Ref. No.: Ex/ChE/T/311/2019 (Old)

B.E. Chemical Engineering 3rd Year 1st Semester Exam 2019 (Old)

Separation Process I

Part I

Answer any two questions

Symbols carry their usual meaning

Assume any missing data

1(a) The liquid phase (x) and vapor phase (y) mole fraction of a component at a cross section in a mass transfer equipment is 0.2 and 0.04 respectively. The magnitude of individual liquid phase and vapor phase mass transfer coefficient is 1.6×10^{-3} kmol $m^{-2}s^{-1}$ and 1.4×10^{-3} kmol $m^{-2}s^{-1}$ respectively.

The equilibrium relation is given by $y = x^{3.2}$

(i) Determine the direction of mass transfer?

(ii) Estimate the overall gas phase mass transfer coefficient and overall liquid phase mass transfer coefficient respectively from the above data. [3+9]

(b) A liquid mixture containing 40 mole% n-heptane and the remaining n-octane is to be continuously flash vaporized at 1 std atm pressure to vaporize 75 mole% of the feed. Determine the composition of the vapor and liquid phase exiting the separator as well as the temperature in the separator. [13]

The vapor-liquid equilibrium data for n-heptane (*A*) and n-octane (*B*) system at 1 std atm is given below

t (°C)	x_A	y_A
98.4	1.0	1.0
105	0.655	0.81
110	0.487	0.674
115	0.312	0.492
120	0.157	0.279
125.6	0	0

Where x_A and y_A is the mole fraction of hexane in liquid and vapor phase respectively.

2(a) A staged column is used to remoter contains toluene from water by stripping with air. The water contains 60×10^{-6} g/g of toluene. The concentration needs to be reduced to 5×10^{-6} g/g. The average pressure within the column is 1.1 atm. The equilibrium relationship is $P_{tol}(atm) = 256x$, where P_{tol} is the partial pressure of toluene in the and x is the mole fraction of toluene in the liquid phase.

(i) Determine the minimum air flow rate in gmol/min for water flow rate of 100 L/min

(ii) Calculate the number of stages for an air flow rate of twice the minimum?

(iii) Determine the concentration of the streams entering and leaving the 2nd stage from the top of the column?

(b) Distinguish between axial dispersion and back mixing? [22 + 3]

3. A liquid mixture containing 40 mole% n-heptane and the remaining n-octane is to be continuously fractionated at standard atmospheric pressure at the rate of 4000 kg/h. The distillate product is to contain 95 mol% hexane and the residue 5 mol%. A total condenser is used and the reflux returned at the bubble point. Determine [25]

(i) the product rates in kg/h

(ii) the minimum reflux ratio

(iii) the number of theoretical stages graphically at a reflux ratio equal to twice the minimum

(iv)Temperature of the feed tray and the composition of the streams exiting and entering the feed tray

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Bachelor of Chemical Engineering Examination 2019 (Old)

Separation Processes I

Part II

Answer any **two**

Assume any missing data

1.i) A solution of washed, raw cane sugar, 48% sucrose by weight, is colored by the presence of small quantities of impurities. It is to be decolorized at 80^0 C by treatment with an absorptive carbon in a contact filtration plant. The data for an equilibrium adsorption isotherm were obtained by adding various amounts of carbon to separate batches of the original solution and observing the equilibrium colour reached in each case. The data, with the quantity of carbon expressed on the basis of sugar content of the solution, are as follows:

Kg C/ Kg dry sugar	0	0.005	0.01	0.015	0.02	0.03
Color removed, %	0	47	70	83	90	95

The original solution has a color concentration of 20, measured on an arbitrary scale, and it is desired to reduce the color to 2.5% of its original value.

a) Convert the equilibrium data to

Y* : color units/kg sugar

X : color units/kg C

Do they follow Freundlich equation? If so, what are the equation constants?

b) Calculate the quantity of fresh carbon necessary, per 1000 Kg of solution, for a single stage process.

ii) In an apparatus, for the absorption of SO_2 in water at one point in the column the conc. of SO_2 in gas phase was 10% SO_2 by volume and was in contact with a liquid containing 0.4% SO_2 by weight. Pressure and temperature of the system are 1 atm and 323 K, respectively. The overall gas phase mass transfer coefficient is 7.36×10^{-10} kmol/m^2-s(N/m^2). Of the total resistance, 45% lies in gas phase and 55% in the liquid phase.

a) Estimate the film coefficients and overall mass transfer coefficient based on liquid phase.

b) Estimate molar flux based on gas phase.

c)

Kg So_2/100 kg water	0.2	0.3	0.5	0.7
Partial pressure of SO_2, mm Hg	29	46	83	119

iii) What is plait point concentration?

12+12+1

2.i) A 2000 Kg batch of pyridine-water solution, 50% pyridine, is to be extracted continuously and counter-currently extracted at the rate of 2.25 Kg/s with chlorobenzene to reduce the pyridine concentration to 2%.

a) Determine the minimum solvent rate required;

b) If 2.3 Kg/s solvent rate is used, what are the number of theoretical stages and the saturated weights of extract and raffinate?

The equilibrium tie line data at 25°C, in weight percent are:

Pyridine	Chlorobenzene	Water	Pyridine	Chlorobenzene	Water
0	99.95	0.05	0	0.08	99.92
11.05	88.28	0.67	5.02	0.16	94.82
18.95	79.9	1.15	11.05	0.24	88.71
24.1	74.28	1.62	18.9	0.38	80.72
28.6	69.15	2.25	25.5	0.58	73.92
31.55	65.58	2.87	36.10	1.85	62.05
35.05	61.0	3.95	44.95	4.18	50.87
40.6	53.0	6.4	53.2	8.9	37.9
49.0	37.8	13.2	49.0	37.8	13.2

ii) Absorption operations are generally gas film controlled. What does it mean? When does it occur?

20+5

3.i) Nicotine is to be extracted from a liquor by using a solvent in a three-stage crosscurrent device. The feed rate is 2000 kg/h, containing 10 mass% nicotine. 95% of the solute has to be recovered. The solvent has 0.001 mass% nicotine in it. The equilibrium of the system can be expressed as $W_I = 0.85W_s$, where W_I is kg nicotine per kg nicotine-free feed and W_s is kg nicotine per kg nicotine free solvent. If equal amounts of solvent are used in each stages, calculate the total solvent requirement for the job.

ii) What are the criteria for selecting solvent for liquid-liquid extraction process?

iv) Which of the following three common trays (a) offers the lowest pressure drop, (b) offers the maximum turndown ratio, (c) enjoys the maximum share of the market?

A) Bubble-cap tray; B) Sieve tray; C) Valve tray

v) Indicate the category to which each of the following devices belongs by mentioning either gas dispersed in the liquid or liquid dispersed in the gas or both the gas and liquid are continuous:

a) tray tower; b) spray tower; c) packed tower; d) falling film absorber;

e) bubble column; f) agitated vessel.

16+3+3+3