The Isotopic Sensitivities and Corresponding Uncertainties in Cryogenic Triple Point Realizations using Commercially Purified Gases

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The estimation of sensitivities of melting temperatures due to isotopic variations in monatomic and diatomic atmospheric gases is developed from a semi-empirical standpoint. While isotopic variations in many elemental and molecular materials are relatively well documented, the degree to which these variations cause measurable changes in thermometric triple-point realizations is only partially documented, and, in some cases, gaps in our knowledge currently exist. The state of what is currently known regarding vapor pressure isotope effects (VPIE) and triple point isotope effects (TPIE) is briefly reviewed for the noble gases (except He), and for molecular hydrogen, oxygen, and nitrogen. In both classes the magnitude of the effects diminishes with increasing molecular mass and increasing temperature. In the case of the noble gases, a rather complete set of VPIE data are available for He through Kr, while practically no data are available on Xe. Similarly, a full set of data are available for H_2 and N_2, but there are no VPIE data on O_2 below 63 K. Fortunately, a well developed and successful theory of the VPIE exits, which enables calculations for a variety of elemental and molecular forms. This is not the case, however, for melting phenomena, and the TPIE generally can not be predicted. The VPIE calculations, together with correlations between the VPIE and TPIE, do allow some estimation to be made for those cases in which no direct VPIE or TPIE data exist. The usefulness of this approach is demonstrated in the estimation of isotopic sensitivities and uncertainties for the triple points of xenon and molecular oxygen, for which very few or, otherwise, no reliable estimates were previously available.