

GUJARAT TECHNOLOGICAL UNIVERSITY
BE - SEMESTER-VIII • EXAMINATION – SUMMER 2014

Subject Code: 180506**Date: 27-05-2014****Subject Name: Chemical System Modeling****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) Write a short note on physical modeling. **07**

(b) Answer the following questions.

(i) Explain the classification of mathematical modeling based on state of process. **04**

(ii) Define modeling. Which is more economical, mathematical modeling or physical modeling? Why? **03**

Q.2 (a) Differentiate between deterministic process and stochastic process. **07**

(b) Differentiate between lumped parameter model and distributed parameter model. **07**

OR

(b) Consider the following batch mixing process as shown in figure 1. Initially the tank is empty. The volume of the tank is $V \text{ m}^3$. 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**

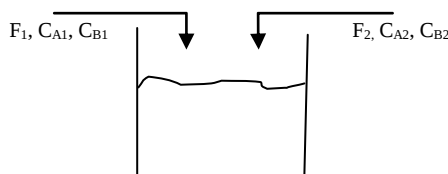
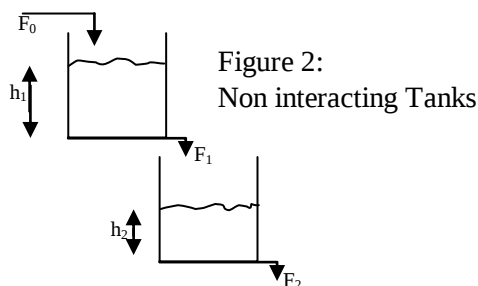


Figure 1: Mixing Process

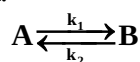
Q.3 (a) Consider two non interacting tanks in series as shown in figure 2, where the flow out of the first tank enters the second tank. Develop model to describe how the heights of liquid in tank 1 and tank 2 changes with time, given the input flow rate F_0 . Flow out of each tank is linear function of the height of liquid in that tank. **07**



(b) Compute the fraction of solute that could be extracted in a single stage solvent extraction using the numerical values of $S = 12 R$, $m = 1/8$, and $c = 0.1 \text{ kg/m}^3$. **07**

OR

Q.3 (a) A perfectly mixed, isothermal CSTR has an outlet weir, as shown in figure 3. The flow rate over the weir is proportional to the height of the liquid over the weir, how, to the 1.5 power. The weir height is h_w . The cross sectional area of the tank is A . Assume constant density. A following first order, reversible reaction takes place in the tank. Write equations describing the system. **07**



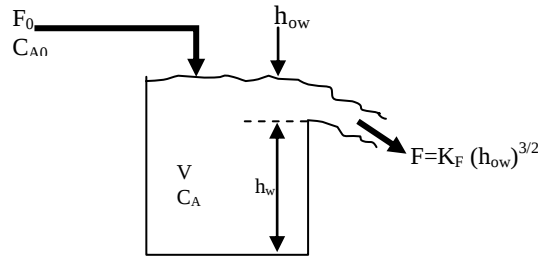


Figure 3: Isothermal CSTR

- (b) 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 countercurrent 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**
- Q.4 (a)** Two thin-walled metal pipes of 25 mm (a m) external diameter are joined by two flanges 12.5 mm thick (w m) and 100 mm in diameter (b m). The pipe is carrying steam at 120 °C (T_s °C). The conductivity of the flange metal is $k = 380$ W/m K, and the exposed surfaces of the flanges lose heat to the surroundings at $T_1 = 16$ °C according to a heat-transfer coefficient $h = 11.4$ W/m² K. Develop a mathematical model for temperature in the differential form under steady-state conditions. **07**
- (b) Derive mathematical model for steady state N-stage counter-current solvent extraction. **07**
- OR**
- Q.4 (a)** A hollow cylinder with an outer diameter of 10 cm and an inner diameter of 5 cm has an inner surface temperature of 200 °C and an outer surface temperature of 100 °C. Determine the temperature of the point halfway between the inner and outer surfaces. If the thermal conductivity of the cylinder material is 70 W/m K, determine the heat flow through the cylinder per linear meter. **07**
- (b) A closed vessel of total surface area 40 m² 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/m² K, find out temperature of the liquid after 1 h. Expression for the variation of T with θ (time) is given as follow: **07**
- $$\frac{T_s - T}{T_s - T_0} = \exp\left(\frac{-h A}{m C_p} \theta\right)$$
- Q.5 (a)** Develop mathematical model for temperature distribution in a transverse cooling fin of triangular cross section. **07**
- (b) A Newtonian fluid is in laminar flow in a narrow slit formed by two parallel walls a distance $2B$ apart. It is understood that $B \ll W$, so that 'edge effects' are unimportant. Make a differential momentum balance and obtain the model equations for momentum flux and velocity distributions. **07**
- OR**
- Q.5 (a)** Develop mathematical model for heat losses through pipe flange, clearly mentioning all the assumptions. **07**
- (b) Develop mathematical model for temperature profile in fixed bed catalytic reactor, clearly mentioning all the assumptions. **07**
