UNIVERSITY OF GHANA

B.Sc ENGINEERING SECOND SEMESTER EXAMINATION: 2015/2016
SCHOOL OF ENGINEERING SCIENCES
FPEN 302: SEPARATION PROCESSES (2 Credits)

INSTRUCTIONS

ANSWER FOUR QUESTIONS

EQUILIBRIUM CURVE FOR METHANOL/WATER SYSTEM IS PROVIDED.

TRIANGULAR DIAGRAM FOR ACETONE-MIK-WATER IS PROVIDED.

TIME ALLOWED: TWO (2) HOURS

1. An expression for the number of ideal stages, N, in a system with straight operating and equilibrium lines for the removal of a component from a liquid feed using clean air, can be derived from the Kremser equation as

$$N = \frac{\ln[(y_a - y_a^*)/(y_b - y_b^*)]}{\ln[(y_a - y_b)/(y_a^* - y_b^*)]}$$

   a) On a y-x diagram, draw the operating and equilibrium lines for such a system and indicate all the quantities involving *y's* in the equation above on the diagram.
   b) The denominator defines the absorption factor A. Show that the number of ideal stages can be related to the absorption factor as

$$A^N = \frac{y_a - y_a^*}{y - y_b^*}$$

   c) In terms of the slopes of the operating and equilibrium lines, define the absorption factor, A.

2. Ammonia is stripped from a dilute aqueous solution by countercurrent contact with air in a column containing nine sieve trays. The equilibrium relationship is $y_e = 0.85x_e$ and when the molar flow of air is 1.4 times that of the solution, 95% of the ammonia is removed.

a) Draw a column showing all the inflows and outflows and their corresponding mole fractions
b) Calculate the number of ideal stages present in the column, analytically.
c) What is the stage efficiency of the column?

3. a) State two laws that can be used to relate phase compositions in vapour-liquid equilibrium in dilute systems

b) A soluble gas is absorbed in water using a packed tower. The equilibrium relationship may be taken as $y_e = 0.08x_e$. Terminal compositions are as follows:

Mol. fraction	Top	Bottom
x	0	0.075
y	0.0015	0.008

If $H_x = 0.35$ m and $H_y = 0.45$ m, what is the height of the packed section of the column?

$H_{Oy} = H_y + m\frac{V}{L}H_x$; $N_{Oy} = \frac{y_b - y_a}{\Delta y_{LM}}$

(Note: All symbols have their usual meanings)

4. a) State the three assumptions usually made in the application of the McCabe-Thiele method of analysis in distillation and other stagewise operations.

b) A plant must distill a mixture containing 60 mol percent methanol and 40 percent water. The overhead product is to contain 96 mol % methanol and the bottom product 3.0 mol%. The feed is saturated vapour. The reflux ratio at the top of the column is 1.4, and the reflux is at its bubble point. Calculate

i. The molar ratio of the product to feed
ii. The minimum number of plates
iii. The number of plates using a total condenser and a reboiler, assuming an average Murphree plate efficiency of 72 percent.
iv. Indicate the feed tray.

5. A mixture containing 50% weight percent acetone and 50% weight water is contacted with an equal amount of methyl isobutyl ketone (MIK).

a) What will be the amounts and compositions of the extract and raffinate phases?
b) What fraction of the acetone can be extracted?
c) What fraction of the acetone could be extracted if the fresh solvent were divided into two parts and two successive extractions are made?

Methanol/Water Equlibrium Graph