

It is simpler when both liquid & vapour states are in one diagram.
 X → mole fraction of entire system.

We may start from any high pressure liquid state, like 'a'. When pressure is decreased, it moves from point 'o' to 'l' in a straight line. At 'l', first vapour appears which is rich

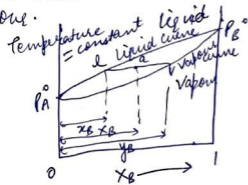
of pressure, point 'a' is reached. Here composition of liquid is x' & that of vapour is y' . On further reduction of pressure, point 'a'' is obtained where very small amount of liquid of composition x'' is there. Liquid is richer in less volatile component A. Composition 'X' remains same throughout. On further reduction of pressure, point 'a''' is reached which is complete vapour state.

This method of isothermal reduction of pressure is used to separate mixtures that would decompose if distilled by ordinary method.

Composition of liquid & vapour at each point can be obtained from lever rule.

Lever Rule:

To understand this rule, let us take one point 'a' inside the curve having both liquid & vapour.



Composition of entire system may vary between limits x & y depending on relative amounts of liquid & vapour present.

→ If state 'a' is very near to liquid curve, system consists large amount of liquid & relatively small amount of vapour.

→ If 'a' is near vapour curve, system consists of more amount of vapour & less amount of liquid.

Relative amounts of liquid & vapour present are calculated by LEVER RULE:

$$\text{let } n_B = n_B(\text{liq.}) + n_B(\text{vap.})$$

$n_B(\text{liq.})$ = number of moles of component B in liquid.

$n_B(\text{vap.})$ = number of moles of component B in vapour.

n_B = total number of moles of component B.

$$n = n_{\text{liq.}} + n_{\text{vap.}}$$

n = Total number of moles of both components.

$$n_{\text{liq.}} = n_A(\text{liq.}) + n_B(\text{liq.})$$

= Total number of moles of both components in liquid.

$$n_{\text{vap.}} = n_A(\text{vap.}) + n_B(\text{vap.})$$

= Total number of moles of both components in vapour.

$$a_l = X_B - x_B = \frac{n_B}{n} - \frac{n_B(\text{liq.})}{n_{\text{liq.}}} \quad \text{--- (1)}$$

$$a_v = y_B - x_B = \frac{n_B(\text{vap.})}{n_{\text{vap.}}} - \frac{n_B}{n} \quad \text{(2)}$$

Multiply eq. (1) by $n_{\text{liq.}}$ & (2) by $n_{\text{vap.}}$,

$$a_l \times n_{\text{liq.}} = \left(\frac{n_B}{n} - \frac{n_B(\text{liq.})}{n_{\text{liq.}}} \right) \times n_{\text{liq.}} \quad \text{(3)}$$

$$a_v \times n_{\text{vap.}} = \left(\frac{n_B(\text{vap.})}{n_{\text{vap.}}} - \frac{n_B}{n} \right) \times n_{\text{vap.}} \quad \text{(4)}$$

Subtract eq. (4) from eq. (3)

$$n_{\text{liq.}}(a_l) - n_{\text{vap.}}(a_v) = \frac{n_B}{n} (n_{\text{liq.}} + n_{\text{vap.}}) - (n_B(\text{liq.}) + n_B(\text{vap.})) = n_B - n_B = 0$$

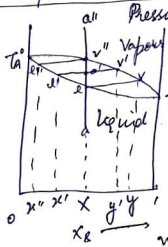
$$\boxed{\frac{a_v}{a_l} = \frac{n_{liq.}}{n_{vap.}}} \quad (5)$$

Point 'o' is fulcrum of lever. 

If point 'a' lies close to 'v', a_v will be small & $n_{vap.} \gg n_{liq.}$ i.e. system consists more of vapours. (has more volatile component B in large quantity)

Similarly, if point 'a' lies close to 'l', a_l will be small & $n_{liq.} \gg n_{vap.}$ i.e. system consists more of liquid (has less volatile component A in large quantity).

Temperature - Composition Diagram :



From a'' , as temperature is decreased point v'' has last trace of liquid of composition x'' which disappears.

At l , first trace of vapours appears having composition y .

$T_B \rightarrow$ low boiling point means more volatile component.

Separation of mixture of volatile components by distillation.