

NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY
BACHELOR OF ENGINEERING (HONS) DEGREE
Part Two Examination May 2011

TCE2003 MASS TRANSFER PROCESSES

Duration of Examination : 3Hours

Instructions to Candidates

1. Answer four questions only.
 2. Each question carries equal marks.
 3. Show all your steps clearly in your calculation.
 4. Start the answers for each question on a new page.
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1. Straw oil used to absorb benzene from coke oven gas is to be steam-stripped in a sieve plate column at atmospheric pressure to recover the dissolved benzene. Equilibrium conditions at the operating temperature are approximated by Henry's law such that when the oil phase contains 10mol% benzene, benzene partial pressure above the oil is 5.07kPa. The oil may be considered non-volatile. The oil enters containing 6.5mol% benzene, 75% of which is to be recovered. The steam leaving contains 2.5mol% benzene.
 - a) How many theoretical stages are required? [15]
 - b) How many moles of steam are required per 100moles of the oil-benzene mixture? [4]
 - c) If 90% of the benzene is to be recovered with the same oil and steam rates, how many theoretical stages are required? [6]
2.
 - a) Suggest any two industries in which leaching operations have found use and cite the typical solvents for each industry. [5]
 - b) Fresh sugar beets having a composition of 40% sugar by weight are to be treated in a counter-current battery of cells with pure water to contain 0.5kg solution/kg inert solid. 90% of the sugar is recovered in a solution containing 50% by mass sugar. Determine the required number of theoretical stages. [20]

3. a) On what assumption is the McCabe-Thiele method based? State the assumption's requirements. [5]

b) It is desired to separate a 42mol% methanol-methanol-water mixture using a rectification column. Determine the minimum reflux ratio and the number of stages required to obtain a distillate product of 95mol% of the more volatile component and a bottoms product of 93mol% of the less volatile component. The column is operated at 50% above minimum reflux, 1atm and equilibrium may be represented by a relative volatility of 2.5. The feed is a saturated vapor. [20]

4. a) State any two factors that influence the efficiency of any distillation operation and explain how they are qualitatively related to the number of stages required for the distillation operation. [8]

b) A mixture of benzene and toluene is to be separated at atmospheric pressure by distillation using a plate column fitted with a reboiler and a partial condenser. The whole of the liquid condensate is returned to the column as reflux while all the vapor leaving the condenser is removed as top product. The feed contains 39mol% benzene. When introduced as a saturated liquid at its boiling point at a feed rate of 100kmol per hour, the top product is withdrawn at a rate of 40kmol per hour and is found to contain 90mole% benzene. Heat input required to the reboiler is 19770MJ/hr. Use enthalpy-composition data to calculate

i) Composition and flow rate of the bottom product, [5]

ii) The operating reflux ratio [5]

iii) The number of theoretical stages in the column assuming feed is introduced at the optimum location [7]

Enthalpy-composition data

$$H_L = 220 - 10x \text{ MJ/kmol}$$

$$H_V = 520 - 10y \text{ MJ/kmol}$$

Equilibrium data

<i>x</i>	<i>0.0</i>	<i>0.2</i>	<i>0.4</i>	<i>0.6</i>	<i>0.8</i>	<i>1.0</i>
<i>y</i>	<i>0.0</i>	<i>0.35</i>	<i>0.65</i>	<i>0.78</i>	<i>0.92</i>	<i>1.0</i>

5. a) Hot dry air at 40°C and 10% relative humidity passes through an evaporative cooler. Water is added as the air passes through a series of wicks and the mixture exits at 27°C. Using the psychrometric chart determine

i) The outlet relative humidity [2]

ii) The amount of water added and [4]

iii) The lowest temperature that could be realized **[4]**

b) i) Explain why drying is an essential part of the manufacturing process for example in the fertilizer industry. **[3]**

ii) A wet solid is dried from 25% to 10% moisture under constant drying conditions in 4.17hrs. If the critical and the equilibrium moisture contents are 15% and 5% respectively, how long will it take to dry the solid from 30% to 8% moisture under the same drying conditions? **[12]**

END OF QUESTION PAPER!!!!