text{ kcal/mol}$, $E_2 = 15,000 \text{ kcal/mol}$ and $E_3 = 20,000 \text{ kcal/mol}$ respectively. Suggest the suitable reactor, operating temperature, concentrations and exit conversion to maximize the selectivity of B for an entering concentration of A of 0.4 M and volumetric flow rate of $2 \text{ dm}^3/\text{s}$.

- b) Expound briefly the different cases for maximizing the selectivity of desired product for one reactant of parallel reactions. **04**

- Q.4** a) Derive the energy balance equation on the coolant heat transfer fluids for co-current and counter current flow. **07**

- b) .Write in brief about reactor staging with inter stage cooling and heating with suitable example. **07**

OR

- Q.4** a) For the elementary solid-catalyzed liquid phase reaction $A \rightleftharpoons B$, make a plot of equilibrium conversion as a function of temperature. Determine the adiabatic equilibrium temperature and conversion when pure A is fed to the reactor at a temperature of 300 K. **14**

Data:-

$$H_A^0(298 \text{ K}) = -40000 \text{ cal/mol}$$

$$H_B^0(298 \text{ K}) = -60000 \text{ cal/mol}$$

$$C_{PA} = 50 \text{ cal/mol.K}$$

$$C_{PB} = 50 \text{ cal/mol.K}$$

$$K_e = 100000 \text{ at } 298 \text{ K}$$

- Q.5** a) Derive the equation for effectiveness factor for a LPCVD reactor. **07**

- b) Explain the construction and working of Monolithic reactors. **07**

OR

- Q.5** a) State and explain Monod equation of microbial growth. How do you determine the kinetic parameters of the above equation graphically? **07**

- b) Derive the design equation of microbial growth in two continuous stirred tank fermentor in series. **07**
