Wide-ranging Speed of Sound Measurements and Derived Thermodynamic Properties of Neon

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Neon is currently considered as an alternative working fluid to helium for different gas thermometry techniques. However, despite offering certain advantages, its application is hindered by the fact that the thermophysical properties of neon are far less accurately known than those of helium. Therefore, we carried out comprehensive and accurate measurements of the speed of sound in neon. The measurements were performed using a double-path-length pulse-echo technique and cover the temperature range from 80 K to 420 K at pressures up to 100 MPa. To cover such a wide range of states, two thermostat arrangements were used, one for the cryogenic temperature range below 200 K and one for the higher temperatures. The relative expanded measurement uncertainty (at the 0.95 confidence level) is 0.015%. Furthermore, we derived other thermodynamic properties of neon, such as the density and isobaric and isochoric heat capacities, by the method of thermodynamic integration from the speed of sound data in the region of the measurements. The initial values of the density and isobaric heat capacity for the thermodynamic integration were calculated with a recent first-principles virial equation of state [1]. An auxiliary experiment was set up to measure the speed of sound in neon between 200 kPa and 700 kPa at 273.16 K using a large-volume copper spherical resonator. From the results of this experiment, we determined the molar mass of the neon sample used for the high-pressure speed of sound measurements and, additionally, the second acoustic virial coefficient at 273.16 K. The results for the latter validate a recent first-principles calculation of the second acoustic virial coefficients of neon [2].

References

1. R. Hellmann and G. Garberoglio (unpublished).
2. R. Hellmann, C. Gaiser, B. Fellmuth, T. Vasyltsova, and E. Bich, *J. Chem. Phys.* **154**, 164304 (2021).