Abdelhafid Boussouf University Center – Mila
Institute of Science & Technology
Department of Process Engineering
Chemical Engineering – M1
Unit Operations I – UEF 1.1.1

Academic year: **2025-2026** Instructor: **Dr. M. Bouti**

Homework n° 01

Problem:

A binary distillation column separates a saturated-liquid feed stream. Component A is more volatile.

Parameter	Value
Feed flow rate (F)	100 kmol/h
Feed composition (x_F)	0.50
Distillate composition (x_D)	0.95
Bottom composition (x_B)	0.05
Relative volatility (α)	2.0
Feed condition	Saturated liquid (q = 1)
Assumptions	Ideal stages, constant molar overflow

Objective: Determine the number of theoretical stages and feed-stage location using Excel to construct McCabe-Thiele diagram.

Part A — Excel Setup

Q1. In Excel, create a column for liquid composition **"*x*"** ranging from **0** to **1** with increments of **0.01**

Q2. In a second column, calculate the corresponding vapor composition **"*y*"** using the equilibrium relation:

$$y = \frac{\alpha x}{1 + (\alpha - 1)x}$$

Deliverable: Table of ***x*** and ***y*** values.

Part B — Plot the Diagram

Q3. In Excel, plot:

1. Equilibrium curve ***y*** = *f*(***x***).
2. 45-degree line *y* = *x*.

(*Use:* ***Scatter plot with smooth lines***)

Part C — q-Line

For saturated liquid (**q = 1**):

$$\text{slope} = \frac{q}{q - 1} \rightarrow \infty$$

Q4. In Excel, draw a vertical line at $x = x_F = 0.50$.

Part D — Minimum Reflux Ratio R_{min}

Q5. On the Excel chart:

1. Draw a line from (x_D, x_D) to the equilibrium curve at $x_F = 0.50$.
2. Extend this line to intersect the *y*-axis ($x = 0$).

Q6. Determine R_{min} from the slope of this line:

(*Use: y-intercept from the line equation in Excel*).

Part E — Practical Reflux Ratio

Q7. Compute the working reflux ratio: $R = 1,5.R_{min}$

Q8. Calculate the rectifying operating line (ROL).

Q9. Calculate stripping line by connecting x_B with feed intersection point.

(*Use Excel formulas for each operating line for x values*)

Part F — Stage Construction

Q10. On the Excel graph, perform **stepwise construction** between:

- Equilibrium curve, and
- Operating lines.

Q11. Count stages from top to bottom, and report:

a) Total number of theoretical stages.

b) Feed stage (counting from top).

Expected Submission Format

Students should submit on the e-learning platform:

- **Excel file** containing all calculations.
- McCabe-Thiele diagram (with equilibrium, 45° line, q-line, OLs, stages), on Excel file **OR** Word file.
- **Word file** containing final answers:

  → R_{min}.

  → R used.

  → Number of theoretical stages.

  → Feed stage location.