Exam Date & Time: 04-Dec-2023 (02:30 PM - 05:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

DEPARTMENT OF BIOTECHNOLOGY
FIFTH SEMESTER B.TECH END SEMESTER EXAMINATIONS, NOV DEC 2023

SEPARATION PROCESSES [BIO 3154]

Marks: 50 **Duration: 180 mins.**

A

Answer all the questions.

Missing data may be suitably assumed

1) Explain the various process parameters that affect the efficiency of steam distillation? (2)

A)

B) Assuming constancy of relative volatility at α=2, determine the value of x at which difference between x and y is maximum.

$$\alpha = \frac{y(1-x)}{x(1-y)}$$ (3)

C) The enthalpy concentration data for binary system (Methanol and water) are as follows. Draw the xy, corresponding H-xy diagrams, with the tie lines. Draw the tie-lines for x=0.1, 0.3, 0.7. Report the values of corresponding y, H_L, H_V

x	y	Hv (kJ/kmol)	H_L (kJ/kmol)
0	0	7536	4819
0.2	0.58	6419	4652
0.4	0.73	5908	4491
0.60	0.82	5605	4337
0.9	0.96	5326	4112
1	1	5233	4044

(5)

2) Equilibrium relationship for adsorption of Phenol by Carbon is given by q=1.3*C, where q=amount of phenol adsorbed in mg Phenol per gram of Carbon, C= concentration of Phenol in mg per kg of water in solution. It is desired to treat 1.3 litre of a solution with

A) phenol concentration of 200mg/kg water in 2 stage cross current treatment with equal amount of carbon in each stage (1 g each). Feed Carbon is pure and assume that 1 litre of solution contains 1 kg water. Determine final solution concentration (C_2) in mg-Phenol/kg-water. Assume basis as one hour of operation, and that 1 litre solution =1 kg water. Do not use graph. (5)

B) What is Hofmeister series? Describe the principles of HIC. (3)

C) How do we quantify the capacity of Ion Exchange Chromatography (2)

3) What does the various values of k_d in size exclusion chromatography indicate k_d [0,1; >1] ? (2)

A)

B) The amount of camphor in an analgesic ointment is determined by GC using the method of internal standards. A standard sample is prepared by placing 45.2 mg of camphor and 2.00 mL of a 6.00 mg/mL internal standard solution of terpene hydrate in a 25-mL volumetric flask and diluting to volume with CCl_4. When an approximately 2-μL sample of the standard is injected, the FID signals for the two components are measured (in arbitrary units) as 67.3 for camphor and 19.8 for terpene hydrate. A 53.6-mg sample of an analgesic ointment is prepared for analysis by placing it in a 50-mL Erlenmeyer flask along with 10 mL of CCl_4. After heating to 50°C in a water bath, the sample is cooled to below room temperature and filtered. The residue is washed with two 5-mL portions of $CCl_4$and the combined filtrates are collected in a 25-mL volumetric flask. After adding 2.00 mL of the internal standard solution, the contents of the flask are diluted to volume with CCl_4. Analysis of an approximately 2-μL sample gives FID signals of 13.5 for the terpene hydrate and 24.9 for the camphor. Report the %w/w camphor in the analgesic ointment. FID signal is directly proportional to concentration/amount of the sample/analyte. (3)

C) Benzene in an air benzene mixture is to be reduced from initial mole ratio of 0.02 by contacting with wash oil in a four stage countercurrent gas absorber. The inlet flow rate of air-benzene mixture is 10 mol/s while benzene free wash oil enters at 9.8 mol/s. If the equilibrium curve is given by Y=X, where Y and X are equilibrium mole ratios of benzene in air and benzene in oil respectively, compute the concentration of benzene in outlet air and concentration (mole fraction) of benzene in outgoing wash oil. Solve the problem graphically, by trial and error method. (5)

4) Compare and contrast the three adsorption isotherm models that you have studied (2)

A)

B) Complete the following table

N_B	α	k_B	R_{AB}
100000	1.05	0.5	
10000	1.1		1.5
10000		3.0	1.0

(3)

$$R_{AB} = \frac{\sqrt{N_B}}{4} \times \frac{\alpha - 1}{\alpha} \times \frac{k_B}{1 + k_B}$$

C) The data in Table below have been measured for the growth of crystals of an antibiotic. From this data set, obtain an expression for the relationship between *dL/dt* and the supersaturation $c - c*$ (5)

$$\frac{dL}{dt} = k_g(c - c^*)^g$$

$c - c^*$ (g/liter)	dL/dt (μm/min)
0.20	0.21
0.35	0.45
0.67	0.90
1.25	1.80
2.05	3.30
2.75	5.00

5) A chromatographic separation of four compounds gave the following results,

A)

Analyte	1	2	3	4
Retention Time, sec (RT)	100	220	290	500
Peak width at base, sec (wb)	20	60	45	80

The dead time/mobile phase residence time (tm) is 15 sec, t_R is retention time (RT),

a. Compute the capacity factor (k`) for all analytes ? (3)

$$t_R = t_m(1 + k')$$

b. What is the maximum number of plates (n) for the column?

$n=16(t_R/wb)^2$

c. What is the resolution factor for analytes 1&2, 2&3 and 3&4?

$$R_s = 2\left[\frac{t_{R2} - t_{R1}}{W_{h1} + W_{h2}}\right]$$

B) Explain Meir's theorem (2)

C) Drying rate data have been obtained for three biological solids (see Table below). Based on these data,

a. Determine the type of material – (i) Non hygroscopic (ii) Partially Hygroscopic (iii) Hygroscopic (5)

b. Classify the drying operation based on the following (i) boundary layer control, (ii) internal diffusion control

Material 1		Material 2		Material 3	
Moisture content (kg/kg)	Drying rate $\times 10^4$ (kg m^{-2} s^{-1})	Moisture content (kg/kg)	Drying rate $\times 10^4$ (kg m^{-2} s^{-1})	Moisture content (kg/kg)	Drying rate $\times 10^4$ (kg m^{-2} s^{-1})
0.06	0.3	0.03	0.5	0.02	3.0
0.13	0.9	0.07	1.6	0.06	5.5
0.21	1.5	0.12	2.7	0.11	6.7
0.26	2.4	0.18	3.8	0.16	7.7
0.31	3.3	0.22	4.8	0.20	8.3
0.35	4.4	0.26	5.7	0.23	8.6
0.38	5.5	0.29	6.4	0.27	8.6
0.40	6.8	0.32	7.0	0.34	8.6
				0.38	8.6

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