MANIPAL INSTITUTE OF TECHNOLOGY

## VII SEMESTER B.TECH. (CHEMICAL ENGINEERING) MAKE-UP EXAMINATIONS, DEC- 2017

Reg. No.

## SUBJECT: PROCESS MODELLING AND SIMULATION[CHE 4101]

REVISED CREDIT SYSTEM (20 /12/2017, AN)

Time: 3 Hours

MAX. MARKS: 50

## Instructions to Candidates:

✤ Answer <u>ALL</u> questions.

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- ✤ Missing data may be suitably assumed.
- Draw Information flow diagram wherever necessary.

## **1A.** Consider a set of reversible reaction:

$$A \iff B \text{ and } B \iff C$$

$$K_2 \qquad K_4$$

Where  $N_A, N_B$ ,  $N_C$  be the moles of A, B,C respectively present at any time t. Since the reaction is constant volume,  $N_A, N_B$ ,  $N_C$  are proportional to concentration. Derive

$$\frac{d^2 N_A}{dt^2} + (K_1 + K_2 + K_3 + K_4) \frac{dN_A}{dt} + ((K_1 * K_3) + (K_2 * K_4) + (K_1 * K_4))N_A - (K_2 * K_4) = 0$$

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- **1B.** Water flows from a conical tank at a rate of  $0.02(2+h)^2 \text{ m}^3/\text{min}$ . The diameter and height of the conical tank is 8m and 5m respectively. If the tank is initially full, how long will it take for 40% of water to flow out of the tank. What is the flow rate at that time.?
- **2A.** A 18% Na<sub>2</sub>SO<sub>4</sub> solution is fed at a rate of 12kg/min into a mixer that initially holds 150 kg of a 50-50 mixture of Na<sub>2</sub>SO<sub>4</sub> and water. The exit solution leaves at the rate of 10 kg/min. Assume uniform mixing, what is the concentration of Na<sub>2</sub>SO<sub>4</sub> in the mixer at the end of 12 minute? Ignore any volume changes on mixing.
- **2B.** Write down the step by step procedure for modeling any process in chemical engineering.
- **3.** Develop a mathematical model for dynamic response of the unsteady state one dimensional heat conduction through a rod. Derive the finite difference equations to determine the temperature distribution in the rod. List all the assumptions.

4A. Develop the mathematical model of the steady state counter current flow heat exchange in a double pipe heat exchanger. Give brief solution procedure. List all the assumptions.

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**4B.** Explain the mechanistic and empirical model

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**5A.** Find the molar volume using Redlich-Kwong equation of state given by

$$= \frac{RT}{(V-b)} \quad \stackrel{--}{-} \frac{a}{V(V+b)T^{0.5}}$$

Where  $a = 0.42747 (R^2Tc^{2.5} / Pc)$  and b = 0.08664 (RTc/ Pc)Given P =56 atm, R=0.08206 (atm L/ gmole K), T= 450K, Tc = 405.5K, Pc =111.3 atm. Use Wegstein method. (two iteration only)

5B. The chlorination of benzene produces mono-chlorobenzene (C<sub>6</sub>H<sub>5</sub>Cl), di-chlorobenzene(C<sub>6</sub>H<sub>4</sub>Cl<sub>2</sub>) and tri-chlorobenzene(C<sub>6</sub>H<sub>4</sub>Cl<sub>3</sub>) with reaction rate of K<sub>1</sub>, K<sub>2</sub>, K<sub>3</sub> respectively. The reaction is exothermic and carried out in semi-batch reactor fitted with cooling coils and reflux condenser. Develop model equations for maximizing the yield of the products formed.

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