THERMODYNAMIC PROPERTIES OF NEON

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Introduction

Neon, which has a normal boiling point of 27.24° K, is a possible cryogenic fluid for the region above liquid helium and hydrogen and below liquid nitrogen. Neon has a relatively high refrigerating capacity at low temperatures and is chemically inert. For temperatures approaching the boiling point of hydrogen, it is a safe and attractive refrigerant.

Neon has been used as an intermediate fluid in hydrogen liquefaction. It should be an effective refrigerant for use with such cryogenic apparatus as minicoolers and masers, for magnet cooling, and for certain electronic devices such as infra-red detectors.

Equation of State

Tables of the thermodynamic properties of neon have been computed using an electronic digital computer. An equation of state with 12 constants was fitted to PVT data for neon. The 102 points measured at Leiden were used because they lie in the temperature region of interest. The form of the equation was chosen to allow evaluation of the constants directly from the data using the method of least squares.

This equation of state with its calculated constants is shown below:

\[
\frac{P}{\rho R T} - 1 = \sum \left[ a_{pq} \frac{\rho^q}{T^p} \right]
\] (1)

Beattie-Bridgeman, 7 terms, \(a_{01}, a_{11}, a_{31}, a_{02}, a_{12}, a_{32}, a_{33}\),
2 non-linearly dependent constants

Benedict-Webb-Rubin, 7 independent terms, \(a_{01}, a_{11}, a_{31}, a_{02}, a_{12}, a_{32}, a_{15}\)
plus exponential term, \(a_{36}, a_{38}, a_{3,10}, a_{3,12}, \text{etc.}\)
these non-linearly dependent on an eighth constant.

Constants for neon: \(T, ^\circ\text{K}; \rho, \text{gram-mols per liter.}\)
\[
\begin{align*}
a_{01} & = +1.6316815 \times 10^{-2} & a_{33} & = +1.0313714 \times 10^0 \\
a_{11} & = -2.0246323 & a_{34} & = -5.8725328 \times 10^{-1} \\
a_{31} & = -1.8231557 \times 10^3 & a_{15} & = -3.4991978 \times 10^{-7} \\
a_{02} & = +1.0561839 \times 10^{-3} & a_{36} & = +6.5018182 \times 10^{-4} \\
a_{12} & = -7.8057495 \times 10^{-2} & a_{38} & = -4.4338622 \times 10^{-7} \\
a_{32} & = +1.2710574 \times 10^2 & a_{3,10} & = +1.2287681 \times 10^{-10}
\end{align*}
\]

The terms in this equation of state are pressure, \(p\),
density, \(\rho\), gas constant, \(R\), temperature, \(T\), and a group of constants \(a_{pq}\). The subscripts \(p\) and \(q\) are also the exponents of \(T\) and \(\rho\). For example, \(a_{32}\), which is roughly \(+127\) in the working equation is the coefficient of a term \(\rho^2/T^3\). This form