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This Week's Citation Classic

Othmer D F & Thakar M S. Correlating diffusion coefficients in liquids. *Ind. Eng Chem.* **45**:589-93, 1953. [Polytechnic Institute of Brooklyn, NY]

Diffusion coefficients of any substance in any liquid are expressed closely by, or determined from, a simple, thermodynamically derived linear equation, or its nomogram, using only the substance's formula and the viscosity and latent heat of the liquid. [The *SCI*® indicates that this paper has been cited in over 90 publications since 1961]

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"Diffusion in liquids of molecules of solids, liquids, and gases is very important in theoretical studies and actual design of chemical and petroleum plants for distillation, gas absorption, extraction, and chemical reaction. Rates are difficult to measure and few data are available compared with, e.g., solubilities, viscosities, and vapor pressures.

"This general method correlates and predicts diffusion coefficients using all available data. Their scope is expanded greatly by the thermodynamic equation and the resulting nomogram. The method is based on and intimately interrelated to much better studied liquid properties — viscosity, vapor pressure, and latent heat — and it determines the energy of diffusion.

"To dissolve in gasoline, alcohol for gasohol must be dehydrated. Pressure distillation does this,[1] and the optimum pressure must be found. Methods using differentials and maxima were tried. The search found that, at the same temperatures, the differential of the log of the vapor pressure of any compound is a linear function of the differential of the log of the pressure of any other compound. The slope of the plotted line is the ratio of the latent heats of the two compounds — a constant, *m* — and all lines pass through the origin. Hence, a single term equation gives the vapor pressure-temperature-latent heat relation exactly. More useful was the integral form: at the same temperatures, the log of the vapor pressure of one substance is equal to the log of the vapor pressure of any other substance times *m*, plus the integration constant, or $\log P = m \log P' + C$.

"But one doesn't publish a simple accident! He digs up relevant axioms and develops them into an elegant syllogism! So, 16 big pages of a full-dress, thermodynamic paper showed how, simply and accurately, to correlate and predict vapor pressures and latent heats of all substances, and also a dozen related properties, as freezing points, heats of chemical reactions, enthalpy charts, vapor-liquid compositions, etc.[2]

"Some 50 papers[3,4] with my students at the Polytechnic Institute of New York followed to develop, similarly from the interrelation of molecular and physical functions of solids, liquids, and gases, the correlation and prediction of 25 or 30 other physical and chemical properties, including viscosities, vapor compositions, chemical reaction rates, diffusion in liquids and in gases, and a new equation of state. This is possible because properties for any substance vary the same as for any other substance, taken as a reference. These studies refined the technics, quantified assumptions, and produced simple and thermodynamically exact equations with two or three terms, usually expressing data, including diffusion, better than others published with eight to 21 terms, mainly empirical."

1. **Othmer D F & Wentworth T O.** Absolute alcohol, an economical method for its manufacture. *Ind. Eng Chem.* **32**:1588-93, 1940.
2. **Othmer D F.** Correlating vapor pressure and latent heat data, a new plot. *Ind. Eng. Chem* **32**:841-56, 1940.
3. .... Engineering and chemical data correlation. (Bushey G J, Eastman C I, Klingsberg A & Spiro L, eds.) *Kirk-Othmer encyclopedia of chemical technology*. New York: Wiley, 1980. Vol. 9. p. 45-117.
4. **Othmer D F & Chen H T.** Correlating and predicting thermodynamic data *Ind. Eng. Chem.* **60**:39-61, 1968.