**A gas mixture exiting from sour-gas treatment process contains 35 mol% $CO_2$ and 65 mol% $H_2S$. For design of a separation process to separate these components, it is necessary to determine their fugacity in the mixture. The following data is available**

| | $CO_2$ (1) | $H_2S$ (2) | (1-2) |
|---|---|---|---|
| $T_c$ (K) | 304.2 | 373.2 | |
| $P_c$ (bar) | 73.8 | 89.4 | |
| $v_c$ ($m^3$/molx$10^6$) | 94.0 | 98.5 | |
| $z_c$ | 0.274 | 0.284 | |
| $\omega$ | 0.225 | 0.100 | |
| $B_i$($m^3$/molx$10^6$) | -7.34 | -31.6 | |

a) Calculate the fugacity of the $H_2S$ if the mixture is at 350°C and 101.3 bars. Assume that $k_{12} = 0.08$ and use the virial EOS.

b) Estimate as in part (a) but using the Lewis-Randall rule.

c) Estimate as in part (a) but assuming ideal gas mixture model.

d) Comment on your results..

The following experimental tie-lines of the system lim (1) + lina (2) + PDO (3)

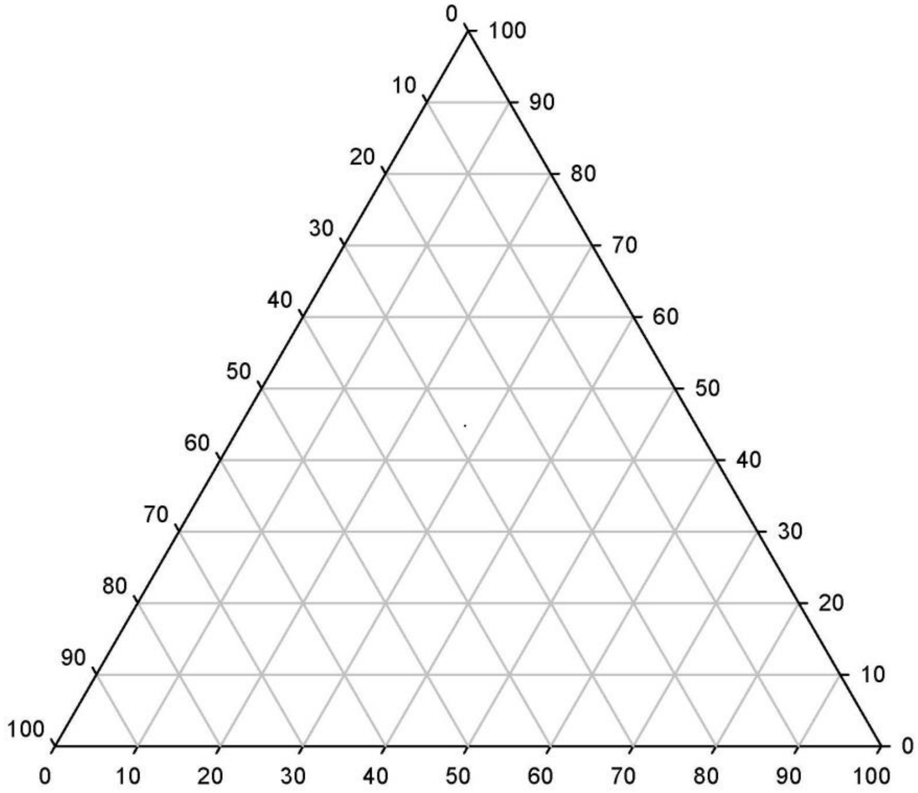
| PDO-rich phase | | | Lim-rich phase | | |
|---|---|---|---|---|---|
| $x_1$ | $x_2$ | $x_3$ | $x_1$ | $x_2$ | $x_3$ |
| 0.01 | 0.000 | 0.99 | 0.99 | 0.000 | 0.01 |
| 0.02 | 0.08 | 0.90 | 0.70 | 0.25 | 0.05 |
| 0.06 | 0.16 | 0.78 | 0.65 | 0.28 | 0.07 |
| 0.10 | 0.24 | 0.66 | 0.55 | 0.32 | 0.13 |
| 0.13 | 0.27 | 0.60 | 0.42 | 0.35 | 0.23 |
| 0.14 | 0.28 | 0.58 | 0.31 | 0.39 | 0.30 |

a. Use the provided ternary diagram to plot the given tie line data. Clearly show the components on the vertices of the triangle.

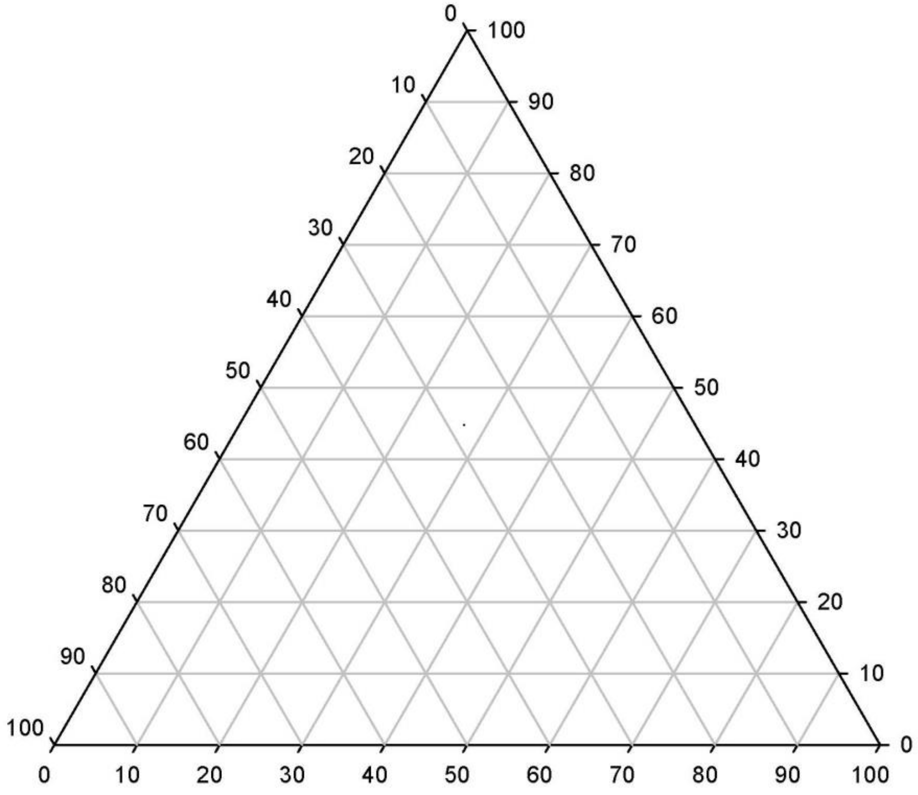
b. Which solvent is more selective towards linalool: limonene or 13PDO?

c. Locate on the diagram a mixture of the composition (0.45, 0.10, 0.45) and clearly label it as point **M**. Calculate the fraction of the Limonene-rich phase and 13PDO-rich phase assuming the mass of the mixture is 1 kg.

d. Provide an estimate to the plait point (don’t plot just judge from tie line data)



0
10
20
30
40
50
60
70
80
90
100



0
10
20
30
40
50
60
70
80
90
100

At 20°C, the density of a 20% by mass ethanol-water solution is 968.7 kg.m$^{-3}$ . Given that the partial molar volume of ethanol in the solution is 52.2 cm$^{-3}$.mol$^{-1}$, calculate the partial molar volume of the water.

Let A denote water and B ethanol. The total volume of the solution is $v = \sum x_i \bar{v}_i$ . We know $\bar{v}_B$ ; we need to determine $x_A$ and $x_B$ in order to solve for $\bar{v}_A$ .
Assume we have 100 cm$^3$ of solution; then the mass is

$$0.9687 \frac{g}{cm^3} (100\, cm^3) = 96.87 \text{ g.}$$

of which

$$m_A = 0.8(96.87) = 77.496 \text{ g water}$$

$$m_B = 0.2(96.87) = 19.374 \text{ g ethanol}$$

Convert the masses into their molar equivalents

$$n_A = \frac{77.496}{18.02} = 4.3006 \text{ mol water}$$

$$n_B = \frac{19.374}{46.07} = 0.42053 \text{ mol ethanol}$$

$$n = n_A + n_B = 4.3006 + 0.42053 = 4.7211 \text{ mol}$$

$$v = \frac{100}{4.7211} = 21.182 \text{ cm}^3\text{/mol}$$

$$x_A = \frac{4.3006}{4.7211} = 0.91093$$

$$x_B = 1 - 0.91093 = 0.08907.$$

Now, evaluate the partial molar volume of water as

$$v = x_A \bar{v}_A + x_B \bar{v}_B$$

$$\bar{v}_A = \frac{v - x_B \bar{v}_B}{x_A} = \frac{21.182 - 0.08907(52.2)}{0.91093} = 18.149 \text{ cm}^3\text{/mol.}$$

This value of partial molar volume of water is essentially the same as that of pure water. This is to be expected since water is concentrated in this solution.