BACHELOR OF CHEMICAL ENGINEERING FOURTH YEAR FIRST SEMESTER EXAMINATION, 2024

SUBJECT: CHEMICAL PROCESS SYNTHESIS

Time: Three hours   Full Marks: 100

Assume any missing data
All the symbols have their usual meaning
Answer ALL the questions

1. Consider the following raw material and reaction list, and synthesize a steady state process flow sheet to obtain a mixture of A_6 and B_9 at a temperature of 50°C and 1 atm pressure. **[25]**

Raw materials				Reactions				
Stream	Species (liq.)	Temp, °C	Pressure, atm	Reaction	Reactants	Products	Temp, °C	Pressure, atm
S_1	A_5, A_4	25	1	$2A_1+A_2 \rightarrow 2A_3+A_4$	A_1, A_2	A_1, A_3, A_4 (liq)	100	2
S_2	A_2, B_3	25	1	$A_3+2A_5 \rightarrow A_6+A_7$	A_3, A_5	A_6, A_3 (liq) A_7, A_5 (gas)	80	1
S_3	A_1, B_1, B_2	25	1	$A_3+2A_8 \rightarrow A_9+7A_{10}$	A_3, A_8	A_8, A_9, A_{10} (liq)	50	1
S_4	A_8, B_9	25	1					

2. Consider the following process streams available in a plant and using Pinch Technology for Heat Exchanger Network, find the following:

a) Draw a composite hot and cold streams diagram on a graph paper. **[15]**
b) Indicate the pinch location with an approach temperature of 10°C on the plot. **[2]**
c) The hot and cold utility load from the plot with the same approach temperature. **[3]**

Stream No.	Inlet temperature (°C)	Outlet temperature (°C)	Heat capacity (kW/°C)
1	400	60	0.2
2	375	125	0.2
3	210	40	0.4
4	20	160	0.3
5	100	300	0.5
6	100	250	0.8

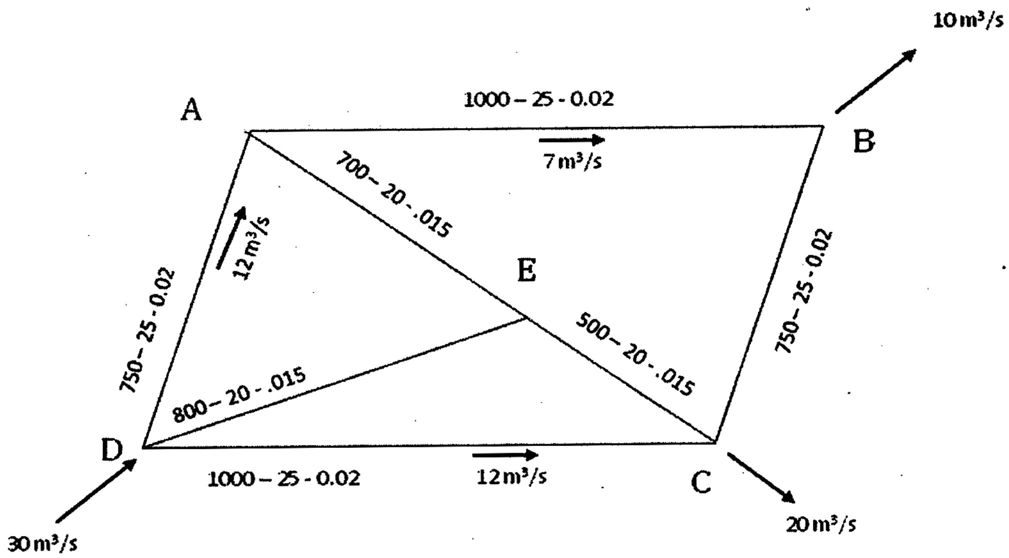
3. There are four pipe lines which are carrying process fluids in a chemical plant. To make a proper network of heat exchanger using 'Pinch Technology', find the following:
a) The hot and cold utility load with an approach temperature of 20°C by Temperature Interval Diagram (TID) Method. **[10]**

b) Design a proper Heat Exchanger Network indicating all the heat loads and intermediate temperatures with same approach temperature. **[10]**

The stream description is given in the following table.

Stream No.	Inlet temperature (°C)	Outlet temperature (°C)	Heat capacity (kW/°C)
1	450	110	0.2
2	220	50	0.4
3	40	180	0.3
4	120	320	0.5

4. The pipe network shown below is to be analyzed by the Hardy Cross method. The hydraulic properties and geometry are labeled on each pipe (i.e. length of the pipe in meter, diameter of the pipe in cm and friction coefficient for Manning equation). Find the flow rate in each pipe through the proposed analysis method in a tabular form **(complete ONE iteration)**. The initial guess of flow rate in some of the pipe is indicated in figure. Draw the optimal pipe network indicating the corrected flow rate and direction of flow in each pipe. **[20]**



5. Develop an optimal separation flowsheet using Motard empirical method to achieve goals G_1, G_2 and G_3 when two streams S_1 and S_2 are available. The order of achieving the goal is G_2, G_1 and G_3. Show the necessary table and procedure for Motard empirical method for minimization of separation load. **[15]**

	Components	
Stream	X_A	X_B
S_1	3	7
S_2	7	3
G_1	2	0
G_2	3	7
G_3	5	3