

97013

Issued June 1997

Orthobaric densities and molar volumes of liquids

Aliphatic and alicyclic amines
I: Primary amines

Endorsed by
The Institution of Chemical Engineers



ESDU DATA ITEM No. 97013

ESDU DATA ITEMS

Data Items provide validated information for use in engineering design and analysis by, or under the supervision of, professionally qualified engineers. The data are founded on an evaluation of all the relevant information, both published and unpublished, and invariably supported by original work of ESDU staff engineers or consultants. The whole process is subject to independent review for which crucial support is provided by industrial companies, government research laboratories, universities and others from around the world through the participation of some of their leading experts on ESDU Technical Committees. This process ensures that the results of much valuable work (theoretical, experimental and operational), which may not be widely available or in a readily usable form, can be communicated concisely and accurately to the engineering community.

THE PREPARATION OF THIS DATA ITEM

The work on this particular Data Item was monitored and guided by the Physical Data and Reaction Kinetics Committee, which first met in 1966 and now has the following membership:

Chairman	
Dr D.T.Jamieson	— Independent
Vice-Chairman	
Mr C.F.Beaton	— Independent
Members	
Dr D.Ambrose [†]	— Independent
Dr M.W.Chase*	— National Institute of Standards and Technology, Gaithersburgh, USA
Dr J.R.Downey*	— Dow Chemical, Midland, USA
Dr B.Edmonds	— Infochem Computer Services Ltd
Dr K.R.Hall	— Thermodynamics Research Center, USA
Dr G.Hobson	— Imperial Chemical Industries plc, Petrochemicals and Plastics Division
Dr A.E.Humphreys	— Independent
Mr S.R.Knight	— Stone & Webster Engineering Ltd
Dr A.P.Laughton	— British Gas plc
Dr K.N.Marsh*	— University of Canterbury, New Zealand
Mrs K.M.deReuck	— Imperial College of Science, Technology and Medicine
Mr J.T.R.Watson	— National Engineering Laboratory.

The technical work involved in the assessment of the available information and the construction and subsequent development of the Data Item was undertaken (under contract to ESDU) by

Mr J.Walton — Independent

in consultation with Dr D.Ambrose

The person with overall responsibility for the work in this subject area is Mr S.J.Pugh, Head of Thermofluids Group.

(Continued on inside back cover)

*Corresponding Member
[†]Emeritus Member

**ORTHOBARIC DENSITIES and MOLAR VOLUMES OF LIQUIDS
ALIPHATIC AND ALICYCLIC AMINES - I: PRIMARY AMINES****CONTENTS**

	Page
1. INTRODUCTION	1
2. NOTATION AND UNITS	1
3. THE CRITICAL DENSITY	2
4. EVALUATION AND CORRELATION	2
5. UNCERTAINTIES	2
6. REFERENCES	3
TABLE 1, Summary of constants in the liquid density equation	5
TABLES for each compound are given on data sheets in the following order	

PRIMARY ALKYLAMINES

1	CH_3NH_2	Methanamine	Methylamine	7
2	$\text{CH}_3\text{CH}_2\text{NH}_2$	Ethanamine	Ethylamine	9
3	$\text{CH}_3(\text{CH}_2)_2\text{NH}_2$	1-Propanamine	Propylamine	11
4	$\text{CH}_3\text{CH}(\text{NH}_2)\text{CH}_3$	2-Propanamine	Isopropylamine	13
5	$\text{CH}_3(\text{CH}_2)_3\text{NH}_2$	1-Butanamine	Butylamine	15
6	$\text{CH}_3\text{CH}_2\text{CH}(\text{NH}_2)\text{CH}_3$	2-Butanamine	<i>sec</i> -Butylamine	17
7	$(\text{CH}_3)_2\text{CHCH}_2\text{NH}_2$	2-Methyl-1-propanamine	Isobutylamine	19
8	$(\text{CH}_3)_3\text{CNH}_2$	2-Methyl-2-propanamine	<i>tert</i> -butylamine	21
9	$\text{CH}_3(\text{CH}_2)_4\text{NH}_2$	1-Pentanamine	Pentylamine	23
10	$\text{CH}_3(\text{CH}_2)_2\text{CH}(\text{NH}_2)\text{CH}_3$	2-Pentanamine	1-Methylbutylamine	25
11	$\text{CH}_3\text{CH}_2\text{CH}(\text{NH}_2)\text{CH}_2\text{CH}_3$	3-Pentanamine	1-Ethylpropylamine	27
12	$\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{NH}_2$	2-Methyl-1-butanamine	2-Methylbutylamine	29
13	$(\text{CH}_3)_2\text{CH}(\text{CH}_2)_2\text{NH}_2$	3-Methyl-1-butanamine	3-Methylbutylamine	31
14	$\text{CH}_3\text{CH}_2\text{C}(\text{NH}_2)(\text{CH}_3)_2$	2-Methyl-2-butanamine	1,1-Dimethylpropylamine	33
15	$(\text{CH}_3)_2\text{CHCH}(\text{NH}_2)\text{CH}_3$	3-Methyl-2-butanamine	1,2-Dimethylpropylamine	35
16	$(\text{CH}_3)_3\text{CCH}_2\text{NH}_2$	2,2-Dimethyl-1-propanamine	2,2-Dimethylpropylamine	37
17	$\text{CH}_3(\text{CH}_2)_5\text{NH}_2$	1-Hexanamine	Hexylamine	39
18	$\text{CH}_3(\text{CH}_2)_3\text{CH}(\text{NH}_2)\text{CH}_3$	2-Hexanamine	1-Methylpentylamine	41
19	$\text{CH}_3(\text{CH}_2)_2\text{CH}(\text{NH}_2)\text{CH}_2\text{CH}_3$	3-Hexanamine	1-Ethylbutylamine	43
20	$(\text{CH}_3)_2\text{CH}(\text{CH}_2)_3\text{NH}_2$	4-Methyl-1-pentanamine	4-Methylpentylamine	45
21	$\text{CH}_3(\text{CH}_2)_2\text{C}(\text{NH}_2)(\text{CH}_3)_2$	2-Methyl-2-pentanamine	1,1-Dimethylbutylamine	47
22	$(\text{CH}_3)_2\text{CHCH}_2\text{CH}(\text{NH}_2)\text{CH}_3$	4-Methyl-2-pentanamine	1,3-Dimethylbutylamine	49
23	$(\text{CH}_3\text{CH}_2)_2\text{C}(\text{CH}_3)\text{NH}_2$	3-Methyl-3-pentanamine	1-Methyl-1-ethylpropylamine	51
24	$\text{CH}_3\text{CH}_2\text{C}(\text{CH}_3)_2\text{CH}_2\text{NH}_2$	2,2-Dimethyl-1-butanamine	2,2-Dimethylbutylamine	53
25	$(\text{CH}_3)_2\text{CHCH}(\text{CH}_3)\text{CH}_2\text{NH}_2$	2,3-Dimethyl-1-butanamine	2,3-Dimethylbutylamine	55
26	$(\text{CH}_3)_3\text{CCH}(\text{NH}_2)\text{CH}_3$	3,3-Dimethyl-2-butanamine	1,2,2-Trimethylpropylamine	57
27	$\text{CH}_3(\text{CH}_2)_6\text{NH}_2$	1-Heptanamine	Heptylamine	59
28	$\text{CH}_3(\text{CH}_2)_7\text{NH}_2$	1-Octanamine	Octylamine	61
29	$\text{CH}_3(\text{CH}_2)_8\text{NH}_2$	1-Nonanamine	Nonylamine	63
	$\text{CH}_3(\text{CH}_2)_5\text{CH}(\text{CH}_3)\text{CH}_2\text{NH}_2$	2-Methyl-1-Octanamine (not issued)		

Continued on next page

CONTENTS continued

30	$\text{CH}_3(\text{CH}_2)_9\text{NH}_2$	1-Decanamine	Decylamine	65
31	$\text{CH}_3(\text{CH}_2)_{10}\text{NH}_2$	1-Undecanamine	Undecylamine	67
32	$\text{CH}_3(\text{CH}_2)_{11}\text{NH}_2$	1-Dodecanamine	Dodecylamine	69
33	$\text{CH}_3(\text{CH}_2)_{12}\text{NH}_2$	1-Tridecanamine	Tridecylamine	71
34	$\text{CH}_3(\text{CH}_2)_{13}\text{NH}_2$	1-Tetradecanamine	Tetradecylamine	73
35	$\text{CH}_3(\text{CH}_2)_{14}\text{NH}_2$	1-Pentadecanamine	Pentadecylamine	75
36	$\text{CH}_3(\text{CH}_2)_{15}\text{NH}_2$	1-Hexadecanamine	Hexadecylamine	77
37	$\text{CH}_3(\text{CH}_2)_{16}\text{NH}_2$	1-Heptadecanamine	Heptadecylamine	79
38	$\text{CH}_3(\text{CH}_2)_{17}\text{NH}_2$	1-Octadecanamine	Octadecylamine	81

PRIMARY ALKENYLAMINES

39	$\text{CH}_2=\text{CHCH}_2\text{NH}_2$	1-Prop-2-enamine	Allylamine	83
----	--	------------------	------------	----

PRIMARY CYCLOALKYLAMINES

40	$(\text{cy-C}_3\text{H}_5)\text{NH}_2$	Cyclopropanamine	Cyclopropylamine	85
41	$(\text{cy-C}_5\text{H}_9)\text{NH}_2$	Cyclopentanamine	Cyclopentylamine	87
42	$(\text{cy-C}_6\text{H}_{11})\text{NH}_2$	Cyclohexanamine	Cyclohexylamine	89
	$\text{CH}_3(\text{cy-C}_6\text{H}_{10})\text{NH}_2$	2-Methylcyclohexanamine (not issued)		
	$(\text{CH}_3)_2(\text{cy-C}_6\text{H}_9)\text{NH}_2$	2,4-Dimethylcyclohexanamine (not issued)		
	$(\text{CH}_3)_3(\text{cy-C}_6\text{H}_8)\text{NH}_2$	3,5,5-Trimethylcyclohexanamine (not issued)		



ORTHOBARIC DENSITIES AND MOLAR VOLUMES OF LIQUIDS ALIPHATIC AND ALICYCLIC AMINES - I: PRIMARY AMINES

1. INTRODUCTION

This Data Item presents orthobaric densities and molar volumes of the primary amines arranged in the order shown on the Contents page.

Table 1 gives the constants in the liquid density equation for all the compounds. On the following Sheets the values of density and molar volume for each compound have been obtained by calculation from the equation given, with its numerical coefficients, at the top of each Sheet. This equation was fitted to the data that had been selected after critical assessment of all the data. The value of the critical temperature for each compound was taken from Item 97012, which gives the vapour pressures. For completeness all the critical parameters of each compound are given in the Tables which also show the density at 298.15 K, where applicable, and for convenience, the normal boiling point and the approximate melting point. Brackets enclose the data at those temperatures which are outside the range of supporting experimental data.

The table of Data at Specified Temperatures for each compound gives the density, the molar volume and their derivatives with respect to temperature. In addition this table also gives an assessment of the data quality indicated, in decreasing order, by one of the letters 'A', 'B' or 'C', at each temperature. The estimated uncertainties in density and molar volume are shown below each letter in the units of density and molar volume rounded to 1, 2 or 5 times a power of 10.

In the main tables the uncertainties in the tabulated values of density and molar volume are shown for each value. The number of decimal places in each value is adjusted to be consistent with the uncertainty. Data quality and uncertainties are discussed at greater length in Section 5.

The sources of information which give liquid density or liquid molar volume data for the compound considered are listed on the reverse side of each sheet. Those sources that were used to derive the critical density and the coefficients of the liquid density/molar volume equation are shown together with the temperature ranges (ambient, low, medium, high or critical) of their data.

2. NOTATION AND UNITS

All temperatures are based on the International Temperature Scale (ITS-90).

N_1, N_2, N_3, N_4	non-dimensional coefficients of the density/molar volume equation
T	Kelvin temperature
t	Celsius temperature ($T-273.15$)
V	liquid molar volume
ρ	liquid density
τ	$(1-T/T_c)^{1/3}$

Note. The units of temperature, density and molar volume are shown in each table.

Subscripts

b	denotes value at normal boiling point
c	denotes value at critical point
m	denotes value at normal melting point
r	denotes reduced quantity, e.g. $T_r = T/T_c$

3. THE CRITICAL DENSITY

Estimates of the critical density of a compound may be made using both the Riedel equation, see Reference 1, and the latest form of Rackett equation, see References 2, 3 and 4. Both these equations require reliable values of the critical temperature and the critical pressure but neither represents experimental data over a wide range of temperature as satisfactorily as does the equation, see Table 1, which is used in this Item. However, provided the use of the Riedel equation is limited to non-associated liquids, both equations usually yield reliable values of the critical density for a wide variety of compounds. It may be noted that the Rackett equation usually gives a higher estimate than the Riedel equation and that for a homologous series this difference increases with increasing molecular weight.

For the compounds considered here estimates of the critical density of each compound were made using both the Riedel and the Rackett equations. In contrast with other groups of non-associated liquids, there was a larger difference between the two estimates than might have been expected. Critical densities, based on liquid density measurements and estimates of vapour density at high reduced temperatures, have been reported for eight of the compounds considered here. For these eight compounds the estimated critical densities given by the Rackett equation were usually in good agreement with the reported values and therefore in this Item the estimated critical density given by this equation only was selected for all of the compounds.

4. EVALUATION AND CORRELATION

References 5 and 6 present, for the eight C_1 to C_4 compounds considered there, tabulated values of the densities of the saturated liquids calculated from the saturated liquid density equation used there, which had been fitted to selected critically evaluated data. The values of saturated liquid density for these eight compounds presented here are, in general, derived from the coefficients of the saturated liquid density used here which had been fitted to the values tabulated in References 5 and 6. In cases where this is not so it is due to the use here of data that was not available to the authors of References 5 and 6.

For eight primary amines, five secondary amines and three tertiary amines there are extensive medium pressure range data and for some of these compounds the data extends a short way into the high pressure range (above the normal boiling point). Reliable data for the remaining compounds considered here are confined to shorter temperature ranges in the medium pressure range. The data for the above sixteen compounds were fitted by the liquid density equation and the coefficients of their equations were used to derive a reduced temperature - reduced density correlation analogous to that derived for vapour pressures, see Item 97012. This correlation which was then used to fit the data of the remaining compounds.

The liquid density equations presented here were derived in parallel with the vapour pressure equations presented in Item 97012, and where necessary the estimated values of critical temperature, critical pressure and critical density for some compounds were adjusted until they were optimum values for both vapour pressure and liquid density.

5. UNCERTAINTIES

At any temperature, the estimated uncertainties in the tabulated values of density and molar volume are dependent upon the rates of change of these properties with temperature and the quality of the experimental or estimated data upon which they are based. The table of Data at Specified Temperatures shows these derivatives, the assessed data quality (indicated by one of the letters 'A', 'B' or 'C') and the corresponding uncertainties at various points of the liquid range. At low and medium reduced temperatures average quality data, denoted by the letter 'B', have uncertainties varying from 0.1 to 1 per cent, increasing to between 1 and 10 per cent at the critical point. Data with lower or higher uncertainties than these bands are graded 'A' and 'C' respectively. When the data quality is 'C' it will be appreciated that the uncertainties are necessarily rather speculative and that for some compounds they may be underestimated.

For those compounds for which the data quality at the critical pressure is denoted by 'C' the values of critical temperature and critical density given in the Tables should be regarded only as correlating parameters.

6. REFERENCES

1. RIEDEL, L. Liquid density in the saturation state. Investigations on an extension of the theorem of corresponding states. Part 2 (in German). *Chem.-Ingr.-Tech.*, Vol.26, pp.259-264, 1954.
2. RACKETT, H.G. Equation of state for saturated liquids. *J. Chem. Eng. Data*, Vol.15, No.4, pp.514-517, 1970.
3. SPENCER, C.F.,
DANNER, R.P.J. Improved equation for prediction of saturated liquid density. *J. Chem. Eng. Data*, Vol.17, No.2, pp.236-241, 1972.
4. CAMPBELL, S.W.
THODOS, G. Prediction of saturated-liquid densities and critical volumes for polar and non-polar substances. *J. Chem. Eng. Data*, Vol.30, No.1, pp.102-111, 1985.
5. CHAO, J.
GADALLA, N.A.M.
et al. Thermodynamic and thermophysical properties of organic nitrogen compounds. Part I. Methanamine, ethanamine, 1- and 2-propanamine, benzenamine, 2-, 3- and 4-methylbenzenamine. *J. Phys. Chem. Ref. Data*, Vol.19, pp.1547-1615, 1990.
6. DAS, A.
FRENKEL, M.
et al. Thermodynamic and thermophysical properties of organic nitrogen compounds. Part II. 1- and 2-butanamine, 2-methyl-1-propanamine, 2-methyl-2-propanamine, pyrrole, 1-, 2- and 3-methylpyrrole, pyridine, 2-, 3- and 4-methylpyridine, pyrrolidine, piperidine, indole, quinoline, isoquinoline, acridine, carbazole, phenanthridine, 1- and 2-naphthalenamine and 9-methylcarbazole. *J. Phys. Chem. Ref. Data*, Vol.22, pp.659-782, 1993.

97013

TABLE 1

Summary of Constants in the Liquid Density equation

$$\ln \rho = \ln \rho_c + N_1 \tau + N_2 \tau^2 + N_3 \tau^3 + N_4 \tau^4 \quad \text{where } \tau = (1 - T/T_c)^{1/3}$$

No.	Name	T_c K	ρ_c kg/m ³	N_1	N_2	N_3	N_4
PRIMARY ALKYLAMINES							
1	Methanamine	430.7	255.	2.70135	-4.27562	4.70622	-1.82127
2	Ethanamine	456.2	252.	1.72188	-0.51830	-0.04804	0.20803
3	1-Propanamine	497.	256.	2.10353	-1.70743	1.08151	-0.11143
4	2-Propanamine	471.9	255.	2.09472	-2.08507	2.00240	-0.68830
5	1-Butanamine	531.9	260.	1.75049	-0.61981	0	0.20640
6	2-Butanamine	514.3	263.	1.76243	-0.90735	0.59098	-0.16728
7	2-Methyl-1-propanamine	519.	261.	2.00640	-1.46738	0.91269	-0.12768
8	2-Methyl-2-propanamine	483.9	254.	1.63563	-0.47289	0.13103	0.03520
9	1-Pentanamine	559.	251.	1.97792	-0.92962	0	0.33333
10	2-Pentanamine	539.	263.	1.95156	-1.06336	0	0.46150
11	3-Pentanamine	535	266	1.95420	-1.06466	0	0.46220
12	2-Methyl-1-butanamine	546.	261.	1.98900	-1.08208	0	0.47076
13	3-Methyl-1-butanamine	547.	260.	1.98216	-1.07037	0	0.46223
14	2-Methyl-2-butanamine	525.	267.	1.92343	-1.04973	0	0.45361
15	3-Methyl-2-butanamine	531.	271.	1.94940	-1.06230	0	0.46093
16	2,2-Dimethyl-1-propanamine	523.	268.	1.92003	-1.04810	0	0.45259
17	1-Hexanamine	586.	249.	1.99538	-0.95778	0	0.35703
18	2-Hexanamine	563.	261.	1.99183	-1.08352	0	0.47141
19	3-Hexanamine	563.	263.	2.00111	-1.08827	0	0.47348
20	4-Methyl-1-pentanamine	574.	260.	2.00998	-1.09284	0	0.47538
21	2-Methyl-2-pentanamine	552.	263.	1.95611	-1.06560	0	0.46270
22	4-Methyl-2-pentanamine	556.	264.	1.94456	-1.05993	0	0.45962
23	3-Methyl-3-pentanamine	583.	257.	2.00058	-1.08800	0	0.47336
24	2,2-Dimethyl-1-butanamine	566.	262.	1.98115	-1.07810	0	0.46893
25	2,3-Dimethyl-1-butanamine	551.	263.	1.97738	-1.07620	0	0.46803
26	3,3-Dimethyl-2-butanamine	553.	267.	1.95671	-1.06590	0	0.46286
27	1-Heptanamine	611.	248.	1.98840	-0.91466	0	0.31652
28	1-Octanamine	635.	243.	2.10293	-1.14246	0	0.49161
29	1-Nonanamine	655.	242.	2.10837	-1.14545	0	0.49236
	2-Methyl-1-Octanamine (not issued)						
30	1-Decanamine	674.	239.	2.12957	-1.15720	0	0.49513
31	1-Undecanamine	691.	237.	2.13763	-1.16170	0	0.49611
32	1-Dodecanamine	707.	235.	2.14892	-1.16803	0	0.49741
33	1-Tridecanamine	722.	234.	2.15341	-1.17056	0	0.49791
34	1-Tetradecanamine	736.	232.	2.16730	-1.17843	0	0.49938
35	1-Pentadecanamine	749.	230.	2.18222	-1.18692	0	0.50083
36	1-Hexadecanamine	762.	230.	2.17644	-1.18363	0	0.50028
37	1-Heptadecanamine	772.	228.	2.19613	-1.19490	0	0.50207
38	1-Octadecanamine	782.	228.	2.19464	-1.19404	0	0.50194
PRIMARY ALKENYLAMINES							
39	1-Prop-2-enamine	507.	269.	2.00528	-1.09041	0	0.47438

Continued on next page

JUNE 1997



Documents

Document Sharing Hub

TABLE 1 continued

No.	Name	T_c K	ρ_c kg/m ³	N_1	N_2	N_3	N_4
PRIMARY CYCLOALKYLAMINES							
40	Cyclopropanamine	514.	288.	2.00764	-1.09163	0	0.47489
41	Cyclopentanamine	582.	300.	1.95140	-1.08693	0	0.48167
42	Cyclohexanamine	625.	287.	2.02672	-1.17144	0	0.54027
	2-Methylcyclohexanamine (not issued)						
	2,4-Dimethylcyclohexanamine (not issued)						
	3,5,5-Trimethylcyclohexanamine (not issued)						



97013

CH₃NH₂ Methanamine; Methylamine; AminomethaneCH₅N

CAS Reg. No. 74-89-5

Mol. Wt. 31.06

Orthobaric Liquid Density and Molar Volume $\ln(\rho/\rho_c) = -\ln(V/V_c) = N_1\tau + N_2\tau^2 + N_3\tau^3 + N_4\tau^4$ where ρ is the density, ρ_c is the critical density, V is the molar volume, V_c is the critical molar volume and $\tau = (1 - T/T_c)^{1/3}$, where T is the temperature and T_c is the critical temperature in kelvins.

Critical Temperature	T_c	= 430.7 K	(t_c	= 157.55 °C)
Critical Pressure	p_c	= 7614. kPa	(p_c	= 75.14 atm)
Critical Density	ρ_c	= 255. kg/m ³	(V_c	= 121.80 cm ³ /mol)
Critical Compression Factor	Z_c	= 0.259		

$$N_1 = 2.70135 \quad N_2 = -4.27562 \quad N_3 = 4.70622 \quad N_4 = -1.82127$$

Density at 298.15 K (25 °C)	ρ_{25}	= 655.94 kg/m ³	(V_{25}	= 47.35 cm ³ /mol)
Normal Boiling Point	T_b	= 266.8 K	(t_b	= -6.350 °C)
Melting Point	T_m	= 180.	(t_m	= -93. °C)

Data at Specified Temperatures

$t/^\circ\text{C}$	-93	0	25	-6.35	50	100	157.55
T/K	180.15	273.15	298.15	266.80	323.15	373.15	430.70
$\rho/(\text{kg/m}^3)$	(788.47)	686.35	655.94	693.84	623.71	549.62	255.00
$(d\rho/dT)/(\text{kg/m}^3 \text{ K})$	(-1.02)	-1.19	-1.25	-1.17	-1.33	-1.70	$-\infty$
$V/(\text{cm}^3/\text{mol})$	(39.39)	45.25	47.35	44.77	49.80	56.51	121.80
$(dV/dT)/(\text{cm}^3/\text{mol K})$	(0.05)	0.08	0.09	0.08	0.11	0.18	∞
Data Quality	(B)	B	B	B	B	B	B
Uncertainty in ρ (kg/m ³)	(1.)	1.	1.	1.	2.	2.	5.
Uncertainty in V (cm ³ /mol)	(0.05)	0.05	0.05	0.05	0.2	0.2	2.

Orthobaric Liquid Density of MethanamineUnits: kg/m³ v. °C

t °C	ρ kg/m ³	Uncert. in ρ kg/m ³	t °C	ρ kg/m ³	Uncert. in ρ kg/m ³	t °C	ρ kg/m ³	Uncert. in ρ kg/m ³	t °C	ρ kg/m ³	Uncert. in ρ kg/m ³
-90	(785.)	1.	0	686.	1.	100	550.	2.			
-85	(780.)	1.	5	680.	1.	105	541.	2.			
-80	775.	1.	10	674.	1.	110	532.	2.			
			15	668.	1.	115	522.	2.			
			20	662.	1.	120	512.	2.			
-75	770.	1.	25	656.	1.	125	501.	2.			
-70	765.	1.	30	650.	2.	130	489.	2.			
-65	759.	1.	35	643.	2.	135	475.	2.			
-60	754.	1.	40	637.	2.	140	460.	5.			
-55	749.	1.	45	630.	2.	145	441.	5.			
-50	743.	1.	50	624.	2.	150	415.	5.			
-45	738.	1.	55	617.	2.	155	371.	5.			
-40	732.	1.	60	610.	2.						
-35	727.	1.	65	603.	2.						
-30	721.	1.	70	596.	2.						
-25	715.	1.	75	589.	2.						
-20	710.	1.	80	581.	2.						
-15	704.	1.	85	574.	2.						
-10	698.	1.	90	566.	2.						
-5	692.	1.	95	558.	2.						

JUNE 1997

CH₅N

Orthobaric Liquid Molar Volume of Methanamine

Units: cm³/mol v. K

T K	V cm ³ /mol	Uncert. in V cm ³ /mol	T K	V cm ³ /mol	Uncert. in V cm ³ /mol	T K	V cm ³ /mol	Uncert. in V cm ³ /mol	T K	V cm ³ /mol	Uncert. in V cm ³ /mol
185	(39.64)	0.05	275	45.40	0.05	375	56.8	0.2			
190	(39.90)	0.05	280	45.80	0.05	380	57.8	0.2			
195	40.17	0.05	285	46.21	0.05	385	58.8	0.2			
			290	46.63	0.05	390	59.9	0.2			
			295	47.07	0.05	395	61.1	0.2			
200	40.45	0.05	300	47.5	0.1	400	62.5	0.5			
205	40.73	0.05	305	48.0	0.1	405	64.2	0.5			
210	41.01	0.05	310	48.5	0.1	410	66.1	0.5			
215	41.30	0.05	315	49.0	0.1	415	68.5	0.5			
220	41.60	0.05	320	49.5	0.2	420	71.8	0.5			
225	41.91	0.05	325	50.0	0.2	425	77.2	1.			
230	42.22	0.05	330	50.5	0.2	430	93.	1.			
235	42.54	0.05	335	51.1	0.2						
240	42.87	0.05	340	51.7	0.2						
245	43.20	0.05	345	52.3	0.2						
250	43.55	0.05	350	53.0	0.2						
255	43.90	0.05	355	53.7	0.2						
260	44.26	0.05	360	54.4	0.2						
265	44.63	0.05	365	55.2	0.2						
270	45.01	0.05	370	56.0	0.2						

The following Sources give liquid density or liquid molar volume data for this compound. Those Sources used to derive the coefficients of the liquid density/molar volume equation are indicated by the temperature range (ambient 'A', low 'L', medium 'M', high 'H' or critical 'C') of their data. An asterisk (*) indicates that the Source is not a primary source of experimental data.

- 1 HOFMAN, A. W.; *Chem.Ber.*, Vol.22, p.699, 1889.
- 2 MULLER, -.; *Ann.Chim.(Paris)*, Vol.20, p.122, 1910.
- 3 JAEGER, -.; *Z.Anorg.Allg.Chem.*, Vol.101, p.86, 1917.
- 4 FELSING, W. A.; THOMAS, A. R.; *Ind.Eng.Chem.*, Vol.21, p.1269, 1929.
- 5 FELSING, W. A.; PHILLIPS, B. A.; *J.Am.Chem.Soc.*, Vol.58, p.1973, 1936.
- 6 Le FEVRE, R. J. W.; RUSSELL, P.; *Trans.Faraday Soc.*, Vol.43, p.374, 1947.
- 7 ISAKOVA, N. P.; ADZHEMYAN, R. Ts.; et al.; *Russ.J.Phys.Chem.*, Vol.40, p.1341, 1966.
- 8 TALALSEK, -.; *Coll.Czech.Chem.Comm.*, Vol.33, p.731, 1968.
- 9 LI, L.; KIRAN, E.; *J.Chem.Eng.Data*, Vol.33, p.342, 1988.
- 10 SOMAYAJULU, G. R.; *J.Chem.Eng.Data*, Vol.34, p.106, 1989.*
- 11 CHAO,J.; GADALLA,N.A.M.; et al.; *J.Phys.Chem.Ref.Data*, Vol.19, p.1547, 1990.* L M H C
- 12 TRC Thermodynamic Tables, Texas A & M Univ., Loose leaf data sheets extant 1996.*



97013

C₂H₅NH₂ Ethanamine; Ethylamine; Aminoethane**C₂H₇N**

CAS Reg. No. 75-04-7

Mol. Wt. 45.09

Orthobaric Liquid Density and Molar Volume $\ln(\rho/\rho_c) = -\ln(V/V_c) = N_1\tau + N_2\tau^2 + N_3\tau^3 + N_4\tau^4$ where ρ is the density, ρ_c is the critical density, V is the molar volume, V_c is the critical molar volume and $\tau = (1-T/T_c)^{1/3}$, where T is the temperature and T_c is the critical temperature in kelvins.

Critical Temperature	T_c	= 456.2 K	(t_c	= 183.05 °C)
Critical Pressure	p_c	= 5630. kPa	(p_c	= 55.56 atm)
Critical Density	ρ_c	= 252. kg/m ³	(V_c	= 178.93 cm ³ /mol)
Critical Compression Factor	Z_c	= 0.266		

$$N_1 = 1.72188 \quad N_2 = -0.51830 \quad N_3 = -0.04804 \quad N_4 = 0.20803$$

Density at 298.15 K (25 °C)	ρ_{25}	= 676.60 kg/m ³	(V_{25}	= 66.64 cm ³ /mol)
Normal Boiling Point	T_b	= 289.74 K	(t_b	= 16.590 °C)
Melting Point	T_m	= 193.	(t_m	= -80. °C)

Data at Specified Temperatures

$t/^\circ\text{C}$	-80	0	25	50	16.59	100	183.05
T/K	193.15	273.15	298.15	323.15	289.74	373.15	456.20
$\rho/(\text{kg/m}^3)$	(792.88)	706.11	676.60	645.23	686.71	573.38	252.00
$(d\rho/dT)/(\text{kg/m}^3 \text{ K})$	(-1.04)	-1.15	-1.21	-1.30	-1.19	-1.62	$-\infty$
$V/(\text{cm}^3/\text{mol})$	(56.87)	63.86	66.64	69.88	65.66	78.64	178.93
$(dV/dT)/(\text{cm}^3/\text{mol K})$	(0.07)	0.10	0.12	0.14	0.11	0.22	∞
Data Quality	(B)	B	B	B	B	B	B
Uncertainty in ρ (kg/m ³)	(1.)	1.	1.	1.	2.	2.	5.
Uncertainty in V (cm ³ /mol)	(0.05)	0.1	0.1	0.1	0.2	0.2	5.

Orthobaric Liquid Density of EthanamineUnits: kg/m³ v. °C

t °C	ρ kg/m ³	Uncert. in ρ kg/m ³	t °C	ρ kg/m ³	Uncert. in ρ kg/m ³	t °C	ρ kg/m ³	Uncert. in ρ kg/m ³	t °C	ρ kg/m ³	Uncert. in ρ kg/m ³
-80	(793.)	1.	0	706.	1.	100	573.	2.			
			5	700.	1.	105	565.	2.			
			10	694.	1.	110	557.	2.			
			15	689.	1.	115	548.	2.			
			20	683.	1.	120	539.	2.			
-75	788.	1.	25	677.	1.	125	529.	2.			
-70	782.	1.	30	670.	1.	130	519.	2.			
-65	777.	1.	35	664.	1.	135	509.	2.			
-60	772.	1.	40	658.	1.	140	498.	2.			
-55	767.	1.	45	652.	1.	145	486.	2.			
-50	761.	1.	50	645.	1.	150	473.	2.			
-45	756.	1.	55	639.	2.	155	460.	5.			
-40	751.	1.	60	632.	2.	160	444.	5.			
-35	745.	1.	65	625.	2.	165	427.	5.			
-30	740.	1.	70	618.	2.	170	407.	5.			
-25	734.	1.	75	611.	2.	175	381.	5.			
-20	729.	1.	80	604.	2.	180	342.	5.			
-15	723.	1.	85	597.	2.						
-10	718.	1.	90	589.	2.						
-5	712.	1.	95	581.	2.						

JUNE 1997

C₂H₇N

Orthobaric Liquid Molar Volume of Ethanamine

Units: cm³/mol v. K

T K	V cm ³ /mol	Uncert. in V cm ³ /mol	T K	V cm ³ /mol	Uncert. in V cm ³ /mol	T K	V cm ³ /mol	Uncert. in V cm ³ /mol	T K	V cm ³ /mol	Uncert. in V cm ³ /mol
			275	64.05	0.1	375	79.1	0.2			
			280	64.58	0.1	380	80.2	0.2			
			285	65.13	0.1	385	81.5	0.2			
			290	65.69	0.1	390	82.8	0.5			
195	57.01	0.05	295	66.27	0.1	395	84.2	0.5			
200	57.38	0.05	300	66.86	0.1	400	85.8	0.5			
205	57.77	0.05	305	67.5	0.1	405	87.5	0.5			
210	58.16	0.1	310	68.1	0.1	410	89.3	0.5			
215	58.56	0.1	315	68.8	0.1	415	91.3	0.5			
220	58.96	0.1	320	69.4	0.1	420	93.6	0.5			
225	59.38	0.1	325	70.1	0.2	425	96.3	0.5			
230	59.80	0.1	330	70.9	0.2	430	99.3	1.			
235	60.23	0.1	335	71.6	0.2	435	102.9	1.			
240	60.67	0.1	340	72.4	0.2	440	107.	1.			
245	61.12	0.1	345	73.2	0.2	445	113.	1.			
250	61.58	0.1	350	74.1	0.2	450	122.	2.			
255	62.05	0.1	355	75.0	0.2	455	142.	2.			
260	62.53	0.1	360	75.9	0.2						
265	63.03	0.1	365	76.9	0.2						
270	63.53	0.1	370	78.0	0.2						

The following Sources give liquid density or liquid molar volume data for this compound. Those Sources used to derive the coefficients of the liquid density/molar volume equation are indicated by the temperature range (ambient 'A', low 'L', medium 'M', high 'H' or critical 'C') of their data. An asterisk (*) indicates that the Source is not a primary source of experimental data.

- | | | |
|---------------------------------------|---|---------|
| 1 WURTZ, A.; | <i>Ann.Chim.Phys.</i> , Vol.30, p.491, 1850. | |
| 2 WURTZ, A.; | <i>Liebigs Ann.Chem.</i> , Vol.76, p.325, 1850. | |
| 3 HOFMAN, A. W.; | <i>Chem.Ber.</i> , Vol.22, p.699, 1889. | |
| 4 PERKIN, W. H.; | <i>J.Chem.Soc.</i> , Vol.55, p.680, 1889. | |
| 5 TIMMERMANS, J.; | <i>Bull.Soc.Chim.Belg.</i> , Vol.24, p.244, 1910. | |
| 6 TIMMERMANS, J.; | <i>Proc.R.Dublin Soc.</i> , Vol.13, p.310, 1912. | |
| 7 JAEGER, -.; | <i>Z.Anorg.Allg.Chem.</i> , Vol.101, p.86, 1917. | |
| 8 ELSEY, -.; | <i>J.Am.Chem.Soc.</i> , Vol.42, p.2476, 1920. | |
| 9 SOMERVILLE, -.; | <i>J.Phys.Chem.</i> , Vol.35, p.2414, 1931. | |
| 10 POHLAND, E.; MEHL, W.; | <i>Z.Phys.Chem.Abt.A</i> , Vol.164, p.48, 1933. | |
| 11 SWIFT, E.; | <i>J.Am.Chem.Soc.</i> , Vol.64, p.115, 1942. | |
| 12 BARCELO, J. R.; et al.; | <i>Trans.Faraday Soc.</i> , Vol.46, p.812, 1950. | |
| 13 STOELZER, C.; SIMON, A.; | <i>Chem.Ber.</i> , Vol.93, p.1323, 1960. | |
| 14 TALALSEK, -.; | <i>Coll.Czech.Chem.Comm.</i> , Vol.33, p.731, 1968. | |
| 15 SOMAYAJULU, G. R.; | <i>J.Chem.Eng.Data</i> , Vol.34, p.106, 1989.* | |
| 16 CHAO, J.; GADALLA, N.A.M.; et al.; | <i>J.Phys.Chem.Ref.Data</i> , Vol.19, p.1547, 1990.* | L M H C |
| 17 AMBROSE, D.; | in <i>Hndbk.Chem.Phys.</i> , CRC Press, 72nd.ed., pp.6-49 to 6-63, 1991.* | |
| 18 TRC Thermodynamic Tables, | Texas A & M Univ., Loose leaf data sheets extant 1996.* | |



97013

CH₃(CH₂)₂NH₂ 1-Propanamine; Propylamine; 1-Aminopropane**C₃H₉N**

CAS Reg. No. 107-10-8

Mol. Wt. 59.11

Orthobaric Liquid Density and Molar Volume $\ln(\rho/\rho_c) = -\ln(V/V_c) = N_1 \tau + N_2 \tau^2 + N_3 \tau^3 + N_4 \tau^4$ where ρ is the density, ρ_c is the critical density, V is the molar volume, V_c is the critical molar volume and $\tau = (1 - T/T_c)^{1/3}$, where T is the temperature and T_c is the critical temperature in kelvins.

Critical Temperature	T_c	= 497. K	(t_c	= 223.85 °C)
Critical Pressure	p_c	= 4720. kPa	(p_c	= 46.58 atm)
Critical Density	ρ_c	= 256. kg/m ³	(V_c	= 230.90 cm ³ /mol)
Critical Compression Factor	Z_c	= 0.264		

$$N_1 = 2.10353 \quad N_2 = -1.70743 \quad N_3 = 1.08151 \quad N_4 = -0.11143$$

Density at 298.15 K (25 °C)	ρ_{25}	= 711.92 kg/m ³	(V_{25}	= 83.03 cm ³ /mol)
Normal Boiling Point	T_b	= 320.368 K	(t_b	= 47.218 °C)
Melting Point	T_m	= 188.	(t_m	= -85. °C)

Data at Specified Temperatures

$t/^\circ\text{C}$	-85	0	25	50	47.22	100	223.85
T/K	188.15	273.15	298.15	323.15	320.37	373.15	497.00
$\rho/(\text{kg/m}^3)$	(820.45)	737.31	711.92	685.74	688.70	629.41	(256.00)
$(d\rho/dT)/(\text{kg/m}^3 \text{ K})$	(-0.96)	-1.00	-1.03	-1.07	-1.06	-1.20	$-\infty$
$V/(\text{cm}^3/\text{mol})$	(72.05)	80.17	83.03	86.20	85.83	93.91	(230.90)
$(dV/dT)/(\text{cm}^3/\text{mol K})$	(0.08)	0.11	0.12	0.13	0.13	0.18	∞
Data Quality	(B)	B	B	B	B	B	(B)
Uncertainty in ρ (kg/m ³)	(1.)	1.	1.	1.	2.	2.	(5.)
Uncertainty in V (cm ³ /mol)	(0.1)	0.1	0.1	0.1	0.2	0.2	(5.)

Orthobaric Liquid Density of 1-PropanamineUnits: kg/m³ v. °C

t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.
$^\circ\text{C}$	kg/m ³	kg/m ³	$^\circ\text{C}$	kg/m ³	kg/m ³	$^\circ\text{C}$	kg/m ³	kg/m ³	$^\circ\text{C}$	kg/m ³	kg/m ³
			0	737.	1.	100	629.	2.	200	(461.)	5.
			5	732.	1.	105	623.	2.	205	(445.)	5.
			10	727.	1.	110	617.	2.	210	(426.)	5.
-85	(820.)	1.	15	722.	1.	115	611.	2.	215	(402.)	5.
-80	(816.)	1.	20	717.	1.	120	604.	2.	220	(366.)	5.
-75	(811.)	1.									
-70	(806.)	1.	25	712.	1.	125	598.	2.			
-65	(801.)	1.	30	707.	1.	130	591.	2.			
-60	796.	1.	35	702.	1.	135	584.	2.			
-55	791.	1.	40	696.	1.	140	(577.)	2.			
			45	691.	1.	145	(570.)	2.			
-50	787.	1.									
-45	782.	1.	50	686.	1.	150	(562.)	2.			
-40	777.	1.	55	680.	2.	155	(555.)	2.			
-35	772.	1.	60	675.	2.	160	(547.)	2.			
-30	767.	1.	65	670.	2.	165	(538.)	2.			
			70	664.	2.	170	(529.)	2.			
-25	762.	1.									
-20	757.	1.	75	658.	2.	175	(520.)	2.			
-15	752.	1.	80	653.	2.	180	(510.)	5.			
-10	747.	1.	85	647.	2.	185	(499.)	5.			
-5	742.	1.	90	641.	2.	190	(488.)	5.			
			95	635.	2.	195	(475.)	5.			

JUNE 1997



Orthobaric Liquid Molar Volume of 1-Propanamine

Units: cm^3/mol v. K

T	V	Uncert.	T	V	Uncert.	T	V	Uncert.	T	V	Uncert.
K	cm^3/mol	cm^3/mol	K	cm^3/mol	cm^3/mol	K	cm^3/mol	cm^3/mol	K	cm^3/mol	cm^3/mol
			275	80.4	0.1	375	94.2	0.2	475	(130.)	1.
			280	80.9	0.1	380	95.2	0.2	480	(135.)	1.
			285	81.5	0.1	385	96.1	0.2	485	(141.)	2.
190	(72.20)	0.1	290	82.1	0.1	390	97.1	0.5	490	(151.)	2.
195	(72.63)	0.1	295	82.7	0.1	395	98.2	0.5	495	(172.)	2.
200	(73.06)	0.1	300	83.3	0.1	400	99.3	0.5			
205	(73.50)	0.1	305	83.9	0.1	405	100.4	0.5			
210	(73.95)	0.1	310	84.5	0.1	410	101.6	0.5			
215	74.40	0.1	315	85.1	0.1	415	(102.9)	0.5			
220	74.86	0.1	320	85.8	0.1	420	(104.2)	0.5			
225	75.32	0.1	325	86.4	0.2	425	(105.6)	0.5			
230	75.79	0.1	330	87.1	0.2	430	(107.1)	0.5			
235	76.27	0.1	335	87.8	0.2	435	(108.8)	0.5			
240	76.75	0.1	340	88.6	0.2	440	(110.5)	0.5			
245	77.2	0.1	345	89.3	0.2	445	(112.4)	0.5			
250	77.7	0.1	350	90.1	0.2	450	(114.5)	1.			
255	78.3	0.1	355	90.8	0.2	455	(116.8)	1.			
260	78.8	0.1	360	91.7	0.2	460	(119.4)	1.			
265	79.3	0.1	365	92.5	0.2	465	(122.3)	1.			
270	79.8	0.1	370	93.4	0.2	470	(126.)	1.			

The following Sources give liquid density or liquid molar volume data for this compound. Those Sources used to derive the coefficients of the liquid density/molar volume equation are indicated by the temperature range (ambient 'A', low 'L', medium 'M', high 'H' or critical 'C') of their data. An asterisk (*) indicates that the Source is not a primary source of experimental data.

- EYKMAN, J. F.; *Rec.Trav.Chim.*, Vol.12, p.268, 1893.
- BRUHL, J. W.; *J.Phys.Chem.Stoech.Verwand.*, Vol.16, p.193, 1895.
- TURNER, W. E. S.; MERRY, E. W.; *J.Chem.Soc.*, Vol.97, p.2069, 1910.
- EYKMAN, J. F.; *Nat.Verh.Holl.Maat.Wet.Haarlem*, Vol.8, p.438, 1919.
- VOGEL, A. I.; *J.Chem.Soc.*, p.1820, 1948.
- COWLEY, E. G.; *J.Chem.Soc.*, p.3557, 1952.
- HANSSON, -; *Svensk.Kem.Tridskr.*, Vol.67, p.263, 1955.
- GALLAIS, -; VOIGT, -; *C.R.Hebd.Sean.Acad.Sci.*, Vol.243, p.942, 1956.
- MICHAILOV, -; *Trud.Inst.C.Chim.Reakt*, No.21, p.72, 1956.
- PLATE, -; et al.; *J.Gen.Chem.USSR*, Vol.26, p.785, 1956.
- SOROKIN, -; et al.; *Trud.Mosk.Chim.Tech.Inst.*, No.25, p.58, 1957.
- COSTELLO, J. M.; BOWDEN, S. T.; *Rec.Trav.Chim.*, Vol.78, p.391, 1959.
- WASIF, -; *J.Chem.Soc.*, p.1324, 1964.
- TALALSEK, -; *Coll.Czech.Chem.Comm.*, Vol.33, p.731, 1968.
- EREMENKO, -; *Bull.Acad.Sci.USSR,Chem.Sci.*, p.46, 1970.
- KRICHEVTSOV, B. K.; KOMAROV, V. M.; *J.Appl.Chem.*, Vol.43, p.104, 1970.
- LETCHER, T. M.; *J.Chem.Thermodyn.*, Vol.4, p.159, 1972.
- LETCHER, T. M.; *J.Chem.Thermodyn.*, Vol.4, p.551, 1972.
- PATIL, K. J.; *Indian J.Pure Appl.Phys.*, Vol.16, p.608, 1978.
- KACZMAREK, B.; *Pol.J.Chem.*, Vol.57, p.617, 1983.
- SOMAYAJULU, G. R.; *J.Chem.Eng.Data*, Vol.34, p.106, 1989.*
- CHAO, J.; GADALLA, N.A.M.; et al.; *J.Phys.Chem.Ref.Data*, Vol.19, p.1547, 1990.* L M H C
- PAPAIOANNOU, D.; et al.; *J.Chem.Eng.Data*, Vol.40, p.202, 1995.
- TRC Thermodynamic Tables, Texas A & M Univ., Loose leaf data sheets extant 1996.*

CH₃CH(NH₂)CH₃ 2-Propanamine; Isopropylamine; 2-AminopropaneC₃H₉N

CAS Reg. No. 75-31-0

Mol. Wt. 59.11

Orthobaric Liquid Density and Molar Volume $\ln(\rho/\rho_c) = -\ln(V/V_c) = N_1\tau + N_2\tau^2 + N_3\tau^3 + N_4\tau^4$ where ρ is the density, ρ_c is the critical density, V is the molar volume, V_c is the critical molar volume and $\tau = (1 - T/T_c)^{1/3}$, where T is the temperature and T_c is the critical temperature in kelvins.

Critical Temperature	T_c	= 471.9 K	(t_c	= 198.75 °C)
Critical Pressure	p_c	= 4540. kPa	(p_c	= 44.81 atm)
Critical Density	ρ_c	= 255. kg/m ³	(V_c	= 231.80 cm ³ /mol)
Critical Compression Factor	Z_c	= 0.268		

$$N_1 = 2.09472 \quad N_2 = -2.08507 \quad N_3 = 2.00240 \quad N_4 = -0.68830$$

Density at 298.15 K (25 °C)	ρ_{25}	= 683.44 kg/m ³	(V_{25}	= 86.49 cm ³ /mol)
Normal Boiling Point	T_b	= 304.907 K	(t_b	= 31.757 °C)
Melting Point	T_m	= 178.	(t_m	= -95. °C)

Data at Specified Temperatures

$t/^\circ\text{C}$	-95	0	25	50	31.76	150	198.75
T/K	178.15	273.15	298.15	323.15	304.91	423.15	471.90
$\rho/(\text{kg/m}^3)$	(804.60)	710.48	683.44	655.01	675.90	(512.13)	(255.00)
$(d\rho/dT)/(\text{kg/m}^3 \text{ K})$	(-0.94)	-1.06	-1.11	-1.17	-1.12	(-1.93)	$-\infty$
$V/(\text{cm}^3/\text{mol})$	(73.47)	83.20	86.49	90.24	87.45	(115.42)	(231.80)
$(dV/dT)/(\text{cm}^3/\text{mol K})$	(0.09)	0.12	0.14	0.16	0.15	(0.44)	∞
Data Quality	(B)	B	B	B	C	(C)	(B)
Uncertainty in ρ (kg/m ³)	(5.)	2.	2.	5.	5.	(10.)	(10.)
Uncertainty in V (cm ³ /mol)	(0.5)	0.2	0.2	0.5	1.	(2.)	(10.)

Orthobaric Liquid Density of 2-PropanamineUnits: kg/m³ v. °C

t	ρ	Uncert.		t	ρ	Uncert.		t	ρ	Uncert.		t	ρ	Uncert.	
°C	kg/m ³	kg/m ³		°C	kg/m ³	kg/m ³		°C	kg/m ³	kg/m ³		°C	kg/m ³	kg/m ³	
-95	(805.)	5.		0	710.	2.		100	(592.)	5.					
-90	(800.)	5.		5	705.	2.		105	(585.)	5.					
-85	(795.)	5.		10	700.	2.		110	(578.)	5.					
-80	(790.)	5.		15	694.	2.		115	(571.)	5.					
				20	689.	2.		120	(563.)	5.					
-75	(786.)	5.		25	683.	2.		125	(555.)	10.					
-70	(781.)	5.		30	678.	2.		130	(547.)	10.					
-65	(776.)	5.		35	672.	2.		135	(539.)	10.					
-60	771.	5.		40	667.	2.		140	(531.)	10.					
-55	766.	2.		45	661.	2.		145	(522.)	10.					
-50	761.	2.		50	655.	5.		150	(512.)	10.					
-45	757.	2.		55	649.	5.		155	(502.)	10.					
-40	752.	2.		60	643.	5.		160	(492.)	10.					
-35	747.	2.		65	637.	5.		165	(480.)	10.					
-30	741.	2.		70	631.	5.		170	(468.)	10.					
-25	736.	2.		75	625.	5.		175	(454.)	10.					
-20	731.	2.		80	618.	5.		180	(439.)	10.					
-15	726.	2.		85	612.	5.		185	(420.)	10.					
-10	721.	2.		90	605.	5.		190	(397.)	10.					
-5	716.	2.		95	599.	5.		195	(362.)	10.					



Orthobaric Liquid Molar Volume of 2-Propanamine

Units: cm^3/mol v. K

T K	V cm^3/mol	Uncert. in V cm^3/mol	T K	V cm^3/mol	Uncert. in V cm^3/mol	T K	V cm^3/mol	Uncert. in V cm^3/mol	T K	V cm^3/mol	Uncert. in V cm^3/mol
180	(73.6)	0.5	275	83.4	0.2	375	(100.)	1.			
185	(74.1)	0.5	280	84.1	0.2	380	(101.)	1.			
190	(74.5)	0.5	285	84.7	0.2	385	(103.)	1.			
195	(74.9)	0.5	290	85.4	0.2	390	(104.)	1.			
			295	86.1	0.2	395	(106.)	1.			
200	(75.4)	0.5	300	86.7	0.2	400	(107.)	1.			
205	(75.9)	0.5	305	87.5	0.2	405	(109.)	2.			
210	(76.3)	0.5	310	88.2	0.5	410	(110.)	2.			
215	76.8	0.2	315	89.0	0.5	415	(112.)	2.			
220	77.3	0.2	320	89.7	0.5	420	(114.)	2.			
225	77.8	0.2	325	90.5	1.	425	(116.)	2.			
230	78.3	0.2	330	91.4	1.	430	(119.)	2.			
235	78.8	0.2	335	92.2	1.	435	(121.)	2.			
240	79.4	0.2	340	93.1	1.	440	(124.)	2.			
245	79.9	0.2	345	94.0	1.	445	(128.)	2.			
250	80.5	0.2	350	95.	1.	450	(132.)	2.			
255	81.0	0.2	355	96.	1.	455	(137.)	2.			
260	81.6	0.2	360	97.	1.	460	(143.)	2.			
265	82.2	0.2	365	98.	1.	465	(153.)	5.			
270	82.8	0.2	370	99.	1.	470	(174.)	5.			

The following Sources give liquid density or liquid molar volume data for this compound. Those Sources used to derive the coefficients of the liquid density/molar volume equation are indicated by the temperature range (ambient 'A', low 'L', medium 'M', high 'H' or critical 'C') of their data. An asterisk (*) indicates that the Source is not a primary source of experimental data.

- 1 SIERSCH, A.; *Liebigs Ann.Chem.*, Vol.148, p.263, 1868.
- 2 BRUHL, J. W.; *J.Phys.Chem.Stoe.Verw.*, Vol.16, p.193, 1895.
- 3 JAEGER, -; *Z.Anorg.Allg.Chem.*, Vol.101, p.86, 1917.
- 4 HOUGH, E. W.; et al.; *J.Am.Chem.Soc.*, Vol.72, p.5775, 1950.
- 5 NORTON, D. G.; HAURY, V. E.; et al.; *J.Org.Chem.*, Vol.19, p.1054, 1954.
- 6 PLATE, -; et al.; *J.Gen.Chem.USSR*, Vol.26, p.785, 1956.
- 7 SHIRAI, M.; *Sci.Pap.Coll.Gen.Educ.Univ.Tokyo*, p.39, 1958.
- 8 SHIRAI, M.; *Bull.Chem.Soc.Japan*, Vol.29, p.518, 1956.
- 9 COSTELLO, J. M.; BOWDEN, S. T.; *Rec.Trav.Chim.*, Vol.78, p.391, 1959.
- 10 PADMINI, P. R. K. L.; et al.; *Trans.Faraday Soc.*, Vol.56, p.1404, 1960.
- 11 TALALSEK, -; *Coll.Czech.Chem.Comm.*, Vol.33, p.731, 1968.
- 12 UNION CARBIDE CORP., *Chemicals & Plastics Phys.Prop. (Product Bull.)*, 1968.
- 13 KOMAROV, V. M.; KRICHEVTSOV, B. K.; *J.Appl.Chem.*, Vol.42, p.2624, 1969.
- 14 SOMAYAJULU, G. R.; *J.Chem.Eng.Data*, Vol.34, p.106, 1989.*
- 15 CHAO, J.; GADALLA, N.A.M.; et al.; *J.Phys.Chem.Ref.Data*, Vol.19, p.1547, 1990.* L M H C
- 16 AMBROSE, D.; in *Hndbk.Chem.Phys.*, CRC Press, 72nd.ed., pp.6-49 to 6-63, 1991.*
- 17 TRC Thermodynamic Tables, Texas A & M Univ., Loose leaf data sheets extant 1996.*



97013

CH₃(CH₂)₃NH₂ 1-Butanamine; Butylamine; 1-AminobutaneC₄H₁₁N

CAS Reg. No. 109-73-9

Mol. Wt. 73.14

Orthobaric Liquid Density and Molar Volume $\ln(\rho/\rho_c) = -\ln(V/V_c) = N_1\tau + N_2\tau^2 + N_3\tau^3 + N_4\tau^4$ where ρ is the density, ρ_c is the critical density, V is the molar volume, V_c is the critical molar volume and $\tau = (1 - T/T_c)^{1/3}$, where T is the temperature and T_c is the critical temperature in kelvins.

Critical Temperature	T_c	= 531.9 K	(t_c	= 258.75 °C)
Critical Pressure	p_c	= 4250. kPa	(p_c	= 41.94 atm)
Critical Density	ρ_c	= 260. kg/m ³	(V_c	= 281.31 cm ³ /mol)
Critical Compression Factor	Z_c	= 0.270		

$$N_1 = 1.75049 \quad N_2 = -0.61981 \quad N_3 = 0.00000 \quad N_4 = 0.20640$$

Density at 298.15 K (25 °C)	ρ_{25}	= 736.74 kg/m ³	(V_{25}	= 99.27 cm ³ /mol)
Normal Boiling Point	T_b	= 350.15 K	(t_b	= 77. °C)
Melting Point	T_m	= 224.	(t_m	= -49. °C)

Data at Specified Temperatures

$t/^\circ\text{C}$	-49	0	25	77	100	200	258.75
T/K	224.15	273.15	298.15	350.15	373.15	473.15	531.90
$\rho/(\text{kg/m}^3)$	803.09	759.75	736.74	685.98	661.73	527.85	260.00
$(d\rho/dT)/(\text{kg/m}^3 \text{ K})$	-0.87	-0.91	-0.94	-1.03	-1.09	-1.79	$-\infty$
$V/(\text{cm}^3/\text{mol})$	91.07	96.27	99.27	106.62	110.53	138.56	281.31
$(dV/dT)/(\text{cm}^3/\text{mol K})$	0.10	0.11	0.13	0.16	0.18	0.47	∞
Data Quality	B	B	B	B	B	B	B
Uncertainty in ρ (kg/m ³)	5.	5.	5.	2.	2.	5.	10.
Uncertainty in V (cm ³ /mol)	0.5	0.5	0.5	0.2	0.2	1.	10.

Orthobaric Liquid Density of 1-ButanamineUnits: kg/m³ v. °C

t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.
$^\circ\text{C}$	kg/m ³	kg/m ³	$^\circ\text{C}$	kg/m ³	kg/m ³	$^\circ\text{C}$	kg/m ³	kg/m ³	$^\circ\text{C}$	kg/m ³	kg/m ³
-45	800.	5.	50	713.	2.	150	603.	2.	250	390.	10.
-40	795.	5.	55	708.	2.	155	596.	2.	255	356.	10.
-35	791.	5.	60	703.	2.	160	590.	2.			
-30	787.	5.	65	698.	2.	165	583.	5.			
			70	693.	2.	170	576.	5.			
-25	782.	5.	75	688.	2.	175	568.	5.			
-20	778.	5.	80	683.	2.	180	561.	5.			
-15	773.	5.	85	678.	2.	185	553.	5.			
-10	769.	5.	90	672.	2.	190	545.	5.			
-5	764.	5.	95	667.	2.	195	537.	5.			
0	760.	5.	100	662.	2.	200	528.	5.			
5	755.	5.	105	656.	2.	205	519.	5.			
10	751.	5.	110	651.	2.	210	509.	5.			
15	746.	5.	115	645.	2.	215	499.	5.			
20	741.	5.	120	639.	2.	220	488.	5.			
25	737.	5.	125	634.	2.	225	476.	5.			
30	732.	5.	130	628.	2.	230	463.	5.			
35	727.	5.	135	622.	2.	235	449.	10.			
40	723.	5.	140	616.	2.	240	433.	10.			
45	718.	5.	145	609.	2.	245	414.	10.			

JUNE 1997



Orthobaric Liquid Molar Volume of 1-Butanamine

Units: cm^3/mol v. K

T K	V cm^3/mol	Uncert. in V cm^3/mol	T K	V cm^3/mol	Uncert. in V cm^3/mol	T K	V cm^3/mol	Uncert. in V cm^3/mol	T K	V cm^3/mol	Uncert. in V cm^3/mol
225	91.2	0.5	325	102.9	0.5	425	121.8	0.5	525	193.	5.
230	91.7	0.5	330	103.6	0.5	430	123.2	0.5	530	218.	5.
235	92.2	0.5	335	104.3	0.5	435	124.6	0.5			
240	92.7	0.5	340	105.0	0.5	440	126.1	1.			
245	93.2	0.5	345	105.8	0.2	445	127.7	1.			
250	93.7	0.5	350	106.6	0.2	450	129.3	1.			
255	94.2	0.5	355	107.4	0.2	455	131.1	1.			
260	94.8	0.5	360	108.2	0.2	460	133.	1.			
265	95.3	0.5	365	109.1	0.2	465	135.	1.			
270	95.9	0.5	370	110.0	0.2	470	137.	1.			
275	96.5	0.5	375	110.9	0.2	475	139.	1.			
280	97.1	0.5	380	111.8	0.5	480	142.	1.			
285	97.7	0.5	385	112.8	0.5	485	145.	2.			
290	98.3	0.5	390	113.7	0.5	490	148.	2.			
295	98.9	0.5	395	114.8	0.5	495	151.	2.			
300	99.5	0.5	400	115.8	0.5	500	155.	2.			
305	100.1	0.5	405	116.9	0.5	505	160.	2.			
310	100.8	0.5	410	118.1	0.5	510	165.	2.			
315	101.5	0.5	415	119.3	0.5	515	172.	2.			
320	102.2	0.5	420	120.5	0.5	520	180.	5.			

The following Sources give liquid density or liquid molar volume data for this compound. Those Sources used to derive the coefficients of the liquid density/molar volume equation are indicated by the temperature range (ambient 'A', low 'L', medium 'M', high 'H' or critical 'C') of their data. An asterisk (*) indicates that the Source is not a primary source of experimental data.

- | | | | | |
|----|--|--|------------------------------|----------|
| 1 | FRIEND, J. N.; HARGREAVES, W. D.; | <i>Phil.Mag.</i> , | Vol.35, p.57, 1944. | |
| 2 | VOGEL, A. I.; | <i>J.Chem.Soc.</i> , | p.1820, 1948. | |
| 3 | COSTELLO, J. M.; BOWDEN, S. T.; | <i>Rec.Trav.Chim.</i> , | Vol.78, p.391, 1959. | M |
| 4 | ZHIGUNOV, I. S.; AMPELOGOVA, N. I.; | <i>Fiz.Khim.Rastvorov</i> , | p.181, 1972. | |
| 5 | DUTTA-CHOUDHURY, M. K.; MATHUR, H. B.; | <i>J.Chem.Eng.Data</i> , | Vol.19, p.145, 1974. | |
| 6 | DUTTA-CHOUDHURY, M. K.; MATHUR, H. B.; | <i>Indian J.Chem.A</i> , | Vol.14, p.371, 1976. | |
| 7 | RATKOVICS, F.; SALAMON, T.; | <i>Magy.Kem.Foly.</i> , | Vol.83, p.112, 1977. | |
| 8 | PATIL, K. J.; | <i>Indian J.Pure Appl.Phys.</i> , | Vol.16, p.608, 1978. | |
| 9 | SREENIVASULU, M.; NAIDU, P. R.; | <i>J.Chem.Thermodynamics</i> , | Vol.10, p.1019, 1978. | |
| 10 | KRISHNAIAH, A.; et al.; | <i>Can.J.Chem.</i> , | Vol.57, p.1915, 1979. | |
| 11 | SREENIVASULU, M.; NAIDU, P. R.; | <i>Aust.J.Chem.</i> , | Vol.32, p.471, 1979. | |
| 12 | SREENIVASULU, M.; NAIDU, P. R.; | <i>Aust.J.Chem.</i> , | Vol.32, p.1649, 1979. | |
| 13 | KRISHNAIAH, A.; et al.; | <i>Acta Chim.Acad.Sci.Hung.</i> , | Vol.104, p.295, 1980. | |
| 14 | TOCZYLIKIN, L. S.; YOUNG, C. L.; | <i>J.Chem.Thermodyn.</i> , | Vol.12, p.365, 1980. | |
| 15 | PFESTORF, R.; et al.; | <i>Z.Phys.Chem.(Leipzig)</i> , | Vol.263, p.233, 1982. | |
| 16 | KACZMAREK, B.; | <i>Pol.J.Chem.</i> , | Vol.57, p.617, 1983. | |
| 17 | CHANDRASEKHAR, A.; et al.; | <i>Pol.J.Chem.</i> , | Vol.61, p.839, 1987. | |
| 18 | ACEVEDO, I. L.; KATZ, M.; | <i>J.Solution Chem.</i> , | Vol.19, p.1041, 1990. | M |
| 19 | De SCHAEFER, C. R.; et al.; | <i>J.Solution Chem.</i> , | Vol.19, p.289, 1990. | M |
| 20 | DAS, A.; FRENKEL, M.; et al.; | <i>J.Phys.Chem.Ref.Data</i> , | Vol.22, p.659, 1993.* | |
| 21 | PAPAIOANNOU, D.; et al.; | <i>J.Chem.Eng.Data</i> , | Vol.38, p.370, 1993. | |
| 22 | OSWAL, S. L.; PATEL, S. G.; | <i>J.Chem.Soc.Faraday Trans.</i> , | Vol.90, p.1083, 1994. | |
| 23 | OSWAL, S.; PATEL, A. T.; | <i>J.Chem.Eng.Data</i> , | Vol.40, p.194, 1995. | |
| 24 | TRC Thermodynamic Tables, | Texas A & M Univ., Loose leaf data sheets extant | 1996.* | |



97013

CH₃CH₂CH(NH₂)CH₃ 2-Butanamine; *sec*-Butylamine; 2-Aminobutane"C₄H₁₁N

CAS Reg. No. 13952-84-6

Mol. Wt. 73.14

Orthobaric Liquid Density and Molar Volume $\ln(\rho/\rho_c) = -\ln(V/V_c) = N_1\tau + N_2\tau^2 + N_3\tau^3 + N_4\tau^4$

where ρ is the density, ρ_c is the critical density, V is the molar volume, V_c is the critical molar volume and $\tau = (1 - T/T_c)^{1/3}$, where T is the temperature and T_c is the critical temperature in kelvins.

Critical Temperature	T_c	= 514.3 K	(t_c	= 241.15 °C)
Critical Pressure	p_c	= 4200. kPa	(p_c	= 41.45 atm)
Critical Density	ρ_c	= 263. kg/m ³	(V_c	= 278.10 cm ³ /mol)
Critical Compression Factor	Z_c	= 0.273		

$$N_1 = 1.76243 \quad N_2 = -0.90735 \quad N_3 = 0.59098 \quad N_4 = -0.16728$$

Density at 298.15 K (25 °C)	ρ_{25}	= 719.77 kg/m ³	(V_{25}	= 101.62 cm ³ /mol)
Normal Boiling Point	T_b	= 335.879 K	(t_b	= 62.729 °C)
Melting Point	T_m	= 169.	(t_m	= -104. °C)

Data at Specified Temperatures

$t/^\circ\text{C}$	-104	0	25	62.73	100	200	241.15
T/K	169.15	273.15	298.15	335.88	373.15	473.15	514.30
$\rho/(\text{kg/m}^3)$	(827.16)	742.41	719.77	(683.21)	(643.33)	(495.04)	(263.00)
$(d\rho/dT)/(\text{kg/m}^3 \text{ K})$	(-0.76)	-0.88	-0.93	(-1.01)	(-1.13)	(-2.17)	$-\infty$
$V/(\text{cm}^3/\text{mol})$	(88.42)	98.52	101.62	(107.05)	(113.69)	(147.75)	(278.10)
$(dV/dT)/(\text{cm}^3/\text{mol K})$	(0.08)	0.12	0.13	(0.16)	(0.20)	(0.65)	∞
Data Quality	(B)	B	B	(B)	(B)	(B)	(B)
Uncertainty in ρ (kg/m ³)	(1.)	1.	1.	(2.)	(2.)	(5.)	(5.)
Uncertainty in V (cm ³ /mol)	(0.1)	0.1	0.1	(0.2)	(0.5)	(1.)	(5.)

Orthobaric Liquid Density of 2-ButanamineUnits: kg/m³ v. °C

t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.
$^\circ\text{C}$	kg/m ³	kg/m ³	$^\circ\text{C}$	kg/m ³	kg/m ³	$^\circ\text{C}$	kg/m ³	kg/m ³	$^\circ\text{C}$	kg/m ³	kg/m ³
-100	(824.)	1.	0	742.	1.	100	(643.)	2.	200	(495.)	5.
-95	(820.)	1.	5	738.	1.	105	(638.)	2.	205	(484.)	5.
-90	(816.)	1.	10	733.	1.	110	(632.)	2.	210	(472.)	5.
-85	(813.)	1.	15	729.	1.	115	(626.)	2.	215	(458.)	5.
-80	(809.)	1.	20	724.	1.	120	(620.)	2.	220	(443.)	5.
-75	(805.)	1.	25	720.	1.	125	(614.)	2.	225	(426.)	5.
-70	(801.)	1.	30	715.	1.	130	(607.)	2.	230	(405.)	5.
-65	(797.)	1.	35	710.	1.	135	(601.)	2.	235	(378.)	5.
-60	(793.)	1.	40	706.	1.	140	(594.)	2.	240	(326.)	5.
-55	(789.)	1.	45	(701.)	1.	145	(587.)	2.			
-50	(785.)	1.	50	(696.)	2.	150	(581.)	2.			
-45	(781.)	1.	55	(691.)	2.	155	(573.)	5.			
-40	(777.)	1.	60	(686.)	2.	160	(566.)	5.			
-35	(772.)	1.	65	(681.)	2.	165	(558.)	5.			
-30	(768.)	1.	70	(676.)	2.	170	(550.)	5.			
-25	(764.)	1.	75	(671.)	2.	175	(542.)	5.			
-20	(760.)	1.	80	(665.)	2.	180	(534.)	5.			
-15	(755.)	1.	85	(660.)	2.	185	(525.)	5.			
-10	(751.)	1.	90	(654.)	2.	190	(515.)	5.			
-5	(747.)	1.	95	(649.)	2.	195	(506.)	5.			

JUNE 1997



Documents

Document Sharing Hub



Orthobaric Liquid Molar Volume of 2-Butanamine

Units: cm^3/mol v. K

T K	V cm^3/mol	Uncert. in V cm^3/mol	T K	V cm^3/mol	Uncert. in V cm^3/mol	T K	V cm^3/mol	Uncert. in V cm^3/mol	T K	V cm^3/mol	Uncert. in V cm^3/mol
			250	(95.9)	0.1	350	(109.4)	0.5	450	(135.7)	1.
			255	(96.5)	0.1	355	(110.3)	0.5	455	(137.9)	1.
			260	(97.0)	0.1	360	(111.2)	0.5	460	(140.)	1.
			265	(97.6)	0.1	365	(112.1)	0.5	465	(143.)	1.
170	(88.5)	0.1	270	(98.2)	0.1	370	(113.1)	0.5	470	(146.)	1.
175	(88.9)	0.1	275	98.7	0.1	375	(114.1)	0.5	475	(149.)	1.
180	(89.3)	0.1	280	99.3	0.1	380	(115.1)	0.5	480	(153.)	1.
185	(89.7)	0.1	285	99.9	0.1	385	(116.2)	0.5	485	(157.)	1.
190	(90.2)	0.1	290	100.6	0.1	390	(117.3)	0.5	490	(161.)	2.
195	(90.6)	0.1	295	101.2	0.1	395	(118.4)	0.5	495	(167.)	2.
200	(91.0)	0.1	300	101.9	0.1	400	(119.6)	0.5	500	(175.)	2.
205	(91.5)	0.1	305	102.5	0.2	405	(120.9)	0.5	505	(185.)	2.
210	(92.0)	0.1	310	103.2	0.2	410	(122.2)	0.5	510	(201.)	2.
215	(92.4)	0.1	315	(103.9)	0.2	415	(123.6)	0.5			
220	(92.9)	0.1	320	(104.6)	0.2	420	(125.0)	0.5			
225	(93.4)	0.1	325	(105.4)	0.2	425	(126.6)	1.			
230	(93.9)	0.1	330	(106.1)	0.2	430	(128.2)	1.			
235	(94.4)	0.1	335	(106.9)	0.2	435	(129.9)	1.			
240	(94.9)	0.1	340	(107.7)	0.2	440	(131.7)	1.			
245	(95.4)	0.1	345	(108.5)	0.5	445	(133.6)	1.			

The following Sources give liquid density or liquid molar volume data for this compound. Those Sources used to derive the coefficients of the liquid density/molar volume equation are indicated by the temperature range (ambient 'A', low 'L', medium 'M', high 'H' or critical 'C') of their data. An asterisk (*) indicates that the Source is not a primary source of experimental data.

- | | | | |
|----|--------------------------------------|---|---------|
| 1 | BRUHL, J. W.; | <i>J.Phys.Chem.Stoe.Verw.</i> , Vol.16, p.193, 1895. | |
| 2 | Van ERP, -; | <i>Rec.Trav.Chim.</i> , Vol.14, p.15, 1895. | |
| 3 | GADEMER, -; | <i>Arch.Pharm.(Weinheim Ger.)</i> , Vol.237, p.99, 1889. | |
| 4 | MENSCHUTKIN, -; | <i>Zh.Russ.Fiz.-Khim.O-va</i> , Vol.29, p.454, 1897. | |
| 5 | THOME, L. G.; | <i>Chem.Ber.</i> , Vol.36, p.583, 1903. | |
| 6 | EYKMAN, J. F.; | <i>Nat.Verh.Holl.Maat.Wet.Haarlem</i> , Vol.8, p.438, 1919. | |
| 7 | LEITHE, -; | <i>Chem.Ber.</i> , Vol.63, p.804, 1930. | |
| 8 | NATTA, G.; | <i>Nature (London)</i> , Vol.126, p.387, 1930. | |
| 9 | BALDWIN, -; | <i>Proc.R.Soc.London A</i> , Vol.162, p.216, 1937. | |
| 10 | VOGEL, A. I.; | <i>J.Chem.Soc.</i> , p.1820, 1948. | |
| 11 | POPOV, -; | <i>Izv.Akad.Nauk USSR</i> , p.91, 1953. | |
| 12 | NORTON, D. G.; HAURY, V. E.; et al.; | <i>J.Org.Chem.</i> , Vol.19, p.1054, 1954. | |
| 13 | BRUCK, -; et al.; | <i>J.Chem.Soc.</i> , p.921, 1956. | |
| 14 | OGLOBLIN, K. A.; SAMARTSEV, M. A.; | <i>J.Gen.Chem.USSR</i> , Vol.30, p.820, 1960. | |
| 15 | SMITH, -; et al.; | <i>J.Org.Chem.</i> , Vol.29, p.2265, 1964. | |
| 16 | PATIL, K. J.; | <i>Indian J.Pure Appl.Phys.</i> , Vol.16, p.608, 1978. | |
| 17 | DAS,A.; FRENKEL,M.; et al.; | <i>J.Phys.Chem.Ref.Data</i> , Vol.22, p.659, 1993.* | L M H C |
| 18 | TRC Thermodynamic Tables, | Texas A & M Univ., Loose leaf data sheets extant | 1996.* |

(CH₃)₂CHCH₂NH₂ 2-Methyl-1-propanamine; Isobutylamine; 1-Amino-2-methylpropane C₄H₁₁N

CAS Reg. No. 78-81-9

Mol. Wt. 73.14

Orthobaric Liquid Density and Molar Volume $\ln(\rho/\rho_c) = -\ln(V/V_c) = N_1\tau + N_2\tau^2 + N_3\tau^3 + N_4\tau^4$ where ρ is the density, ρ_c is the critical density, V is the molar volume, V_c is the critical molar volume and $\tau = (1-T/T_c)^{1/3}$, where T is the temperature and T_c is the critical temperature in kelvins.

Critical Temperature	T_c	= 519. K	(t_c	= 245.85 °C)
Critical Pressure	p_c	= 4070. kPa	(p_c	= 40.17 atm)
Critical Density	ρ_c	= 261. kg/m ³	(V_c	= 280.23 cm ³ /mol)
Critical Compression Factor	Z_c	= 0.264		

$$N_1 = 2.00640 \quad N_2 = -1.46738 \quad N_3 = 0.91269 \quad N_4 = -0.12768$$

Density at 298.15 K (25 °C)	ρ_{25}	= 728.51 kg/m ³	(V_{25}	= 100.40 cm ³ /mol)
Normal Boiling Point	T_b	= 340.7 K	(t_b	= 67.550 °C)
Melting Point	T_m	= 186.	(t_m	= -87. °C)

Data at Specified Temperatures

$t/^\circ\text{C}$	-87	0	25	67.55	100	200	245.85
T/K	186.15	273.15	298.15	340.70	373.15	473.15	519.00
$\rho/(\text{kg/m}^3)$	(827.36)	751.51	728.51	687.32	653.38	(514.22)	(261.00)
$(d\rho/dT)/(\text{kg/m}^3 \text{ K})$	(-0.85)	-0.91	-0.94	-1.01	-1.09	(-1.99)	$-\infty$
$V/(\text{cm}^3/\text{mol})$	(88.40)	97.32	100.40	106.41	111.94	(142.23)	(280.23)
$(dV/dT)/(\text{cm}^3/\text{mol K})$	(0.09)	0.12	0.13	0.16	0.19	(0.55)	∞
Data Quality	(B)	B	B	B	B	(B)	(B)
Uncertainty in ρ (kg/m ³)	(1.)	1.	1.	2.	2.	(5.)	(5.)
Uncertainty in V (cm ³ /mol)	(0.1)	0.1	0.1	0.2	0.5	(1.)	(5.)

Orthobaric Liquid Density of 2-Methyl-1-propanamineUnits: kg/m³ v. °C

t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.
$^\circ\text{C}$	kg/m ³	kg/m ³	$^\circ\text{C}$	kg/m ³	kg/m ³	$^\circ\text{C}$	kg/m ³	kg/m ³	$^\circ\text{C}$	kg/m ³	kg/m ³
			0	752.	1.	100	653.	2.	200	(514.)	5.
			5	747.	1.	105	648.	2.	205	(504.)	5.
			10	742.	1.	110	642.	2.	210	(493.)	5.
-85	(826.)	1.	15	738.	1.	115	637.	2.	215	(481.)	5.
-80	(821.)	1.	20	733.	1.	120	631.	2.	220	(467.)	5.
-75	(817.)	1.	25	729.	1.	125	625.	2.	225	(452.)	5.
-70	(813.)	1.	30	724.	1.	130	619.	2.	230	(435.)	5.
-65	(809.)	1.	35	719.	1.	135	613.	2.	235	(413.)	5.
-60	804.	1.	40	714.	1.	140	607.	2.	240	(384.)	5.
-55	800.	1.	45	710.	1.	145	600.	2.	245	(324.)	5.
-50	796.	1.	50	705.	2.	150	594.	2.			
-45	791.	1.	55	700.	2.	155	587.	5.			
-40	787.	1.	60	695.	2.	160	(580.)	5.			
-35	783.	1.	65	690.	2.	165	(573.)	5.			
-30	778.	1.	70	685.	2.	170	(566.)	5.			
-25	774.	1.	75	680.	2.	175	(558.)	5.			
-20	769.	1.	80	675.	2.	180	(550.)	5.			
-15	765.	1.	85	669.	2.	185	(542.)	5.			
-10	761.	1.	90	664.	2.	190	(533.)	5.			
-5	756.	1.	95	659.	2.	195	(524.)	5.			



Orthobaric Liquid Molar Volume of 2-Methyl-1-propanamine

Units: $\text{cm}^3/\text{mol v. K}$

T - K	V ----- cm^3/mol	Uncert. in V	T -	V -----	Uncert. in V	T -	V -----	Uncert. in V	T -	V -----	Uncert. in V
190	(88.8)	0.1	275	97.5	0.1	375	112.3	0.5	475	(143.)	1.
195	(89.2)	0.1	280	98.1	0.1	380	113.3	0.5	480	(146.)	1.
			285	98.7	0.1	385	114.2	0.5	485	(150.)	1.
			290	99.4	0.1	390	115.3	0.5	490	(154.)	1.
			295	100.0	0.1	395	116.3	0.5	495	(158.)	2.
200	(89.7)	0.1	300	100.6	0.1	400	117.4	0.5	500	(164.)	2.
205	(90.1)	0.1	305	101.3	0.2	405	118.6	0.5	505	(171.)	2.
210	(90.6)	0.1	310	102.0	0.2	410	119.8	0.5	510	(181.)	2.
215	91.1	0.1	315	102.6	0.2	415	121.0	0.5	515	(198.)	2.
220	91.6	0.1	320	103.3	0.2	420	122.3	0.5			
225	92.1	0.1	325	104.1	0.2	425	123.7	0.5			
230	92.6	0.1	330	104.8	0.2	430	125.1	1.			
235	93.1	0.1	335	105.5	0.2	435	(126.7)	1.			
240	93.6	0.1	340	106.3	0.2	440	(128.3)	1.			
245	94.2	0.1	345	107.1	0.2	445	(130.0)	1.			
250	94.7	0.1	350	107.9	0.5	450	(131.8)	1.			
255	95.3	0.1	355	108.7	0.5	455	(133.7)	1.			
260	95.8	0.1	360	109.6	0.5	460	(135.8)	1.			
265	96.4	0.1	365	110.5	0.5	465	(138.)	1.			
270	97.0	0.1	370	111.4	0.5	470	(141.)	1.			

The following Sources give liquid density or liquid molar volume data for this compound. Those Sources used to derive the coefficients of the liquid density/molar volume equation are indicated by the temperature range (ambient 'A', low 'L', medium 'M', high 'H' or critical 'C') of their data. An asterisk (*) indicates that the Source is not a primary source of experimental data.

- | | | | |
|----|----------------------------------|--|-------------------------------|
| 1 | SCHIFF, R.; | <i>Chem. Ber.</i> , | Vol.19, p.560, 1886. |
| 2 | GLADSTONE, J. H.; PERKIN, W. H.; | <i>J. Chem. Soc.</i> , | Vol.55, p.680, 1889. |
| 3 | PERKIN, W. H.; | <i>J. Chem. Soc.</i> , | Vol.55, p.680, 1889. |
| 4 | BRUHL, J. W.; | <i>J. Phys. Chem. Stoe. Verw.</i> , | Vol.16, p.193, 1895. |
| 5 | Van ERP, -; | <i>Rec. Trav. Chim.</i> , | Vol.14, p.15, 1895. |
| 6 | JAEGER, -; | <i>Z. Anorg. Allg. Chem.</i> , | Vol.101, p.86, 1917. |
| 7 | EYKMAN, J. F.; | <i>Nat. Verh. Holl. Maat. Wet. Haarlem</i> , | Vol.8, p.438, 1919. |
| 8 | VOGEL, A. I.; | <i>J. Chem. Soc.</i> , | p.1820, 1948. |
| 9 | COSTELLO, J. M.; BOWDEN, S. T.; | <i>Rec. Trav. Chim.</i> , | Vol.78, p.391, 1959. |
| 10 | GOOD, W. D.; MOORE, R. T.; | <i>J. Chem. Eng. Data</i> , | Vol.15, p.150, 1970. |
| 11 | PATIL, K. J.; | <i>Indian J. Pure Appl. Phys.</i> , | Vol.16, p.608, 1978. |
| 12 | KACZMAREK, B.; | <i>Pol. J. Chem.</i> , | Vol.57, p.617, 1983. |
| 13 | DAS, A.; FRENKEL, M.; et al.; | <i>J. Phys. Chem. Ref. Data</i> , | Vol.22, p.659, 1993.* L M H C |
| 14 | TRC Thermodynamic Tables, | Texas A & M Univ., Loose leaf data sheets extant | 1996.* |



97013

(CH₃)₃CNH₂ 2-Methyl-2-propanamine; *tert*-Butylamine; 2-Amino-2-methylpropane C₄H₁₁N

CAS Reg. No. 75-64-9

Mol. Wt. 73.14

Orthobaric Liquid Density and Molar Volume $\ln(\rho/\rho_c) = -\ln(V/V_c) = N_1\tau + N_2\tau^2 + N_3\tau^3 + N_4\tau^4$ where ρ is the density, ρ_c is the critical density, V is the molar volume, V_c is the critical molar volume and $\tau = (1-T/T_c)^{1/3}$, where T is the temperature and T_c is the critical temperature in kelvins.

Critical Temperature	T_c	= 483.9 K	(t_c	= 210.75 °C)
Critical Pressure	p_c	= 3840. kPa	(p_c	= 37.90 atm)
Critical Density	ρ_c	= 254. kg/m ³	(V_c	= 287.95 cm ³ /mol)
Critical Compression Factor	Z_c	= 0.275		

$$N_1 = 1.63563 \quad N_2 = -0.47289 \quad N_3 = 0.13103 \quad N_4 = 0.03520$$

Density at 298.15 K (25 °C)	ρ_{25}	= 689.79 kg/m ³	(V_{25}	= 106.03 cm ³ /mol)
Normal Boiling Point	T_b	= 317.189 K	(t_b	= 44.039 °C)
Melting Point	T_m	= 206.	(t_m	= -67. °C)

Data at Specified Temperatures

$t/^\circ\text{C}$	-67	0	25	44.04	100	150	210.75
T/K	206.15	273.15	298.15	317.19	373.15	423.15	483.90
$\rho/(\text{kg/m}^3)$	(782.14)	716.32	689.79	(668.61)	(599.33)	(521.35)	(254.00)
$(d\rho/dT)/(\text{kg/m}^3 \text{ K})$	(-0.94)	-1.04	-1.09	(-1.14)	(-1.36)	(-1.83)	$-\infty$
$V/(\text{cm}^3/\text{mol})$	(93.51)	102.11	106.03	(109.39)	(122.04)	(140.29)	(287.95)
$(dV/dT)/(\text{cm}^3/\text{mol K})$	(0.11)	0.15	0.17	(0.19)	(0.28)	(0.49)	∞
Data Quality	(B)	B	B	(B)	(B)	(B)	(B)
Uncertainty in ρ (kg/m ³)	(1.)	1.	1.	(2.)	(2.)	(5.)	(5.)
Uncertainty in V (cm ³ /mol)	(0.1)	0.1	0.2	(0.2)	(0.5)	(1.)	(5.)

Orthobaric Liquid Density of 2-Methyl-2-propanamineUnits: kg/m³ v. °C

t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.
°C	kg/m ³	kg/m ³	°C	kg/m ³	kg/m ³	°C	kg/m ³	kg/m ³	°C	kg/m ³	kg/m ³
-65	(780.)	1.	25	690.	1.	125	(563.)	2.			
-60	(776.)	1.	30	684.	1.	130	(555.)	5.			
-55	(771.)	1.	35	679.	1.	135	(547.)	5.			
			40	(673.)	2.	140	(539.)	5.			
			45	(668.)	2.	145	(530.)	5.			
-50	(766.)	1.	50	(662.)	2.	150	(521.)	5.			
-45	(761.)	1.	55	(656.)	2.	155	(512.)	5.			
-40	(756.)	1.	60	(650.)	2.	160	(502.)	5.			
-35	(752.)	1.	65	(644.)	2.	165	(492.)	5.			
-30	(747.)	1.	70	(638.)	2.	170	(481.)	5.			
-25	(742.)	1.	75	(632.)	2.	175	(469.)	5.			
-20	(737.)	1.	80	(626.)	2.	180	(457.)	5.			
-15	(732.)	1.	85	(619.)	2.	185	(443.)	5.			
-10	(727.)	1.	90	(613.)	2.	190	(428.)	5.			
-5	(721.)	1.	95	(606.)	2.	195	(410.)	5.			
0	716.	1.	100	(599.)	2.	200	(389.)	5.			
5	711.	1.	105	(592.)	2.	205	(361.)	5.			
10	706.	1.	110	(585.)	2.	210	(305.)	5.			
15	701.	1.	115	(578.)	2.						
20	695.	1.	120	(571.)	2.						

JUNE 1997



Orthobaric Liquid Molar Volume of 2-Methyl-2-propanamine

Units: cm^3/mol v. K

T K	V cm^3/mol	Uncert. in V cm^3/mol	T K	V cm^3/mol	Uncert. in V cm^3/mol	T K	V cm^3/mol	Uncert. in V cm^3/mol	T K	V cm^3/mol	Uncert. in V cm^3/mol
			300	106.3	0.2	400	(130.5)	1.			
			305	107.2	0.2	405	(132.4)	1.			
210	(93.9)	0.1	310	108.1	0.2	410	(134.4)	1.			
215	(94.5)	0.1	315	(109.0)	0.2	415	(136.5)	1.			
220	(95.1)	0.1	320	(109.9)	0.2	420	(139.)	1.			
225	(95.7)	0.1	325	(110.9)	0.5	425	(141.)	1.			
230	(96.3)	0.1	330	(111.9)	0.5	430	(144.)	1.			
235	(96.9)	0.1	335	(112.9)	0.5	435	(147.)	1.			
240	(97.6)	0.1	340	(114.0)	0.5	440	(150.)	1.			
245	(98.2)	0.1	345	(115.0)	0.5	445	(153.)	1.			
250	(98.9)	0.1	350	(116.2)	0.5	450	(157.)	1.			
255	(99.5)	0.1	355	(117.4)	0.5	455	(162.)	2.			
260	(100.2)	0.1	360	(118.6)	0.5	460	(167.)	2.			
265	(100.9)	0.1	365	(119.8)	0.5	465	(174.)	2.			
270	(101.6)	0.1	370	(121.2)	0.5	470	(182.)	2.			
275	102.4	0.1	375	(122.6)	0.5	475	(193.)	2.			
280	103.1	0.1	380	(124.0)	0.5	480	(211.)	2.			
285	103.9	0.1	385	(125.5)	0.5						
290	104.7	0.1	390	(127.1)	0.5						
295	105.5	0.2	395	(128.8)	1.						

The following Sources give liquid density or liquid molar volume data for this compound. Those Sources used to derive the coefficients of the liquid density/molar volume equation are indicated by the temperature range (ambient 'A', low 'L', medium 'M', high 'H' or critical 'C') of their data. An asterisk (*) indicates that the Source is not a primary source of experimental data.

- | | |
|---------------------------------------|---|
| 1 LINNEMANN, -.; BRAUNER, -.; | <i>Liebigs Ann. Chem.</i> , Vol.192, p.72, 1878. |
| 2 RUDNEV, -.; | <i>Zh.Russ.Fiz.-Khim.O-va</i> , Vol.11, p.167, 1879. |
| 3 Van ERP, -.; | <i>Rec.Trav.Chim.</i> , Vol.14, p.15, 1895. |
| 4 BRUHL, J. W.; | <i>J.Phys.Chem.Leipzig.</i> , Vol.22, p.373, 1897. |
| 5 MENSCHUTKIN, -.; | <i>Zh.Russ.Fiz.-Khim.O-va</i> , Vol.29, p.455, 1897. |
| 6 JAEGER, -.; | <i>Z.Anorg.Allg.Chem.</i> , Vol.101, p.86, 1917. |
| 7 KARABINOS, -.; SERIJAN, -.; | <i>J.Am.Chem.Soc.</i> , Vol.67, p.1856, 1945. |
| 8 BROWN, R.; JONES, W. E.; | <i>J.Chem.Soc.</i> , p.781, 1946. |
| 9 FEW, A. V.; SMITH, J. W.; | <i>J.Chem.Soc.</i> , p.2663, 1949. |
| 10 HANSSON, -.; | <i>Sven.Kem.Tidskr.</i> , Vol.67, p.263, 1955. |
| 11 KRISHNAJI, -.; MANSINGH, A.; | <i>J.Chem.Phys.</i> , Vol.42, p.2503, 1965. |
| 12 KOBE, K. A.; MATTHEWS, J. F.; | <i>J.Chem.Eng.Data</i> , Vol.15, p.182, 1970. |
| 13 OTIN, S.; GRACIA, M.; LOSA, C. G.; | <i>J.Chim.Phys.</i> , Vol.10, p.1232, 1973. |
| 14 PATIL, K. J.; | <i>Indian J.Pure Appl.Phys.</i> , Vol.16, p.608, 1978. |
| 15 WHITMER, J. C.; CYVIN, S. J.; | <i>Naturforsch.,A</i> , Vol.33, p.45, 1978. |
| 16 AMBROSE, D.; | in <i>Hndbk.Chem.Phys.</i> , CRC Press, 72nd.ed., pp.6-49 to 6-63, 1991.* |
| 17 DAS,A.; FRENKEL,M.; et al.; | <i>J.Phys.Chem.Ref.Data</i> , Vol.22, p.659, 1993.* L M H C |
| 18 KIPKEMBOI, P. K.; EASTEAL, A. J.; | <i>Can.J.Chem.</i> , Vol.72, p.1937, 1994. |
| 19 TRC Thermodynamic Tables, | Texas A & M Univ., Loose leaf data sheets extant 1996.* |

CH₃(CH₂)₄NH₂ 1-Pentanamine; Pentylamine; Amylamine; 1-AminopentaneC₅H₁₃N

CAS Reg. No. 110-58-7

Mol. Wt. 87.17

Orthobaric Liquid Density and Molar Volume $\ln(\rho/\rho_c) = -\ln(V/V_c) = N_1 \tau + N_2 \tau^2 + N_3 \tau^3 + N_4 \tau^4$

where ρ is the density, ρ_c is the critical density, V is the molar volume, V_c is the critical molar volume and $\tau = (1 - T/T_c)^{1/3}$, where T is the temperature and T_c is the critical temperature in kelvins.

Critical Temperature	T_c	= 559. K	(t_c	= 285.85 °C)
Critical Pressure	p_c	= 3350. kPa	(p_c	= 33.06 atm)
Critical Density	ρ_c	= 251. kg/m ³	(V_c	= 347.29 cm ³ /mol)
Critical Compression Factor	Z_c	= 0.250		

$$N_1 = 1.97792 \quad N_2 = -0.92962 \quad N_3 = 0.00000 \quad N_4 = 0.33333$$

Density at 298.15 K (25 °C)	ρ_{25}	= 750.68 kg/m ³	(V_{25}	= 116.12 cm ³ /mol)
Normal Boiling Point	T_b	= 377.827 K	(t_b	= 104.677 °C)
Melting Point	T_m	= 230.	(t_m	= -43. °C)

Data at Specified Temperatures

$t/^\circ\text{C}$	-43	0	25	50	104.68	200	285.85
T/K	230.15	273.15	298.15	323.15	377.83	473.15	559.00
$\rho/(\text{kg/m}^3)$	807.87	771.99	750.68	728.86	678.35	(569.91)	(251.00)
$(d\rho/dT)/(\text{kg/m}^3 \text{ K})$	-0.83	-0.84	-0.86	-0.89	-0.97	(-1.41)	$-\infty$
$V/(\text{cm}^3/\text{mol})$	107.90	112.92	116.12	119.60	128.50	(152.95)	(347.29)
$(dV/dT)/(\text{cm}^3/\text{mol K})$	0.11	0.12	0.13	0.15	0.18	(0.38)	∞
Data Quality	B	B	B	B	B	(B)	(C)
Uncertainty in ρ (kg/m ³)	1.	1.	1.	2.	5.	(5.)	(10.)
Uncertainty in V (cm ³ /mol)	0.1	0.1	0.2	0.2	1.	(2.)	(20.)

Orthobaric Liquid Density of 1-PentanamineUnits: kg/m³ v. °C

t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.
$^\circ\text{C}$	kg/m ³	kg/m ³	$^\circ\text{C}$	kg/m ³	kg/m ³	$^\circ\text{C}$	kg/m ³	kg/m ³	$^\circ\text{C}$	kg/m ³	kg/m ³
-40	805.	1.	50	729.	2.	150	632.	5.	250	(481.)	10.
-35	801.	1.	55	724.	2.	155	626.	5.	255	(469.)	10.
-30	797.	1.	60	720.	2.	160	620.	5.	260	(455.)	10.
-25	793.	1.	65	715.	2.	165	615.	5.	265	(440.)	10.
-20	789.	1.	70	711.	2.	170	609.	5.	270	(422.)	10.
-15	785.	1.	75	706.	2.	175	603.	5.	275	(400.)	10.
-10	780.	1.	80	702.	2.	180	(596.)	5.	280	(370.)	10.
-5	776.	1.	85	697.	2.	185	(590.)	5.	285	(311.)	10.
0	772.	1.	90	692.	2.	190	(584.)	5.			
5	768.	1.	95	688.	5.	195	(577.)	5.			
10	764.	1.	100	683.	5.	200	(570.)	5.			
15	759.	1.	105	678.	5.	205	(563.)	5.			
20	755.	1.	110	673.	5.	210	(555.)	5.			
25	751.	1.	115	668.	5.	215	(548.)	10.			
30	746.	1.	120	663.	5.	220	(540.)	10.			
35	742.	1.	125	658.	5.	225	(531.)	10.			
40	738.	2.	130	653.	5.	230	(522.)	10.			
45	733.	2.	135	648.	5.	235	(513.)	10.			
			140	642.	5.	240	(503.)	10.			
			145	637.	5.	245	(493.)	10.			



Orthobaric Liquid Molar Volume of 1-Pentanamine

Units: cm^3/mol v. K

T K	V cm^3/mol	Uncert. in V cm^3/mol	T K	V cm^3/mol	Uncert. in V cm^3/mol	T K	V cm^3/mol	Uncert. in V cm^3/mol	T K	V cm^3/mol	Uncert. in V cm^3/mol
235	108.4	0.1	325	119.9	0.2	425	138.	1.	525	(183.)	5.
240	109.0	0.1	330	120.6	0.5	430	140.	1.	530	(188.)	5.
245	109.6	0.1	335	121.4	0.5	435	141.	1.	535	(194.)	5.
			340	122.1	0.5	440	142.	1.	540	(201.)	5.
			345	122.9	0.5	445	144.	1.	545	(210.)	5.
250	110.1	0.1	350	123.7	0.5	450	145.	1.	550	(223.)	5.
255	110.7	0.1	355	124.5	0.5	455	(147.)	2.	555	(245.)	5.
260	111.3	0.1	360	125.4	0.5	460	(148.)	2.			
265	111.9	0.1	365	126.2	0.5	465	(150.)	2.			
270	112.5	0.1	370	127.1	0.5	470	(152.)	2.			
275	113.1	0.1	375	128.0	0.5	475	(154.)	2.			
280	113.8	0.1	380	128.9	1.	480	(156.)	2.			
285	114.4	0.2	385	129.8	1.	485	(158.)	2.			
290	115.0	0.2	390	130.8	1.	490	(160.)	2.			
295	115.7	0.2	395	131.8	1.	495	(162.)	2.			
300	116.4	0.2	400	132.8	1.	500	(165.)	2.			
305	117.0	0.2	405	133.9	1.	505	(168.)	2.			
310	117.7	0.2	410	135.	1.	510	(171.)	2.			
315	118.4	0.2	415	136.	1.	515	(175.)	2.			
320	119.1	0.2	420	137.	1.	520	(178.)	2.			

The following Sources give liquid density or liquid molar volume data for this compound. Those Sources used to derive the coefficients of the liquid density/molar volume equation are indicated by the temperature range (ambient 'A', low 'L', medium 'M', high 'H' or critical 'C') of their data. An asterisk (*) indicates that the Source is not a primary source of experimental data.

- | | | | | |
|----|-------------------------------------|--|-----------------------|-----|
| 1 | WURTZ, A.; | <i>Ann.Chim.Phys.</i> , | Vol.30, p.491, 1850. | |
| 2 | SILVA, R. D.; | <i>Z.Chem.</i> , | Vol.1, p.457, 1867. | |
| 3 | SCHIFF, R.; | <i>Chem.Ber.</i> , | Vol.19, p.560, 1886. | |
| 4 | MENSCHUTKIN, -.; | <i>Zh.Russ.Fiz.-Khim.O-va</i> , | Vol.29, p.455, 1897. | |
| 5 | MARCKWALD, D. W.; | <i>Chem.Ber.</i> , | Vol.37, p.1038, 1904. | |
| 6 | VOGEL, A. I.; | <i>J.Chem.Soc.</i> , | p.1820, 1948. | |
| 7 | MUMFORD, S. A.; PHILLIPS, J. W. C.; | <i>J.Chem.Soc.</i> , | p.75, 1950. | |
| 8 | COSTELLO, J. M.; BOWDEN, S. T.; | <i>Rec.Trav.Chim.</i> , | Vol.78, p.391, 1959. | M H |
| 9 | KAGAN, -.; et al., | <i>Petrol.Chem.USSR</i> , | Vol.1, p.451, 1962. | |
| 10 | SACHARKIN, -.; et al., | <i>Bull.Acad.Sci.USSR, Chem.Sci.</i> , | p.521, 1964. | |
| 11 | EREMENKO, -.; | <i>Bull.Acad.Sci.USSR, Chem.Sci.</i> , | p.46, 1970. | |
| 12 | LETCHER, T. M.; | <i>J.Chem.Thermodynamics</i> , | Vol.4, p.551, 1972. | |
| 13 | ZHIGUNOV, I. S.; AMPELOGOVA, N. I.; | <i>Fiz.Khim.Rastvorov</i> , | p.181, 1972. | |
| 14 | BASHKIROV, -.; et al., | Soviet Patent SU 2078977, | 1976. | |
| 15 | KLIGER, -.; et al., | <i>Petrol.Chem.USSR</i> , | Vol.18, p.98, 1978. | |
| 16 | TRC Thermodynamic Tables, | Texas A & M Univ., Loose leaf data sheets extant | 1996.* | |



97013

CH₃(CH₂)₂CH(NH₂)CH₃ 2-Pentanamine; 1-Methylbutylamine; 2-Aminopentane**C₅H₁₃N**

CAS Reg. No. 625-30-9

Mol. Wt. 87.17

Orthobaric Liquid Density and Molar Volume $\ln(\rho/\rho_c) = -\ln(V/V_c) = N_1\tau + N_2\tau^2 + N_3\tau^3 + N_4\tau^4$ where ρ is the density, ρ_c is the critical density, V is the molar volume, V_c is the critical molar volume and $\tau = (1 - T/T_c)^{1/3}$, where T is the temperature and T_c is the critical temperature in kelvins.

Critical Temperature	T_c	= 539. K	(t_c	= 265.85 °C)
Critical Pressure	p_c	= 3700. kPa	(p_c	= 36.52 atm)
Critical Density	ρ_c	= 263. kg/m ³	(V_c	= 331.44 cm ³ /mol)
Critical Compression Factor	Z_c	= 0.274		

$$N_1 = 1.95156 \quad N_2 = -1.06336 \quad N_3 = 0.00000 \quad N_4 = 0.46150$$

Density at 298.15 K (25 °C)	ρ_{25}	= 735.31 kg/m ³	(V_{25}	= 118.55 cm ³ /mol)
Normal Boiling Point	T_b	= 363.15 K	(t_b	= 90. °C)
Melting Point	T_m	= -	(t_m	= -)

Data at Specified Temperatures

$t/^\circ\text{C}$	-75	0	25	50	90	200	265.85
T/K	198.15	273.15	298.15	323.15	363.15	473.15	539.00
$\rho/(\text{kg/m}^3)$	(824.13)	(757.57)	(735.31)	(712.75)	(675.43)	(548.22)	(263.00)
$(d\rho/dT)/(\text{kg/m}^3 \text{ K})$	(-0.89)	(-0.89)	(-0.90)	(-0.91)	(-0.96)	(-1.54)	$-\infty$
$V/(\text{cm}^3/\text{mol})$	(105.77)	(115.07)	(118.55)	(122.30)	(129.06)	(159.01)	(331.44)
$(dV/dT)/(\text{cm}^3/\text{mol K})$	(0.11)	(0.13)	(0.14)	(0.16)	(0.18)	(0.45)	∞
Data Quality	(B)	(B)	(B)	(B)	(B)	(B)	(C)
Uncertainty in ρ (kg/m ³)	(1.)	(1.)	(1.)	(2.)	(5.)	(5.)	(10.)
Uncertainty in V (cm ³ /mol)	(0.1)	(0.2)	(0.2)	(0.2)	(1.)	(2.)	(10.)

Orthobaric Liquid Density of 2-PentanamineUnits: kg/m³ v. °C

t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.
$^\circ\text{C}$	kg/m ³	kg/m ³	$^\circ\text{C}$	kg/m ³	kg/m ³	$^\circ\text{C}$	kg/m ³	kg/m ³	$^\circ\text{C}$	kg/m ³	kg/m ³
-75	(824.)	1.	25	(735.)	1.	125	(641.)	5.	225	(504.)	10.
-70	(820.)	1.	30	(731.)	1.	130	(635.)	5.	230	(493.)	10.
-65	(815.)	1.	35	(726.)	1.	135	(630.)	5.	235	(481.)	10.
-60	(811.)	1.	40	(722.)	2.	140	(625.)	5.	240	(468.)	10.
-55	(806.)	1.	45	(717.)	2.	145	(619.)	5.	245	(453.)	10.
-50	(802.)	1.	50	(713.)	2.	150	(613.)	5.	250	(436.)	10.
-45	(797.)	1.	55	(708.)	2.	155	(608.)	5.	255	(414.)	10.
-40	(793.)	1.	60	(704.)	2.	160	(602.)	5.	260	(385.)	10.
-35	(789.)	1.	65	(699.)	2.	165	(596.)	5.	265	(325.)	10.
-30	(784.)	1.	70	(694.)	2.	170	(590.)	5.			
-25	(780.)	1.	75	(690.)	2.	175	(583.)	5.			
-20	(775.)	1.	80	(685.)	2.	180	(577.)	5.			
-15	(771.)	1.	85	(680.)	5.	185	(570.)	5.			
-10	(766.)	1.	90	(675.)	5.	190	(563.)	5.			
-5	(762.)	1.	95	(671.)	5.	195	(556.)	5.			
0	(758.)	1.	100	(666.)	5.	200	(548.)	5.			
5	(753.)	1.	105	(661.)	5.	205	(540.)	5.			
10	(749.)	1.	110	(656.)	5.	210	(532.)	5.			
15	(744.)	1.	115	(651.)	5.	215	(523.)	10.			
20	740.	1.	120	(646.)	5.	220	(514.)	10.			

JUNE 1997