Reprint from

International DATA Series, Series A

SELECTED DATA ON MIXTURES

Volume 1992, No. 1, pages 45-49
Excess Volumes of Some Binary Mixtures Containing Chlorobenzene

W. E. Acree Jr.* and I-L. Teng
(Department of Chemistry, University of North Texas,
Denton, TX 76203-5068, USA)
Ser. A. Thermodynamic Properties of Non-reacting Binary Systems of Organic Substances

Volume 1992, No. 1, pages 45-49

Excess Volumes of Some Binary Mixtures Containing Chlorobenzene

W. E. Acree Jr.* and I-L. Teng
(Department of Chemistry, University of North Texas,
Denton, TX 76203-5068, USA)

FIRST PUBLISHED RESULTS

2c. Excess volume, pp. 45-49

*Author to whom correspondence should be addressed

Published and distributed by Thermodynamics Research Center
The Texas A&M University System, College Station, TX 77843-3111
SELECTED DATA ON MIXTURES
International DATA Series*
2c. EXCESS VOLUME

Components: 1. Chlorobenzene, C₆H₅Cl
2. Heptane, C₇H₁₆

State: Binary system, single-phase liquid; pure components, both liquid

Variables: \( V^E \), molar excess volume
\( x_i \), mole fraction of component i

Parameters: \( T \), temperature
\( P \), pressure

Method: Calculation of \( V^E \) from density measurements at constant \( T \) and \( P \) and variable \( x_i \); ref. 1

Notes: \( P \), atm.

<table>
<thead>
<tr>
<th>( T/K = 298.15 )</th>
<th>( x_1 )</th>
<th>( V^E/10^{-9} )</th>
<th>( m^3/mol^-1 )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.1455</td>
<td>(-68)</td>
<td>284</td>
</tr>
<tr>
<td></td>
<td>0.2709</td>
<td>(-140)</td>
<td>271</td>
</tr>
<tr>
<td></td>
<td>0.3856</td>
<td>(-204)</td>
<td>218</td>
</tr>
<tr>
<td></td>
<td>0.4875</td>
<td>(-252)</td>
<td>171</td>
</tr>
<tr>
<td></td>
<td>0.5891</td>
<td>(-271)</td>
<td>178</td>
</tr>
<tr>
<td></td>
<td>0.6841</td>
<td>(-261)</td>
<td>218</td>
</tr>
<tr>
<td></td>
<td>0.7672</td>
<td>(-218)</td>
<td>171</td>
</tr>
<tr>
<td></td>
<td>0.8465</td>
<td>(-177)</td>
<td>171</td>
</tr>
<tr>
<td></td>
<td>0.9245</td>
<td>(-96)</td>
<td>171</td>
</tr>
</tbody>
</table>

Points, direct experimental \( V^E \) values; curves, \( V^E \)_calc calculated from the smoothing equation.

SMOOTHING EQUATION

\[ V^E_{\text{calc}} = x_1 x_2 \sum_{i=1}^{n} a_i (x_1 - x_2)^{i-1} \]

Coeffs. \( a_i \) in the smoothing eq., std. deviation \( \sigma \) and max. deviation \( \sigma_m \) detd. by least-squares anal.

<table>
<thead>
<tr>
<th>( T/K )</th>
<th>( a_1 )</th>
<th>( a_2 )</th>
<th>( a_3 )</th>
<th>( a_4 )</th>
<th>( a_5 )</th>
<th>( a_6 )</th>
<th>( \sigma_m )</th>
</tr>
</thead>
<tbody>
<tr>
<td>298.15</td>
<td>(-1013)</td>
<td>(-566)</td>
<td>169</td>
<td>50</td>
<td>4.6</td>
<td>8.4</td>
<td></td>
</tr>
</tbody>
</table>

The std. deviations \( \sigma \) of the coeff. \( a_i \) are given in parentheses

\( \sigma_m = \max \left\{ |V^E_{\text{calc}} - V^E|; \sigma_a = \sqrt{\sum (V^E_{\text{calc}} - V^E)^2/(N - n)} \right\} \)

\( N \), no. of direct expl. values; \( n \), no. of coeff. \( a_i \)

All direct expl. values equally weighted

AUXILIARY INFORMATION

Apparatus: Vibrating tube densimeter (Anton Paar, Graz, Austria), model DMA 55, equipped with a thermostating water bath (Neslab Instruments, Portsmouth, NH, USA). Temp. was controlled to within 0.005 K and was measured by means of a Beckman thermometer (Beckman Instruments Inc., Fullerton, CA, USA) which was periodically compared against a calibrated (National Bureau of Stds., USA) Pt resistance thermometer.

Procedure: Density, \( \rho \), was calcld. from period of vibration, \( r \). V, \( \rho \), and \( \rho_0 \) were calculated by calibrating the app. with benzene, \( \rho \)(298.15 K)/kg m⁻³ = 873.63, doubly distilled and degassed water \( \rho \)(298.15 K)/kg m⁻³ = 997.04, and cyclohexane \( \rho \)(298.15 K)/kg m⁻³ = 773.85. Mixts. were prepd. by weighing, \( V^E \) was calcld. from \( V^E = V - (x_1 V^E_1 + x_2 V^E_2) \), where \( V = (x_1 M_1 + x_2 M_2)/\rho \) is the molar vol. of the mixt. and \( V^E \) = \( V(x_1 = 1) \) and \( M_1 \) are, resp., the molar vol. and the molar mass of component i.

Materials: 1. Aldrich Chem. Co. Inc. (Milwaukee, WI, USA) HPLC grade material of stated purity > 99.9 mole %, stored over mol. sieves and used without further purification; \( \rho \)(298.15 K)/kg m⁻³ = 1101.98; \( M_1/10^{-3} \) kg mol⁻¹ = 112.5584.
2. Aldrich Chem. Co. Inc. (Milwaukee, WI, USA) HPLC grade material of stated purity > 99 mole %, stored over mol. sieves and used without further purification. Purity tested by GLC, > 99.8 mole %; \( \rho \)(298.15 K)/kg m⁻³ = 679.55; \( M_2/10^{-3} \) kg mol⁻¹ = 100.20404.

Errors: \( \delta T \) (reproducibility)/K < 0.003; \( \delta T \) (IPST-68)/K = 0.01; \( \delta \rho \) = 0.0001; \( \delta V^E/10^{-9} m^3/mol^{-1} \) < 20.

REFERENCES


Footnotes:

*Ser. A. Thermodynamic Properties of Non-reacting Binary Systems of Organic Substances
SELECTED DATA ON MIXTURES
International DATA Series*

EXCESS VOLUME

Components: 1. Chlorobenzene, C₆H₅Cl
2. Octane, C₈H₁₈

Variables: Vₑ, molar excess volume
xᵢ, mole fraction of component i

Parameters: T, temperature

Constants: P, pressure

Method: Calculation of Vₑ from density measurements at constant T and P and variable xᵢ; ref. 1

Notes: P, atm.

T/K = 298.15

<table>
<thead>
<tr>
<th>x₁</th>
<th>Vₑ[10⁻⁹ m³mol⁻¹]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1595</td>
<td>6</td>
</tr>
<tr>
<td>0.2920</td>
<td>-8</td>
</tr>
<tr>
<td>0.4130</td>
<td>-31</td>
</tr>
<tr>
<td>0.5119</td>
<td>-55</td>
</tr>
<tr>
<td>0.6127</td>
<td>-72</td>
</tr>
<tr>
<td>0.7082</td>
<td>-83</td>
</tr>
<tr>
<td>0.7879</td>
<td>-83</td>
</tr>
<tr>
<td>0.8630</td>
<td>-68</td>
</tr>
<tr>
<td>0.9340</td>
<td>-43</td>
</tr>
</tbody>
</table>

DIRECT EXPERIMENTAL VALUES

298.15 K

POINTS, direct experimental Vₑ values; curves, Vₑ calc calculated from the smoothing equation.

SMOOTHING EQUATION

Vₑ calc = x₁ x₂ \sum_{i=1}^{n} a_i (x₁ - x₂)^{i-1}

Coefs. aᵢ in the smoothing eq., std. deviation σ₀ and max. deviation δₓ,d detd. by least-squares anal.

<table>
<thead>
<tr>
<th>T/K</th>
<th>a₁</th>
<th>a₂</th>
<th>a₃</th>
<th>a₄</th>
<th>a₅</th>
<th>σ₀</th>
<th>δₓ,d</th>
</tr>
</thead>
<tbody>
<tr>
<td>298.15</td>
<td>-202.5 (2.8)</td>
<td>-439.7 (5.7)</td>
<td>-114 (13)</td>
<td>1.2</td>
<td>1.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The std. deviations σ₀ of the coefs. aᵢ are given in parentheses

δₓ,d = max | [Vₑ(calc) - Vₑ] | ; σₓ = \sqrt{\sum_{i=1}^{N} (Vₑ(calc) - Vₑ)^{2}/(N-n)}^{1/2}

N, no. of direct expl. values; n, no. of coefs. aᵢ
All direct expl. values equally weighted

AUXILIARY INFORMATION

Apparatus: Vibrating tube densimeter (Anton Paar, Graz, Austria), model DMA 55, equipped with a thermostating water bath (Neslab Instruments, Portsmith, NH, USA). Temp. was controlled to within 0.005 K and was measured by means of a Beckman thermometer (Beckman Instruments, Inc., Fullerton, CA, USA) which was periodically compared against a calibrated (National Bureau of Stds., USA) Pt-resistance thermometer. Samples were introduced by means of a glass syringe.

Procedure: Density, ρ, was calc'd, from period of vibration, τ, ρ = a + b τ². Consis. a and b were detd. by calibrating the app., with benzene, ρ(298.15 K)/kg m⁻³ = 873.63, doubly distd. and degassed water ρ(298.15 K)/kg m⁻³ = 997.04, and cyclohexane ρ(298.15 K)/kg m⁻³ = 773.85. Mixts. were prep'd by weighing. Vₑ was calc'd from Vₑ = V - (x₁ V₁ + x₂ V₂), where V = (x₁M₁ + x₂M₂), V₁ is the molar vol. of the mixt. and V₂ = V(x₁ = 1) and Mᵢ are, resp., the molar vol. and the molar mass of component i.

Materials: 1. Aldrich Chem. Co. Inc. (Milwaukee, WI, USA) HPLC grade material of stated purity > 99.9 mole %, stored over mol. sieves and used without further purification; ρ(298.15 K)/kg m⁻³ = 1101.98; M₁/10⁻³ kg mol⁻¹ = 112.5584.
2. Aldrich Chem. Co. Inc. (Milwaukee, WI, USA) anhydrous material of stated purity > 99 mole %, stored over mol. sieves and used without further purification. Purity tested by GLC, > 99.8 mole %; ρ(298.15 K)/kg m⁻³ = 696.61; M₂/10⁻³ kg mol⁻¹ = 114.23692.

Errors: δ(τ) (reproducibility) K < 0.003; δ(τ)(IPPS-68) K = 0.01; δx₁ = 0.001; δVₑ/10⁻³ m³mol⁻¹ < 0.5

REFERENCES


*Ser. A. Thermodynamic Properties of Non-reacting Binary Systems of Organic Substances

Published by Thermodynamics Research Center
The Texas A&M University System, College Station, TX 77843-3111

Received: December 20, 1991
Published: January 31, 1992
**SELECTED DATA ON MIXTURES**

**International DATA Series**

2c. EXCESS VOLUME

The Texas A&M University System, College Station, TX 77843-3111

Components: 1. Chlorobenzene, C₆H₅Cl
   2. 2,2,4-Trimethylpentane, C₉H₂₀

State: Binary system, single-phase liquid; pure components, both liquid

Variables: \( V^E \), molar excess volume; \( \chi_i \), mole fraction of component \( i \)

Constants: \( T \), temperature; \( P \), pressure

Method: Calculation of \( V^E \) from density measurements at constant \( T \) and \( P \) and variable \( \chi_i \); ref. 1

**SOURCES OF DATA**

Acree Jr., W. E. (Department of Chemistry, University of North Texas, Denton, TX 76203 - 5068, USA); Teng, I.-L.

Edited by: Kehiaian, H. V. (Institut de Topologie et de Dynamique des Systèmes, Université Paris VII, CNRS, 1, Rue Guy de la Brosse, 75005 Paris, France)

**DIRECT EXPERIMENTAL VALUES**

<table>
<thead>
<tr>
<th>( T/K ) = 298.15</th>
<th>( \chi_i )</th>
<th>( V^E ), ( 10^{-5} ) m³ mol⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1632</td>
<td>−147</td>
<td></td>
</tr>
<tr>
<td>0.2983</td>
<td>−226</td>
<td></td>
</tr>
<tr>
<td>0.4174</td>
<td>−303</td>
<td></td>
</tr>
<tr>
<td>0.5243</td>
<td>−341</td>
<td></td>
</tr>
<tr>
<td>0.6217</td>
<td>−344</td>
<td></td>
</tr>
<tr>
<td>0.7108</td>
<td>−323</td>
<td></td>
</tr>
<tr>
<td>0.7910</td>
<td>−285</td>
<td></td>
</tr>
<tr>
<td>0.9025</td>
<td>−236</td>
<td></td>
</tr>
<tr>
<td>0.8281</td>
<td>−119</td>
<td></td>
</tr>
</tbody>
</table>

**SMOOTHING EQUATION**

\[
V^E_{\text{calc}} = \chi_1 \chi_2 \sum_{i=1}^{n} a_i (\chi_1 - \chi_2)^{i-1}
\]

Coeffs. \( a_i \) in the smoothing eq., std. deviation \( \sigma_p \) and max. deviation \( \delta_m \) detd. by least-squares anal.

<table>
<thead>
<tr>
<th>( T/K )</th>
<th>( a_1 )</th>
<th>( a_2 )</th>
<th>( a_3 )</th>
<th>( a_4 )</th>
<th>( a_5 )</th>
<th>( \delta_m )</th>
</tr>
</thead>
<tbody>
<tr>
<td>298.15</td>
<td>−1316</td>
<td>−757</td>
<td>−255</td>
<td>9.2</td>
<td>14</td>
<td></td>
</tr>
</tbody>
</table>

The std. deviations on of the coefs. \( a_i \) are given in parentheses

\( \delta_m = \max \left| V^E_{\text{calc}} - V^E_{\text{calc}} \right| ; \sigma_p = \sqrt{\frac{1}{N} \sum_{i=1}^{N} (V^E_{\text{calc}} - V^E_{\text{calc}})^2} \frac{1}{N-n} \right|^{1/2} \)

\( N \), no. of direct expl. values; \( n \), no. of coefs. \( a_i \)

All direct expl. values equally weighted

**REFERENCES**


**Apparatus**

Vibrating tube densimeter (Anton Paar, Graz, Austria), model DMA 55, equipped with a thermostating water bath (Neslab Instruments, Portsmouth, NH, USA). Temp. was controlled to within 0.005 K and was measured by means of a Beckman thermometer (Beckman Instruments, Inc., Fullerton, CA, USA) which was periodically compared against a calibrated (National Bureau of Stds., USA) Pt-resistance thermometer.

**Procedure**

Density, \( \rho \), was calcld. from the period of vibration, \( \tau \): \( \rho = \frac{a + b \tau^2}{\tau} \). Consts. \( a \) and \( b \) were detd. by calibrating the app. with benzene, \( \rho(298.15 \text{ K})/ \text{kg m}^{-3} = 873.63 \), doubly distd. and degassed water \( \rho(298.15 \text{ K})/ \text{kg m}^{-3} = 997.04 \), and cyclohexane \( \rho(298.15 \text{ K})/ \text{kg m}^{-3} = 773.85 \). Mixts. were prepd. by weighing. \( V^E \) was calcld. from \( V^E = V - (\chi_1 V^I_1 + \chi_2 V^I_2) \), where \( V = (x_1M_1 + x_2M_2)/\rho \) is the molar vol. of the mixt. and \( V^I = V(x_1 = 1) \) and \( M_1 \) are, resp., the molar vol. and the molar mass of component \( i \).

**Materials**

1. Aldrich Chem. Co. Inc. (Milwaukee, WI, USA) HPLC grade material of stated purity > 99.9 mole %, stored over mol. sieves and used without further purification; \( \rho_1(298.15 \text{ K})/ \text{kg m}^{-3} = 1101.98; M_1/10^{-3} \text{ kg mol}^{-1} = 112.5584 \).

2. Aldrich Chem. Co. Inc. (Milwaukee, WI, USA) HPLC grade material of stated purity > 99.7 mole %, stored over mol. sieves and used without further purification. Purity tested by GLC; > 99.8 mole %; \( \rho_2(298.15 \text{ K})/ \text{kg m}^{-3} = 687.91; M_2/10^{-3} \text{ kg mol}^{-1} = 114.23092 \).

**Errors**

\( \delta T(\text{repeatability})/K < 0.003; \delta T(\text{IFT-58})/K = 0.01; \delta \chi_1 = 0.0001; \delta V^E/10^{-5} \text{ m}^3 \text{ mol}^{-1} < 20 \).

©1992 Thermodynamics Research Center

Received: December 20, 1991

*Ser. A. Thermodynamic Properties of Non-reacting Binary Systems of Organic Substances*
SELECTED DATA ON MIXTURES
International DATA Series*

2c. EXCESS VOLUME

Author(s): Acree Jr, W. E. (Department of Chemistry, University of North Texas, Denton, TX 76203–5068, USA); Teng, I-L.
Edited by: Kehian, H. V. (Institut de Topologie et de Dynamique des Systèmes, Université Paris VII, CNRS, 1, Rue Guy de la Brosse, 75005 Paris, France)

SOURCE OF DATA
Acree Jr, W. E.; Teng, I-L. (Department of Chemistry, University of North Texas, Denton, TX, USA); FIRST PUBLISHED RESULTS

Notes: $P$, atm.

\( T/K = 298.15 \)

\( x_1 \times 10^{-9} \)

\( \text{m}^{-3} \text{mol}^{-1} \)

0.1123 186
0.2139 283
0.3105 321
0.4108 340
0.5150 315
0.6169 273
0.7052 208
0.8036 148
0.9054 63

\( V^E/10^{-9} \text{m}^{-3} \text{mol}^{-1} \)

\( x_1 \)

298.15 K

Points, direct experimental \( V^E \) values; curves, \( V^E_{\text{calc}} \) calculated from the smoothing equation.

SMOOTHING EQUATION

\( V^E_{\text{calc}} = x_1 x_2 \sum_{i=1}^{n} a_i (x_1 - x_2)^i \)

Coefs. \( a_i \) in the smoothing eq., std. deviation \( \sigma_d \) and max. deviation \( \delta_m \) detd. by least-squares anal.

<table>
<thead>
<tr>
<th>T/K</th>
<th>( a_1 )</th>
<th>( a_2 )</th>
<th>( a_3 )</th>
<th>( a_4 )</th>
<th>( a_5 )</th>
<th>( \sigma_d )</th>
<th>( \delta_m )</th>
</tr>
</thead>
<tbody>
<tr>
<td>298.15</td>
<td>1289.4</td>
<td>−649</td>
<td>(26)</td>
<td>5.6</td>
<td>7.7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The std. deviations \( \sigma_d \) of the coefs. \( a_i \) are given in parentheses.

\( \delta_m = \max | V^E_{\text{calc}} - V^E |; \sigma_d = [\sum (V^E_{\text{calc}} - V^E)^2/(N - n)]^{1/2} \)

\( N \), no. of direct expl. values; \( n \), no. of coefs. \( a_i \)

All direct expl. values equally weighted

AUSTRALIAN INFORMATION

Apparatus: Vibrating tube densimeter (Anton Paar, Graz, Austria), model DMA 55, equipped with a thermostating water bath (Neslab Instruments, Portsmouth, NH, USA). Temp. was controlled to within 0.005 K and was measured by means of a Beckman thermometer (Beckman Instruments, Inc., Fullerton, CA, USA) which was periodically compared against a calibrated (National Bureau of Stds., USA) Pt-resistance thermometer. Samples were introduced by means of a glass syringe.

Procedure: Density, \( \rho \), was calcld. from period of vibration, \( \tau; \rho = \alpha + b \tau^2 \). Consts. \( a \) and \( b \) were detd. by calibrating the app, with benzene, \( \rho(298.15 \text{ K})/\text{kg m}^{-3} = 873.63 \), doubly distd. and degassed water \( \rho(298.15 \text{ K})/\text{kg m}^{-3} = 997.04 \), and cyclohexane \( \rho(298.15 \text{ K})/\text{kg m}^{-3} = 773.85 \). Mxts. were prepd. by weighing, \( V^E \) was calcld. from \( V^E = V - (x_1 M_1 + x_2 M_2)/\rho \), where \( V = (x_1 M_1 + x_2 M_2)/\rho \) is the molar vol. of the mxt. and \( V^E = V(1/x_1) \) and \( M_i \) are, resp., the molar vol. and the molar mass of component \( i \).

Materials: 1. Aldrich Chem. Co. Inc. (Milwaukee, WI, USA) HPLC grade material of stated purity > 99.9 mole %, stored over mol. sieves and used without further purification; \( \rho(298.15 \text{ K})/\text{kg m}^{-3} = 1101.98 \); \( M_i/10^{-2} \text{kg mol}^{-1} = 112.5684 \).
2. Aldrich Chem. Co. Inc. (Milwaukee, WI, USA) HPLC grade material of stated purity > 99.9 mole %, stored over mol. sieves and used without further purification; \( \rho(298.15 \text{ K})/\text{kg m}^{-3} = 773.85 \); \( M_i/10^{-2} \text{kg mol}^{-1} = 84.16128 \).

Errors: \( \Delta T \) (reproducibility)/K < 0.003; \( \Delta T \) (IPTS-68)/K = 0.01; \( \delta x_1 = 0.0001 \); \( \delta V^E/10^{-9} \text{m}^{-3} \text{mol}^{-1} < 20 \).

REFERENCES


Ser. A. Thermodynamic Properties of Non-reacting Binary Systems of Organic Substances

Published: January 31, 1992
**SELECTED DATA ON MIXTURES**

**International DATA Series**

2e. EXCESS VOLUME

Published by Thermodynamics Research Center

The Texas A&M University System, College Station, TX 77843-3111

Components:
1. Chlorobenzene, C₆H₅Cl
2. Dibutyl ether, C₄H₉O

State: Binary system, single-phase liquid; pure components, both liquid

Variables:
\( \nu^E \), molar excess volume

Parameters:
\( T \), temperature

Constants:
\( P \), pressure

Method:
Calculation of \( \nu^E \) from density measurements at constant \( T \) and \( P \) and variable \( x_i \); ref. 1

**SOURCES OF DATA**

Acree Jr., W. E.; Teng, I.-L. (Department of Chemistry, University of North Texas, Denton, TX, USA); FIRST PUBLISHED RESULTS

**DIRECT EXPERIMENTAL VALUES**

<table>
<thead>
<tr>
<th>( T/K = 298.15 )</th>
<th>( \nu^E/10^{-9} ) m³ mol⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1693</td>
<td>-309</td>
</tr>
<tr>
<td>0.3029</td>
<td>-473</td>
</tr>
<tr>
<td>0.4232</td>
<td>-559</td>
</tr>
<tr>
<td>0.5306</td>
<td>-571</td>
</tr>
<tr>
<td>0.6280</td>
<td>-548</td>
</tr>
<tr>
<td>0.7115</td>
<td>-492</td>
</tr>
<tr>
<td>0.7924</td>
<td>-409</td>
</tr>
<tr>
<td>0.8649</td>
<td>-291</td>
</tr>
<tr>
<td>0.9333</td>
<td>-156</td>
</tr>
</tbody>
</table>

\( \nu^E \), calculated from the smoothing equation.

**SMOOTHING EQUATION**

\[ \nu^E_{\text{calc}} = x_1 x_2 \sum_{i=1}^{n} a_i (x_1 - x_2)^{i-1} \]

Coeffs. \( a_i \) in the smoothing eq., std. deviation \( \sigma_d \) and max. deviation \( \delta_m \) detd. by least-squares anal.

<table>
<thead>
<tr>
<th>( T/K )</th>
<th>( a_1 )</th>
<th>( a_2 )</th>
<th>( a_3 )</th>
<th>( a_4 )</th>
<th>( a_5 )</th>
<th>( \sigma_d )</th>
<th>( \delta_m )</th>
</tr>
</thead>
<tbody>
<tr>
<td>298.15</td>
<td>-2297.7</td>
<td>-199</td>
<td>-106</td>
<td>4.1</td>
<td>5.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The std. deviations \( \sigma_d \) of the coeffs. \( a_i \) are given in parentheses

\[ \delta_m = \max \left[ \nu^E_{\text{calc}} - \nu^E_i \right] ; \sigma_d = \sqrt{\frac{2 \left( \nu^E_{\text{calc}} - \nu^E_i \right)^2 (N - n)}{N - 1}} \]

\( N \), no. of direct expl. values; \( n \), no. of coeffs. \( a_i \)

All direct expl. values equally weighted

**AUXILIARY INFORMATION**

Apparatus:
Vibrating tube densimeter (Anton Paar, Graz, Austria), model DMA 55, equipped with a thermostating water bath (Neslab Instruments, Portsmouth, NH, USA). Temp. was controlled to within 0.005 K and was measured by means of a Beckman thermometer (Beckman Instruments, Inc., Fullerton, CA, USA) which was periodically checked against a calibrated (National Bureau of Stds., USA) Pt-resistance thermometer.

Samples were introduced by means of a glass syringe.

Procedure:
Density, \( \rho \), was calc'd. from period of vibration, \( \tau \). \( \rho = \alpha + \beta \tau^2 \). Constr. \( \alpha \) and \( \beta \) were detd. by calibrating the app. with benzene, \( \rho(298.15 \text{ K}) \text{kg m}^{-3} = 873.63 \text{ kg m}^{-3} \), doubly distilled and degassed water \( \rho(298.15 \text{ K}) \text{kg m}^{-3} = 997.04 \text{ kg m}^{-3} \), and cyclohexane \( \rho(298.15 \text{ K}) \text{kg m}^{-3} = 773.85 \text{ kg m}^{-3} \). Mists. were prep'd. by weighing. \( \nu^E \) was calc'd. from \( \nu^E = V - (x_1 \nu_1^E + x_2 \nu_2^E) \), where \( V = (x_1 M_1 + x_2 M_2) / \rho \) is the molar vol. of the mixt. and \( \nu_1^E \) = \( V(x_1 = 1) \) and \( M_i \) are, resp., the molar vol. and the molar mass of component \( i \).

Materials:
1. Aldrich Chem. Co. Inc. (Milwaukee, WI, USA) HPLC grade material of stated purity > 99.9 mole %, stored over mol. sieves and used without further purification; \( \rho(298.15 \text{ K}) \text{kg m}^{-3} = 1101.98 \text{ kg m}^{-3} \), \( M_1/10^{-3} \text{ kg mol}^{-1} = 112.5584 \).
2. Aldrich Chem. Co. Inc. (Milwaukee, WI, USA) anh. grade material of stated purity > 99 mole %, stored over mol. sieves and used without further purification. Purity tested by GLC, > 99.8 mole %; \( \rho(298.15 \text{ K}) \text{kg m}^{-3} = 764.20 \text{ kg m}^{-3} \), \( M_1/10^{-3} \text{ kg mol}^{-1} = 130.23032 \).

Errors:
\[ \delta \nu^E \text{(reproducibility)} \leq 0.003; \delta (\text{IPTS-68}) \leq 0.001; \delta \rho \leq 0.0001; \delta M_i/10^{-3} \text{kg mol}^{-1} \leq 20 \]

Received: December 20, 1991

*Ser. A. Thermodynamic Properties of Non-reacting Binary Systems of Organic Substances*