



LIQUID AIR COMPOSITION

Statement

Evaluate liquid air composition at 100 kPa. In particular:

- Temperature range where nitrogen-oxygen two-phase mixtures of any composition may be at equilibrium.
- Temperature range for two-phase mixtures of air.
- Composition at 80 K.

🇪🇸 Se trata del estudio del aire líquido a presión ambiente. Se pide:

- Intervalo de temperatura en el que podría haber mezcla bifásica de nitrógeno y oxígeno, si no se conocieran las concentraciones.
- Intervalo de temperatura en el que habrá mezcla bifásica para el aire.
- Determinar la composición de las fases del aire a 80 K

Solution.

- For ideal mixtures, the temperatures bounding the two-phase region are the boiling points of the pure components: $T_{b,N_2}=77.4$ K and $T_{b,O_2}=90.2$ K.
- If the overall composition is known to be $x_{N_2}=0.79$ ($x_{O_2}=0.21$), thence the gas will not start to condense until:

$$\frac{x_{01}}{x_{L1}} = \frac{p_1^*(T)}{p} = \frac{0.79}{x_{L1}} = \frac{p_{N_2}^*(T)}{100 \text{ kPa}}, \quad \frac{1-x_{01}}{1-x_{L1}} = \frac{p_2^*(T)}{p} = \frac{0.21}{1-x_{L1}} = \frac{p_{O_2}^*(T)}{100 \text{ kPa}}$$

that, with Antoine equation for the vapour pressure, finally yields $T_{\text{cond}}=82$ K and $x_{N_2,\text{liq}}=0.46$.
and, the condensation will not end until:

$$\frac{x_{V1}}{x_{01}} = \frac{p_1^*(T)}{p} = \frac{x_{V1}}{0.79} = \frac{p_{N_2}^*(T)}{100 \text{ kPa}}, \quad \frac{1-x_{V1}}{1-x_{01}} = \frac{p_2^*(T)}{p} = \frac{1-x_{V1}}{0.21} = \frac{p_{O_2}^*(T)}{100 \text{ kPa}}$$

that, with Antoine equation for the vapour pressure, finally yields $T_{\text{boil}}=79$ K and $x_{N_2,\text{vap}}=0.95$.
The T - x_{N_2} diagram is:

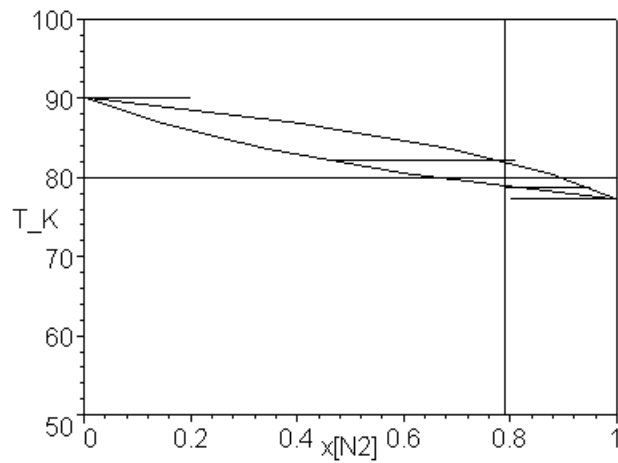


Fig. 1. T - x diagram for nitrogen-oxygen mixtures.

- c) At 80 K, $p_{v,N_2}=137$ kPa, $p_{v,O_2}=30$ kPa, 56% of the total amount of substance is in the vapour phase, with a nitrogen mol fraction of $x_{N_2,vap}=0.90$, and 44% in the liquid phase with a nitrogen mol fraction of $x_{N_2,liq}=0.65$.

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