In-Class Exercises n° 02

(Distillation – Flash Distillation)

Exercise 01: Flash Equilibrium of a Binary n-Heptane/n-Octane Mixture

A liquid mixture of **100 mol** containing **50 mol%** n-heptane and **50 mol%** n-octane at **30°C** is to be continuously flash vaporized at 1 std atm to vaporize **60 mol%** of the feed. What will be the composition of the vapor and liquid for an equilibrium stage?

Mole fractions of n-heptane in liquid x	1.0	0.655	0.487	0.312	0.1571	0
Mole fractions of n-heptane in vapor y	1.0	0.810	0.674	0.492	0.297	0

Exercise 02:

Using mass balances for a single-stage flash distillation process, give the general operating line equation, where this equation relates the compositions of the two phases leaving the flash drum.

1.1) Define the **fraction vaporized** $f = \frac{V}{F}$ and, using the total mass balance, derive the expression of the ratio $\frac{L}{V}$ in terms of f.

Show that:

$$\frac{L}{V} = \frac{1-f}{f}$$

1.2) Determine $\frac{F}{V}$ in terms of f.

1.3) Substitute these two expressions into the general operating line equation and simplify to obtain

$$y = -\left(\frac{1-f}{f}\right)x + \frac{z}{f}$$

1.4) Interpret physically the **slope** and **intercept** of this linear relationship between y and x.

2.1) Define the **fraction of liquid remaining** $q = \frac{L}{F}$.

2.2) Using again the total mass balance, derive the expression of $\frac{L}{V}$ and $\frac{F}{V}$ in terms of q.

Show that:

$$\frac{L}{V} = \frac{q}{1-q} \quad \text{and} \quad \frac{F}{V} = \frac{1}{1-q}$$

2.3) Substitute these results into the general operating line equation and simplify to obtain:

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

<u>Exercise 03</u>: Multi-component Flash

Calculate the **vapor ratio**, **ψ**, and the vapor and liquid stream compositions for a multi-component flash operation. The feed mole fractions and phase equilibrium constants (at the flash temperature and pressure) are provided in Table 1. Given that the feed flow is **1 250 lbmol/h**, what are the liquid and vapor molar flow rates?

Table 1 – Multi-component Flash Data for Practical Example

Component	Mole fraction (z_i)	Equilibrium ratio (K_i)
1	0.28	2.93
2	0.24	1.55
3	0.24	0.87
4	0.08	0.49
5	0.16	0.138