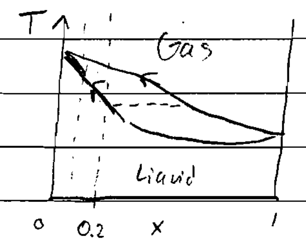
May 2000 #1 (SM)

1. $X = \frac{M_A}{M_A + M_B}$ $\qquad X_i = 0.2$

$T_{gas}(x) = T_0 - x \qquad T_{liquid}(x) = T_0 - 3x$



a. decreases; on the liquid side, as temperature increases, x decreases so the liquid phase has [A] decrease

b. x_L starts out at 0.2

- Factor of 2 finishes at $x_L = 0.1$
- Temperature of $T_{Liquid} = T_0 - 3(0.1) = T_0 - 0.3$
- Gas at same temperature: $T_{gas}(x_g) = T_0 - x_g = T_0 - 0.3$

$\Rightarrow X_G = 0.3$

<u>Lever Rule</u>: $\frac{M_L}{M_G} = \frac{(X_G - X)}{(X - X_L)}$

<u>Proof</u>: $X_G = \frac{M_{AG}}{M_G} \qquad X = \frac{M_A}{M_A + M_B} \qquad X_L = \frac{M_{AL}}{M_L}$

$$\frac{(X_G - X)}{(X - X_L)} = \frac{\frac{M_{AG}}{M_G} - \frac{M_A}{M_A+M_B}}{\frac{M_A}{M_A+M_B} - \frac{M_{AL}}{M_L}} = \frac{M_{AG}(M_A+M_B) - M_A M_G}{M_G(M_A+M_B)} \cdot \frac{M_L(M_A+M_B)}{M_A M_L - M_{AL}(M_A+M_B)}$$

$$= \frac{M_L}{M_G} \cdot \frac{M_{AG}(M_{AG}+M_{AL}+M_{BG}+M_{BL}) - (M_{AG}+M_{AL})(M_{AG}+M_{BG})}{(M_{AG}+M_{AL})(M_{AL}+M_{BL}) - M_{AL}(M_{AG}+M_{AL}+M_{BG}+M_{BL})}$$

$$= \frac{M_L}{M_G} \cdot \frac{M_{AG}M_{BL} - M_{AL}M_{BG}}{M_{AG}M_{BL} - M_{AL}M_{BG}}$$

$$= \frac{M_L}{M_G} \quad \square$$

Thus $\frac{M_L}{M_G} = \frac{0.3-0.2}{0.2-0.1} = \frac{0.1}{0.1} = 1$

$\frac{M_G}{M} = \frac{1}{2}$ $\frac{1}{2}$ of the liquid needs to be boiled off