Gas Viscosity Ratios Measured with a Capillary Flow Meter

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A recently developed meter for gas flow rates below 0.001 mol/s also yields gas viscosity ratios. The flow meter measures the input and output pressures as the gas flows through a long (6 m), small-diameter (0.3 mm) quartz capillary. A hydrodynamic model based on corrections to Poiseuille's law then determines the molar flow rate from the two pressures, the gas temperature, and the gas properties. The model uses published values for the gas properties, which include the viscosity (evaluated in the limit of zero pressure at 25 °C), the molar mass, the second virial pressure coefficient, and the thermal conductivity. It also uses the first temperature and density derivatives of viscosity. (For propane and sulfur hexafluoride, the second derivatives also were used.)

Measurements with helium, nitrogen, argon, propane, and sulfur hexafluoride demonstrated that the model could describe the flow rates of gases with widely varying properties with only one free parameter, the capillary radius. (The momentum accommodation coefficient also was needed for helium.) The flow meter's precision (0.03 %) was smaller than the published uncertainties of the gas viscosities. The data thus yielded independent determinations of gas viscosity ratios. Remarkably, the ratio of the best published viscosity of each gas to that of nitrogen is correct to within 0.12 %.