Department of Chemical Engineering **IIT Delhi**

CHL 735 Design of Separation Processes **Term : Jan. 2008**

Max. 40 points
Time 2 hr.

28. 4. 2008

Major

Answer should be brief and to the point.
Maintain the continuity of the parts of each question

1. (a) Although in the lecture class it is pointed out (wrongly!) during question-answer session that cross over ratio, R, does not play any role in deciding choice of regeneration cycle (TSA or PSA). From common sense, can you recommend what would be the regeneration cycle if R = 14 and 0.4.
(b) The separation of propane and propylene is accomplished by distillation, but at the expense of more than 100 trays and has been investigated in number of studies. Jarvelin and Fair (Ind. Eng. Chem Res, 32, 2201-2207 (1993)) measured adsorption equilibrium data at 25 °C for three different zeolite molecular sieves (ZMSs) and activated carbon. The data were fitted to the Langmuir isotherm with the following results:

Adsorbent	Adsorbate	q_m	K
ZMS-4A	C_3	0.226	9.770
	$C_3^=$	2.092	95.096
ZMS-5A	C_3	1.919	100.223
	$C_3^=$	2.436	147.260
ZMS-13X	C_3	2.130	55.412
	$C_3^=$	2.680	100.00
Activated carbon	C_3	4.239	58.458
	$C_3^=$	4.889	34.915

Where, q_m and q are in mmol/g, p is in bar and $\theta = q/q_m$. q_m is the maximum loading corresponds to complete coverage of adsorbent.

(a) Which component is most strongly adsorbed by each of the adsorbent?
(b) Which adsorbent has the greatest adsorption capacity?
(c) Which adsorbent has the greatest selectivity?
(d) Based on equilibrium consideration, which adsorbent is the best for separation?

4+8 = 12

2. (i) If bed utilization is low in an adsorption column how it can be improved?
(ii) Explain whether MTZ would increase or decrease with the length of the adsorption column for type III adsorption isotherm.
(iii) Give example of an emulsion liquid membrane proeess clearly identifying role of each phases.
(iv) Calculate feed time for a TSA process with feed of 0.30 mole fraction of propane, total molar flow rate of 100 mol/s, 120 kg of activated carbon adsorbent and q = 10 m mol /g.
(v) Plot HETP versus total flow rate for different extraetors (RDC, YS, Sieve tray col, structured packing eol, centrifugal extractors) and write significance of sueh plot (2/3 sentences).

5x2 = 10

3. (a) What is micells and why they are formed when large quantity surfactants are dissolved in water?
(b) Why aphron stability increases with the surfaetants concentration and decreases with the increase in salt concentrations ?

(c) Acetic acid is continuously extracted from a 3 wt% dilute solution in water with a solvent of isopropyl ether in a mixer-settler unit. The flow rates of the feed and solvent are 12,400 and 24,000 kg/h respectively. Assuming a residence time of 1.5 min in the mixer and settling vessel capacity of 4 gal/min-ft^2, (1 gal = 3.785 L) estimate (a) diameter and height of mixing vessel (b) diameter and length of settling vessel assuming $L/D_S = 4$ (e) residence time in min in settling vessel. Assume sp gravity of feed is 7.

2+2+6

4. Consider the separation by distillation of a chlorination effluent to recover C_2H_5Cl. The feed is a bubble point liquid at the column pressure of 240 psia with the following composition and K-values for the column conditions:

Comp.	Mole fraetion	K
C_2H_4	0.05	5.1
HCl	0.05	3.8
C_2H_6	0.10	3.4
C_2H_5Cl	0.80	0.15

Specifications are (X_D/X_B) for $C_2H_5Cl = 0.01$; (X_D/X_B) for $C_2H_6 = 75$

Caleulate the minimum theoretical stages, product distribution - (X_D/X_B) for HCl and C_2H_4 and show that there are three possible roots for θ and whieh one should be used for calculation of R_{min}

8