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

0147-1503/88/8802-183$2.20

Components: 1. 1-Propanol, C_3H_8O
2. Undecane, $C_{11}H_{24}$

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

Constants: P, pressure

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

Author(s): Ortega, J. (Universidad Politecnica de Las Palmas, Escuela Superior de Ingenieros Industriales, Cátedra de Termodinámica y Fisicoquimica, Las Palmas de Gran Canaria, Islas Canarias, Spain)
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)

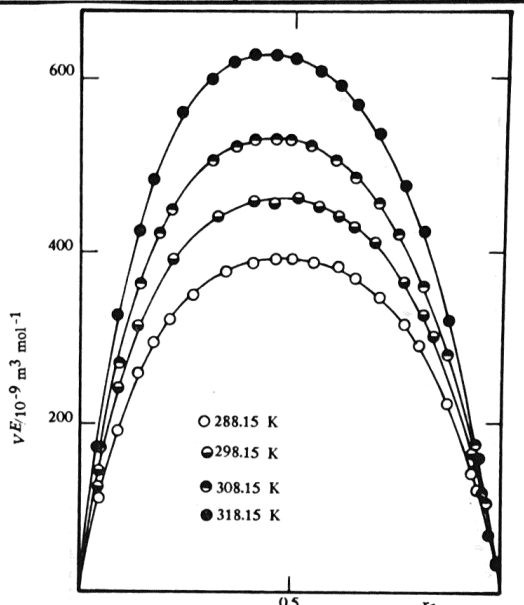
SOURCE OF DATA

Ortega, J.; Matos, J. S.; Peña, J. A.; Paz Andrade, M. I.; Pias, L.; Fernandez, J. (Polytechnic University of Canarias, Canary Islands, Spain); FIRST PUBLISHED RESULTS (see also ref. 2)

DIRECT EXPERIMENTAL VALUES

Notes: P, atm.

T/K = 288.15		T/K = 298.15		T/K = 308.15		T/K = 318.15	
x_1	$V^E/10^{-9}$ m^{3}mol^{-1}	x_1	$V^E/10^{-9}$ m^{3}mol^{-1}	x_1	$V^E/10^{-9}$ m^{3}mol^{-1}	x_1	$V^E/10^{-9}$ m^{3}mol^{-1}
0.0445	110.4	0.0387	120.6	0.0466	168.7	0.0387	168.9
0.0880	190.7	0.0457	140.8	0.0881	270.7	0.0883	325.1
0.1399	257.0	0.0900	239.6	0.1394	363.7	0.1377	427.0
0.1787	296.3	0.1376	312.7	0.1829	420.8	0.1659	481.7
0.2138	321.0	0.2193	389.6	0.2129	448.1	0.2420	562.8
0.2662	348.8	0.3271	440.1	0.3107	506.7	0.3034	598.7
0.3420	376.0	0.4070	457.0	0.3634	522.1	0.3598	617.4
0.4060	385.3	0.4540	453.6	0.4070	530.2	0.4048	625.0
0.4611	390.8	0.5064	461.8	0.4552	530.5	0.4555	627.8
0.5023	389.0	0.5565	450.2	0.4904	529.6	0.5003	620.1
0.5579	385.8	0.6024	440.7	0.5406	522.4	0.5581	606.6
0.6054	379.0	0.6399	427.6	0.5964	505.0	0.6081	588.2
0.6463	367.0	0.6870	408.8	0.6417	485.2	0.6444	567.2
0.7065	345.4	0.7619	362.5	0.7028	455.8	0.6974	536.1
0.7648	315.7	0.8032	327.2	0.7439	419.8	0.7618	474.4
0.8013	288.1	0.8302	297.6	0.8048	359.4	0.8061	422.8
0.8726	218.5	0.9279	159.6	0.8666	279.5	0.8701	321.1
0.9308	140.7	0.9335	146.1	0.9254	177.6	0.9464	155.4
0.9409	120.4	0.9720	67.5	0.9591	106.3	0.9607	117.8
0.9868	32.7	0.9865	35.8	0.9861	37.1	0.9790	64.3



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

SMOOTHING EQUATION

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

Coeffs. a_i in the smoothing eq., std. deviation σ_d, and max. deviation δ_m detd. by least-squares anal.

T/K	a_1	a_2	a_3	a_4	a_5	σ_d	δ_m
	10^{-9} m^3 mol^{-1}						
288.15	1561.1	−58.3	770	−159	318	1.2	1.8
	(2.3)	(7.9)	(24)	(19)	(39)		
298.15	1829.6	−113	906	−373	381	2.1	4.8
	(4.0)	(15)	(43)	(33)	(68)		
308.15	2114.7	−218	926	−435	472	1.8	4.2
	(3.3)	(12)	(36)	(29)	(60)		
318.15	2483.4	−313	1236	−486	365	2.2	5.7
	(4.2)	(14)	(45)	(35)	(73)		

The std. deviations σa_i of the coeffs. a_i are given in parentheses

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

N, no. of direct expti. values; n, no. of coeffs. a_i

All direct expti. values equally weighted

AUXILIARY INFORMATION

Apparatus: Vibrating tube densimeter type DMA 60 equipped with a cell model 602 (Anton Paar, Graz, Austria). Temp. was controlled to within 0.01 K with a Heto thermostat and was measured by means of a calibrated Pt resistance thermometer.

Procedure: Density, ρ, was calcd. from period of vibration, τ: $\rho = a + b\tau^2$. Consts. a and b were detd. by calibrating the app. with doubly distd. and degassed H_2O and nonane (Fluka AG, Buchs, Switzerland, 'purum', Lot No. 74252, of stated purity > 99 mole %) at each T (ref. 3). The values used for $\rho(T)$/kg m^{-3} at 288.15, 298.15, 308.15, and 318.15 K were, resp.: 999.098, 997.043, 994.029, 990.21 (H_2O, ref. 4) and 723.151, 713.855, 705.959, 698.063 (nonane, ref. 5). Mixts. were prepd. by weighing. V^E was calcd. from $V^E = V - (x_1 V_1^* + x_2 V_2^*)$, where $V = (x_1 M_1 + x_2 M_2)/\rho$ is the molar vol. of the mixt. and $V_i^* = V(x_i = 1)$ and M_i are, resp., the molar vol. and the molar mass of component i.

Materials: 1. Fluka AG (Buchs, St. Gallen, Switzerland) "puriss p.a." grade material, of stated purity > 99 mole %, was degassed and dried over mol. sieve Type 4A (from Fluka) and used without further purification; T, $\rho_1(T)$/kg m^{-3} and n(D, T) are: 288.15, 808.37, 1.3869; 298.15, 799.65, 1.3831; 308.15, 791.48, 1.3791; 318.15, 783.21, 1.3750; $M_1/10^{-3}$ kg mol^{-1} = 60.0956.

2. Fluka AG (Buchs, St. Gallen, Switzerland) "puriss" grade material, of stated purity > 99 mole %, was degassed and dried over mol. sieve Type 4A (from Fluka) and used without further purification; T, $\rho_2(T)$/kg m^{-3} and n(D, T) are: 288.15, 744.78, 1.4190; 298.15, 736.27, 1.4150; 308.15, 728.76, 1.4105; 318.15, 721.31, 1.4062; $M_2/10^{-3}$ kg mol^{-1} = 156.3106.

Errors: δT(reproducibility)/K < 0.01; δT(IPTS-68)/K = 0.01; δx_1 = 0.0001; $\delta V^E/10^{-9}$ m^3 mol^{-1} = 2.

REFERENCES

1. *Int. DATA Ser., Ser. A, Guideline 2c*, **1979**.
2. Ortega, J.; Matos, J. S.; Peña, J. A.; Paz Andrade, M. I.; Pias, L.; Fernandez, J. *Thermochim. Acta* **1988**, in press.
3. Ortega, J.; Matos, J. S.; Paz Andrade, M. I.; Jimenez, E. J. *J. Chem. Thermodyn.* **1985**, *17*, 1127.
4. Riddick, J. A.; Bunger, W. B. *Organic Solvents, II*, in *Techniques of Chemistry* Weissberger, A., Editor, Wiley-Interscience, New York, **1970**.
5. *Anton Paar Information Bull.* No. 6, March **1982**.

Received: April 25, 1988
Published: July 31, 1988

SELECTED DATA ON MIXTURES
International DATA Series*
2c. EXCESS VOLUME

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

0147-1503/88/8802-184$2.20

Components: 1. 1-Propanol, C_3H_8O
2. Dodecane, $C_{12}H_{26}$

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

Constants: P, pressure

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

Author(s): Ortega, J. (Universidad Politecnica de Las Palmas, Escuela Superior de Ingenieros Industriales, Cátedra de Termodinámica y Fisicoquimica, Las Palmas de Gran Canaria, Islas Canarias, Spain)

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)

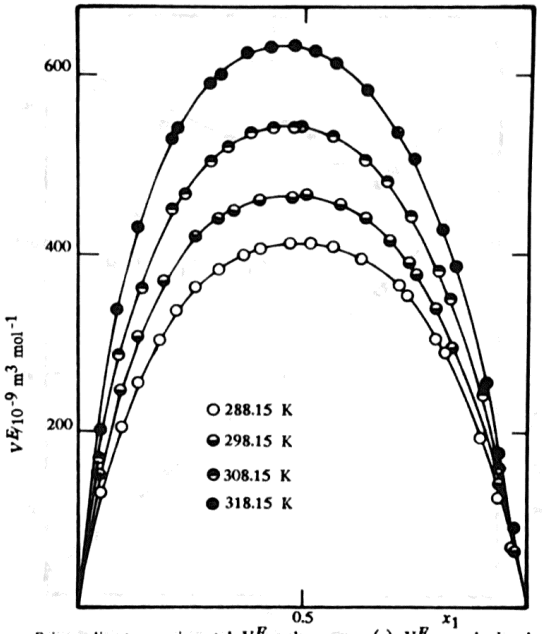
SOURCE OF DATA

Ortega, J.; Matos, J. S.; Peña, J. A.; Paz Andrade, M. I.; Pias, L.; Fernandez, J. (Polytechnic University of Canarias, Canary Islands, Spain); FIRST PUBLISHED RESULTS (see also ref. 2)

DIRECT EXPERIMENTAL VALUES

Notes: P, atm.

T/K = 288.15		T/K = 298.15		T/K = 308.15		T/K = 318.15	
x_1	$V^E/10^{-9}$ m^{3}mol^{-1}	x_1	$V^E/10^{-9}$ m^{3}mol^{-1}	x_1	$V^E/10^{-9}$ m^{3}mol^{-1}	x_1	$V^E/10^{-9}$ m^{3}mol^{-1}
0.0505	129.6	0.0490	151.7	0.0485	170.3	0.0476	202.8
0.0936	202.7	0.0963	245.8	0.0940	283.7	0.0947	341.5
0.1343	255.2	0.1366	307.5	0.1373	362.7	0.1402	434.8
0.1800	303.2	0.1909	368.6	0.2063	449.1	0.2102	531.2
0.2219	336.2	0.2613	418.4	0.2286	469.7	0.2247	541.2
0.2681	361.8	0.2644	419.9	0.2921	507.8	0.2970	592.9
0.3162	381.3	0.3160	441.8	0.3231	519.2	0.3184	601.1
0.3758	398.9	0.3447	451.0	0.3787	538.8	0.3759	623.2
0.4047	404.5	0.4087	461.3	0.4251	540.4	0.4261	629.2
0.4772	410.2	0.4771	463.8	0.4794	541.9	0.4818	630.2
0.5156	410.4	0.5112	465.8	0.4909	540.3	0.5231	624.9
0.5719	408.7	0.5860	452.1	0.5616	529.5	0.5697	608.8
0.6289	395.9	0.6345	434.7	0.6348	502.4	0.6343	580.7
0.7144	363.9	0.6923	412.5	0.6832	479.2	0.7035	534.3
0.7338	353.4	0.7355	388.1	0.7379	442.8	0.7385	503.6
0.7984	305.8	0.7510	375.8	0.7986	380.7	0.8041	426.2
0.8193	287.8	0.7933	340.2	0.8237	352.2	0.8314	382.5
0.8962	195.3	0.8368	295.8	0.8948	243.0	0.9027	253.2
0.9372	127.1	0.9366	142.8	0.9372	160.1	0.9363	176.2
0.9678	71.9	0.9745	64.7	0.9672	91.7	0.9672	95.1



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

SMOOTHING EQUATION

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

Coeffs. a_i in the smoothing eq., std. deviation σ_d, and max. deviation δ_m detd. by least-squares anal.

T/K	a_1	a_2	a_3	a_4	a_5	σ_d	δ_m
	10^{-9} m^3 mol^{-1}						
288.15	1648.1 (3.4)	21 (11)	761 (33)	−287 (28)	241 (56)	1.8	4.5
298.15	1858.3 (4.0)	−112 (12)	880 (38)	−312 (33)	366 (65)	2.0	5.0
308.15	2160.3 (3.0)	−202.5 (9.8)	1030 (30)	−351 (25)	326 (50)	1.6	3.3
318.15	2508.8 (3.9)	−230 (13)	1090 (39)	−670 (32)	480 (65)	2.0	3.1

The std. deviations σa_i of the coeffs. a_i are given in parentheses

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

N, no. of direct expti. values; n, no. of coeffs. a_i

All direct expti. values equally weighted

AUXILIARY INFORMATION

Apparatus: Vibrating tube densimeter type DMA 60 equipped with a cell model 602 (Anton Paar, Graz, Austria). Temp. was controlled to within 0.01 K with a Heto thermostat and was measured by means of a calibrated Pt resistance thermometer.

Procedure: Density, ρ, was calcd. from period of vibration, τ: $\rho = a + b\tau^2$. Consts. a and b were detd. by calibrating the app. with doubly distd. and degassed H_2O and nonane (Fluka AG, Buchs, Switzerland, 'purum', Lot No. 74252, of stated purity > 99 mole %) at each T (ref. 3). The values used for $\rho(T)$/kg m^{-3} at 288.15, 298.15, 308.15, and 318.15 K were, resp.: 999.098, 997.043, 994.029, 990.21 (H_2O, ref. 4) and 723.151, 713.855, 705.959, 698.063 (nonane, ref. 5). Mixts. were prepd. by weighing. V^E was calcd. from $V^E = V - (x_1V_1^* + x_2V_2^*)$, where $V = (x_1M_1 + x_2M_2)/\rho$ is the molar vol. of the mixt. and $V_i^* = V(x_i = 1)$ and M_i are, resp., the molar vol. and the molar mass of component i.

Materials: 1. Fluka AG (Buchs, St. Gallen, Switzerland) "puriss p.a." grade material, of stated purity > 99 mole %, was degassed and dried over mol. sieve Type 4A (from Fluka) and used without further purification; T, $\rho_1(T)$/kg m^{-3} and n(D, T) are: 288.15, 808.37, 1.3869; 298.15, 799.65, 1.3831; 308.15, 791.48, 1.3791; 318.15, 783.21, 1.3750; $M_1/10^{-3}$ kg mol^{-1} = 60.0956.

2. Fluka AG (Buchs, St. Gallen, Switzerland) "puriss" grade material, of stated purity > 99 mole %, was degassed and dried over mol. sieve Type 4A (from Fluka) and used without further purification; T, $\rho_2(T)$/kg m^{-3} and n(D, T) are: 288.15, 753.75, 1.4237; 298.15, 745.34, 1.4196; 308.15, 737.96, 1.4155; 318.15, 730.67, 1.4111; $M_2/10^{-3}$ kg mol^{-1} = 170.3374.

Errors: δT(reproducibility)/K < 0.01; δT(IPTS-68)/K = 0.01; δx_1 = 0.0001; $\delta V^E/10^{-9}$ m^3 mol^{-1} = 2.

REFERENCES

1. *Int. DATA Ser., Ser. A, Guideline 2c*, **1979**.
2. Ortega, J.; Matos, J. S.; Peña, J. A.; Paz Andrade, M. I.; Pias, L.; Fernandez, J. *Thermochim. Acta* **1988**, in press.
3. Ortega, J.; Matos, J. S.; Paz Andrade, M. I.; Jimenez, E. J. *J. Chem. Thermodyn.* **1985**, *17*, 1127.
4. Riddick, J. A.; Bunger, W. B. *Organic Solvents, II*, in *Techniques of Chemistry* Weissberger, A., Editor, Wiley-Interscience, New York, **1970**.
5. *Anton Paar Information Bull.* No. 6, March **1982**.

Received: April 25, 1988 — **Published:** July 31, 1988

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