BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(MID SEMESTER EXAMINATION)

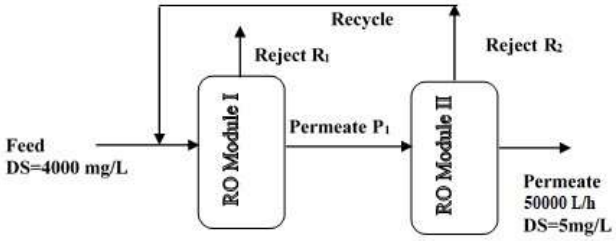
CLASS: BE **SEMESTER: V**
BRANCH: CHEMICAL **SESSION : MO/2019**

SUBJECT : CL5007 COMPUTER AIDED PROCESS ENGINEERING

TIME: 1.5 HOURS **FULL MARKS: 25**

INSTRUCTIONS:
1. The total marks of the questions are 30.
2. Candidates may attempt for all 30 marks.
3. In those cases where the marks obtained exceed 25 marks, the excess will be ignored.
4. Before attempting the question paper, be sure that you have got the correct question paper.
5. The missing data, if any, may be assumed suitably.

Q1 (a) A reverse osmosis plant produces 50000L/h of treated water (permeate) with 5mg/L dissolved solid. The supply (feed) water contains 4000 mg/L dissolved solid (DS). The two reverse osmosis membrane modules are used to produce treated water in the following scheme, [3]



Construct required independent material balance equations of the reverse osmotic system with degree of freedom analysis where feed flow rate F, reject rate at the module I is R_1, reject rate at the module II is same as recycle rate R_2, permeate rate at the module I is P_1, and dissolved solid concentrations of all the streams not mentioned are unknowns. Assume that the density of all the streams are same.

(b) Demonstrate suitable Matlab function with routine to solve the above system. [2]

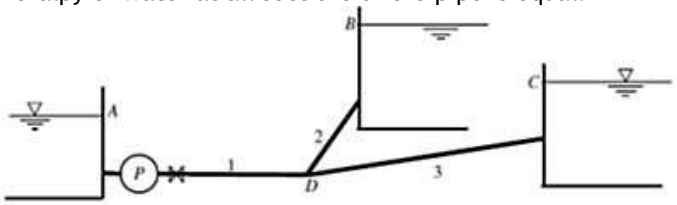
Q2 (a) Oxidation of sulphur dioxide is carried out in a converter reactor with 95% conversion. The gases leave the reactor at 600 ^oC. The inlet gas flowrate is 100 kmol/hr and compositions are 8% SO_2, 10% O_2, 82% N_2. The reaction is given by, [2]

$$\boldsymbol{SO_2(g) + \frac{1}{2}O_2(g) = SO_3(g)}$$

Calculate the outlet gas compositions and extent of the reaction.

(b) Construct the energy balance equation of the sulphur dioxide oxidation reaction to estimate heat duty per kmol of SO_2 gas for isothermal operation at 1 bar pressure and 500^oC feed temperature. Heat of formation at 25^oC and specific heat capacity at the temperature span of 500^oC-600^oC for all the components are given by $\{(\boldsymbol{H_f})_i\}$ and $\{\boldsymbol{C_p(i,T)}\}$, where $\boldsymbol{i = 1,2,3,4}$ are the number species in the reaction. Must present it from the original derivation combined with material balance equations of the species. [3]

Q3 (a) Construct energy equations for pipe 1, 2, and 3 with respect to junction D of head H_D. from the given figure. The pump head – discharge curve is $\boldsymbol{H_p = 20 - 30Q^2}$, where the head is in m and the discharge Q is in m^3/s. H_A=10 m, H_B=20 m, H_C=18 m, R_1=112.1 s^2/m^5, R_2= 232.4 s^2/m^5, R_3=1173 s^2/m^5. Note: Head loss in the line, $\boldsymbol{h_L = RQ^2}$. Assume enthalpy of water at all sections of the pipe is equal. [2]



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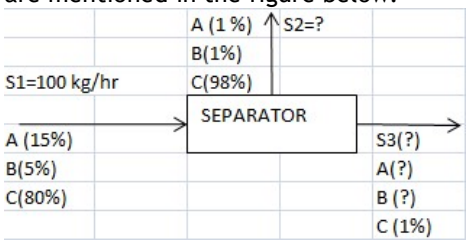
(b) Solve for Q_2, and Q_3 using trial and error method assuming Q_1, until the continuity equation $\boldsymbol{Q_1 = Q_2 + Q_3}$ is satisfied. Proceed for at least 3 trials. [3]

Q4 (a) Develop the independent material balance equations of the separator system where s1, s2 and s3 are stream mass flow rates with mass fractions of three components A, B, C are mentioned in the figure below. [2]



(b) Demonstrate required numerical method to solve the system with its algorithm. [3]

Q5 Determine bubble point temperature of liquid mixture with 60% pentane (1) and 40% hexane (2) at 5 bar pressure. Where, $\boldsymbol{log_{10}P_{sat}(bar) = A - \frac{B}{T(K)+C}}$.Assume ideal mixtures. Show 2 iterations in a suitable numerical scheme. [5]

Components	A	B	C
pentane	3.97786	1064.840	-41.136
hexane	4.00139	1170.875	-48.833

Q6 (a) Demonstrate the NRTL model with their properties in liquid-liquid equilibria. [2]

(b) Derive required independent equations for the determination of liquid-liquid equilibria for a liquid mixture of 3 components. Consider nonideal solution. [3]

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