Ex/PG/ChE/T/112B/5/2017

M. Chem. 1st Year 1st Semester Examination, 2017

Advanced Mass Transfers

Time: Three hours | Full Marks: 100

Answer ***any four*** questions.
Assume any missing data.

1. (a) Find the bubble point (BP) and dew point (DP) temperature of the following mixture at 8 atm assuming ideal mixture behavior.

Benzene:	60%
Toluene:	10%
Styrene:	30%

Assume ideality in vapor and liquid phase, and use Antoine's equation for correlating vapor pressure with temperature. Take suitable initial guess giving proper justification. The equilibrium data are given in **Table: 1**.

(b) Find the BP and DP temperature of the above mixture at same pressure, i.e. 8 atm, using relative volatility approach. Highlight the advantage of the relative volatility over the iterative method.

10+(10+5) = 25

2. (a) Without determining bubble point and dew point temperatures, how can you be sure that flash temperature lies within bubble point and dew point temperature of the feed?

(b) Consider a ternary mixture of propane (C_3), n-butane (n-C_4) and n-pentane (n-C_5) with respective molar compositions being 20%, 30% and 50%. This feed stream enters into a flash tower at 80°C. Find the pressure which must be maintained within the flash tower for 70% vaporization. Determine the compositions of the respective streams under this condition. Assume ideal behavior. The equilibrium data are given in Table: 1.

(c) Sometimes relative volatility is used instead of K_i in multicomponent separation calculations – Why? Show that the bubble point function expressed in terms of relative volatility can be expressed as $K_b = \left[\sum_{i=1}^{c} \alpha_i x_i\right]^{-1}$, where the symbols have their usual meaning.

5+10+10 = 25

3. (a) A multicomponent feed stream is flashed adiabatically in a flash tower maintained at pressure P_F. The feed temperature is T, molar flow rate F and composition z_{Fi}, $(i=1,...,c)$, where c is the total number of component. All these parameters are supposed to be known. Suggest a suitable method to estimate the required flash temperature (T_F) that has to be maintained within the flash column for the operation to occur adiabatically. Write a complete step-by-step algorithm to solve the above problem.

(b) Determine the "**degrees of freedom**" of a multistage simple distillation column, equipped with N number of stages and fed with F kmol/s of a stream containing c number of components. The distillation column may be assumed to be equipped with a total condenser and partial re-boiler. Suggest a suitable specification of variables (as suggested by Thiele – Geddes method) for solving a simulation problem. Follow **Holland and Van Winkle approach.**.

(c) A feed mixture containing 20% C_3, 40% n-C_4 and rest n-C_5 enters into a distillation column at 60°C and 8 atm. pressure. It is proposed to obtain a distillate containing 95% of C_3 and not more than 5% of n-C_5 contained in the feed. In the context of the above problem, estimate the key components giving reason and justify your estimate employing SHG (Shiras-Hamson-Gibson) equation. Use Antoine's equation and Ideal mixture assumption.

10+5+10 = 25

5. A benzene-toluene cut at its bubble point, containing 50mole % benzene and 50mole % toluene is to be fractionated at 6 atm pressure to recover benzene of 99.9% purity with a yield of 95% of benzene in the feed. Assume ideal behavior and use Antoine's equation for VLE calculation.
   a) Determine minimum reflux by Underwood method.
   b) Determine minimum number of plates at total reflux by Fenske's method.
   c) Use Gilliland correlation to find actual number of plates at operating reflux ratio $R_{opt} = 1.5R_m$
   d) Find feed plate location using Kirkbride correlation

10+5+5+5 = 25

6. (a) Write the general algorithm for calculation of minimum reflux ratio by Underwood method for the case of non-adjacent keys. Clearly write all the specified variables. Also determine the composition of distillate and bottoms at minimum reflux ratio.

(b) What do you mean by temperature correction in FUG method? How this is accomplished in Underwood or Fenske's method?

(c) Consider an equilibrium stage with heat addition, feed stream, and side-stream. Analyze the variance of the process and suggest a suitable variable specification based on **Kwauk approach.**

10+5+10 = 25

Table: 1

Antoine's constants, vapor pressure in mm Hg and temperature in Kelvin

Component	A_i	B_i	C_i
Ethane (C_2)	15.6637	1511.42	-17.16
Propane (C_3)	15.7260	1872.49	-25.16
n-Butane (n-C_4)	15.6782	2154.90	-34.42
n-Pentane (n-C_5)	15.8333	2477.07	-39.94
n-Hexane (c-C_6)	15.8366	2697.55	-48.78
Benzene	15.9008	2788.51	-52.36
Toluene	16.0137	3096.52	-53.67
Ethyl benzene	16.0195	3276.47	-59.95
Styrene	16.0193	3328.57	-63.72