condenser area is available to maintain a pressure of 0.9492lb/in^2 (absolute) in the vapour space of the evaporator. On the basis of overall heat transfer coefficients of 300 Btu/hr ft^2 ^{o}F. Compute

i. Heating area required and

ii. Steam consumption and steam economy.

(b) Draw the temperature profile curve in a double tube heat exchanger for co-current and counter current flow.

8 + 4 = 12

7. The exothermic elementary liquid-phase reaction

$$A + B \xrightarrow{k} C, \quad r = kC_A C_B$$

is carried out in a batch reactor with a cooling coil to keep the reactor isothermal at 27^{o}C. The reactor is initially charged with equal concentrations of A and B and no C,

Data Given: $C_{A0} = C_{B0} = 2.0 mol/L,\ C_{C0} = 0$

i. How long does it take to reach 95% conversion?

ii. What is the total amount of heat (kcal) that must be removed by the cooling coil when this conversion is reached?

iii. What is the maximum rate at which heat must be removed by the cooling coil (kcal/min) and at what time does this maximum occur?

iv. What is the adiabatic temperature rise for this reactor and what is its significance?

12

Group - E

8. (a) Derive the expression for the modelling of electrical conductivity of a ternary mixture of carbon-polymer composite bipolar plate for PEM fuel cell.

(b) Discuss the polarization curve of a PEMFC Stack.

8 + 4 = 12

9. (a) Describe the solar thermal hot water system with internal heat exchanger built in the storage tank with schematic diagram.

(b) Explain the storage tank model without built in heat exchanger.

9 + 3 = 12

PROCESS MODELING AND SIMULATION IN ENERGY SYSTEM (REEN 5201)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Distributed parameter model stands for situation
(a) when the process variables vary only in time coordinate
(b) when the process variables vary only in space coordinate
(c) when the process variables vary both in time and space coordinates
(d) none of these.

(ii) The overall heat transfer coefficient between steam and coolant in a condenser in case of drop wise condensation is ..... than that of a film wise condensation.
(a) 2 to 3 times lesser (b) 2-3 times greater
(c) 5-10 times lesser (d) 5-10 times greater.

(iii) Modelling a distributed parameter system gives rise to a
(a) ODE (b) PDE
(c) ODE & PDE (d) none of these.

(iv) The equilibrium constant of chemical reaction _____ in presence of catalyst.
(a) increases
(b) decreases
(c) remain unaffected
(d) can either increase or decrease (depends on the type of catalyst).

(v) Study of chemical kinetics is the easiest in case of _____ reactions.
(a) irreversible (b) reversible (c) surface (d) side.

(vi) Lumped parameter model is represented by
(a) ODE (b) PDE
(c) a set of linear equation (d) none of these.

(vii) Degree of freedom is defined as
(a) total number of variables
(b) total number of equations
(c) total number of variables - total number of equations
(d) total number of equations - total number of variables.

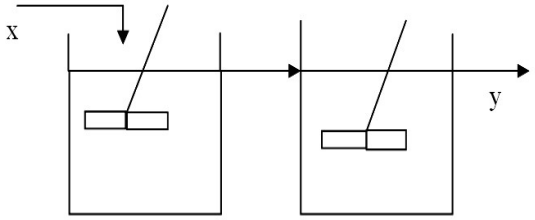
(viii) For flow along a flat plate, the critical Reynold's number is
(a) 5×10^5 (b) 1×10^4 (c) 2×10^7 (d) none of these.

(ix) Ddispersion number for a CSTR is
(a) 0 (b) 1 (c) <1 (d) ∞.

(x) Which of the following type of collector is used for low temperature systems?
(a) Flat plate collector
(b) Line focussing parabolic collector
(c) Paraboloid dish collector
(d) All of the above.

Group - B

2.



In the two tank mixing process as shown in above figure, the inlet salt concentration x varies from 0 to 16 g/lit. according to a step function. The inlet flow rate is 83 lit/min. The holdup volume in each tank is 170 lit. Develop a model equation relating the outlet salt concentration of tank 2, y to the inlet salt concentration to tank 1, x assuming solution density to be constant.

At what time does the outlet salt concentration from tank 2 reaches 10 gm/lit.

12

3. (a) Differentiate between stochastic process and deterministic process.

(b) The temperature of a gas stream is measured with a thermocouple. The junction may be approximated as a sphere of diameter 1 mm, thermal conductivity $k = 26\text{W/(m.}^o\text{C)}$, density ρ=8400 kg/m3 and specific heat $c_p = 0.38$ kJ/kg. The heat transfer coefficient between junction and the stream is 562 W/(m².C). How long will it take for the thermocouple to record 98 % of the applied temperature difference? Derive the model used.

3 + 9 = 12

Group - C

4. (a) A marble slab [k = 2 W/(m.°C), α = 1 × 10^{-6} m²/s] 2cm thick is initially at a uniform temperature T_i = 200°C. Suddenly one of its surfaces is lowered to 0°C and is maintained at that temperature, while the other surface is kept insulated. Develop an explicit finite-difference scheme for the determination of the temperature distribution in the slab as a function of position and time.

(b) State the significance of Biot no. and Fourier no.?

10 + 2 = 2

5. (a) Derive the explicit finite-difference form of one-dimensional, time dependent heat conduction equation.

(b) Atmospheric air at 400K with a velocity 1.6 m/s flows over a flat plate L = 2.2 m long maintained at a uniform temperature of 300K. Calculate the heat transfer rate from the airstream to the plate if width of the plate is 0.5 m.
Given: The local Nusselt no. for laminar flow along a flat plate is given by :

$$Nu_x = \frac{h_x.x}{k} = 0.33\,\text{Pr}^{1/3}\,\text{Re}_x^{1/2},$$

[For air, at 350K, Pr = 0.7, Kinematic viscosity = 0.2cm²/s, k = 0.03W/(m.°C).]

7 + 5 = 2

Group - D

6. (a) A single effect evaporator is to be designed to concentrate a 15 wt.% solution of sodium hydroxide to a 45% solution. The dilute solution at 200 °F is to be fed to the evaporator at the rate of 40,000 lb/hr. for heating purposes; a saturated steam at 50 °F is used. Sufficient