Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE – SEMESTER – VIII.EXAMINATION – WINTER 2016

Subject Code: 180506 Date: 24/10/2016

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

Time: 02:30 PM to 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)** Explain any four fundamental laws used in modelling. **07**

(b) Describe classification of mathematical modelling based on state of the process **07**

Q.2 **(a)** $160cm^3/s$ of a solvent S is used to treat $400cm^3/s$ of a 10% by weight solution of A in B, where A is being extracted from B in a two-stage counter current liquid-liquid extraction column. The distribution coefficient m=3 and the densities of A, B and S are 1200, 1000 and 800 kg/m^3, respectively. All the quantities are expressed on a solute free basis. (a) What is the composition of raffinate leaving from stage 1 and stage 2? (b) What is the final fraction extracted? **07**

(b) Benzoic acid is continuously extracted from toluene using water as solvent in a counter current mode using N stages under steady state conditions. Each stage consists of (1) a mixer where vigorous stirring of the contents takes place and (2) a settler where the mixture pumped from a mixture is allowed to settle into two layers. The upper toluene layer from the second stage and lower water layer from first stage are removed separately. Develop a mathematical model to find the final fraction of benzoic acid extracted by clearly mentioning the assumptions involved in the analysis. **07**

OR

(b) Explain analogy among heat, mass and energy with mathematical equations. **07**

Q.3 **(a)** Consider CSTR with heat removal as shown in figure where liquid enters with flow rate F_o (m^3 /hr), temperature T_o (°C), and concentration of A (C_{AO} $kmol/m^3$). Write down overall energy balance equation if the following reaction takes place. **07**

$A \rightarrow$ product

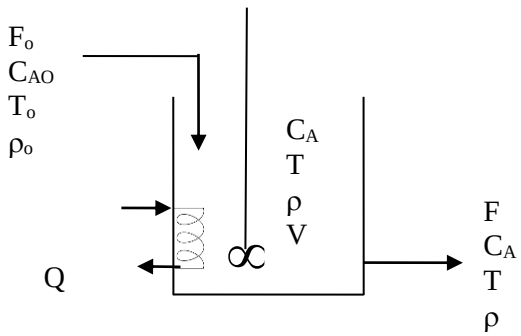

Figure: CSTR

(b) Derive Kremser –Brown Equation **07**

OR

Q.3 **(a)** Construct a model of temperature profile of fixed bed catalytic reactor. **07**

(b) A thermometer having a time constant of 0.2 min is at a steady state temperature of 0° C. at time t = o, the thermometer is placed in a temperature bath maintained at 100° C. determine the time period for the thermometer to read 40° C. **07**

Q.4 **(a)** Derive static distributed parameter rigid analytical model in Heat Transfer Operation **07**

(b) 10000 kg/h of acid having a specific heat of 0.35 enters a well agitated tank containing 10000 kg of acid and leaves at the same rate in a steady state process. The inlet and outlet temperatures of acid are 443 K and 363 K, respectively. This is maintained by cooling water, flowing at 8000 kg/h having a heat capacity of 4187 J/kg K. the inlet temperature of water is 298 K. (a) calculate the outlet temperature of water. (b) If cooling water suddenly fails, what is the temperature of the acid in the tank after 30 min? **07**

OR

Q.4 **(a)** Two concentric cylinder metallic shells are separated by a solid material. A constant rate of heat q (W/m^3) is generated within the cylinder, while the boundary surfaces at $r = r_i$ and $r = r_o$ are maintained at different temperatures. Determine the steady state temperature distribution and the radial heat flow rate within the separating material? **07**

(b) A Closed kettle of total surface area A m^2 is heated through this surface by condensing steam at temperature T_s K. the kettle is charged with M kg of liquid of heat capacity C_p J/kg at a temperature T_o K. if the process is controlled by a heat transfer coefficient h W/m^2K, how does the temperature of liquid vary with time? **07**

Q.5 **(a)** Construct a mathematical model of flow through a packed bed column. **07**

(b) Explains the model formulation principles **07**

OR

Q.5 **(a)** Develop a model and obtain expression for the steady state two stage solvent extractions. **07**

(b) Derive the velocity profile and average velocity for falling film problem **07**

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