Note Title 1/18/2018

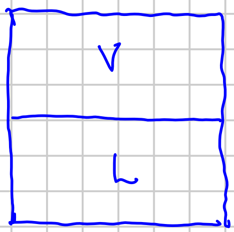
Binary Phase Behavior

How the 2 components partition into the two phases of interest (Vapor | Gas) and/or (Liquid | Oil), # Phases (1 or 2) and if one (single) phase, "saturated" or "undersaturated" phase.

$CO_2 + H_2O$ $\quad j = \{CO_2, H_2O\}$

n_j, n_t

$z_j = \frac{n_j}{n_t}$



$y_j \equiv \frac{n_{jV}}{n_V}$ $\quad \sum y_i = 1$

$x_j \equiv \frac{n_{jL}}{n_L}$ $\quad \sum x_i = 1$

(p, T)

$$\sum_{j=1}^{2} z_j = 1$$

For Binary Systems: @ (p,T) having 2 phases

$y_j(p,T)$

$x_j(p,T)$

$\neq f(z_j)$ Independent of the z_i

For $N > 2$ $\quad y_j(p, T, z)$

$x_j(p, T, z)$

$u_i \; \{z_i, y_i, x_i\}$

V — m — n of the phases

$$\rho = \frac{m}{V} \qquad \text{mass density} \qquad \rho(p, T, u_i)$$

$$M = \frac{m}{n}$$

$$M = \frac{\sum m_i}{\sum n_i} = \sum u_i M_i$$

$$M_L = \sum x_i M_i \qquad M_V = \sum y_i M_i$$

i = component I = Initial F = final

Material Balance

- Mass balance
- Mole balance

} on components / compound

Any time

$$n_i = n_{iV} + n_{iL}$$

$$z_{iI} \cdot n_t = n_V \, y_i + n_L \cdot x_i$$

$$z_i = \frac{n_V}{n_t} y_i + \frac{n_L}{n_t} x_i$$

$$z_i = \frac{n_V}{n_t} y_i + \frac{(n_t - n_V)}{n_t} x_i$$

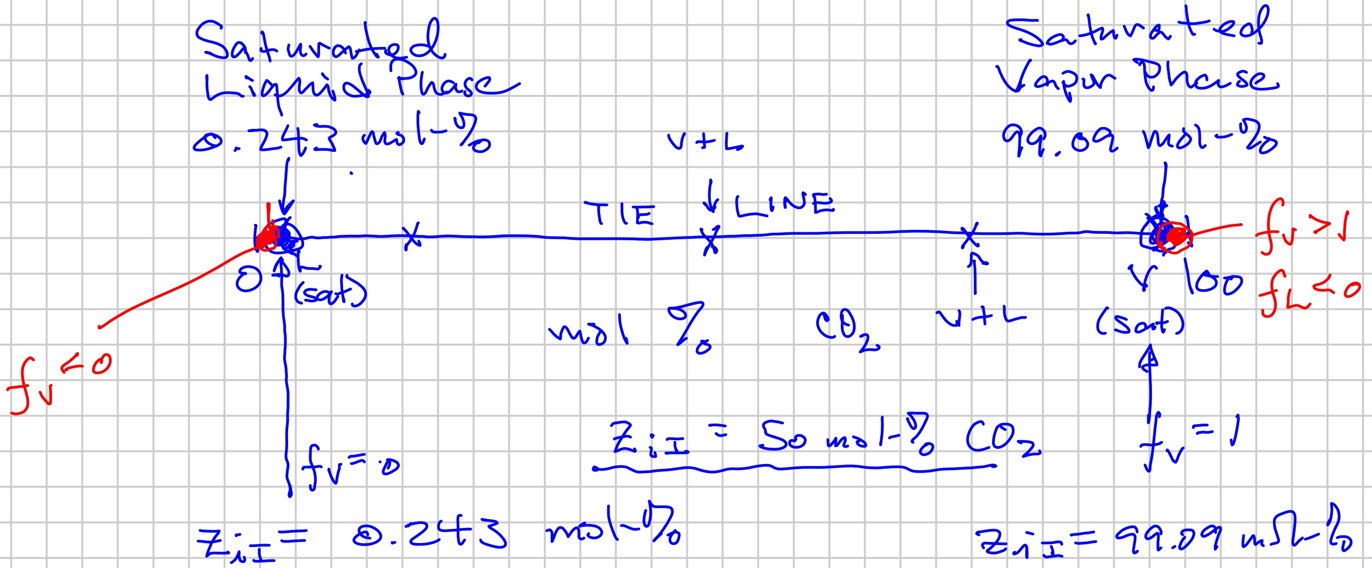
Fraction of n_t moles that is vapor

$$f_V = \frac{n_V}{n_t}$$

$$\boxed{z_i = f_V \, y_i + \underbrace{(1 - f_V)}_{f_L} \, x_i}$$

$$f_V + f_L = 1$$

At 100 bar | 20°C



L or V ?

Saturated or Undersaturated ?

$$(x_{CO_2} \le z_{CO_2} \le y_{CO_2}) \Rightarrow V + L$$

$$x_{CO_2} = z_{CO_2} \Rightarrow L + \epsilon_V = f_V$$

$$y_{CO_2} = z_{CO_2} \Rightarrow V + \epsilon_L$$

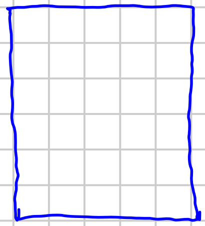
Saturated System } Two Phases exist in equilibrium

Saturated Vapor Phase = vapor phase sat. w/ its eq. liq phase

Saturate Liquid Phase = liquid phase saturated with its eq. vapor phase

Solve:

(1)



$V = 25\,L = 0.025\ m^3$ $\qquad \phi = 0.2$

$p = 100$ bara

$T = 20\,°C$

H_2O sat. w/ CO_2

$z_{CO_2} = x_{CO_2} = 0.00243 \quad 0.243$ mol-%

$z_{H_2O} = x_{H_2O} = 0.99757 \quad 99.757$ mol-%

} saturated L

$$n_I = V_{p'}\, \rho / M$$

$$\frac{(0.2)(0.025\ \cancel{m^3}) \cdot 1005.2\ \cancel{kg}/\cancel{m^3}}{18.078\ \cancel{kg}/kg\text{-mole}} = \underline{\qquad}\ kg\text{-mole}$$

SI : mol $\quad$ g-mole

kg-mole

$$n_{I_i} = n_I \cdot z_i$$

To 1 bara 20 °C (F)

$y_{CO_2} =$ $\qquad$ $y_{H_2O} =$

$x_{CO_2} =$ $\qquad$ $x_{H_2O} =$

$$z_{iI} = f_{vF}\, y_{iF} + (1 - f_{vF})\, x_{iF}$$

✓ ✓ ✓

Solve for f_{vF}

$$\underline{\underline{f_{vF}}} = \frac{z_{iI} - x_{iF}}{y_{iF} - x_{iF}}$$

key

$$V_{tF} = \underbrace{V_{vF} + V_{LF}}$$

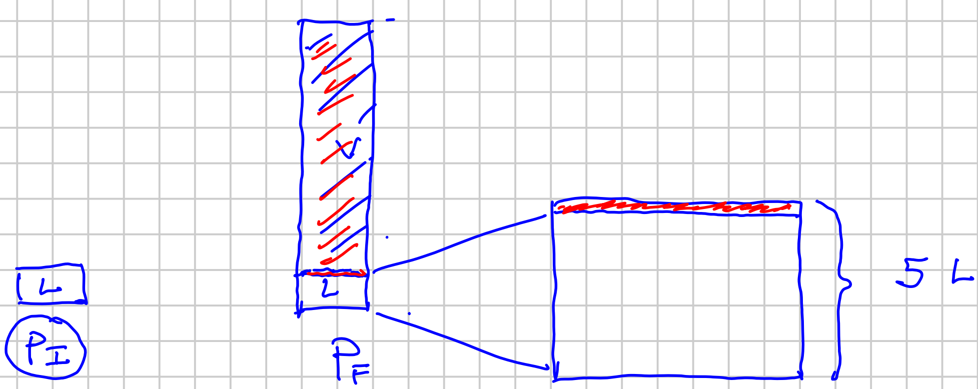
Some remains in contain, rest is produced

$$V_{vF} = \underbrace{n_{vF} \cdot M_{vF}}_{m_{vF}} / \rho_{vF}$$

$$V_{LF} = n_{LF} \, M_{LF} / \rho_{LF}$$

$$n_{vF} = f_{vF} \cdot n_I$$

$$n_{LF} = n_I - n_{vF}$$



Products are defined as what is in the reservoir taken to surface $\Rightarrow$ $\bar{g}$ $\bar{o}$ $\bar{L}$

$V_{\bar{v}p} = V_{\bar{v}I} - V_{\bar{v}F}$ (b) $\sim 70\%$ $RF_{\bar{v}} = \frac{V_{\bar{v}p}}{V_{\bar{v}I}}$ (a) $< 100\%$

$V_{\bar{L}p} = V_{\bar{L}I} - V_{\bar{L}F}$ 100% $RF_{\bar{L}} = \frac{V_{\bar{L}p}}{V_{\bar{L}I}}$ 0%

Produced Initial Remaining