Birla Institute of Technology and Science, Pilani
Second Semester 2021-2022
Comprehensive Examination
CHE F244 Separation Processes-I

DATE: 10.05.2022 **Time: 8.00-11.00 AM** **Maximum Marks: 120**

1. (40 *Marks*) Answer the following questions together and in sequence.
   (a) Briefly discuss on effusion, permeation, dialysis and reverse osmosis with respect to separating agent and the principle of separation. What is the difference between osmosis and reverse osmosis?
   (b) Explain why operating line for stripping section starts from the point (x_w, 0.0) rather than (x_w, x_w) point when open steam is used instead of a reboiler.
   (c) If y-coordinate of feed pinch point becomes greater than or equal to the distillate composition, what should be the value of minimum reflux ratio, and why? In case of tangent pinch, how can you find the minimum reflux ratio?
   (d) What is total reflux? Explain why number of stages are minimum at total reflux?
   (e) Using component balance equations at rectifying and stripping sections, obtain the equation for feed line.
   (f) Using simple distillation, explain how you can obtain the relative volatility of a system.
   (g) With a neat diagram show the different parts of a tray tower. Indicate the functions of weir and the slanting downspout.
   (h) In case of binary gas system total concentration is constant, but in case of binary liquid system it is not so. Explain.
   (i) Explain why total cost passes through a minimum as we go on increasing the reflux ratio for a given condition of separation.
   (j) In leaching, when the overflow and underflow are in equilibrium, how are the respective solute concentrations related? Define plait point and outline the significance of phase envelope in liquid-liquid extraction.

2. (25 Marks)
5000 kg/h of a SO_2-air mixture containing 10 mol% SO_2 is scrubbed with 2 times the minimum water rate in a packed tower to absorb 90 mol% of SO_2. The tower operates at 1 atmosphere. The equilibrium relationship is Y = 0.05 X, where Y = mole SO_2/ mole air and X = mole SO_2/ mole water. Estimate the packed height of the tower, if overall gas transfer coefficient is 5.128×10^{-4} kmol/m^2.s.atm and the interfacial area between the packing is 150 m^2/m of the packed height.

3. (30 *Marks*)

One hundred kmol per hour of a mixture of 40 mol% methanol in water at 30°C and 1 atm is to be separated by distillation at the same pressure into a liquid distillate containing 96 mol% methanol and a bottom liquid product containing 94 mol% water. The enthalpy of the feed mixture is 2000 kJ/kmol.

The reflux is at its bubble point and the reflux ratio is 2.0. Determine (a) Distillate and bottoms flow-rates; (b) the number of ideal trays required using the Ponchon-Savarit method; (c) the heat duty of the condenser and the reboiler; (d) the ideal tray number (from top) at which the feed is to be entered.

The enthalpy-concentration (kJ/kmol; ref. state: pure liquid at 0°C) and the vapor-liquid equilibrium data at the operating pressure of 1 atmosphere are given below:

x, y*	0	0.05	0.10	0.15	0.20	0.30	0.40
H_L	7536	7140	6862	6629	6420	6094	5908
H_V	48195	47730	47311	46892	46520	45683	44915

x, y*	0.50	0.60	0.70	0.80	0.90	1.00
H_L	5745	5606	5513	5420	5327	5234
H_V	44124	43380	42589	41821	41124	40449

(x, y*): (0, 0); (0.02, 0.134); (0.04, 0.23); (0.06, 0.304); (0.08, 0.365); (0.10, 0.418) (0.15, 0.517); (0.20, 0.579); (0.30, 0.665); (0.40, 0.729); (0.50, 0.779); (0.60, 0.825); (0.70, 0.87); (0.80, 0.915); (0.90, 0.958); (0.95, 0.979); (1, 1).

Hint: Take scale, for mole fractions: 1 cm = 0.1, for enthalpy: 1 cm = 10,000 kJ/kmol

4. (25 *Marks*)

Roasted copper ore containing copper as $CuSO_4$ is to be extracted in a counter current extractor. The feed charge to be treated per hour comprises 10 tons of gangue, 1.2 tons of $CuSO_4$ and 0.5 ton of water. The strong solution produced is to consist of 95% water and 5% $CuSO_4$ by weight. The recovery of $CuSO_4$ is to be 90% of that in the ore. Pure water is to be used as the fresh solvent. After each stage, one ton of inert gangue retains 2 tons of water plus the copper sulphate dissolved in that water. How many equilibrium stages are required? Assume no solid is lost in the overflow so that the rate of gangue remains constant in all the stages.

Hint: Take scale, for solute axis: 2 cm = 0.01, for solvent axis: 1 cm = 0.1

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(All the Best)