Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

ME – SEMESTER-1 (NEW) EXAMINATION – WINTER 2016

Subject Code: 2713008 **Date:04/01/2017**

Subject Name: Advanced Reaction Engineering

Time: 2:30 pm to 5:00 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) Derive design equations for moving bed reactors with the help of neat diagram. Also discuss the heat effects in moving beds. 07

b) Gas containing A contacts and reacts with a semi infinite slab of solid B as follows: 07

$$A(g) + B(g) \rightarrow R(g) + S(s)$$

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.

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

Q.2 a) Describe stepwise: Design of combination of catalytic reactor and regenerator 07

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

OR

b) Discuss the new development in Catalysis. Also discuss straight through transport reactor and also derive the performance equation for the same. 07

Q.3 a) Oxidation of ethanol to form acetaldehyde is carried out on a catalyst of 4 wt % Cu – 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 07

of space time. The reactions are irreversible and of first order with respect to ethanol and acetaldehyde.

b) Define and explain desired and undesired reactions, yield and selectivity with necessary equations. Compare the overall and instantaneous selectivities for a CSTR and reaction yield for batch system and flow system. 07

OR

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

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

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

$A \rightarrow Y$ with $-r_{3A} = r_Y = k_3 C_A^2 =$ (0.008 dm^3/mol. s) C_A^2

Specific reaction rates are given at 300 K and activation energies for the reactions are E_1 = 10,000 kcal/mol, E_2 = 15,000 kcal/mol and E_3 = 20,000 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 dm^3/s.

b) State and discuss the various types of reactions with suitable examples. 04

Q.4 a) Write in brief about reactor staging with inter stage cooling and heating with suitable example. 07

b) Derive the energy balance equation for a steady state tubular reactor with heat exchange. 07

OR

Q.4 For the elementary solid-catalyzed liquid phase reaction $A \leftrightarrow B$, 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^O_A (298 K) = – 40000 cal/mol, H^O_B (298 K) = – 60000 cal/mol, C_{PA} = 50 cal/mol K, C_{PB} = 50 cal/mol K and K_e = 100000 at 298 K.

Q.5 a) What are slurry reactors? Derive performance equation for slurry reactor with the help of diagram. 07

b) State and explain Monod equation of microbial growth. Discuss graphical method used to determine the kinetic parameters of the same? 07

OR

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

b) Derive differential form of design equation for gauze reactors. Also discuss the mass transfer correlation for the same. 07