Material Balances:

It is more convenient to express balance equations in terms of mole ratios and on solute free basis:

- Quantities of solvent are unchanged
- Straight line operating lines

Nomenclature:

Gas Phase:

G:= Total gas flow rate mole / time/ unit cross sectional area

G_s:= Flow of insoluble gas (carrier) mole / time/ unit cross sectional area

y := solute mole fraction

Y := solute mole ratio = solute / carrier gas

$\bar{p}$:= Partial pressure of solute

$$Y = \frac{y\,G}{(1-y)G} = \frac{y}{(1-y)} = \frac{\bar{p}}{(p_t - \bar{p})} = \frac{\text{partial pressure of solute}}{\text{partial pressure of carrier}}$$

$$y = \frac{Y}{(1+Y)}$$

$$G_s = (1-y)\,G = \frac{y}{Y}\,G = \frac{Y}{1+Y}\,\frac{1}{Y}\,G$$

$$G_s = \frac{G}{(1+Y)}$$

Liquid Phase:

L:= Total liquid flow rate mole / time/ unit cross sectional area

L_s:= Flow of liquid (carrier) mole / time/ unit cross sectional area

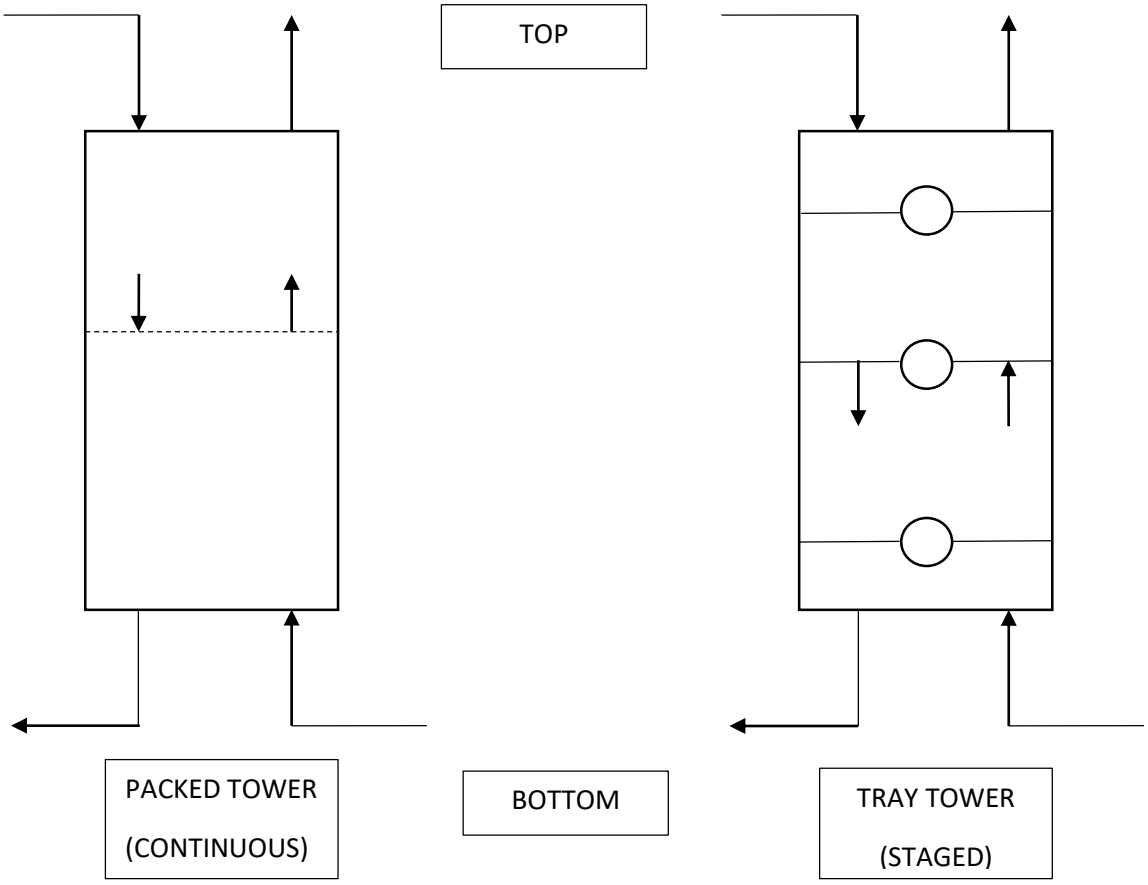
x := solute mole fraction

X := solute mole ratio = solute / solvent

$$X = \frac{x}{(1-x)} \qquad x = \frac{X}{(1+X)}$$

$$L_s = (1-x)\,L \qquad L_s = \frac{L}{(1+X)}$$

Counter Current Flow (Absorption or Stripping)



Operating Lines (Solute Material Balances)

At any section

$$G_s\,(Y_1 - Y) = L_s\,(X_1 - X)$$

$$Y = \frac{L_s}{G_s}\,X + \left[Y_1 - \frac{L_s}{G_s}\,X_1\right]$$

At any Tray

$$G_s\left(Y_{N_p+1} - Y_{n+1}\right) = L_s\left(X_{N_p} - X_n\right)$$

$$Y_{n+1} = \frac{L_s}{G_s}\,X_n + \left[Y_{N_p+1} - \frac{L_s}{G_s}\,X_{N_p}\right]$$

Notes:

- These are straight lines with slope = $\frac{L_s}{G_s}$ giving the relation between passing streams at any section or at any tray.
- For absorption (gas $\rightarrow$ liquid) carrier gas loses solute

  $Y_{bot} > Y_{top}$; $X_{bot} > X_{top}$

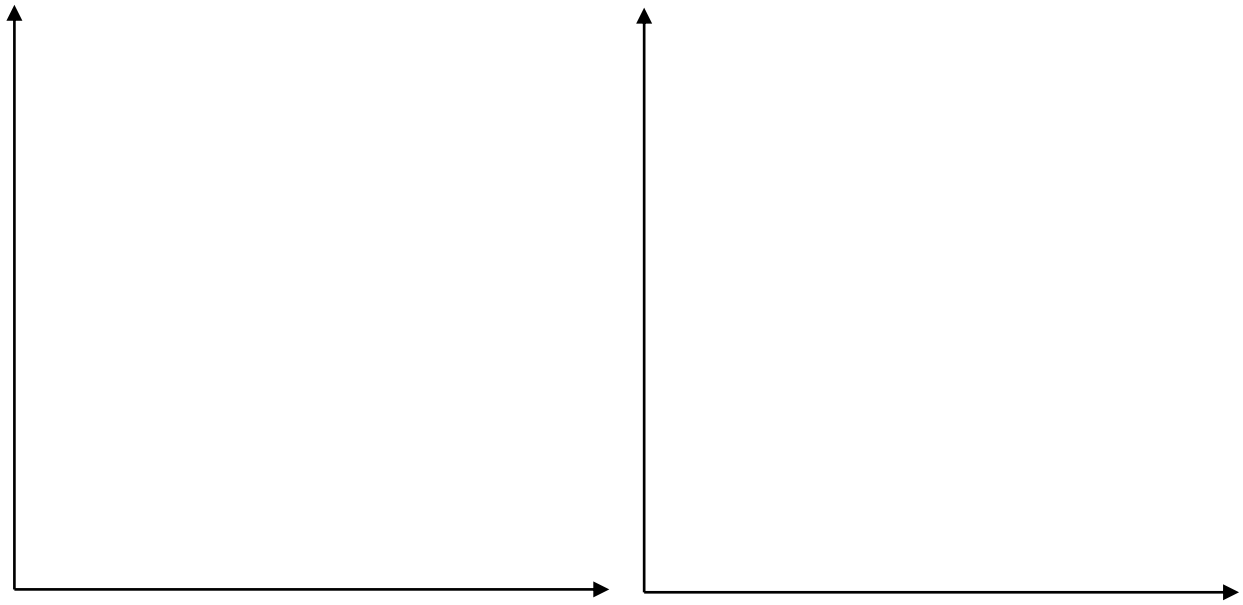
- For stripping (liquid $\rightarrow$ gas) carrier gas gains solute

  $Y_{bot} < Y_{top}$; $X_{bot} < X_{top}$

- For most purposes the pressure and temperature can be considered constant inside the column

The operating lines can be plotted together with equilibrium data on XY diagram.

Absorption Stripping

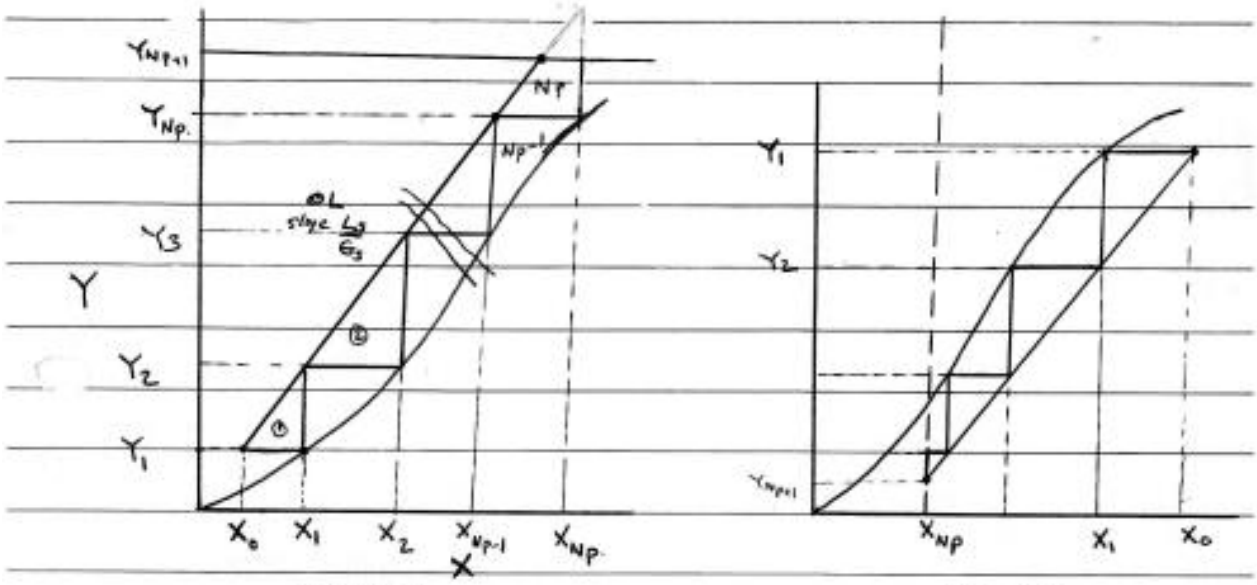


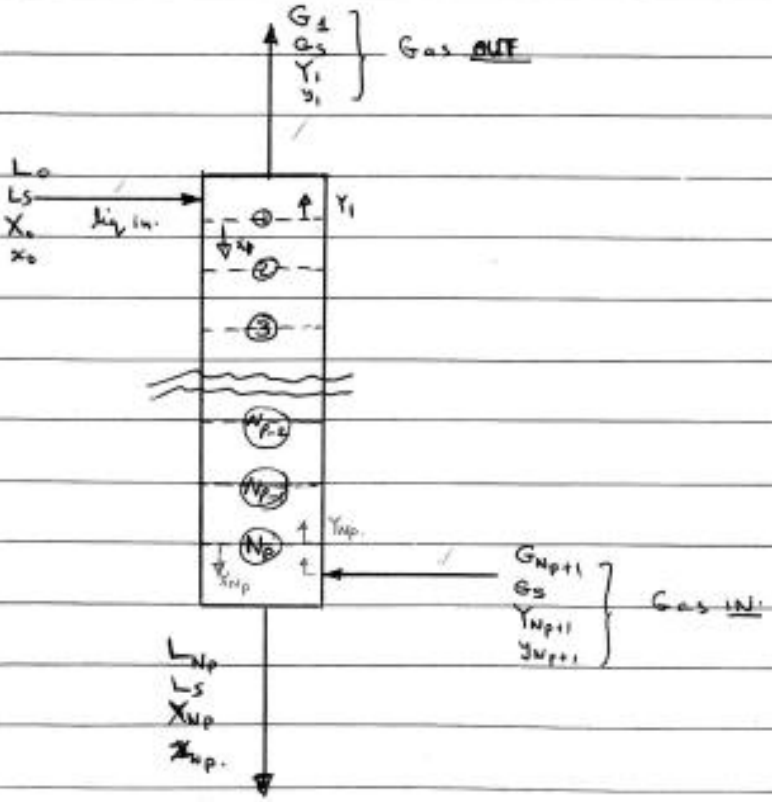
Concentration gradient in direction of mass transfer

TRAY TOWERS: ONE COMPONENT TRANSFERRED

(ABSORBERS OR STRIPPERS)

Number of theoretical plates can be determined graphically.





Absorption Y_{Np+1}, Y_1 and X_0 are fixed

Stripping X_0, X_{Np} and Y_{Np+1} are fixed.