1. Find the bubble point and dew point temperatures of 0.5 benzene and 0.5 toluene, using Raoult's law and Antoine equations. At 95°C, what is the mole fraction of benzene in the liquid phase and vapor phase?

   Solution:

   a) Required: T_{bubble}, T_{dew}

      Let

$$f(T) = \left[x_{benzene} 10^{\left(6.893 - \frac{1203}{T+219.9}\right)} + x_{toluene} 10^{\left(6.958 - \frac{1347}{T+219.7}\right)} \right] - 760$$

      f(100) = 196
      f(90) = - 40
      f(95) = 69.2
      f(92) = - 0.269 $T_{bubble} = 92^{o}C$

      Let

$$g(T) = \left[y_{benzene} \frac{760}{10^{\left(6.893 - \frac{1203}{T+219.9}\right)}} + x_{toluene} \frac{760}{10^{\left(6.958 - \frac{1347}{T+219.7}\right)}} \right] - 1$$

      g(100) = -0.036
      g(90) = 0.306
      g(98) = 0.023
      g(99) = -0.007 $T_{dew} = 99^{o}C$

b) Required: $x_{benzene}$, $y_{benzene}$

$$\left[x_{benzene} 10^{\left(6.893 - \frac{1203}{95+219.9}\right)} + x_{toluene} 10^{\left(6.958 - \frac{1347}{95+219.7}\right)} \right] = 760$$

$$\left[x_{benzene} 10^{\left(6.893 - \frac{1203}{95+219.9}\right)} + (1 - x_{benzene}) 10^{\left(6.958 - \frac{1347}{95+219.7}\right)} \right] = 760$$

$x_{benzene} = 0.4$

$$y_{benzene} = x_{benzene} \frac{P^*_{benzene}(95^o C)}{760}$$

$y_{benzene} = 0.63$

Note: these values compare very closely with figure 6.4-1.

2. 500 moles/h of a mixture containing 40 mol% benzene and 60 mol% toluene is heated to 98°C at 1 atm. How much vapor is produced per hour ?

Solution:

Required: Vapor flow rate out.

Using Figure 6.4-1, $x_{benzene} = 0.31$ and $y_{benzene} = 0.53$

Benzene balance: $0.53\ V + 0.31\ L = 0.4\ (500)$

Total balance: $V + L = 500$

Solving simultaneously,

$$V(0.53 - 0.31) = 500(0.4 - 0.31)$$

V= 204.5

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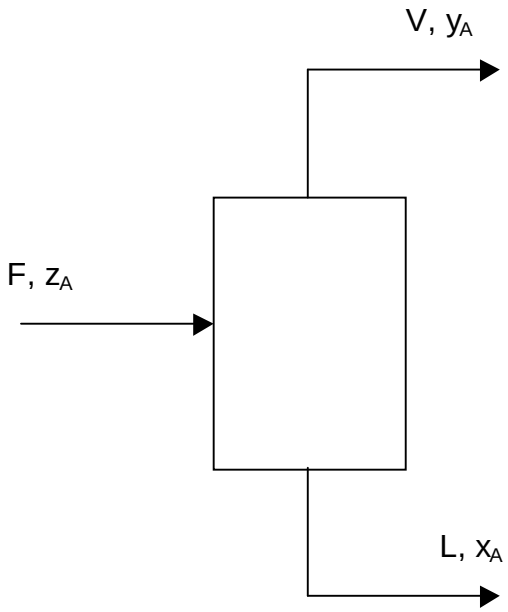


LEVER RULE:

Component balance: $V\ y_A + L\ x_A = F\ z_A$

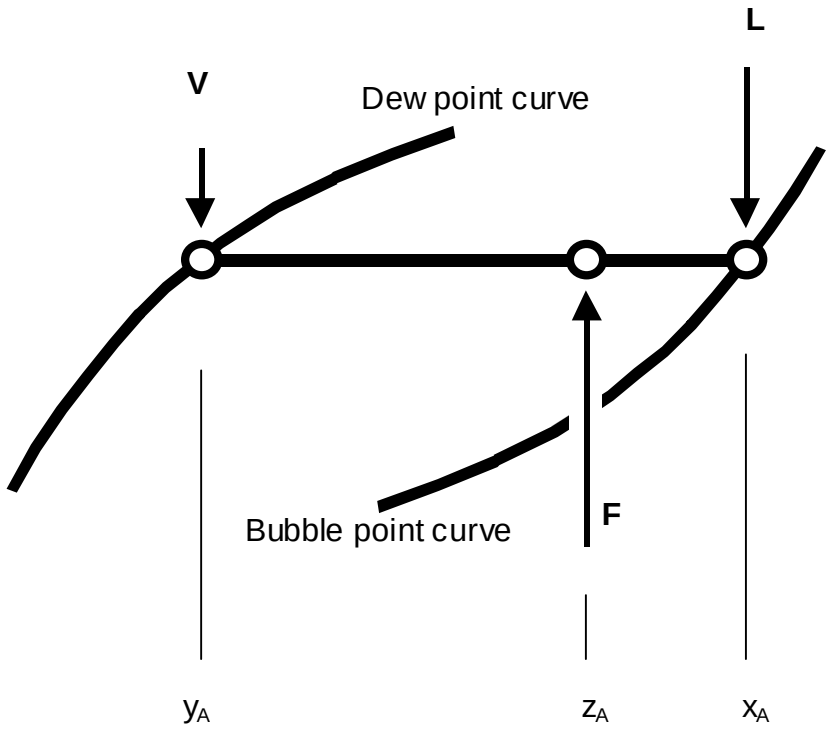
Total Balance: $V + L = F$

then,

$V\ (\ y_A - x_A\ ) = F\ (\ z_A - x_A\ )$

$L\ (\ y_A - x_A) = F\ (\ y_A - z_A\ )$

$V(\ z_A - y_A\ ) = L\ (\ x_A - z_A\ )$


L
V
Dew point curve
Bubble point curve
F
y_A
z_A
x_A