



UNIVERSITY OF
KWAZULU-NATAL
INYUVESI
YAKWAZULU-NATALI

SCHOOL OF ENGINEERING

MAIN EXAMINATIONS: JUNE 2023

COURSE AND CODE: ADVANCED MASS TRANSFER

ENCH4MT

DURATION: 2 HOURS

TOTAL MARKS: 60

INTERNAL EXAMINER:

ASSOC. PROF. W.M. NELSON

INTERNAL MODERATOR:

PROF. A.H. MOHAMMADI

EXTERNAL MODERATOR:

DR. M. LASICH

INSTRUCTIONS:

1. **ALL** questions should be attempted. **Answer in ink.**
2. Any programmable or non-programmable calculator may be used provided it has been cleared of any information that would subvert the purpose of the examination.
3. Calculations must be shown in sufficient detail to illustrate your understanding of the procedure.
4. Formulae sheet is provided on Pages 5 & 6
5. All flows and compositions are on a **molar basis**.

Table 3: Azeotrope and boiling point information.

P / atm	$T / ^\circ\text{C}$	x_{ethanol}	x_{water}
1	78.15	0.8955	0.1045
1	78.31	1	0
1	100.02	0	1
5	125.36	0.8464	0.1536
5	125.79	1	0
5	152.41	0	1

1.1. Utilizing the given information, determine the compositions of the bottoms and distillates of both columns.

[4]

1.2. For this pressure-swing distillation with recycle as indicated in Figure 1, solve for the bottoms and distillate flowrates of both columns.

[10]

1.3. For the first column, and assuming the Fenske equation is applicable, calculate the minimum number of stages required.

[7]

1.4. For the first column determine the minimum internal reflux ratio.

[9]

1.5. Due to the non-ideality of this system, we know that the accuracy of the Fenske equation may be limited. Given that the operating specifications are defined, discuss how one could use a process simulator to determine the minimum number of stages.

[6]

1.6. Briefly list four advantages and four disadvantages of operating a distillation column at high pressure.

[4]

TOTAL /40/

QUESTION 3 [8]

Reverse osmosis is an effective method for desalinating seawater, as it utilizes a semipermeable membrane to separate dissolved salts and impurities from the water. By applying pressure to force the saline water through the membrane, clean and potable water is produced, making it a valuable solution for addressing global water scarcity issues.

4.1. Create a schematic diagram illustrating the overall process, including treatment steps and pumps, for desalinating seawater using reverse osmosis.

[5]

4.2. Discuss any concerns related to the concentrated brine discharge directly into the ocean and briefly discuss any solutions.

[3]

TOTAL /8/

Underwood Equations (Class 2)

$$1 - q = \sum_{i=1}^c \frac{\alpha_{i,r} z_i}{\alpha_{i,r} - \phi}$$
$$\sum_{i=1}^c \frac{\alpha_{i,r} x_{i,D}}{\alpha_{i,r} - \phi} = 1 + R_{\min}$$

Gilliland Correlation (Molokanov Equation)

$$Y = \frac{N - N_{\min}}{N + 1} = 1 - \exp \left[\left(\frac{1 + 54.4X}{11 + 117.2X} \right) \left(\frac{X - 1}{X^{0.5}} \right) \right]$$

$$X = \frac{R - R_{\min}}{R + 1}$$

Kirkbride Equation

$$\frac{N_R}{N_S} = \left[\frac{z_{HK}}{z_{LK}} \left(\frac{x_{LK,B}}{x_{HK,D}} \right)^2 \frac{B}{D} \right]^{0.206}$$

Column Sequencing

$$N = \frac{[2(P - 1)]!}{P! (P - 1)!}$$