Isobaric Equilibrium Calculations

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Dodge and Ibl (3) have pointed out that the thermodynamic consistency criterion proposed by Redlich and Kister (6) should have the following form for the case of variable temperature and constant pressure conditions:

$$\int_0^1 \ln(\gamma_1/\gamma_2)\,dx_1 = \int_0^1 -Z_1\,dx_1 \tag{1}$$

where

$$Z = -\Delta H/RT^2\,(dT/dx_1)_p$$

and

$$\Delta H = H - x_1H^o{}_1 - x_2H^o{}_2$$

Where the enthalpy term is not negligible, the equal area thermodynamic consistency check of Redlich and Kister does not apply. As there is no way of predicting when the Z term may be neglected a priori, its existence can be determined only by drawing the γ-ratio vs. composition graph and checking the area values. There is, therefore, no justification for adjusting this curve for isobaric systems to give equal areas.

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Apparent Inert-Gas Permeation Through Nickel

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For some time it has been considered a fact that the inert gases do not permeate metals (5). This has been attributed to the fact that the gas atoms are not adsorbed on the surface of the metal, and do not penetrate into the metal lattice (4). However, at various times observations have been made which appear to contradict the fact that inert gases do not permeate. For example, at elevated temperatures, gas has been observed to accumulate in an evacuated stainless steel cylinder even though it was surrounded by argon (3, 6). Harden (3) studied the argon-nickel system and his results, though incomplete, indicated that some form of gas-metal permeation occurred. The present study was made to explain the above results and to examine the statement "no rare gas permeates any metal (5)."

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TABLE 1. MASS SPECTROMETER ANALYSIS

	Composition mole %					
Sample	H_2	He	H_2O	N_2	O_2	A
Permeated gas (A-5)	79	0	6	11	3	1
Permeated gas (A-6)	10	0	39	40	10	1
Delivered gas (A-5, A-6)	0	98.9	0.4	0.6	0.1	0

TABLE 2. EXPERIMENTAL RESULTS

Run*	Gas	Temperature, °C.	Pressure, lb./sq.in.abs.	Equilibrium pressure, mm. Hg
A-1	He	793	731	3.8
A-2†	He	793	362	0.015
A-3	He	797	529	0.041
A-4	He	803	702	0.036
A-5	He	804	800	0.085
A-6	He	802	782	0.018
B-1	A	798	597	0.465
B-2†	A	782	584	0.014
B-3	A	793	584	0.108
Ref. 3	A	907	1,475	~2.94
Ref. 3	A	806	1,415	~1.9

* Run sequence was A-1 through A-4, B-1 through B-3, A-5 and A-6.
† Questionable whether permeation was detected.

J. R. Phillips is with the California Research Corporation, Richmond, California.

INFORMATION RETRIEVAL

(*Continued from page 972*)

Aeration in Bernoulli types of devices, Jackson, Melbourne L., **A.I.Ch.E. Journal, 10,** No. 6, p. 836 (November, 1964).

Key Words: Absorption-8, Mass Transfer-8, Aeration-8, Nozzle-10, Orifice-10, Venturi-10, Treatment-8, Performance-9, Energy-7, Interfaces-9, Resistance-8, Coefficients-7, Factors-7, Flow-6, Two Phase-9, Water-1, 5, Air-1, 5, Sulfite-4, Surfactant-4, Waste-4.

Abstract: Venturi, orifice, and nozzle devices are compared as to characteristics of oxygen transfer from aspirated air to a liquid and as to minimum energy consumption for two-phase flow. The Venturi device exhibited the best performance of the group and energy consumption was favorable, especially at low liquid flow rates (5.9 lb. oxygen/hp.-hr. to water). This type of device was found to be more effective for water solutions (sulfite, surfactant, proteinous waste) than for water because of lower interfacial tensions. In many instances, the exit liquid was at or near oxygen saturation.

Mass transfer in fluidized bed crystallization, Bransom, S. H., and G. A. R. Trollope, **A.I.Ch.E. Journal, 10,** No. 6, p. 842 (November, 1964).

Key Words: Input-1, Product-2, Waste-3, Special Agents-4, Solvent Water-5, Independent Variables-6, Dependent Variable-7, Subject of Study-8, Object of Study-9, Device-10.

Abstract: The crystallization of magnesium sulfate in a pilot scale fluidized bed crystallizer was examined by measuring the longitudinal decay of the concentration of the flowing solution. The rate constant of crystal growth at 20°C. was measured and shown to agree with other authors values. It was shown that longitudinal dispersion or bypassing of the liquor stream occurred, and the resulting effect was accounted for as an effective eddy diffusivity. A model, based on the fraction of the liquor stream which bypasses crystals without depositing solute, was thought to require higher accuracy than was achieved in the experimental measurements, although a reasonable value was calculated for the rate constant by means of this model. The effect of the tendency towards size classification was demonstrated by comparing crystal growth rates at the top and bottom of the crystallizer.

Formation of air bubbles at orifices submerged beneath liquids, Sullivan, S. L., Jr., B. W. Hardy, and C. D. Holland, **A.I.Ch.E. Journal, 10,** No. 6, p. 848 (November, 1964).

Key Words: Bubble Formation-8, Interfacial Area-7, Mixing-9, Mass Transfer-9, Viscosity-6, Surface Tension-6, Density-6, Air Rate-6, Liquid Rate-6, Orifice Diameter-6, Bubble Volume-7, Bubble Frequency-7, Constant-Volume Formation-8, Constant-Frequency Formation-8.

Abstract: Air bubbles were formed at orifices submerged beneath each of fourteen liquids. Orifice diameters ranged from 0.159 to 0.396 cm. and air-flow rates from 0.1 to 100 cc/sec. In the first of two investigations, air bubbles were formed at orifices at various angles of inclination. In the second, the effect of the liquid velocity past a horizontal, submerged orifice on the formation of air bubbles was determined. Liquid velocities ranged from 0.34 to 2.5 cm./sec.

Bubble formation was correlated with the physical variables of the system by use of Newton's second law of motion.

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(*Continued from page 968*)

Chao and Hougen (2, 4) have suggested a modified form of the Redlich and Kister equation presented as Equations (2) and (3), in the three-constant form:

$$\ln \gamma_1 = x(1-x)\,[B' + C'(2x-1) + D'(2x-1)^2] + (1-x)\,\{a + b(1-2x) + c[6x(1-x)-1] + d(1-2x)\,[1-8x(1-x)]\} \quad (2)$$

$$\ln \gamma_2 = x(1-x)\,[B' + C'(2x-1) + D'(2x-1)^2] - x\,\{a + b(1-2x) + c[6x(1-x)-1] + d(1-2x)\,[1-8x(1-x)]\} \quad (3)$$

In this modified form the constants B', C', D', b, c, d, are all different, and the equation is unnecessarily complex and unwieldy. The constant, a is introduced to allow for the Z term above. Simplified forms of Equations (2) and (3) are obtained by setting $B' = b = B$, etc., to give Equations (4) and (5).

$$\ln \gamma_1 = x(1-x)[B + C(2x-1) + D(2x-1)^2] + (1-x)\,\{A + B(1-2x) + C[6x(1-x)-1] + D(1-2x)\,[1-8x(1-x)]\} \quad (4)$$

$$\ln \gamma_2 = x(1-x)\,[B + C(2x-1) + D(2x-1)^2] - x\,\{A + B(1-2x) + C[6x(1-x)-1] + D(1-2x)\,[1-8x(1-x)]\} \quad (5)$$

This paper describes a method which may be used to evaluate the four constants A, B, C, and D for an isobaric system by a combination of two procedures. The constant A is evaluated by the previously discussed γ-ratio vs. composition plot, and a modified Schiebel method (7) is used to evaluate the constants B, C, and D. The study was undertaken because some authors (5, 8) have reported difficulty in adequately representing isobaric data for nonideal systems and have recommended some form of the Van Laar equation. The three-constant form of the Redlich and Kister equation used here is particularly suitable for predicting the behavior of ternary systems from binary interaction constants.

METHOD

When Equation (5) is subtracted from Equation (4), a relation for log (γ_1/γ_2) may be obtained:

$$\log(\gamma_1/\gamma_2) = A + B(1-2x) + C[6x(1-x)-1] + D(1-2x)\,[1-8x(1-x)] \quad (6)$$

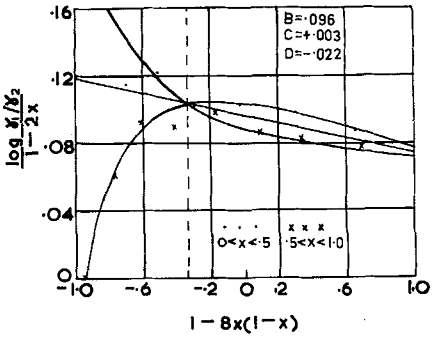

Fig. 1. Schiebel plot for n-octane- ethylbenzene at 760 mm. mercury.

Equation (7) is obtained by dividing by $(1 - 2x)$:

$$\frac{\log(\gamma_1/\gamma_2)}{1-2x} = B + D[1-8x(1-x)] + \frac{A + C[6x(1-x) - 1]}{1-2x} \quad (7)$$

Schiebel's method depends on the symmetry of this equation and enables ready and accurate evaluation of the three constants B, C, and D. Log $(\gamma_1/\gamma_2)/(1 - 2x)$ is plotted as ordinate with $1 - 8x(1 - x)$ as abscissa as shown in Figure 1 for the system n-octane-ethylbenzene at pressures of 760 mm. mercury. Equation (7) is symmetrical about the values of x and the corresponding value of $(1 - x)$; that is, at these values, the arithmetic mean of the left-hand side of Equation (7) will vary linearly with the function $1 - 8x(1 - x)$ with a slope of D and an intercept B. The constant C is obtained from the ordinate difference between the straight and one of the curved lines at an abscissa value of $+1.0$. C is positive if the $0 < x < 0.5$ points are below the straight line in the positive abscissa region and vice-versa. As an aid in positioning the straight and the two curved lines where inadequate data are available,

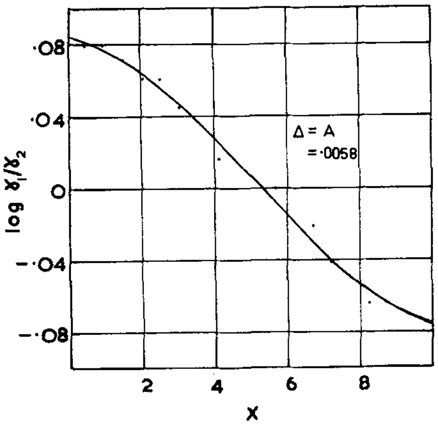

Fig. 2. Log activity coefficient ratio vs. composition for n-octane-ethylbenzene at 760 mm. mercury.

INFORMATION RETRIEVAL

(*Continued from page 974*)

The movement of a soluble material during the washing of a bed of packed solids, Sherman, William R., **A.I.Ch.E. Journal, 10,** No. 6, p. 855 (November, 1964).

Key Words: Transport-8, Movement-8, Washing-8, Beds-5, Packing-5, Glass Beads-5, Dacron Fibers-5, Viscose Fibers-5, Solute-1, Oscilloscope-10, Photocell-10, Diffusion-8, Step Function-6, Displacement-8, Diacetyl-1, Water-1, Solution-2, Light-10, Concentration-7, Equation-10.

Abstract: Movement of soluble material during washing of beds of packed solids was studied. Beds of glass beads, dacron fibers, and viscose fibers were saturated with diacetyl solutions and then washed with water. Input and output stream concentrations were recorded by photographing oscilloscope response of the photocells receiving light beams above and below the bed. The commonly used one-dimensional diffusionlike differential equation was applied to the movement of solute. To avoid experimental difficulties in obtaining a satisfactory step function, the boundary conditions were modified to include the actual input concentration history in the form of an empirical equation.

Vapor-liquid equilibrium in the system bromine pentafluoride-uranium hexafluoride, Liimatainen, Robert C., and Bernet S. Swanson, **A.I.Ch.E. Journal, 10,** No. 6, p. 860 (November, 1964).

Key Words: Thermodynamics-8, Equilibria-8, Distillation-7, 8, Bromine Pentafluoride-9, Uranium Hexafluoride-9, Relative Volatility-7, Vapor Pressure-7, Temperature-6, Fluorine-4, Recirculation Still-10, Composition-7, Experimental-8.

Abstract: Previous studies contain conflicting information on the bromine pentafluoride-uranium hexafluoride system, especially concerning the existence of an azeotrope. In this experimental study, the vapor-liquid equilibria in the bromine pentafluoride-uranium hexafluoride system was determined with a recirculation type of equilibrium cell. Isotherms were obtained at 70° and 90°C. The system showed positive deviation from ideality with no azeotrope. At 3 atm. total pressure, the relative volatility of the binary varied from 1.80 to 1.09 over the complete range of compositions. The results from distillations in packed columns were also in agreement with the phase equilibrium data; both showed that there was no evidence for an azeotrope.

Determination of plate efficiencies from operational data, Taylor, D. L., Parke Davis, and C. D. Holland, **A.I.Ch.E. Journal, 10,** No. 6, p. 864 (November, 1964).

Key Words: Distillation-1, Efficiency-7, Temperature-6, Separations-6, Computer-10, Computations-10, Enthalpy-7, Boiling Points-7, Compositions-7, Pressure-6.

Abstract: Methods for the determination of plate efficiencies for existing columns at either finite or total reflux are presented. Information, such as any combination of product distributions and plate temperatures, which is in addition to that required to solve a problem for a fixed column is used to determine efficiencies.

The isotropic turbulent mixer: Part II. arbitrary Schmidt number, Corrsin, Stanley, **A.I.Ch.E. Journal, 10,** No. 6, p. 870 (November, 1964).

Key Words: Fluid-5, Agitation-6, Energy Spectrum-6, Schmidt Number-6, Turbulence-6, Decay-7, Fluctuation-7, Homogeneity-7, Mixing-8, Scaling-8, Similarity-8, Mixer-10.

Abstract: A slight generalization is made on earlier estimates of relative decay rates of concentration and velocity fluctuations in decaying turbulence at Schmidt numbers less than 1 by including the inertial-diffusive spectral region. Then the problem is extended to large Schmidt numbers by application of Batchelor's theory for the viscous end of the concentration spectrum. Finally, the method is used to extend to very small and large Schmidt numbers the earlier performance estimates and scaling of an idealized mixer containing stationary, isotropic turbulence.

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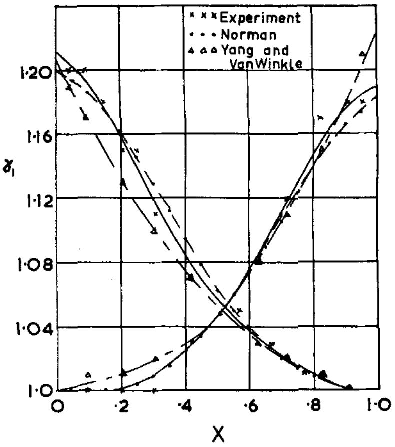

Fig. 3. Activity coefficient vs. composition for n-octane-ethylbenzene at 760 mm. mercury.

it should be noted that Equation (7) predicts that all lines should intersect at an abscissa value of $-1/3$. For isobaric systems the value of the C constant may be subject to modification by the magnitude of the Z effect, represented by A. Two systems will now be studied to demonstrate the utility of the method.

n-Octane-Ethylbenzene

The unsmoothed data of Yang and Van Winkle (*8*) were used to evaluate the constants A, B, C, and D. Figure 2 shows the γ-ratio vs. composition graph for estimating the value of A for one condition of total pressure. Figure 1 shows the graph for the evaluating of the constants B, C, and D. The variations in values of the constants with decreasing pressure may be observed in Table 1, which contains the constants A, B, C, and D for the pressure ranges 760, 500, 200, and 50 mm. mercury.

These constants were used to esti-

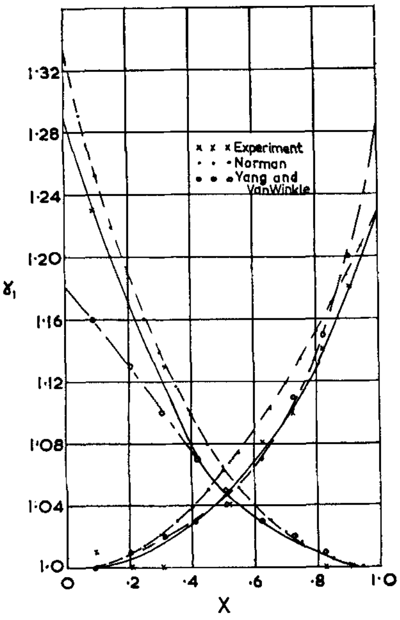

Fig. 4. Activity coefficient vs. composition for n-octane-ethylbenzene at 500 mm. mercury.

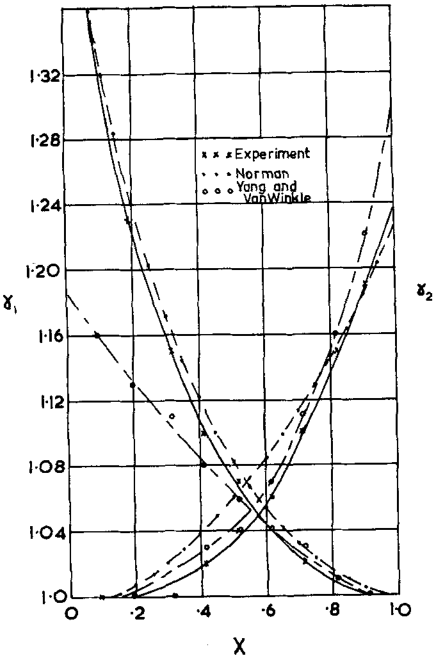

Fig. 5. Activity coefficient vs. composition for n-octane-ethylbenzene at 200 mm. mercury.

mate the change in activity coefficient with composition according to Equations (4) and (5). Yang and Van Winkle reported that their data could not be fitted satisfactorily with the Redlich and Kister equation but could be fitted with the Van Laar equation. Figures 3 to 6 show that the agreement of their smoothed values, using the Van Laar equation, with the experimental values is only valid for the high concentration region, while the discrepancy at low concentrations becomes greater with decreasing pressure. On the other hand, the same figures show how a better representation of the data may be obtained with the procedure outlined in this paper.

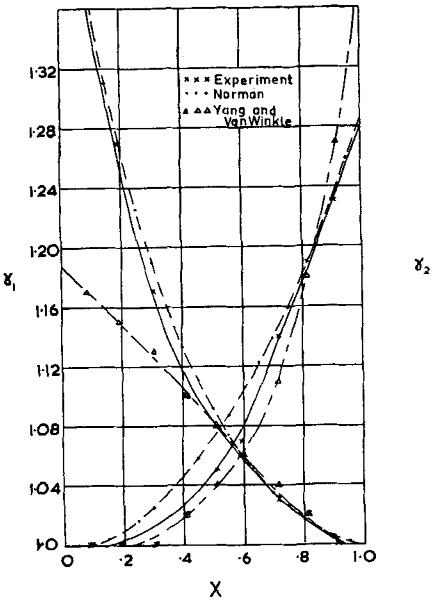

Fig. 6. Activity coefficient vs. composition for n-octane-ethylbenzene at 50 mm. mercury.

Atmospheric Pollution—Its Origin and Prevention, Third Revised Edition, A. R. Meetham, in collaboration with D. W. Bottom and S. Clayton, McMillan, New York, (1964). 301 pages. $10.00.

Like the previous editions, the third edition of Meetham's book deals solely with air pollution in Great Britain. Inasmuch as the serious problem there is pollution from the burning of fuel, attention is directed almost entirely to smoke, SO_2, and ash.

The first half of the book is devoted to descriptive matter on fuels, boilers, industrial furnaces, and domestic services. Treatment is similar to that in elementary texts in heat and power, fuels and combustion, and industrial technology. Most of the chapters have been largely rewritten for the third edition. Emphasis is still on solid fuels, but some material on liquid fuels has been added.

The last half of the book deals with atmospheric pollution in England, its nature, extent, measurement, distribution, effects, and prevention. To me the most interesting chapter was one called "Changes in Pollution," perhaps because of the opening sentence: "The study of atmospheric pollution is admittedly an untidy science." At any rate, the chapter tells of changes in pollution levels as affected by weather variables. The treatment is thorough, easily understandable, and fits air pollution problems everywhere. On the other hand, the chapter on "Prevention" deals only with British practice and is of little value to American engineers.

A completely new chapter on air pollution laws has been added, and contains an excellent discussion on Britain's Clean Air Act, the Alkali Acts, and the Road Traffic Act, together with suggestions for further action. One which intrigued me is: "In particular action is needed regarding low exhaust pipes on vehicles which discharge into houses and shops in narrow streets and into the perambulators of young children."

There is some discussion of legislation in other major countries. There are a few errors such as crediting the Model Smoke Ordinance to the American Society of Chemical Engineers, but in general the discussion is succinct and factual.

The book as a whole is well written and marred only by a few misconceptions such as the statement that the most probable cause of death in the Donora incident was sulfur dioxide. Printing and binding are professionally done, and the price is reasonable.

Those interested in British practice in air pollution matters will find the third revised edition a useful reference.

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Review of Thermodynamics of Irreversible Processes, Pierre Van Rysselberghe, Blaisdell Publishing Company, New York, Toronto and London (1964). 165 pages. $6.50.

In his introduction the author presents this book as a set of lecture notes intended for intermediate-level students in different disciplines where the techniques of irreversible thermodynamics are useful. It is a short book of only 165 pages and is organized in a manner that will be helpful to a student using it as a textbook. The first chapter reviews some basic concepts and definitions in thermodynamics. Succeeding chapters, by specific examples or applications, build and apply the techniques of irreversible thermodynamics. Physical mixing, chemical reactions, electrochemical reactions, and transport processes are treated in the building process. Later chapters deal with thermoelectricity, steady state, viscous flow, and thermodynamic time.

The book is written in a lucid but terse style. As an introductory textbook its style and organization recommend it. However, the treatment is such that both the generality and limitations on defining fluxes and forces and applying the reciprocal relations are obscured. Since these topics are of primary importance to the subject, the reviewer believes that even an introductory text should give some discussion of them per se.

Properly, the author has not duplicated material that is available in reference books on the subject. This book is clearly not intended as a reference on the subject, but even readers well versed in the field may find Van Rysselberghe's treatment interesting. Certainly, anyone teaching the subject will want to consider this book as a possible class text.

The book is notably free of misprints or errors. The type is relatively poor and the printing only fair.

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ERRATUM

In the September issue one of the authors, C. A. Eckert, of the paper "Statistical Surface Thermodynamics of Simple Liquid Mixtures" (page 677) was incorrectly listed as being affiliated with the Cryogenic Engineering Laboratory, Boulder, Colorado. At the time that the work reported in the paper was performed, Dr. Eckert was affiliated with the University of California, where the work was done. The project was supported in part by the Cryogenic Engineering Laboratory of the National Bureau of Standards.

INFORMATION RETRIEVAL

(*Continued from page 976*)

Tube flow of non-Newtonian polymer solutions: Part I. Laminar flow and rheological models, Meter, Donald M., and R. Byron Bird, **A.I.Ch.E. Journal, 10,** No. 6, p. 878 (November, 1964).

Key Words: Polymer Solutions-1, Viscoelastic Fluids-1, Natrosol-1, Hydroxyethyl Cellulose-1, Friction Factors-7, Rheological Models-8, Generalized Newtonian Models-8, Non-Newtonian Viscosity-8, Ellis Model-8, Reiner-Philippoff Model-8, Laminar Flow-8, Dimensionless Groups-9, Characteristic Time-9, Viscometry-10, Tube Flow-10.

Abstract: A four-constant model for non-Newtonian flow of polymer solutions is proposed, and its relation to previously proposed models is pointed out. The use of this model is illustrated by comparison with data on four solutions of Natrosol hydroxyethyl cellulose. It is further shown how one can use this model to obtain the velocity distribution, the volume rate of flow, and the friction factor for laminar tube flow.

Tube flow of non-Newtonian polymer solutions: Part II. Turbulent flow, Meter, Donald M., **A.I.Ch.E. Journal, 10,** No. 6, p. 881 (November, 1964).

Key Words: Polymer Solutions-1, Viscoelastic Fluids-1, Natrosol-1, Hydroxyethyl Cellulose-1, Friction Factors-7, Turbulent Flow-8, Non-Newtonian Viscosity-8, Generalized Newtonian Model-8, Dimensionless Groups-9, Tube Flow-10.

Abstract: A correlation of turbulent tube flow friction factors for non-Newtonian polymer solutions is presented. This correlation has been found to represent data taken on seven solutions of Natrosol hydroxyethyl cellulose in ½- and 1-in. I.D. smooth tubes, with an average accuracy of 10.8%. The correlation enables one to predict the point of transition from laminar to turbulent flow.

Droplet growth in binary liquid systems, Ayen, Richard J., and J. W. Westwater, **A.I.Ch.E. Journal, 10,** No. 6, p. 885 (November, 1964).

Key Words: A. Liquid-1, Droplet-2, Phase Change-2, Growth-2, Binary-1. B. Motion Pictures-4, Microscope-4. C. Acetone-1, Glycerol-1, Isoamyl Alcohol-1. D. Diffusivity-2, Supersaturation-6.

Abstract: Measurements of the growth of liquid drops suspended in three supersaturated liquids were made with cinephotomicrography. Results for acetone drops and isoamyl alcohol drops in glycerol agree with the theoretical expression of Scriven. Free convection occurred for glycerol drops in acetone. The experimental method is a new way to obtain liquid-liquid diffusivities.

Binary liquid-phase adsorption equilibria, Walter, J. F., and E. B. Stuart, **A.I.Ch.E. Journal, 10,** No. 6, p. 889 (November, 1964).

Key Words: Benzene-1, Cyclohexane-1, Toluene-1, Iso-octane-1, Hydrocarbons-1, Adsorbate-2, Silica Gel-4, Silica-4, Silica-Alumina-4, Adsorbent-4, Liquid-Solid-5, Pore Diameter-6, Heats of Adsorption-6, Surface-6, Molecular Diameter-6, Intermolecular Forces-7, Cohesive Energy-7, Adsorptivity or Relative Adsorptivity-7, Adsorption-8, Purification-8, Recovery-8, Removal-8, Stripping-8.

Abstract: A theoretical model describing binary liquid-phase adsorption equilibria is derived from a consideration of the molecular forces involved in nonpolar van der Waals adsorption. This development assumes ideal solutions in both the adsorbed and liquid phases, no adsorbate-adsorbate interaction, and a smooth cylindrical pore adsorbent. The resulting equilibrium equation includes the effects of pore diameter, adsorbent composition, heats of adsorption, molecular diameters, density, intermolecular forces, temperature, and liquid phase concentration. This model is tested by predicting equilibrium concentrations from molecular parameters obtained from the literature and comparing these results with measured data for the benzene-cyclohexane-silica gel and for the toluene-isooctane-silica gel and silica-alumina systems.

(*Continued on page 980*)

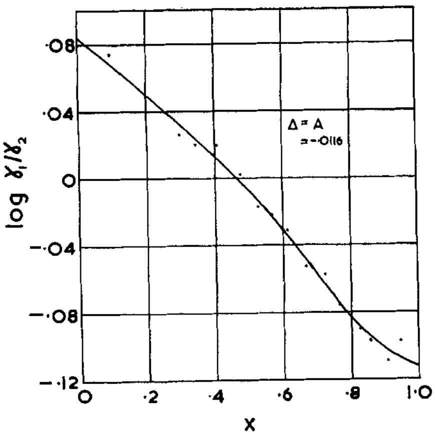

Fig. 7. Log activity coefficient ratio vs. composition for toluene-n-octane at 750 mm. mercury.

Toluene-n-Octane

The data of Bromiley and Quiggle (*1*) were taken for this system and the constants evaluated by the above procedure. Figure 7 shows the γ-ratio vs. composition graph for the evaluation of area difference and hence *A*, and Figure 8 shows the graph for the evaluation of the constants *B*, *C*, and *D*. These constants were used to evaluate the variation of activity coefficient with composition. The dashed lines in Figure 8 represent the first attempt at drawing in the curved lines, giving the constant shown. When these constants were used to obtain values of γ, they gave the results shown by the dashed lines on Figure 9. By inspection, the greatest error in γ occurs at $x = 0.3$; that is 5%. This discrepancy between the calculated and experimental values of γ is due to the inadequate data in both the high and the low concentration regions. New curved lines were then drawn on Figure 8 to obtain a new set of *B*, *C*, and *D* constants which gave the solid line on Figure 9. By a similar procedure inadequancy of data

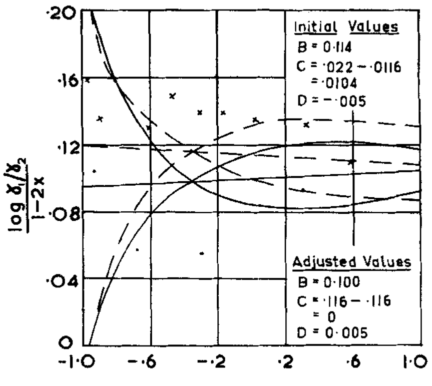

Fig. 8. Schiebel plot for toluene-n-octane at 750 mm. mercury.

(*Continued on page 980*)

INFORMATION RETRIEVAL

(*Continued from page 978*)

Heat transfer in laminar and turbulent flows between parallel plates with transverse flow, Lee, Shaw Mei, and William N. Gill, **A.I.Ch.E. Journal, 10,** No. 6, p. 896 (November, 1964).

Key Words: Duct-5, Fluid-5, Heat Transfer-7, Nusselt Number-7, Momentum Transfer-7, Prandtl Number-6, Reynolds Number-6, Transverse Velocity-6, Transpiration Cooling-8, Turbulent Flow-8, Forced Convection-8, Computer-10, Analysis-10.

Abstract: The effect of constant cross flow on laminar and turbulent channel flows was investigated theoretically, and temperature profiles, velocity distributions, and wall gradients were determined. Transverse flow has a profound influence on heat transfer characteristics, and its importance increases with N_{Pr}.

The results for turbulent forced convection in conduits can be correlated in a remarkably simple manner. That is, the ratio of heat transfer coefficients with and without cross flow, to a good approximation, is a unique function of the reduced transverse velocity divided by the Stanton Number.

Vapor phase activity coefficients and standard state hypothetical vapor fugacities for hydrocarbons, Hoffman, Dwight S., J. Reed Welker, V. N. P. Rao, and James H. Weber, **A.I.Ch.E. Journal, 10,** No. 6, p. 901 (November, 1964).

Key Words: Vapor-Phase Data-1, Fugacity Coefficients-2, Vapor-Phase Activity Coefficients-2, Standard State Hypothetical Vapor Fugacities-2, Van Laar Equation-10, Black's Equation of State-10, Propane-9, *n*-Pentane-9, Benzene-9.

Abstract: From vapor-phase data for binary mixtures, the fugacity coefficients of both of the components and the vapor phase activity coefficients for the more volatile component were calculated from Black's equation of state. These coefficients for the more volatile component were fit to the van Laar equation, and the vapor phase activity coefficients for the less volatile component were evaluated. Then the standard state fugacities for the hypothetical vapors of the less volatile component were determined.

Mixtures were studied where propane, *n*-pentane, or benzene were the less volatile component. Standard state hypothetical vapor fugacities for these components were evaluated and generalized.

Isomerization of *n*-pentane over platinum-alumina catalysts of different activity, Lyster, W. N., J. L. Hobbs, and H. W. Prengle, Jr., **A.I.Ch.E. Journal, 10,** No. 6, p. 907 (November, 1964).

Key Words: *n*-Pentane-1, Iso-Pentane-2, Cracked Products-3, Platinum-Aluminum Oxide-4, Hydrogen-5, Temperature-6, Pressure-6, Hydrogen/Hydrocarbon Ratio-6, Rate of Reaction-7, Isomerization-8, Chlorination-8, Kinetics-9, Vapor-Phase Reaction-10, Solid Catalyst-10, Pore Diffusion-0, Catalytic Reforming-0, Adsorption Equilibrium-0, Surface Reaction-0, Dual-Site Mechanism-0, University of Houston-0.

Abstract: This paper describes a study of vapor-phase isomerization of *n*-pentane over a solid platinum-aluminum oxide catalyst. Data were obtained for the following ranges of conditions: 650° to 900°F., 200 to 600 lb./sq.in. gauge, 9 to 25 g. *n*-pentane/(hr.) (g. catalyst) space velocity.

The catalyst used was a commercial catalytic reforming catalyst; the isomerization activity was changed by varying the chloride content. Activities are compared with others reported in the literature.

A dual-site rate equation is used to describe the data obtained and to characterize the literature data. Diffusion mechanisms are considered in the overall equations developed.

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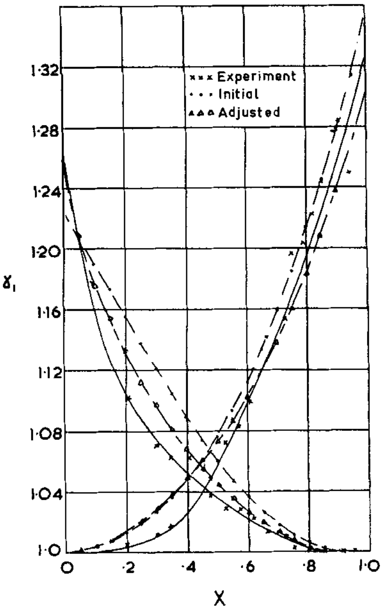

Fig. 9. Activity coefficient vs. composition for toluene-n-octane at 750 mm. mercury.

may be overcome to obtain a suitable representation of the data available.

DISCUSSION

Where suitable data are available it has been demonstrated that the procedure outlined in this paper will enable satisfactory representation of nonideal system behavior using a modified Redlich and Kister equation. In addition, the procedure may be used with some success to represent the behavior of systems when inadequate data are available.

The results of the calculations for the n-octane-ethylbenzene system enable some observations on the variation of the constants with change in total pressure. The constant *B* exhibits almost a linear variation, while the variations of constants *A*, *C*, and *D* exhibit a similar tendency as shown in Table 1.

Where adjustment of the determined constants is required to give a better representation of data, some guidance can be found by noting the net effect of changes in sign and magnitude of the minor constants. Some combinations of constants are plotted in Figure 10 to illustrate this general effect. It should be noted that changing the sign of the constant *C* is tantamount to in-

TABLE 1. VARIATION OF CONSTANTS WITH PRESSURE SYSTEM n-OCTANE-ETHYLBENZENE

Pressure mm. mercury	*A*	*B*	*C*	*D*
760	0.0058	0.096	0.003	—0.022
500	0.0070	0.107	—0.011	0.0
200	0.0189	0.120	—0.0191	0.006
50	0.0160	0.137	—0.016	0.006

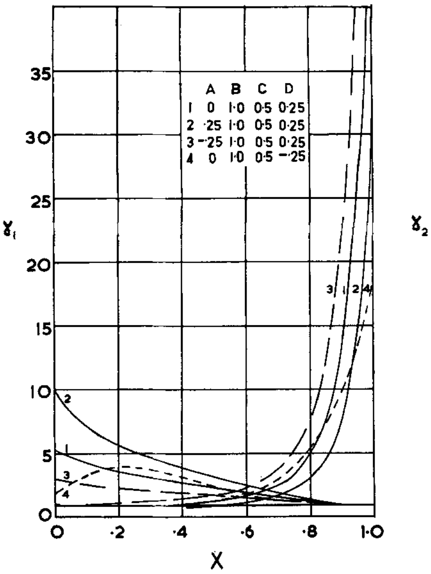

Fig. 10. Effect of variation in constants.

terchanging the subscripts 1 and 2; that is reversing positions of the activity coefficient vs. composition curves.

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NOTATION

A, a, B, b, etc .= constants
H = enthalpy of mixture
H^o = enthalpy of pure component
R = universal gas constant
T = temperature
x = mole fraction of component 1
γ = activity coefficient

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