Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VIII EXAMINATION – WINTER 2015

Subject Code:180506 **Date:12/12/2015**

Subject Name:Chemical System Modelling

Time: 2:30pm to 5:00pm **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)** Describe the classification of mathematical modeling. **07**

(b) Describe the model formulation principles. **07**

Q.2 **(a)** Distinguish among independent variable, dependent variable and parameter with suitable example. **07**

(b) Consider isothermal CSTR shown in figure 1, where liquid mixture enters with flow rate F_0 (m^3/s), temperature T_0 (K), concentration of A, B, C are C_{A0} (mole/m^3), C_{B0} (mole/m^3) and C_{C0} (mole/m^3), respectively. Write down total and component continuity balance equations, if following reaction takes place in CSTR: **07**

(1) Simultaneous Reactions (First Order, isothermal)

$$A \xrightarrow{k_1} B \quad A \xrightarrow{k_2} C$$

(2) Reversible (First Order, isothermal)

$$A \underset{k_2}{\overset{k_1}{\rightleftharpoons}} B$$

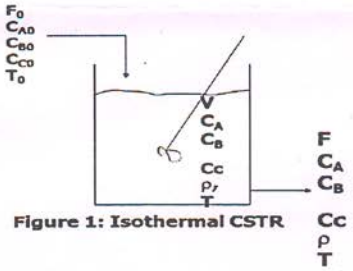

Figure 1: Isothermal CSTR

OR

(b) In above Q. 2 (b), considering CSTR shown in figure 1 as non isothermal CSTR, with cooling coil inside the tank that can remove exothermic heat of reaction λ (cal/mol of A reacted), write down the energy balance equations if following first order irreversible reaction takes place. . The rate of heat removal from the reaction mass to the cooling coil is – Q (energy per time). Check dimensional consistency of derived energy balance equation. **07**

$$A \xrightarrow{k,\lambda} B$$

Q.3 **(a)** Differentiate between physical modeling and mathematical modeling. **07**

(b) 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**

OR

Q.3 **(a)** Differentiate between deterministic process and stochastic process. **07**

(b) Develop model of N-stage counter current solvent extraction and derive the equation for the proportion extracted E. **07**

Q.4 **(a)** Derive mathematical model for heat losses through pipe flange. **07**

(b) What is the composition of the final raffinate and the fraction extracted if 160 cm^3/s of a solvent S is used to treat 400 cm^3/s of a 10% by weight solution of A in B, where A is being extracted from B in a two-stage countercurrent liquid-liquid extraction column. (distribution coefficient) m = 3 and the densities of A, B, and S are 1200, 1000, and 800 kg/m^3, respectively? **07**

OR

Q.4 **(a)** A closed vessel of total surface area 40 m^2 is heated through this surface by condensing steam at a temperature of 100 °C. The vessel is charged with 600 kg of liquid having a heat capacity of 2512 J/kg K at a temperature of 25 °C. If the process is controlled by a heat-transfer coefficient of 142 W/m^2 K, find out temperature of the liquid after 1 h. **07**

Expression for the variation of T with θ(time) is given as follow:

$$\frac{T_s - T}{T_s - T_0} = \exp\left(\frac{-hA}{mC_P}\theta\right)$$

(b) Derive the model for counter current cooling of tanks. **07**

Q.5 **(a)** A Newtonian fluid is in laminar flow in a narrow slit (figure 2) formed by two parallel walls a distance 2B apart. It is understood that **B<<W.** Given momentum flux and velocity distributions, as follow, derive the relation for ratio of the average velocity to the maximum velocity for the flow. **07**

$$\tau_{xz} = \left(\frac{P(0) - P(L)}{L}\right)x$$

$$v_z = \left(\frac{P(0) - P(L)}{2L\mu}\right)B^2\left[1 - \left(\frac{x}{B}\right)^2\right]$$

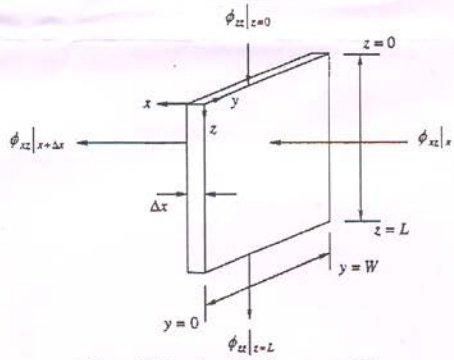

Figure 2: Laminar flow in narrow slit

(b) Derive the dimensionless temperature profile for a transverse cooling fin of triangular cross section. **07**

OR

Q.5 **(a)** Write a short note on concentration profile and temperature of fixed bed catalytic Reactor. **07**

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

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