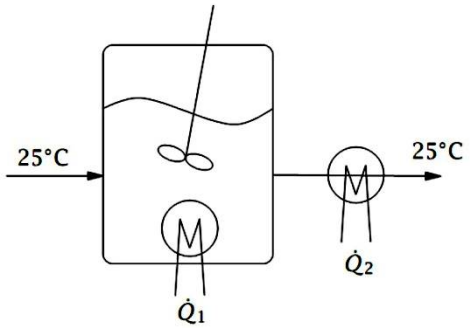
7. An aqueous solution of species A undergoes the following elementary reaction in a 2000 L CSTR. $A \underset{K_2}{\overset{k_1}{\rightleftharpoons}} R \quad \Delta H_R = -18\ kcal/mol$



The feed concentration, C_{Af}, is 4 mol/L and feed flowrate, Q_f, is 250 L/min. The reaction-rate constants have been determined experimentally

$k_1 = 3\times10^7 e^{-5838/T}\ \ \min^{-1}\ \ and\ \ K_2 = 1.9\times10^{-11} e^{9059/T}$

i) At what temperature must the reactor be operated to achieve 80% conversion?

ii) What are the heat duties of the two heat exchangers if the feed enters at 25 °C and the product is to be withdrawn at this temperature? The heat capacity of feed and product streams can be approximated by the heat capacity of water, $\hat{C}_p = 1\ cal/g\,K$.

12

Group - E

8. (a) Describe the nernst equation for the electrochemical oxidation and reduction reaction in the fuel cell environment.

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

5 + 7 = 12

9. (a) Describe the electrical characteristic of the PV cell. Define the solar PV efficiency. Consider a 400W system with an area of 30 ft² and determine the maximum efficiency of the above solar panels under STC.

(b) What is a solar pond? What are the special arrangements made in solar pond to retain the heat energy content in solar pond?

(3 + 2 + 2) + 5 = 12

PROCESS MODELLING 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) A _____ physical model is to show people how a product looks like
(a) mock-up (b) prototype (c) conceptual (d) graphic.

(ii) For Heun's predictor-corrector method the solution given as _____, y^P is the predicted solution.

(a) $y = y^{old} + \frac{h}{2}\left[f\left(y^{old},t\right) + f\left(y^P,t+h\right)\right]$ (b) $y = y^{old} + hf\left(y^{old},t\right)$

(c) $y = y^{old} + \frac{h}{4}\left[f\left(y^{old},t\right) + f\left(y^P,t+h\right)\right]$ (d) $y = y^{old} + \frac{h}{2}f\left(y^{old},t\right)$

(iii) Forced convection is governed by _____ number
(a) Reynolds (b) Euler (c) Grashof (d) Rayleigh.

(iv) Biot number is _____ for lumped parameter analysis with less errors
(a) greater than 1 (b) less than 0.1
(c) greater than 0.1 (d) less than 1.

(v) For a single ideal mixed flow reactor the residence time distribution can be modelled with _____
(a) Poisson distribution (b) Gaussian distribution
(c) Bionomial distribution (d) Boltzmann distribution.

(vi) Stefan-Maxwell Approach should be used for _____ order models
(a) higher (b) zeroth (c) first (d) third.

(vii) The power from the sun intercepted by the earth is approximately
(a) 1.8×10^8 MW (b) 1.8×10^{11} MW
(c) 1.8×10^{14} MW (d) 1.8×10^{17} MW.

(viii) Emissivity of perfect black body is
(a) 1 (b) 0 (c) ∞ (d) None of these.

(ix) The extraterrestrial radiation flux varies by _____ % over a year.
(a) ± 1.1 (b) ± 2.2 (c) ± 3.3 (d) ± 4.4.

(x) A first order reaction requires two equal sized CSTR. The conversion is _____
(a) less when they are connected in series
(b) more when they are connected in parallel
(c) same whether they are connected in series or in parallel
(d) more when they are connected in series.

Group – B

2. (a) Develop a mathematical state space model for an ideal CSTR along with proper diagram.

(b) "A CSTR with nonideality shows stochasticity in the process." – Justify the correctness of the statement.

10 + 2 = 12

3. (a) Develop a mathematical model for multi effect solar evaporator's heater and preheater units for a desalination plant collecting sea water as raw feed.

(b) Brief on a significant difference between mathematical and physical modelling.

10 + 2 = 12

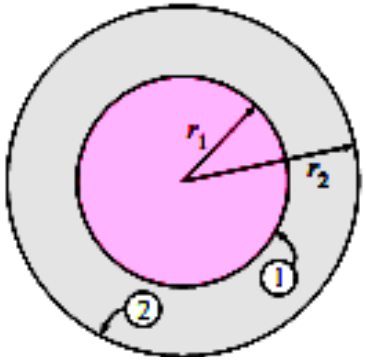
Group - C

4. Cooling down of a hot surface in a water bath (sphere-cooling for short), where a glass sphere with dia D = 1 cm, is taken out of a bath at $T_1 = 100^oC$ and submerged in a bath of ambient water $T_\infty = 15^oC$ with an estimated convective co-efficient of *h* is 500 W/m²K. Find the heat transfer rate during cooling down of the glass ball when $L = \frac{V}{A} = \frac{D}{6}$. Data given $k = 1 w/m.k; \rho = 2500 kg/m^3; C = 800 J/kg.K$

12

5. (a) Engine oil at 60^oC flows over a 5 m long flat plate whose temperature is 20^oC with a velocity of 2 m/s. Determine the total drag force and the rate of heat transfer per unit width of the entire plate.

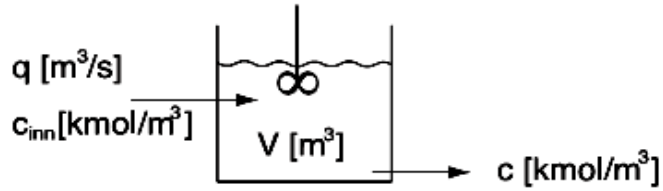
(b) Determine the view factors associated with an enclosure formed by two spheres, shown in Figure.

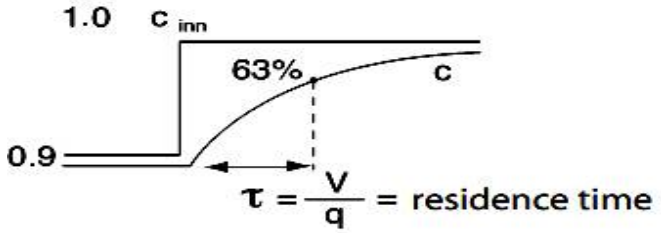


6 + 6 = 12

Group - D

6. Consider the concentration response for component A in a continuous stirred tank without chemical reaction as shown in the figure. It can be assumed that constant liquid density ρ and constant volume V. The system is assumed to be at rest at t = 0. We want to find the step response for t > 0 given the following data V = 5 m³; q = 1 m³/h. Find the Concentration response in continuous stirred tank.





12