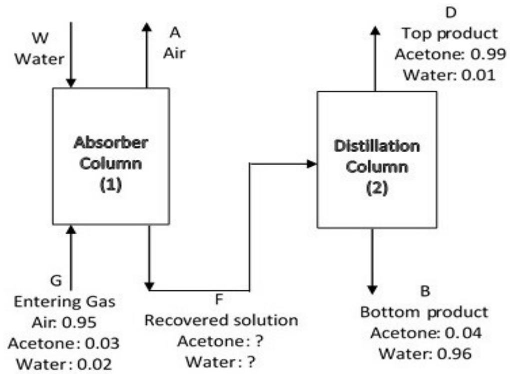
BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: BE **SEMESTER : V**
BRANCH: CHEMICAL **SESSION : MO/19**

SUBJECT: CL5007 COMPUTER AIDED PROCESS ENGINEERING
TIME: 3 HOURS **FULL MARKS: 60**

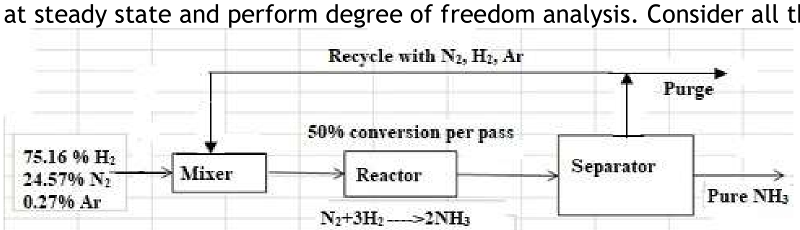
INSTRUCTIONS:
1. The question paper contains 7 questions each of 12 marks and total 84 marks.
2. Candidates may attempt any 5 questions maximum of 60 marks.
3. The missing data, if any, may be assumed suitably.
4. Before attempting the question paper, be sure that you have got the correct question paper.
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

Q.1(a) An acetone recovery system recovers 99 mole% acetone given in the figure below. Formulate all independent material balance equations of the system at steady state. Construct the solution set of equations with degree of freedom analysis. Consider all the flowrate in kmol/hr and composition in mol fraction. [6]



Q.1(b) Construct the solution algorithm with a suitable numerical method for the acetone recovery system. [6]

Q.2(a) In the famous Haber process (Figure below) to manufacture ammonia, the fresh feed of gas composed of 75.16% H_2, 24.57% N_2, and 0.27% Ar is mixed with the recycled gas and enters the reactor that converts 50% the limiting reactant. Formulate independent material balance equations of the system at steady state and perform degree of freedom analysis. Consider all the flowrate in kmol/hr. [6]



Q.2(b) Demonstrate *MATLAB* function and main routine for the solution of the Haber process. [6]

Q.3(a) Differentiate between ideal and nonideal solution. [2]

Q.3(b) Depict different types of property estimation method for gas mixture in chemical process industry with their valid molecules. [2]

Q.3(c) Determine dew point temperature of vapor mixture with 70% hexane (1) and 30% cyclohexane (2) at 4 bar pressure. Where, $\log_{10} P_{sat}(bar) = A - \frac{B}{T(K)+C}$. Assume ideal mixtures. Show two iterations in a suitable numerical scheme. [8]

Components	A	B	C
hexane	4.00139	1170.875	-48.833
cyclohexane	3.93002	1182.774	-52.532

Q.4(a) Write Rachford –Rice equation for isothermal flash calculation with degree of freedom analysis. [2]

Q.4(b) Show the solution methodology of the Rachford –Rice equation in EXCEL spreadsheet. [4]

PTO

Q.4(c) Two centrifugal pumps A and B of characteristics curve $H_{PA} = 20 + 10Q - 110Q^2$ and $H_{PB} = 20 + 10Q - 110Q^2$, respectively. How does one determine pump characteristics curve and flow rate Q for the combined pump-pipe system: i) connected parallelly in a line, ii) connected in series in a line? Take R=80 s^2/m^5 and $H_B - H_A = 20\,m$. [6]

Q.5(a) What is the importance of unsteady state simulation in a chemical process? [2]

Q.5(b) Derive the unsteady state material balance (species) equations of an isothermal CSTR where one fraction (split fraction=0.01) of the product stream is recycled back to the reactor inlet and mixed with the feed stream of pure A (reactant). The reaction is $A \rightarrow B$ with the rate equation $-r_A = kc_A$. Fix the system with degree of freedom analysis. [4]

Q.5(c) For a flash chamber separating a binary mixture, i) derive unsteady state material balance and energy balance equations, ii) present all the independent equations for carrying out transient simulation. [6]

Q.6(a) The gas phase reaction (series) $A \overset{k_1}{\rightarrow} B \overset{k_2}{\rightarrow} C$ is carried out in a PFR. The reaction kinetics are given by $k_1 = k_1^0 \exp(-E_1/RT)\,; n_1 = 1$ for first reaction and $k_2 = k_2^0 \exp(-E_2/RT)\,; n_2 = 1$ for 2nd reaction. Using *ASPEN PLUS* simulation, depict the steps for determination of product (C) conversion and temperature distributions in the reactor for a 10 m^3 reactor volume. All the symbols are used in generalized relation of a reaction kinetic.Assume values of undefined parameters. [6]

Q.6(b) In a process carbon dioxide and hydrogen are reacted to form the methanol product at 400°C and 5 MPa pressure in an adiabatic reactor: $CO_2 + 3H_2 \Leftrightarrow CH_3OH + H_2O$. The reactor effluent is cooled to a temperature of T_S and fed to a separator. Assume reactor conversion is 28%. One fraction (split fraction 0.95) of unreacted gas with water is recycled back to the reactorinlet and mixed with the feed stream. The remaining part is purged. [6]
Feed specifications are as follows: compositions (mol %) hydrogen 74.85, carbon dioxide 24.95, CH_4 0.1, and Argon 0.1; flow rate (kmol/hr) 1000; Temperature (°C) 50; Pressure (MPa) 1 MPa.
Prepare*ASPEN PLUS* flowsheet for the process. Write each block with its name and specifications. Choose suitable blocks in actual and intermediate positions.

Q.7(a) Depict different types of liquid-liquid separator blocks in *ASPEN PLUS* with their specifications. [4]

Q.7(b) In a steam-water (two-phase flow) flow through a pipeline, number of steam bubble dispersed in water have been observed in a specific length of the pipe and in 1 sec interval. The frequency of steam-bubbles with their number are listed below. [8]

Number of bubbles	0	1	2	3	4	4>
frequency	1	3	9	25	12	0

a) Evaluate experimental probability distribution.
b) Estimate the mean and standard deviation of the frequency distribution from the given data.
c) Evaluate normal probability distribution from the experimental data.

:::::02/12/2019:::::M