Thermodynamic Properties of Parahydrogen-Orthohydrogen Mixtures

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Molecular hydrogen is a mixture of two separable nuclear-spin isomers, orthohydrogen and parahydrogen, with potentially significant differences in thermophysical properties. These differences are most apparent for storage applications at cryogenic temperatures where the equilibrium mixture concentration changes substantially with temperature. Recent advances in the equations of state for parahydrogen and orthohydrogen have created the possibility of an orthohydrogen-parahydrogen mixture model. Statistical treatment of the ideal-gas thermodynamic properties of hydrogen isotopic mixtures is presented. A hybrid property model coupling statistical treatment of the ideal-gas contribution to the Helmholtz free energy with that of the real-fluid is developed. Comparisons with experimental measurements of orthohydrogen-parahydrogen mixtures, including normal hydrogen, are presented. Non-idealities associated with the mixing of the separable hydrogen forms are considered. Methods for determining mixture concentrations and equilibration times are discussed.