Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VIII EXAMINATION – SUMMER 2016

Subject Code:180506 **Date:16/05/2016**

Subject Name:Chemical System Modelling (Department Elective-II)

Time:10:30 AM to 01:00 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)** Explain in detail the model formulation principles. **07**

(b) Consider the following batch mixing process as shown in figure 1. Initially the tank is empty. The volume of the tank is 50 m^3. The flow rates are in m^3/s and compositions are in moles per m^3. How long does it take to fill up the tank? **07**

Data Given: $F_1 = F_2 = 5\ m^3/s$

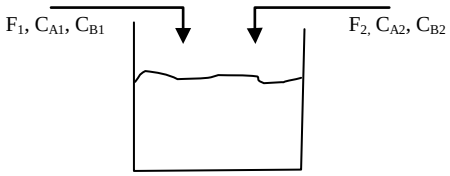

Figure 1: Mixing Process

Q.2 **(a)** Explain in detail the classification of mathematical modeling. **07**

(b) Describe the stages in the development of a complete mathematical model for a chemical process. **07**

OR

(b) Differentiate between deterministic process and stochastic process. **07**

Q.3 **(a)** Discuss physical modeling versus mathematical modeling. **07**

(b) Consider series of constant holdup, isothermal CSTRs as shown in figure 2, where 1st order irreversible reaction A → B takes place with rate constants K_1, K_2 and K_3. Derive the mathematical model. **07**

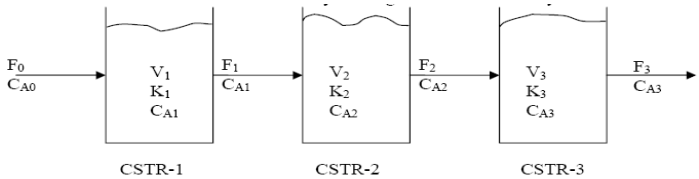

Figure 2: CSTR in Series

OR

Q.3 **(a)** Give a detailed account of fundamental laws used in modeling. **07**

(b) Derive mathematical model for the single perfectly mixed CSTR shown in figure 3 in which first order, isothermal, irreversible reaction $A \xrightarrow{k} B$ is carried out. Pump is provided at the outlet in order to maintain constant out flow. **07**

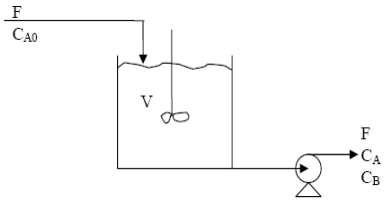

Figure 3: CSTR

Q.4 **(a)** Derive the relation to compute fraction of solute extracted for steady state single stage counter current solvent extraction. Compute the fraction of solute that could be extracted be extracted, if S = 15R, m = 1/6 and c = 0.2 kg/m^3. **07**

(b) 100 cm^3/s of a solvent S is used to treat 200 cm^3/s of a 15 % by weight solution of A in B, where A is being extracted from B in a two-stage countercurrent liquid-liquid extraction column. The distribution coefficient m = 3 and the densities of A, B, and S are 1000, 9000, and 800 kg/m^3, respectively. All the quantities are expressed on a solute-free basis. Volumetric flow rates of A and B are 50 and 400 cm^3/s, respectively. (a) What is the composition of the raffinate leaving from stage 1 and stage 2? (b) What is the final fraction extracted? **07**

OR

Q.4 **(a)** Derive the relation to compute fraction of solute extracted for steady state N-stage counter current solvent extraction. **07**

(b) A hollow cylinder with an outer diameter of 20 cm and an inner diameter of 8 cm has an inner surface temperature of 180 °C and an outer surface temperature of 90°C. Determine the temperature of the point halfway between the inner and outer surfaces. If the thermal conductivity of the cylinder material is 50 W/m K, determine the heat flow through the cylinder per linear meter. **07**

Q.5 **(a)** Derive mathematical model for heat losses through pipe flange, clearly mentioning all the assumptions. **07**

(b) Derive mathematical model for laminar flow in a narrow slit. **07**

OR

Q.5 **(a)** Derive model for unsteady state heat transfer in a tubular gas preheater. **07**

(b) A closed kettle shown in figure 4 of total surface area A m^2 is heated through this surface by condensing steam at temperature T, K. The kettle is charged with M kg of liquid of heat capacity C, J/kg at a temperature of To K. If the process is controlled by a heat-transfer coefficient h W/m^2 K, how does the temperature of the liquid vary with time? **07**

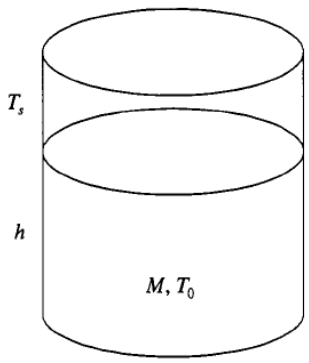

Figure 4: Steam heating of a liquid in a kettle

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