

GUJARAT TECHNOLOGICAL UNIVERSITY**BE SEM-VIII Examination May 2012****Subject code: 180506****Subject Name: Chemical System Modeling****Date: 08/05/2012****Time: 10.30 am – 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) What is modeling? Classify it based on different category and group of models. **07**

(b) Discuss various aspects involved in physical modeling. **07**

Q.2 (a) What are the various model formulation principles? **07**

(b) Distinguish among independent variables, dependent variables, and parameters with suitable examples. **07**

OR

(b) Classify mathematical modeling in the form of a tree structure, and elaborate the various terms involved. **07**

Q.3 (a) Draw a schematic diagram representing various stages in a development of complete mathematical model for a process and discuss it. **07**

(b) Consider idealised single stage extraction of benzoic acid from toluene using water. Make a model for system and derive the equation for the proportion extracted E. **07**

OR

Q.3 (a) 160 cm³/s of a solvent S is used to treat 400 cm³/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. What is the composition of the final raffinate and the fraction extracted if m (distribution coefficient) = 3 and the densities of A, B, and S are 1200, 1000, and 800 kg/m³, respectively? **07**

(b) Consider idealised two stage extraction of benzoic acid from toluene using water. Make a model for system and derive the equation for the proportion extracted E. **07**

Q.4 (a) Develop a model of N-stage counter-current solvent extraction and derive the equation for the proportion extracted E. **07**

(b) A supply of hot air is to be obtained by drawing cool air through a heated cylindrical pipe. The pipe is 0.1 m in diameter and 1.22 m long, and is maintained at a temperature of $T_w = 316^\circ\text{C}$ throughout its length. The average values of the properties of air are as follows: heat capacity (C_p) = 1005 J/kg °C, thermal conductivity (k) = 0.035 W/m °C, density (ρ) = 0.801 kg/m³, flow rate (u) = 7.87×10^{-3} m³/s, **07**

inlet temperature = 21 °C, and overall heat-transfer coefficient (h) = $52.3x^{-1/2}$ W/m² °C, where x is the distance measured in meters from the pipe inlet. Develop a mathematical model for the temperature distribution in the axial direction in the form of a differential equation for the steady-state condition.

OR

Q.4 (a) Construct a mathematical model of The Continuity equation, and write name of different methods used for solving partial differential equations. **07**

(b) Compute the fraction of solute that can be extracted in counter-current solvent extraction with N stages (for values of N from 1 to 20) using the numerical values of $S = 12R$, $m = 1/8$, and $c = 0.1$ kg/m³, which were used for single –stage extraction, and compare the results. **07**

Q.5 (a) Construct a mathematical model of heat loss through pipe flanges. **07**

(b) Develop a model of Laminar flow in a narrow slit. **07**

OR

Q.5 (a) 1.26 kg/s of sulphuric acid of heat capacity 1508 J/ kg K is to be cooled in a two stage counter current cooler. Hot acid at 174 °C is fed to a tank where it is stirred well in contact with cooling coils. The continuous discharge from the tank at 88 °C flows to a second stirred tank and leaves at 45 °C. Cooling water at 20 °C flows into the coil of the second tank and then to the coil of the first tank. The water is at 80 °C as it leaves the coil of the hot acid tank. To what temperature would the contents of each tank rise if, due to trouble in supply, the cooling water is suddenly stopped for 1 hr? Calculate also the intermediate water temperature before failure. The capacity of each tank is 4536 kg of acid and the flow rate of water is 0.975 kg/s. **07**

(b) Construct a model of concentration and temperature profile of fixed bed catalytic reactor. **07**
