A **294B1** Total Pages: **2**

Register No.: .... Name: ....

SAINTGITS COLLEGE OF ENGINEERING (AUTONOMOUS)

(AFFILIATED TO APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY, THIRUVANANTHAPURAM)

SEVENTH SEMESTER B. TECH DEGREE EXAMINATION (R), DECEMBER 2023
CHEMICAL ENGINEERING
(2020 SCHEME)

Course Code: **20CHT401**

Course Name: **Chemical Process Equipment Design - I**

Max. Marks: **100** **Duration: 3 Hours**

Instructions to Candidates

1. *Missing data may be assumed suitably.*
2. *Apart from scientific calculators the following books and data books are permitted for the exam:*
   - *Steam table.*
   - *Perry's Chemical Engineering Handbook.*
   - *Attested copies of Dühring's charts, Nomographs, charts and data tables used in design taken from TEMA standard/ Other editions of Handbook.*

(Answer any ONE question from each module, each question carries 50 marks)

MODULE I

1. 25,000 kg/hr of benzene at 80°C is to be cooled to 60°C using hydrocarbon light oil at 30°C and leaving at 35°C. Design the triangular pitched 1, 2 shell and tube heat exchanger. The properties of the shell side and tube side fluids at average temperature are: (50)

Property	Tube Side (Benzene)	Shell Side (Light Oil)
ρ, kg/m^3	730	820
μ, mNs/m^2	0.32	3.2
C_p, kJ/kg°C	1.97	2.05
k, W/m°C	0.132	0.134
R, m^2 °C/W	0.0002	0.0003

Tubes having ID = 16 mm, OD = 20 mm and tube length = 2 m is used. The thermal conductivity of the tube material is 50 W/m°C. Assume that the overall heat transfer coefficient is 400 W/m^2 °C.

OR

2. Design a double pipe heat exchanger for transferring heat from a hot sodium chloride (NaCl) solution flowing in the tube side to cold water flowing in the annular side. The NaCl solution entering at 80°C with a flow rate of 110 kg/h, has properties including a density of 1200 kg/m³, specific heat of 4.21 kJ/kg°C, viscosity of 0.8 cP, and thermal conductivity of 0.63 W/m°C. Cold water entering at 25°C and exiting at 35°C with a flow rate of 180 kg/h, having a density of 1000 kg/m³, (50)

specific heat of 4.18 kJ/kg°C, viscosity of 0.7 cP, and thermal conductivity of 0.6 W/m°C. The overall heat transfer coefficient is taken to be 500 W/m² °C. To accomplish this, consider a tube with an inner diameter of 20 mm and a 3 mm wall thickness, while the pipe has an inner diameter of 40 mm and a 4 mm wall thickness. Determine the required length of the double pipe heat exchanger, number of hairpin bends (by assuming suitable hairpin length) and pressure drop on both sides under steady-state conditions. The thermal conductivity of the tube material is 50 W/m°C.

MODULE II

3. Design a double effect feed forward evaporator system to concentrate a sugar solution by evaporating 35% of the initial solvent content. The initial sugar solution has a flow rate of 8000 kg/h and contains 20% sugar by mass. The initial solution enters at 50°C, and the concentrated solution exits at 90°C from first stage and 95°C from the second stage. Assume steady-state conditions, negligible heat losses, and no phase change in the solution. The steam used for the heating enters at 2 bar for the first stage. Determine the capacity, steam economy, heat duty required for evaporation in each effect. Estimate the area of the heating surface needed. Assume the overall heat transfer coefficient is 1200 W/m² °C and 1080 W/m² °C for the second stage. (50)

OR

4. Design a wet cooling tower to cool hot water from an industrial process using air. The cooling tower must be able to cool the water from 49°C to 35°C. Given that: Water flow rate = 3785 LPM, Ambient wet-bulb temperature = 29°C, Approach temperature = 6°C, Range = 14°C and allowable drift loss = 0.1%. Calculate cooling capacity, heat transfer area, air flow rate, height and diameter of cooling tower, fan power, and drift loss. (50)

****