Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2022/2023

COURSE NAME	:	SEPARATION ENGINEERING TECHNOLOGY
COURSE CODE	:	DAK 23903
PROGRAMME CODE	:	DAK
EXAMINATION DATE	:	FEBRUARY 2023
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER ALL QUESTIONS
		2. THIS FINAL EXAMINATION IS CONDUCTED VIA **CLOSED BOOK.**
		3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

Q1 (a) Distillation is used in a chemical process to produce high purity product.

(i) Explain the importance of volatility in distillation.

(2 marks)

(ii) Draw a basic distillation column with feed, distillate, reflux and reboiler.

(5 marks)

(b) A Benzene-Toluene mixture containing 48 mol% Benzene is to be separated in a distillation column. The distillation column equipped with a reboiler and partial condenser is used to separate the feed flow into 80 mol% Benzene and 10 mol% Toluene. Based on McCabe Thiele method and **Figure Q1(b)**.
[Please attach the Benzene-Toluene VLE diagram into your answer script]

(i) Calculate the actual number of stages when the feed flow contains 70% saturated vapor (q = 0.3), reflux ratio, R = 1.6 and tray efficiency is 40%.

(15 marks)

(ii) The actual location of feed stage.

(3 marks)

Q2 (a) Short and vertical tubes are one of essential features inside every industrial evaporator. Explain the function and purpose of these tubes in the evaporation process.

(4 marks)

(b) Sketch a detail diagram for each evaporator below.

(i) Short tube evaporator.

(3 marks)

(iii) Long tube vertical evaporator.

(3 marks)

(iii) Falling film evaporator.

(3 marks)

(c) Explain the direction of fluid flow, location of heat transfer and how vaporization occur inside all **three (3)** evaporators in **Q2 (b)**.

(12 marks)

Q3 (a) Leaching is one of a separation process to extract the solute component from a solid. Explain the role of solvent in the leaching process.

(4 marks)

(b) In a single stage leaching, soybean oil is extracted from 200 kg solid soybeans using hexane as a solvent. The solid soybean contains 40 wt% solute oil and 250 kg of fresh hexane solvent is used. The value of N for the slurry underflow is constant at 1.5 kg insoluble solid / kg solution retained (see **Figure Q3(b)**).

(i) Calculate the value of x_M.

(3 marks)

(ii) Calculate the amount (kg) of the overflow, V_1 and its compositions, y_1.

(9 marks)

(iii) Calculate the amount (kg) of the underflow slurry, L_1 and its compositions, x_1.

(9 marks)

Q4 (a) Gas absorption is used in industry to minimize the release of pollutants from the gas into the environment.

(i) State the definition of gas absorption.

(3 marks)

(ii) Explain the term solute, carrier and absorbent in absorption process.

(4 marks)

(b) A packed tower uses an organic amine to absorb carbon dioxide. The entering gas contains 1.35 mol% CO_2 is to leave with only 0.04 mol% CO_2. The amine gas is pure, without any CO_2 content. Assuming that the amine exits in the equilibrium with the entering gas, it would contain 0.8 mol% CO_2. The gas flow is 2.5 gmol/sec while the liquid flow is 6.5 gmol/sec. The tower diameter is 40 centimeters and the overall mass transfer coefficient, Ky per volume is 5×10^{-5} gmol/cm^3.sec. Calculate the packed tower height, Z in centimeter and meter.

(18 marks)

– END OF QUESTIONS –

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List of Formula

Top Operating Line (TOL) Equation;

$$y = \left(\frac{R}{R+1}\right)x + \left(\frac{x_d}{R+1}\right)$$

Q-line Equation;

$$y = \left(\frac{q}{q-1}\right)x - \left(\frac{x_f}{q-1}\right)$$

Number of stages: N – reboiler – condenser

Actual number of stages: Number of stages ÷ efficiency (%)

Liquid mass balance (A + C);

$$L_0 + V_2 = M$$

Component A mass balance (A);

$$y_0 L_0 + x_2 V_2 = x_M M$$

Component B mass balance (B);

$$N_0 L_0 = N_M M$$

$$N_{L1} L_1 = N_M M$$

Total component mass balance;

$$L_0 + V_2 = V_1 + L_1$$

$$G_A(y_0 - y_1) = L_A(x_0 - x_1)$$

$$y_0 = mx_0^*$$

$$Z = \frac{G_A}{A \times K_y}\left[\left(\frac{1}{1 - \frac{mG_A}{L_A}}\right) ln\left(\frac{y_0 - mx_0}{y_1 - mx_1}\right)\right]$$

x_0^* = equilibrium value

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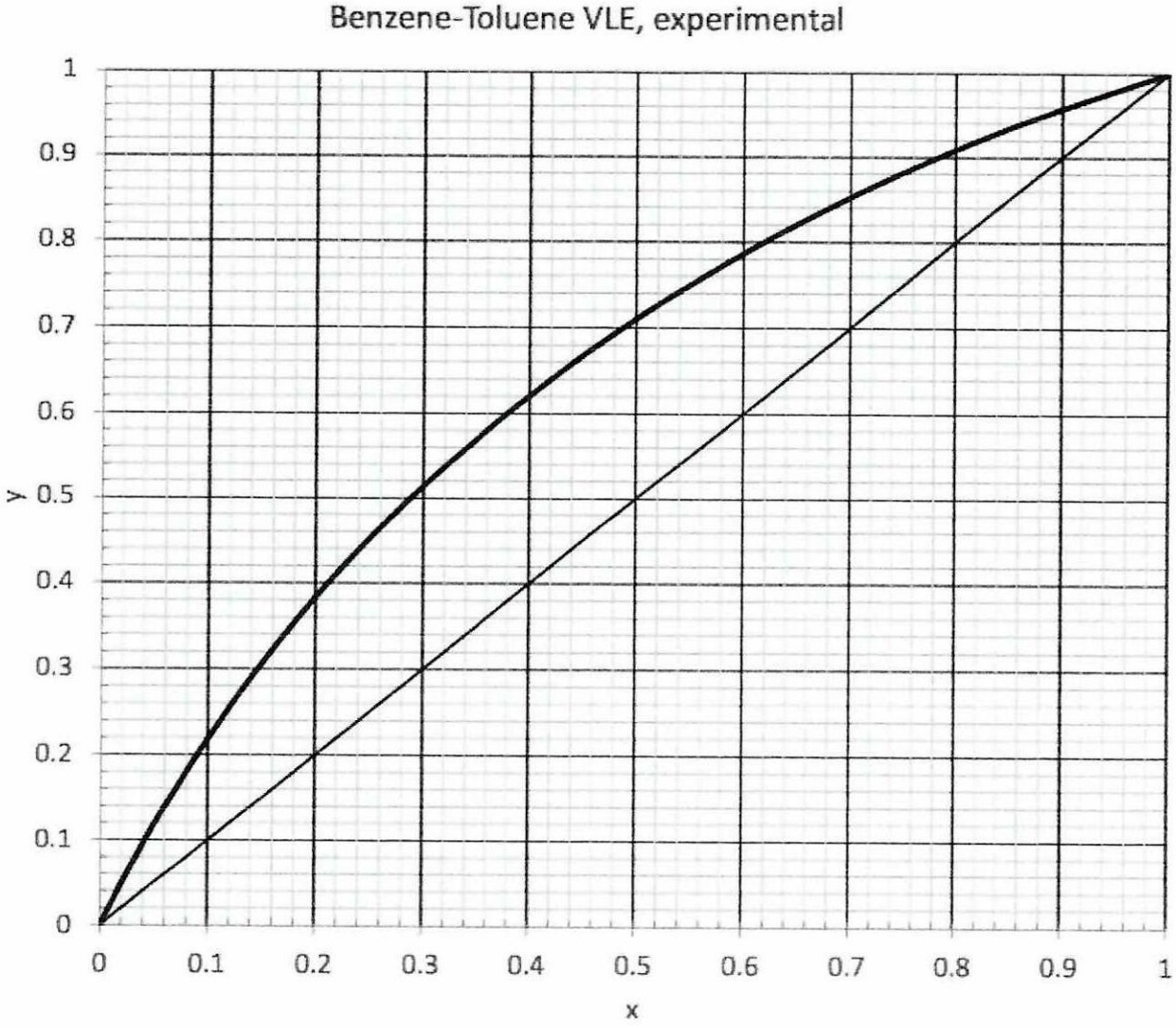

Figure Q1 (b)

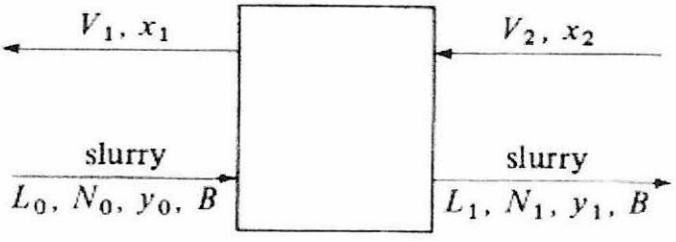

Figure Q3 (b)