Nomenclature, Conversions, Physical Constants, and Fixed Points for Argon

Nomenclature

P – absolute pressure
T – absolute temperature
V – specific volume
ρ – density $= 1/V$
R – universal gas constant
Z – compressibility factor $= PV/RT$
U – specific internal energy
H – specific enthalpy
S – specific entropy
C_p – specific heat capacity at constant pressure
C_v – specific heat capacity at constant volume
μ – Joule-Thomson coefficient
B – second virial coefficient
G – Gibbs function
A – Helmholtz function
$\bar{A}$ – residual work content
E – potential energy
r – distance of molecular separation
σ – molecular separation for $E = 0$
ϵ – Maximum energy of attraction
k – Boltzmann constant
N – Avogadro constant
r^* – reduced distance $= r/\sigma$
T^* – reduced temperature $= kT/\epsilon$
b_0 – reducing parameter $= 2\pi N\sigma^3/3$
B^* – reduced second virial coefficient $= B/b_0$
ρ_0 – distance between cores for minimum energy
h – Planck constant
a – radius of core
m – mass of molecule
$\bar{\Lambda}^*$ – de Broglie wave length $= h/(\sigma\sqrt{m\epsilon})$

Superscripts:
o – ideal gas property
$*$ – real or ideal gas property at very low pressures (P approaching 0) except as noted in symbols above
l – saturated liquid property
g – saturated vapor property

Subscripts:
c – critical point
o – reference state property
sat – property at saturation
t – triple point
expr – experimentally determined property value
calc – calculated property value
melt – melting line property

Subscripts on partial derivatives and integrals indicate which property is being held constant.

Conversions and Physical Constants

1 thermochemical calorie = 4.184 joules
0° C = 273.15 K (Triple point of water = 273.16 K)
Gas constant, $R = 0.0820535$ liter-atm/g-mole K
Planck constant, $h = 6.6256 \times 10^{-34}$ joule-sec
Boltzmann constant, $k = 1.38054 \times 10^{-23}$ joule/K
Avogadro constant, $N = 6.02252 \times 10^{23}$ per mole
Molecular weight of argon = 39.948g/g-mole (based on the carbon-12 scale where the isotope $C^{12} = 12.000\ldots$).

Fixed Points for Argon

Critical pressure = 48.34* atmospheres
Critical density = 300.4* Amagat = 13.41 g-mole/liter
Critical temperature = 150.86* K
Normal boiling point = 87.280 ± 0.015** K
Triple point temperature = 83.80** K
Triple point pressure = 0.68005** atmospheres.

* These fixed points are those listed by Michels et al. [1]. Some recent investigations indicate the critical temperature and pressure may be in error. However, these values appear to be the best estimate available at this writing. In reference [1] the Amagat unit of density is given as 4.4647×10^{-5} moles/cm³, based on the chemical scale. In this work the physical scale is used, resulting in an Amagat density unit of 4.4659×10^{-5} moles/cm³.

** These fixed points are those listed by Ziegler et al. [2]. The value of the normal boiling point calculated by the vapor pressure equation developed in this work agrees with that listed by Ziegler [2]. The value of the triple point temperature calculated by the vapor pressure equation developed in this work deviates from Ziegler's reported value by 0.0045 percent.