LIQUID AIR COMPOSITION

Statement

Evaluate liquid air composition at 100 kPa. In particular:

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

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

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

Solution.

a) For ideal mixtures, the temperatures bounding the two-phase region are the boiling points of the pure components: $T_{b,N2}$=77.4 K and $T_{b,O2}$=90.2 K.
b) If the overall composition is known to be x_{N2}=0.79 (x_{O2}=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_{cond}=82 K and $x_{N2,liq}$=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_{boil}=79 K and $x_{N2,vap}$=0.95. The T-x_{N2} diagram is:

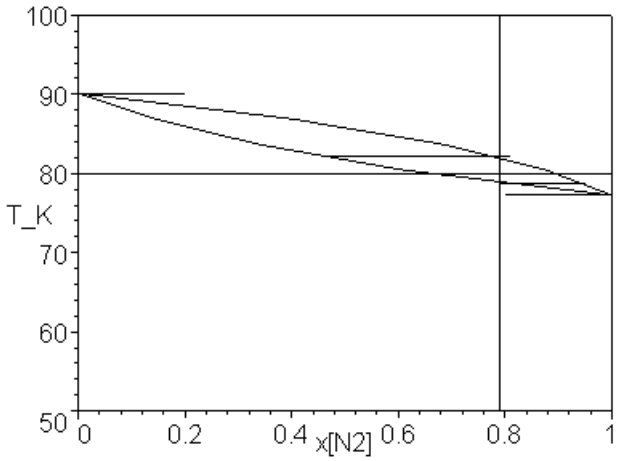

Fig. 1. *T-x* diagram for nitrogen-oxygen mixtures.

c) At 80 K, $p_{v,N2}$=137 kPa, $p_{v,O2}$=30 kPa, 56% of the total amount of substance is in the vapour phase, with a nitrogen mol fraction of $x_{N2,vap}$=0.90, and 44% in the liquid phase with a nitrogen mol fraction of $x_{N2,liq}$=0.65.

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