

Explicit Expressions for the Evaporation and Condensation Coefficients in the Hertz-Knudsen Relation

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Although the classical-kinetic-theory based Hertz-Knudsen (HK) relation is often used to correlate evaporation data, the relation contains two coefficients that must be determined empirically. The lack of consistent values for these coefficients have led investigators to question the validity of this relation. We take the classical limit of the quantum-mechanically-based statistical rate theory expression for the evaporation flux and obtain the Hertz-Knudsen relation, but with explicit expressions for the coefficients that are conceptually different than those of the HK relation: their maximum values are not limited to unity. The expression obtained for the evaporation flux from this limit - the HK-SRT relation - does not contain any fitting parameters. From measurements made during water evaporation, the HK-SRT relation is first used to determine the saturation-vapor pressure, $P_s(T)$, that is valid at temperatures below the water triple point. This expression for $P_s(T)$ is then used with the HK-SRT relation to predict the interfacial temperature discontinuity in 45 independent water evaporation experiments that have been reported in the literature. No measurable disagreement was found, but the coefficients were each greater than unity. Since explicit expressions for the coefficients are now available, investigations of the simplifying assumptions used in the past can be examined. We show that if thermal equilibrium is assumed at the interface and the coefficients are assumed equal, then with the same set of data, the variation in the values of the coefficients required to give the measured value of the evaporation flux can vary by four orders of magnitude.