

95017

Issued July 1995

Orthobaric densities and molar volumes of liquids

Aliphatic and aromatic ethers

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ESDU DATA ITEM No. 95017

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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:

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KEEPING UP TO DATE

We are constantly striving to develop new work and review data already issued. Any comments arising out of your use of our data, or any suggestions for new topics or information that might lead to improvements, will help us to provide a better service.

(Continued on inside back cover)

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ORTHOBARIC DENSITIES AND MOLAR VOLUMES OF LIQUIDS ALIPHATIC AND AROMATIC ETHERS

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TABLE 1 Summary of constants in the liquid density equation

Compound tables for each compound are given on data sheets in the following order:-

1	C ₂ H ₆ O	Dimethyl ether	Methoxymethane	Oxybis-methane	5
2	C ₃ H ₈ O	Methyl ethyl ether	Methoxyethane		7
3	C ₄ H ₁₀ O	Methyl propyl ether	1-Methoxypropane		9
4	C ₄ H ₁₀ O	Methyl isopropyl ether	2-Methoxypropane		11
5	C ₄ H ₁₀ O	Diethyl ether	Ethoxyethane	1,1'-Oxybis-ethane	13
6	C ₅ H ₁₂ O	Methyl butyl ether	1-Methoxybutane		15
7	C ₅ H ₁₂ O	Methyl <i>sec</i> -butyl ether	2-Methoxybutane		17
8	C ₅ H ₁₂ O	Methyl isobutyl ether	1-Methoxy-2-methylpropane		19
9	C ₅ H ₁₂ O	Methyl <i>tert</i> -butyl ether	2-Methoxy-2-methylpropane	MtBE	21
10	C ₅ H ₁₂ O	Ethyl propyl ether	1-Ethoxypropane		23
11	C ₅ H ₁₂ O	Ethyl isopropyl ether	2-Ethoxypropane		25
12	C ₆ H ₁₄ O	Methyl pentyl ether	1-Methoxypentane		27
13	C ₆ H ₁₄ O	Methyl 1-methylbutyl ether	2-Methoxypentane		29
14	C ₆ H ₁₄ O	Methyl 2-methylbutyl ether	2-Methoxymethylbutane		31
15	C ₆ H ₁₄ O	Methyl isopentyl ether	1-Methoxy-3-methylbutane		33
	C ₆ H ₁₄ O	Methyl <i>tert</i> -pentyl ether (not issued)			
16	C ₆ H ₁₄ O	Ethyl butyl ether	1-Ethoxybutane		35
17	C ₆ H ₁₄ O	Ethyl <i>sec</i> -butyl ether	2-Ethoxybutane		37
18	C ₆ H ₁₄ O	Ethyl isobutyl ether	1-Ethoxy-2-methylpropane		39
19	C ₆ H ₁₄ O	Ethyl <i>tert</i> -butyl ether	2-Ethoxy-2-methylpropane		41
20	C ₆ H ₁₄ O	Dipropyl ether	1,1'-Oxybis-propane		43
21	C ₆ H ₁₄ O	Propyl isopropyl ether	2-Propoxypropane		45
22	C ₆ H ₁₄ O	Diisopropyl ether	2,2'-Oxybis-propane		47
23	C ₈ H ₁₈ O	Dibutyl ether	1,1'-Oxybis-butane		49
24	C ₈ H ₁₈ O	Di- <i>sec</i> -butyl ether	2,2'-Oxybis-butane		51
25	C ₈ H ₁₈ O	Diisobutyl ether	1,1'-Oxybis-(2-methylpropane)		53
26	C ₈ H ₁₈ O	Di- <i>tert</i> -butyl ether	2,2'-Oxybis-(2-methylpropane)		55

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27	C ₁₀ H ₂₂ O	Dipentyl ether	1,1'-Oxybis-pentane	57	
28	C ₁₀ H ₂₂ O	Diisopentyl ether	1,1'-Oxybis-(3-methylbutane)	59	
29	C ₁₁ H ₂₄ O	Methyl decyl ether	1-Methoxydecane	61	
30	C ₁₂ H ₂₆ O	Dihexyl ether	1,1'-Oxybis-hexane	63	
31	C ₁₄ H ₃₀ O	Diheptyl ether	1,1'-Oxybis-heptane	65	
32	C ₁₆ H ₃₄ O	Dioctyl ether	1,1-Oxybis-octane	67	
33	C ₇ H ₈ O	Methyl phenyl ether	Methoxybenzene	Anisole	69
34	C ₈ H ₁₀ O	Ethyl phenyl ether	Ethoxybenzene	Phenetole	71
35	C ₉ H ₁₂ O	Propyl phenyl ether	Propoxybenzene		73
36	C ₁₀ H ₁₄ O	Butyl phenyl ether	Butoxybenzene		75
	C ₁₂ H ₁₀ O	Diphenyl ether	See Item 94002		

ORTHOBARIC DENSITIES AND MOLAR VOLUMES OF LIQUIDS ALIPHATIC AND AROMATIC ETHERS

1. INTRODUCTION

This Data Item presents orthobaric densities and molar volumes of the aliphatic and aromatic ethers arranged in the order shown on the Contents page.

Table 1, page 5, 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 95016, 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
ρ	liquid density
q	$(1-T/T_c)^{1/3}$
T	kelvin temperature
t	Celsius temperature ($T-273.15$)
V	liquid molar volume

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

3. THE CRITICAL DENSITY

Critical densities, some with large uncertainties, have been reported for five of the compounds considered here. Estimates of the critical density of each compound were 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 critical temperature and critical pressure but neither represents experimental data over a wide range of temperature as satisfactorily as does the equation 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.

Both estimates of the critical density for the compounds were generally in good agreement and for many compounds there was no significant difference. The Rackett equation tended to give higher estimates than the Riedel equation as the carbon number increased. The mean of the two estimates gave the best fits to the data for the majority of compounds.

4. EVALUATION AND CORRELATION

With the exception of diethyl ether reliable data for the compounds considered are confined to medium reduced temperatures. The data for several compounds up to a carbon number of twelve were the most extensive and these were fitted and correlated in the same way as for the haloethanes, see Item 92009. The equation for hexadecane was included in the present correlation to ensure that it merged into the correlation for the alkanes.

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

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TABLE 1

Summary of Constants in the Liquid Density equation

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

Page	Name	T_c K	ρ_c kg/m ³	N_1	N_2	N_3	N_4
5	Dimethyl ether	400.	272.	1.71665	-0.59626	0	0.20321
7	Methyl ethyl ether	437.85	268.	1.74544	-0.61789	0	0.20797
9	Methyl propyl ether	476.25	264.	1.77738	-0.65585	0	0.22824
11	Methyl isopropyl ether	464.48	265.	1.76845	-0.65256	0	0.22999
13	Diethyl ether	466.65	262.	1.79013	-0.67667	0	0.24168
15	Methyl butyl ether	512.75	261.	1.77701	-0.62373	0	0.19467
17	Methyl <i>sec</i> -butyl ether	500.	264.	1.75129	-0.58318	0	0.16867
19	Methyl isobutyl ether	499.	262.	1.76202	-0.63061	0	0.21122
21	Methyl <i>tert</i> -butyl ether	497.1	266.	1.73995	-0.58636	0	0.17846
23	Ethyl propyl ether	500.4	259.	1.80223	-0.66602	0	0.22307
25	Ethyl isopropyl ether	486.	260.	1.80026	-0.69310	0	0.25252
27	Methyl pentyl ether	546.5	258.	1.82565	-0.70288	0	0.24693
29	Methyl 1-methylbutyl ether	535.	258.	1.81821	-0.68117	0	0.22880
31	Methyl 2-methylbutyl ether	534.	258.	1.80429	-0.66794	0	0.22378
33	Methyl isopentyl ether	532.	258.	1.79897	-0.63144	0	0.18841
	Methyl <i>tert</i> -pentyl ether (not issued)						
35	Ethyl butyl ether	533.	255.	1.83309	-0.69107	0	0.22964
37	Ethyl <i>sec</i> -butyl ether	520.	257.	1.82716	-0.70711	0	0.25056
39	Ethyl isobutyl ether	522.	257.	1.81635	-0.72291	0	0.27365
41	Ethyl <i>tert</i> -butyl ether	514.	261.	1.79399	-0.69248	0	0.25664
43	Dipropyl ether	530.6	256.	1.85122	-0.76085	0	0.29183
45	Propyl isopropyl ether	517.	256.	1.83945	-0.74498	0	0.28300
47	Diisopropyl ether	500.32	256.	1.77849	-0.62069	0	0.19077
49	Dibutyl ether	583.	249.	1.90700	-0.79522	0	0.29183
51	Di- <i>sec</i> -butyl ether	564.	255.	1.83420	-0.70250	0	0.24099
53	Diisobutyl ether	561.	250.	1.86069	-0.72391	0	0.24640
55	Di- <i>tert</i> -butyl ether	550.	260.	1.79186	-0.64148	0	0.203757
57	Dipentyl ether	628.	243.	1.97678	-0.87571	0	0.33056
59	Diisopentyl ether	616.	244.	1.95116	-0.84876	0	0.31910
61	Methyl decyl ether	660.	241.	2.03030	-0.95424	0	0.37730
63	Dihexyl ether	666.	237.	2.04623	-0.94144	0	0.35265
65	Diheptyl ether	699.	232.	2.10927	-1.02616	0	0.39943
67	Dioctyl ether	726.	227.	2.19312	-1.15687	0	0.48091
69	Methyl phenyl ether	645.6	321.	1.80989	-0.67328	0	0.22599
71	Ethyl phenyl ether	647.	304.	1.88843	-0.75915	0	0.26543
73	Propyl phenyl ether	670.	295.	1.89529	-0.76105	0	0.26295
75	Butyl phenyl ether	692.	287.	1.90802	-0.77518	0	0.26948

C₂H₆O Dimethyl ether; Methoxymethane; Oxybis-methane; 'Methyl ether'

CAS Reg. No. 115-10-6

Mol. Wt. 46.07

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

Critical Temperature	T_c	= 400. K	(t_c	= 126.85 °C)
Critical Pressure	p_c	= 5370. kPa	(p_c	= 53.00 atm)
Critical Density	ρ_c	= 272. kg/m ³	(V_c	= 169.38 cm ³ /mol)
Critical Compression Factor	Z_c	= 0.273		

$$N_1 = 1.71665 \quad N_2 = -0.59626 \quad N_3 = 0.00000 \quad N_4 = 0.20321$$

Density at 298.15 K (25 °C)	ρ_{25}	= 656.62 kg/m ³	(V_{25}	= 70.16 cm ³ /mol)
Normal Boiling Point	T_b	= 248.325 K	(t_b	= -24.825 °C)
Melting Point	T_m	= 132.	(t_m	= -141. °C)

Data at Specified Temperatures

$t/^\circ\text{C}$	-141	-24.83	0	25	50	100	126.85
T/K	132.15	248.32	273.15	298.15	323.15	373.15	400.00
$\rho/(\text{kg/m}^3)$	(871.59)	729.03	694.44	656.62	614.22	497.96	272.00
$(d\rho/dT)/(\text{kg/m}^3 \text{ K})$	(-1.16)	-1.35	-1.45	-1.59	-1.82	-3.23	$-\infty$
$V/(\text{cm}^3/\text{mol})$	(52.86)	63.19	66.34	70.16	75.01	92.52	169.38
$(dV/dT)/(\text{cm}^3/\text{mol K})$	(0.07)	0.12	0.14	0.17	0.22	0.60	∞
Data Quality	(C)	C	C	C	C	C	C
Uncertainty in ρ (kg/m ³)	(5.)	5.	5.	5.	5.	10.	20.
Uncertainty in V (cm ³ /mol)	(0.2)	0.5	0.5	0.5	0.5	2.	10.

Orthobaric Liquid Density of Dimethyl etherUnits: 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
-140	(870.)	5.	-75	793.	5.	0	694.	5.	75	564.	5.
-135	(865.)	5.	-70	787.	5.	5	687.	5.	80	553.	10.
-130	(859.)	5.	-65	781.	5.	10	680.	5.	85	540.	10.
			-60	775.	5.	15	672.	5.	90	527.	10.
			-55	768.	5.	20	664.	5.	95	513.	10.
-125	(853.)	5.									
-120	(847.)	5.	-50	762.	5.	25	657.	5.	100	498.	10.
-115	(841.)	5.	-45	756.	5.	30	649.	5.	105	481.	10.
-110	(835.)	5.	-40	749.	5.	35	640.	5.	110	461.	10.
-105	(829.)	5.	-35	743.	5.	40	632.	5.	115	438.	10.
			-30	736.	5.	45	623.	5.	120	407.	20.
-100	(824.)	5.									
-95	(818.)	5.	-25	729.	5.	50	614.	5.	125	356.	20.
-90	(812.)	5.	-20	722.	5.	55	605.	5.			
-85	(806.)	5.	-15	716.	5.	60	595.	5.			
-80	799.	5.	-10	709.	5.	65	585.	5.			
			-5	702.	5.	70	575.	5.			

Orthobaric Liquid Molar Volume of Dimethyl ether

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
135	(53.1)	0.2	200	58.2	0.5	275	66.6	0.5	350	82.	1.
140	(53.4)	0.2	205	58.7	0.5	280	67.3	0.5	355	84.	1.
145	(53.8)	0.2	210	59.2	0.5	285	68.1	0.5	360	86.	1.
			215	59.6	0.5	290	68.8	0.5	365	88.	2.
			220	60.1	0.5	295	69.6	0.5	370	91.	2.
150	(54.1)	0.2	225	60.6	0.5	300	70.5	0.5	375	94.	2.
155	(54.5)	0.2	230	61.2	0.5	305	71.4	0.5	380	97.	2.
160	(54.9)	0.2	235	61.7	0.5	310	72.3	0.5	385	102.	2.
165	(55.3)	0.2	240	62.2	0.5	315	73.3	0.5	390	108.	5.
170	(55.7)	0.2	245	62.8	0.5	320	74.3	0.5	395	117.	5.
175	(56.1)	0.2	250	63.4	0.5	325	75.4	0.5			
180	(56.5)	0.2	255	64.0	0.5	330	76.6	0.5			
185	(56.9)	0.5	260	64.6	0.5	335	77.9	1.			
190	(57.4)	0.5	265	65.2	0.5	340	79.2	1.			
195	57.8	0.5	270	65.9	0.5	345	80.7	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.

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- 16 TRC Thermodynamic Tables, Texas A & M Univ., Loose leaf data sheets extant 1994.*

C₃H₈O Methyl ethyl ether; Methoxyethane

CAS Reg. No. 540-67-0

Mol. Wt. 60.10

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

Critical Temperature	T_c	= 437.85 K	(t_c	= 164.7 °C)
Critical Pressure	p_c	= 4400. kPa	(p_c	= 43.42 atm)
Critical Density	ρ_c	= 268. kg/m ³	(V_c	= 224.25 cm ³ /mol)
Critical Compression Factor	Z_c	= 0.271		

$$N_1 = 1.74544 \quad N_2 = -0.61789 \quad N_3 = 0.00000 \quad N_4 = 0.20797$$

Density at 298.15 K (25 °C)	ρ_{25}	= 692.64 kg/m ³	(V_{25}	= 86.77 cm ³ /mol)
Normal Boiling Point	T_b	= 280.44 K	(t_b	= 7.290 °C)
Melting Point	T_m	= -	(t_m	= -)

Data at Specified Temperatures

$t/^\circ\text{C}$	-125	0	7.29	25	50	100	164.70
T/K	148.15	273.15	280.44	298.15	323.15	373.15	437.85
$\rho/(\text{kg/m}^3)$	(864.95)	724.48	715.40	692.64	658.33	576.69	268.00
$(d\rho/dT)/(\text{kg/m}^3 \text{ K})$	(-1.06)	-1.23	-1.26	-1.32	-1.44	-1.91	$-\infty$
$V/(\text{cm}^3/\text{mol})$	(69.48)	82.96	84.01	86.77	91.29	104.21	224.25
$(dV/dT)/(\text{cm}^3/\text{mol K})$	(0.08)	0.14	0.15	0.17	0.20	0.34	∞
Data Quality	(B)	B	B	B	C	C	C
Uncertainty in ρ (kg/m ³)	(2.)	2.	2.	2.	5.	10.	20.
Uncertainty in V (cm ³ /mol)	(0.2)	0.2	0.2	0.2	0.5	2.	20.

Orthobaric Liquid Density of Methyl ethyl etherUnits: kg/m³ v. °C

t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.
$^\circ\text{C}$	kg/m ³	in ρ	$^\circ\text{C}$	kg/m ³	in ρ	$^\circ\text{C}$	kg/m ³	in ρ	$^\circ\text{C}$	kg/m ³	in ρ
-125	(865.)	2.	-50	(783.)	2.	25	693.	2.	100	577.	10.
-120	(860.)	2.	-45	(778.)	2.	30	686.	2.	105	567.	10.
-115	(854.)	2.	-40	(772.)	2.	35	679.	2.	110	557.	10.
-110	(849.)	2.	-35	(766.)	2.	40	672.	2.	115	546.	10.
-105	(844.)	2.	-30	(760.)	2.	45	665.	5.	120	535.	10.
-100	(838.)	2.	-25	(755.)	2.	50	658.	5.	125	523.	10.
-95	(833.)	2.	-20	(749.)	2.	55	651.	5.	130	510.	10.
-90	(828.)	2.	-15	(743.)	2.	60	644.	5.	135	496.	10.
-85	(822.)	2.	-10	(737.)	2.	65	636.	5.	140	480.	20.
-80	(817.)	2.	-5	(731.)	2.	70	628.	5.	145	463.	20.
-75	(811.)	2.	0	724.	2.	75	620.	5.	150	442.	20.
-70	(806.)	2.	5	718.	2.	80	612.	10.	155	417.	20.
-65	(800.)	2.	10	712.	2.	85	604.	10.	160	382.	20.
-60	(795.)	2.	15	706.	2.	90	595.	10.			
-55	(789.)	2.	20	699.	2.	95	586.	10.			

Orthobaric Liquid Molar Volume of Methyl ethyl ether

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
150	(69.6)	0.2	225	(76.9)	0.2	300	87.1	0.2	375	105.	2.
155	(70.1)	0.2	230	(77.5)	0.2	305	87.9	0.2	380	107.	2.
160	(70.5)	0.2	235	(78.1)	0.2	310	88.8	0.5	385	109.	2.
165	(71.0)	0.2	240	(78.7)	0.2	315	89.7	0.5	390	111.	2.
170	(71.4)	0.2	245	(79.3)	0.2	320	90.7	0.5	395	113.	2.
175	(71.9)	0.2	250	(79.9)	0.2	325	91.7	0.5	400	116.	2.
180	(72.3)	0.2	255	(80.5)	0.2	330	92.7	1.	405	119.	2.
185	(72.8)	0.2	260	(81.2)	0.2	335	93.8	1.	410	123.	5.
190	(73.3)	0.2	265	(81.8)	0.2	340	94.9	1.	415	127.	5.
195	(73.8)	0.2	270	(82.5)	0.2	345	96.	1.	420	132.	5.
200	(74.3)	0.2	275	83.2	0.2	350	97.	1.	425	139.	5.
205	(74.8)	0.2	280	83.9	0.2	355	99.	1.	430	148.	5.
210	(75.3)	0.2	285	84.7	0.2	360	100.	1.	435	165.	10.
215	(75.8)	0.2	290	85.5	0.2	365	102.	2.			
220	(76.4)	0.2	295	86.3	0.2	370	103.	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.

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| 9 | TRC Thermodynamic Tables, | Texas A & M Univ., Loose leaf data sheets extant 1994.* | |

C₄H₁₀O Methyl propyl ether; 1-Methoxypropane

CAS Reg. No. 557-17-5

Mol. Wt. 74.12

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

Critical Temperature	T_c	= 476.25 K	(t_c	= 203.1 °C)
Critical Pressure	p_c	= 3800. kPa	(p_c	= 37.50 atm)
Critical Density	ρ_c	= 264. kg/m ³	(V_c	= 280.76 cm ³ /mol)
Critical Compression Factor	Z_c	= 0.269		

$$N_1 = 1.77738 \quad N_2 = -0.65585 \quad N_3 = 0.00000 \quad N_4 = 0.22824$$

Density at 298.15 K (25 °C)	ρ_{25}	= 718.77 kg/m ³	(V_{25}	= 103.12 cm ³ /mol)
Normal Boiling Point	T_b	= 311.702 K	(t_b	= 38.552 °C)
Melting Point	T_m	= -	(t_m	= -)

Data at Specified Temperatures

$t/^\circ\text{C}$	-125	0	25	38.55	100	150	203.10
T/K	148.15	273.15	298.15	311.70	373.15	423.15	476.25
$\rho/(\text{kg/m}^3)$	(873.94)	746.56	718.77	(703.13)	(624.14)	(540.09)	(264.00)
$(d\rho/dT)/(\text{kg/m}^3 \text{ K})$	(-0.98)	-1.09	-1.14	(-1.17)	(-1.44)	(-2.04)	$-\infty$
$V/(\text{cm}^3/\text{mol})$	(84.81)	99.28	103.12	(105.41)	(118.75)	(137.24)	(280.76)
$(dV/dT)/(\text{cm}^3/\text{mol K})$	(0.09)	0.14	0.16	(0.18)	(0.27)	(0.52)	∞
Data Quality	(B)	B	B	(B)	(B)	(B)	(C)
Uncertainty in ρ (kg/m ³)	(2.)	1.	1.	(1.)	(2.)	(5.)	(20.)
Uncertainty in V (cm ³ /mol)	(0.2)	0.1	0.1	(0.1)	(0.5)	(1.)	(20.)

Orthobaric Liquid Density of Methyl propyl etherUnits: kg/m³ v. °C

t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.
$^\circ\text{C}$	kg/m ³	in ρ	$^\circ\text{C}$	kg/m ³	in ρ	$^\circ\text{C}$	kg/m ³	in ρ	$^\circ\text{C}$	kg/m ³	in ρ
-125	(874.)	2.	-25	(773.)	1.	75	(658.)	2.	175	(480.)	10.
-120	(869.)	2.	-20	(768.)	1.	80	(652.)	2.	180	(464.)	10.
-115	(864.)	2.	-15	(763.)	1.	85	(645.)	2.	185	(447.)	10.
-110	(859.)	2.	-10	(757.)	1.	90	(638.)	2.	190	(426.)	10.
-105	(854.)	2.	-5	(752.)	1.	95	(631.)	2.	195	(400.)	20.
-100	(849.)	2.	0	747.	1.	100	(624.)	2.	200	(360.)	20.
-95	(844.)	2.	5	741.	1.	105	(617.)	2.			
-90	(839.)	2.	10	736.	1.	110	(609.)	2.			
-85	(834.)	2.	15	730.	1.	115	(602.)	2.			
-80	(829.)	2.	20	724.	1.	120	(594.)	2.			
-75	(824.)	2.	25	719.	1.	125	(586.)	2.			
-70	(819.)	2.	30	713.	1.	130	(577.)	2.			
-65	(814.)	2.	35	(707.)	1.	135	(569.)	5.			
-60	(809.)	2.	40	(701.)	1.	140	(559.)	5.			
-55	(804.)	2.	45	(696.)	1.	145	(550.)	5.			
-50	(799.)	2.	50	(690.)	1.	150	(540.)	5.			
-45	(794.)	1.	55	(683.)	1.	155	(530.)	5.			
-40	(789.)	1.	60	(677.)	1.	160	(519.)	5.			
-35	(784.)	1.	65	(671.)	1.	165	(507.)	5.			
-30	(779.)	1.	70	(665.)	1.	170	(494.)	10.			

Orthobaric Liquid Molar Volume of Methyl propyl ether

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
150	(85.0)	0.2	250	(96.1)	0.2	350	(113.0)	0.2	450	(156.)	2.
155	(85.5)	0.2	255	(96.8)	0.1	355	(114.2)	0.2	455	(162.)	5.
160	(86.0)	0.2	260	(97.4)	0.1	360	(115.4)	0.2	460	(169.)	5.
165	(86.4)	0.2	265	(98.1)	0.1	365	(116.6)	0.2	465	(178.)	5.
170	(86.9)	0.2	270	(98.8)	0.1	370	(117.9)	0.5	470	(191.)	10.
175	(87.5)	0.2	275	99.6	0.1	375	(119.3)	0.5	475	(222.)	10.
180	(88.0)	0.2	280	100.3	0.1	380	(120.7)	0.5			
185	(88.5)	0.2	285	101.0	0.1	385	(122.2)	0.5			
190	(89.0)	0.2	290	101.8	0.1	390	(123.8)	0.5			
195	(89.6)	0.2	295	102.6	0.1	395	(125.4)	0.5			
200	(90.1)	0.2	300	103.4	0.1	400	(127.2)	0.5			
205	(90.7)	0.2	305	104.3	0.1	405	(129.1)	1.			
210	(91.2)	0.2	310	(105.1)	0.1	410	(131.1)	1.			
215	(91.8)	0.2	315	(106.0)	0.2	415	(133.)	1.			
220	(92.4)	0.2	320	(106.9)	0.2	420	(136.)	1.			
225	(93.0)	0.2	325	(107.8)	0.2	425	(138.)	1.			
230	(93.6)	0.2	330	(108.8)	0.2	430	(141.)	2.			
235	(94.2)	0.2	335	(109.8)	0.2	435	(144.)	2.			
240	(94.8)	0.2	340	(110.8)	0.2	440	(148.)	2.			
245	(95.4)	0.2	345	(111.9)	0.2	445	(152.)	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.

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C₄H₁₀O Methyl isopropyl ether; 2-Methoxypropane; Methyl 1-methylethyl ether

CAS Reg. No. 598-53-8

Mol. Wt. 74.12

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

Critical Temperature	T_c	= 464.48 K	(t_c	= 191.33 °C)
Critical Pressure	p_c	= 3762. kPa	(p_c	= 37.13 atm)
Critical Density	ρ_c	= 265. kg/m ³	(V_c	= 279.70 cm ³ /mol)
Critical Compression Factor	Z_c	= 0.272		

$$N_1 = 1.76845 \quad N_2 = -0.65256 \quad N_3 = 0.00000 \quad N_4 = 0.22999$$

Density at 298.15 K (25 °C)	ρ_{25}	= 709.79 kg/m ³	(V_{25}	= 104.43 cm ³ /mol)
Normal Boiling Point	T_b	= 303.919 K	(t_b	= 30.769 °C)
Melting Point	T_m	= -	(t_m	= -)

Data at Specified Temperatures

$t/^\circ\text{C}$ T/K	-125	0	25	30.77	100	150	191.33
	148.15	273.15	298.15	303.92	373.15	423.15	464.48
$\rho/(\text{kg/m}^3)$ ($d\rho/dT/(\text{kg/m}^3 \text{ K})$)	(869.85) (-1.01)	738.61 -1.13	(709.79) (-1.18)	(702.92) (-1.20)	(610.16) (-1.54)	(517.14) (-2.36)	(265.00) -∞
$V/(\text{cm}^3/\text{mol})$ ($dV/dT/(\text{cm}^3/\text{mol K})$)	(85.21) (0.10)	100.35 0.15	(104.43) (0.17)	(105.45) (0.18)	(121.48) (0.31)	(143.33) (0.65)	(279.70) ∞
Data Quality	(B)	B	(B)	(B)	(C)	(C)	(C)
Uncertainty in ρ (kg/m ³)	(2.)	2.	(2.)	(2.)	(5.)	(10.)	(20.)
Uncertainty in V (cm ³ /mol)	(0.2)	0.2	(0.2)	(0.5)	(1.)	(2.)	(20.)

Orthobaric Liquid Density of Methyl isopropyl etherUnits: 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
-125	(870.)	2.	-25	(766.)	2.	75	(646.)	5.	175	(442.)	20.
-120	(865.)	2.	-20	(761.)	2.	80	(640.)	5.	180	(420.)	20.
-115	(860.)	2.	-15	(755.)	2.	85	(632.)	5.	185	(390.)	20.
-110	(855.)	2.	-10	(750.)	2.	90	(625.)	5.	190	(336.)	20.
-105	(850.)	2.	-5	(744.)	2.	95	(618.)	5.			
-100	(845.)	2.	0	739.	2.	100	(610.)	5.			
-95	(840.)	2.	5	733.	2.	105	(602.)	5.			
-90	(834.)	2.	10	727.	2.	110	(594.)	5.			
-85	(829.)	2.	15	721.	2.	115	(586.)	5.			
-80	(824.)	2.	20	716.	2.	120	(577.)	5.			
-75	(819.)	2.	25	(710.)	2.	125	(568.)	5.			
-70	(814.)	2.	30	(704.)	2.	130	(559.)	10.			
-65	(809.)	2.	35	(698.)	2.	135	(549.)	10.			
-60	(803.)	2.	40	(692.)	2.	140	(539.)	10.			
-55	(798.)	2.	45	(686.)	2.	145	(529.)	10.			
-50	(793.)	2.	50	(679.)	2.	150	(517.)	10.			
-45	(788.)	2.	55	(673.)	5.	155	(505.)	10.			
-40	(782.)	2.	60	(666.)	5.	160	(492.)	10.			
-35	(777.)	2.	65	(660.)	5.	165	(477.)	10.			
-30	(772.)	2.	70	(653.)	5.	170	(461.)	10.			

Orthobaric Liquid Molar Volume of Methyl isopropyl ether

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
150	(85.4)	0.2	250	(97.0)	0.2	350	(115.1)	1.	450	(171.)	5.
155	(85.9)	0.2	255	(97.7)	0.2	355	(116.4)	1.	455	(181.)	10.
160	(86.4)	0.2	260	(98.4)	0.2	360	(117.7)	1.	460	(198.)	10.
165	(86.9)	0.2	265	(99.1)	0.2	365	(119.1)	1.			
170	(87.4)	0.2	270	(99.9)	0.2	370	(120.5)	1.			
175	(88.0)	0.2	275	100.6	0.2	375	(122.)	1.			
180	(88.5)	0.2	280	101.4	0.2	380	(124.)	1.			
185	(89.0)	0.2	285	102.2	0.2	385	(125.)	1.			
190	(89.6)	0.2	290	103.0	0.2	390	(127.)	1.			
195	(90.1)	0.2	295	103.9	0.2	395	(129.)	2.			
200	(90.7)	0.2	300	(104.7)	0.2	400	(131.)	2.			
205	(91.3)	0.2	305	(105.6)	0.5	405	(133.)	2.			
210	(91.9)	0.2	310	(106.6)	0.5	410	(136.)	2.			
215	(92.5)	0.2	315	(107.5)	0.5	415	(138.)	2.			
220	(93.1)	0.2	320	(108.5)	0.5	420	(141.)	2.			
225	(93.7)	0.2	325	(109.5)	0.5	425	(145.)	2.			
230	(94.3)	0.2	330	(110.5)	0.5	430	(148.)	2.			
235	(95.0)	0.2	335	(111.6)	0.5	435	(152.)	5.			
240	(95.6)	0.2	340	(112.7)	0.5	440	(157.)	5.			
245	(96.3)	0.2	345	(113.9)	0.5	445	(163.)	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.

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C₄H₁₀O Diethyl ether; Ethoxyethane; 1,1'-Oxybis-ethane; 'Ethyl ether'

CAS Reg. No. 60-29-7

Mol. Wt. 74.12

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

Critical Temperature	T_c	= 466.65 K	(t_c	= 193.5 °C)
Critical Pressure	p_c	= 3650. kPa	(p_c	= 36.02 atm)
Critical Density	ρ_c	= 262. kg/m ³	(V_c	= 282.90 cm ³ /mol)
Critical Compression Factor	Z_c	= 0.266		

$$N_1 = 1.79013 \quad N_2 = -0.67667 \quad N_3 = 0.00000 \quad N_4 = 0.24168$$

Density at 298.15 K (25 °C)	ρ_{25}	= 707.76 kg/m ³	(V_{25}	= 104.73 cm ³ /mol)
Normal Boiling Point	T_b	= 307.578 K	(t_b	= 34.428 °C)
Melting Point	T_m	= 157.	(t_m	= -116. °C)

Data at Specified Temperatures

$t/^\circ\text{C}$	-116	0	25	34.43	100	150	193.50
T/K	157.15	273.15	298.15	307.58	373.15	423.15	466.65
$\rho/(\text{kg/m}^3)$	858.03	736.34	707.76	696.59	609.41	518.59	262.00
$(d\rho/dT)/(\text{kg/m}^3 \text{ K})$	-1.01	-1.12	-1.17	-1.20	-1.52	-2.28	$-\infty$
$V/(\text{cm}^3/\text{mol})$	86.38	100.66	104.73	106.40	121.63	142.92	282.90
$(dV/dT)/(\text{cm}^3/\text{mol K})$	0.10	0.15	0.17	0.18	0.30	0.63	∞
Data Quality	B	B	B	B	B	B	C
Uncertainty in ρ (kg/m ³)	2.	2.	1.	1.	2.	5.	20.
Uncertainty in V (cm ³ /mol)	0.2	0.2	0.1	0.2	0.5	1.	20.

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

t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.
$^\circ\text{C}$	kg/m ³	in ρ	$^\circ\text{C}$	kg/m ³	in ρ	$^\circ\text{C}$	kg/m ³	in ρ	$^\circ\text{C}$	kg/m ³	in ρ
-115	857.	2.	-25	764.	2.	75	645.	2.	175	447.	10.
-110	852.	2.	-20	758.	2.	80	638.	2.	180	427.	10.
-105	847.	2.	-15	753.	2.	85	631.	2.	185	401.	20.
			-10	747.	2.	90	624.	2.	190	363.	20.
			-5	742.	2.	95	617.	2.			
-100	842.	2.	0	736.	2.	100	609.	2.			
-95	837.	2.	5	731.	2.	105	602.	2.			
-90	832.	2.	10	725.	2.	110	594.	2.			
-85	827.	2.	15	719.	1.	115	586.	2.			
-80	821.	2.	20	714.	1.	120	577.	2.			
-75	816.	2.	25	708.	1.	125	569.	2.			
-70	811.	2.	30	702.	1.	130	559.	2.			
-65	806.	2.	35	696.	1.	135	550.	5.			
-60	801.	2.	40	690.	1.	140	540.	5.			
-55	796.	2.	45	684.	1.	145	530.	5.			
-50	790.	2.	50	678.	1.	150	519.	5.			
-45	785.	2.	55	671.	1.	155	507.	5.			
-40	780.	2.	60	665.	1.	160	494.	5.			
-35	774.	2.	65	658.	1.	165	480.	10.			
-30	769.	2.	70	652.	1.	170	465.	10.			

Orthobaric Liquid Molar Volume of Diethyl ether

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
160	86.7	0.2	250	97.3	0.2	350	115.3	0.2	450	168.	5.
165	87.2	0.2	255	98.0	0.2	355	116.6	0.2	455	177.	5.
170	87.7	0.2	260	98.7	0.2	360	117.9	0.2	460	191.	10.
			265	99.4	0.2	365	119.3	0.5	465	219.	10.
			270	100.2	0.2	370	120.7	0.5			
175	88.2	0.2	275	100.9	0.2	375	122.2	0.5			
180	88.8	0.2	280	101.7	0.2	380	123.8	0.5			
185	89.3	0.2	285	102.5	0.2	385	125.4	0.5			
190	89.9	0.2	290	103.3	0.2	390	127.2	0.5			
195	90.4	0.2	295	104.2	0.2	395	129.1	0.5			
200	91.0	0.2	300	105.0	0.1	400	131.1	1.			
205	91.6	0.2	305	105.9	0.2	405	133.3	1.			
210	92.2	0.2	310	106.9	0.2	410	135.7	1.			
215	92.8	0.2	315	107.8	0.2	415	138.	1.			
220	93.4	0.2	320	108.8	0.2	420	141.	1.			
225	94.0	0.2	325	109.8	0.2	425	144.	1.			
230	94.6	0.2	330	110.8	0.2	430	148.	2.			
235	95.3	0.2	335	111.9	0.2	435	152.	2.			
240	95.9	0.2	340	113.0	0.2	440	156.	2.			
245	96.6	0.2	345	114.1	0.2	445	162.	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.

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- TRC Thermodynamic Tables, Texas A & M Univ., Loose leaf data sheets extant 1994.

C₅H₁₂O Methyl butyl ether; 1-Methoxybutane

CAS Reg. No. 628-28-4

Mol. Wt. 88.15

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

Critical Temperature	T_c	= 512.75 K	(t_c	= 239.6 °C)
Critical Pressure	p_c	= 3345. kPa	(p_c	= 33.01 atm)
Critical Density	ρ_c	= 261. kg/m ³	(V_c	= 337.74 cm ³ /mol)
Critical Compression Factor	Z_c	= 0.265		

$$N_1 = 1.77701 \quad N_2 = -0.62373 \quad N_3 = 0.00000 \quad N_4 = 0.19467$$

Density at 298.15 K (25 °C)	ρ_{25}	= 739.30 kg/m ³	(V_{25}	= 119.24 cm ³ /mol)
Normal Boiling Point	T_b	= 343.293 K	(t_b	= 70.143 °C)
Melting Point	T_m	= 158.	(t_m	= -115. °C)

Data at Specified Temperatures

$t/^\circ\text{C}$ T/K	-115	0	25	70.14	100	200	239.60
	158.15	273.15	298.15	343.29	373.15	473.15	512.75
$\rho/(\text{kg/m}^3)$ ($d\rho/dT/(\text{kg/m}^3 \text{ K})$)	(868.92) (-0.88)	763.93 -0.97	739.30 -1.00	(691.90) (-1.10)	(657.60) (-1.20)	(499.98) (-2.34)	(261.00) -∞
$V/(\text{cm}^3/\text{mol})$ ($dV/dT/(\text{cm}^3/\text{mol K})$)	(101.45) (0.10)	115.39 0.15	119.24 0.16	(127.40) (0.20)	(134.05) (0.24)	(176.31) (0.83)	(337.74) ∞
Data Quality	(B)	B	B	(B)	(B)	(B)	(C)
Uncertainty in ρ (kg/m ³)	(2.)	2.	1.	(1.)	(2.)	(5.)	(20.)
Uncertainty in V (cm ³ /mol)	(0.5)	0.2	0.2	(0.2)	(0.5)	(2.)	(20.)

Orthobaric Liquid Density of Methyl butyl ether

Units: 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
-115	(869.)	2.	-25	(788.)	2.	75	(687.)	1.	175	(551.)	5.
-110	(865.)	2.	-20	(783.)	2.	80	(681.)	1.	180	(541.)	5.
-105	(860.)	2.	-15	(778.)	2.	85	(675.)	1.	185	(532.)	5.
			-10	(774.)	2.	90	(669.)	2.	190	(522.)	5.
			-5	(769.)	2.	95	(664.)	2.	195	(511.)	5.
-100	(856.)	2.									
-95	(851.)	2.	0	764.	2.	100	(658.)	2.	200	(500.)	5.
-90	(847.)	2.	5	759.	2.	105	(652.)	2.	205	(488.)	5.
-85	(842.)	2.	10	754.	2.	110	(645.)	2.	210	(475.)	5.
-80	(838.)	2.	15	749.	1.	115	(639.)	2.	215	(460.)	10.
			20	744.	1.	120	(633.)	2.	220	(444.)	10.
-75	(834.)	2.	25	739.	1.	125	(626.)	2.	225	(424.)	10.
-70	(829.)	2.	30	734.	1.	130	(619.)	2.	230	(401.)	10.
-65	(825.)	2.	35	729.	1.	135	(613.)	2.	235	(368.)	20.
-60	(820.)	2.	40	724.	1.	140	(606.)	2.			
-55	(815.)	2.	45	(719.)	1.	145	(599.)	2.			
-50	(811.)	2.	50	(714.)	1.	150	(591.)	2.			
-45	(806.)	2.	55	(708.)	1.	155	(584.)	2.			
-40	(802.)	2.	60	(703.)	1.	160	(576.)	2.			
-35	(797.)	2.	65	(698.)	1.	165	(568.)	5.			
-30	(792.)	2.	70	(692.)	1.	170	(559.)	5.			

Orthobaric Liquid Molar Volume of Methyl butyl ether

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
160	(101.6)	0.2	250	(112.2)	0.2	350	(128.8)	0.2	450	(161.)	1.
165	(102.2)	0.2	255	(112.8)	0.2	355	(129.9)	0.2	455	(164.)	1.
170	(102.7)	0.2	260	(113.5)	0.2	360	(131.0)	0.2	460	(167.)	1.
			265	(114.2)	0.2	365	(132.1)	0.2	465	(170.)	2.
			270	(114.9)	0.2	370	(133.3)	0.5	470	(174.)	2.
175	(103.2)	0.2	275	115.7	0.2	375	(134.5)	0.5	475	(178.)	2.
180	(103.7)	0.2	280	116.4	0.2	380	(135.8)	0.5	480	(182.)	2.
185	(104.3)	0.2	285	117.2	0.2	385	(137.1)	0.5	485	(188.)	2.
190	(104.8)	0.2	290	117.9	0.2	390	(138.4)	0.5	490	(194.)	5.
195	(105.4)	0.2	295	118.7	0.2	395	(139.9)	0.5	495	(202.)	5.
200	(106.0)	0.2	300	119.5	0.2	400	(141.3)	0.5	500	(212.)	5.
205	(106.5)	0.2	305	120.4	0.2	405	(142.9)	0.5	505	(226.)	10.
210	(107.1)	0.2	310	121.2	0.2	410	(144.5)	0.5	510	(252.)	10.
215	(107.7)	0.2	315	(122.1)	0.2	415	(146.2)	0.5			
220	(108.3)	0.2	320	(123.0)	0.2	420	(147.9)	1.			
225	(108.9)	0.2	325	(123.9)	0.2	425	(149.8)	1.			
230	(109.6)	0.2	330	(124.8)	0.2	430	(151.8)	1.			
235	(110.2)	0.2	335	(125.8)	0.2	435	(153.9)	1.			
240	(110.8)	0.2	340	(126.7)	0.2	440	(156.)	1.			
245	(111.5)	0.2	345	(127.8)	0.2	445	(159.)	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.

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- AMBROSE,D., *in Hndbk.Chem.Phys.*, CRC Press, 72nd.ed., pp.6-49 to 6-63, 1991.*
- TRC Thermodynamic Tables, Texas A & M Univ., Loose leaf data sheets extant 1994.*

C₅H₁₂O Methyl *sec*-butyl ether; 2-Methoxybutane; Methyl 1-methylpropyl ether

CAS Reg. No. 6795-87-5

Mol. Wt. 88.15

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

Critical Temperature	T_c	= 500. K	(t_c	= 226.85 °C)
Critical Pressure	p_c	= 3400. kPa	(p_c	= 33.56 atm)
Critical Density	ρ_c	= 264. kg/m ³	(V_c	= 333.90 cm ³ /mol)
Critical Compression Factor	Z_c	= 0.273		

$$N_1 = 1.75129 \quad N_2 = -0.58318 \quad N_3 = 0.00000 \quad N_4 = 0.16867$$

Density at 298.15 K (25 °C)	ρ_{25}	= 736.61 kg/m ³	(V_{25}	= 119.67 cm ³ /mol)
Normal Boiling Point	T_b	= 332.15 K	(t_b	= 59. °C)
Melting Point	T_m	= -	(t_m	= -)

Data at Specified Temperatures

$t/^\circ\text{C}$	-125	0	25	59	100	200	226.85
T/K	148.15	273.15	298.15	332.15	373.15	473.15	500.00
$\rho/(\text{kg/m}^3)$	(878.18)	762.13	736.61	(699.77)	(650.66)	(472.05)	(264.00)
$(d\rho/dT)/(\text{kg/m}^3 \text{ K})$	(-0.88)	-1.00	-1.04	(-1.13)	(-1.28)	(-2.98)	$-\infty$
$V/(\text{cm}^3/\text{mol})$	(100.38)	115.66	119.67	(125.97)	(135.48)	(186.74)	(333.90)
$(dV/dT)/(\text{cm}^3/\text{mol K})$	(0.10)	0.15	0.17	(0.20)	(0.27)	(1.18)	∞
Data Quality	(B)	B	B	(B)	(B)	(B)	(C)
Uncertainty in ρ (kg/m ³)	(2.)	2.	1.	(1.)	(2.)	(5.)	(20.)
Uncertainty in V (cm ³ /mol)	(0.2)	0.2	0.2	(0.2)	(0.5)	(2.)	(20.)

Orthobaric Liquid Density of Methyl *sec*-butyl etherUnits: kg/m³ v. °C

t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.
$^\circ\text{C}$	kg/m ³	in ρ	$^\circ\text{C}$	kg/m ³	in ρ	$^\circ\text{C}$	kg/m ³	in ρ	$^\circ\text{C}$	kg/m ³	in ρ
-125	(878.)	2.	-25	(787.)	2.	75	(681.)	1.	175	(533.)	5.
-120	(874.)	2.	-20	(782.)	2.	80	(675.)	1.	180	(522.)	5.
-115	(869.)	2.	-15	(777.)	2.	85	(669.)	2.	185	(511.)	5.
-110	(865.)	2.	-10	(772.)	2.	90	(663.)	2.	190	(499.)	5.
-105	(860.)	2.	-5	(767.)	2.	95	(657.)	2.	195	(486.)	5.
-100	(856.)	2.	0	762.	2.	100	(651.)	2.	200	(472.)	5.
-95	(852.)	2.	5	757.	2.	105	(644.)	2.	205	(456.)	5.
-90	(847.)	2.	10	752.	2.	110	(638.)	2.	210	(438.)	10.
-85	(843.)	2.	15	747.	1.	115	(631.)	2.	215	(417.)	10.
-80	(838.)	2.	20	742.	1.	120	(624.)	2.	220	(388.)	10.
-75	(833.)	2.	25	737.	1.	125	(617.)	2.	225	(341.)	20.
-70	(829.)	2.	30	731.	1.	130	(610.)	2.			
-65	(824.)	2.	35	(726.)	1.	135	(602.)	2.			
-60	(820.)	2.	40	(721.)	1.	140	(595.)	2.			
-55	(815.)	2.	45	(715.)	1.	145	(587.)	2.			
-50	(810.)	2.	50	(710.)	1.	150	(579.)	2.			
-45	(806.)	2.	55	(704.)	1.	155	(570.)	2.			
-40	(801.)	2.	60	(699.)	1.	160	(561.)	2.			
-35	(796.)	2.	65	(693.)	1.	165	(552.)	5.			
-30	(791.)	2.	70	(687.)	1.	170	(543.)	5.			

Orthobaric Liquid Molar Volume of Methyl sec-butyl ether

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
150	(100.6)	0.2	250	(112.3)	0.2	350	(129.8)	0.2	450	(167.)	1.
155	(101.1)	0.2	255	(113.0)	0.2	355	(130.9)	0.2	455	(170.)	1.
160	(101.6)	0.2	260	(113.7)	0.2	360	(132.1)	0.2	460	(174.)	2.
165	(102.1)	0.2	265	(114.4)	0.2	365	(133.4)	0.5	465	(178.)	2.
170	(102.6)	0.2	270	(115.2)	0.2	370	(134.6)	0.5	470	(183.)	2.
175	(103.2)	0.2	275	115.9	0.2	375	(136.0)	0.5	475	(189.)	2.
180	(103.7)	0.2	280	116.7	0.2	380	(137.4)	0.5	480	(196.)	2.
185	(104.3)	0.2	285	117.5	0.2	385	(138.8)	0.5	485	(205.)	5.
190	(104.8)	0.2	290	118.3	0.2	390	(140.3)	0.5	490	(216.)	5.
195	(105.4)	0.2	295	119.1	0.2	395	(141.9)	0.5	495	(235.)	10.
200	(106.0)	0.2	300	120.0	0.2	400	(143.5)	0.5	500	(334.)	20.
205	(106.6)	0.2	305	120.9	0.2	405	(145.2)	0.5			
210	(107.2)	0.2	310	(121.7)	0.2	410	(147.1)	0.5			
215	(107.8)	0.2	315	(122.7)	0.2	415	(149.0)	0.5			
220	(108.4)	0.2	320	(123.6)	0.2	420	(151.0)	1.			
225	(109.0)	0.2	325	(124.5)	0.2	425	(153.2)	1.			
230	(109.6)	0.2	330	(125.5)	0.2	430	(155.5)	1.			
235	(110.3)	0.2	335	(126.6)	0.2	435	(157.9)	1.			
240	(111.0)	0.2	340	(127.6)	0.2	440	(161.)	1.			
245	(111.6)	0.2	345	(128.7)	0.2	445	(163.)	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.

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|---|-------------------------------|---|---|
| 1 | BENNET,G.M., PHILIP,W.G., | <i>J.Chem.Soc.</i> ,p.1930, 1928. | |
| 2 | VON DOERING,W.E., YOUNG,R.W., | <i>J.Am.Chem.Soc.</i> , Vol.74, p.2997, 1952. | |
| 3 | WIBERG,K.B., | <i>J.Am.Chem.Soc.</i> , Vol.74, p.3891, 1952. | |
| 4 | OBAMA,M., OODERA,Y., et al., | <i>J.Chem.Eng.Data</i> , Vol.30, p.1, 1985. | M |
| 5 | TRC Thermodynamic Tables, | Texas A & M Univ., Loose leaf data sheets extant 1994.* | |

C₅H₁₂O Methyl isobutyl ether; 1-Methoxy-2-methylpropane; Methyl 2-methylpropyl ether

CAS Reg. No. 625-44-5

Mol. Wt. 88.15

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

Critical Temperature	T_c	= 499. K	(t_c = 225.85 °C)
Critical Pressure	p_c	= 3400. kPa	(p_c = 33.56 atm)
Critical Density	ρ_c	= 262. kg/m ³	(V_c = 336.45 cm ³ /mol)
Critical Compression Factor	Z_c	= 0.276	

$$N_1 = 1.76202 \quad N_2 = -0.63061 \quad N_3 = 0.00000 \quad N_4 = 0.21122$$

Density at 298.15 K (25 °C)	ρ_{25}	= 726.55 kg/m ³	(V_{25} = 121.33 cm ³ /mol)
Normal Boiling Point	T_b	= 331.15 K	(t_b = 58. °C)
Melting Point	T_m	= -	(t_m = -)

Data at Specified Temperatures

$t/^\circ\text{C}$	-125	0	25	58	100	200	225.85
T/K	148.15	273.15	298.15	331.15	373.15	473.15	499.00
$\rho/(\text{kg/m}^3)$	(870.09)	752.09	726.55	(691.02)	(641.32)	(464.81)	(262.00)
$(d\rho/dT)/(\text{kg/m}^3 \text{ K})$	(-0.91)	-1.00	-1.04	(-1.12)	(-1.26)	(-2.98)	$-\infty$
$V/(\text{cm}^3/\text{mol})$	(101.31)	117.21	121.33	(127.57)	(137.45)	(189.65)	(336.45)
$(dV/dT)/(\text{cm}^3/\text{mol K})$	(0.11)	0.16	0.17	(0.21)	(0.27)	(1.22)	∞
Data Quality	(B)	B	B	(B)	(B)	(B)	(C)
Uncertainty in ρ (kg/m ³)	(2.)	2.	1.	(1.)	(2.)	(5.)	(20.)
Uncertainty in V (cm ³ /mol)	(0.2)	0.2	0.2	(0.2)	(0.5)	(2.)	(20.)

Orthobaric Liquid Density of Methyl isobutyl etherUnits: kg/m³ v. °C

t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.
$^\circ\text{C}$	kg/m ³	in ρ	$^\circ\text{C}$	kg/m ³	in ρ	$^\circ\text{C}$	kg/m ³	in ρ	$^\circ\text{C}$	kg/m ³	in ρ
-125	(870.)	2.	-25	(777.)	2.	75	(672.)	1.	175	(525.)	5.
-120	(866.)	2.	-20	(772.)	2.	80	(666.)	1.	180	(515.)	5.
-115	(861.)	2.	-15	(767.)	2.	85	(660.)	2.	185	(504.)	5.
-110	(856.)	2.	-10	(762.)	2.	90	(654.)	2.	190	(492.)	5.
-105	(852.)	2.	-5	(757.)	2.	95	(648.)	2.	195	(479.)	5.
-100	(847.)	2.	0	752.	2.	100	(641.)	2.	200	(465.)	5.
-95	(843.)	2.	5	747.	2.	105	(635.)	2.	205	(449.)	5.
-90	(838.)	2.	10	742.	2.	110	(628.)	2.	210	(431.)	10.
-85	(833.)	2.	15	737.	1.	115	(622.)	2.	215	(408.)	10.
-80	(829.)	2.	20	732.	1.	120	(615.)	2.	220	(379.)	10.
-75	(824.)	2.	25	727.	1.	125	(608.)	2.	225	(320.)	20.
-70	(820.)	2.	30	721.	1.	130	(601.)	2.			
-65	(815.)	2.	35	(716.)	1.	135	(594.)	2.			
-60	(810.)	2.	40	(711.)	1.	140	(586.)	2.			
-55	(805.)	2.	45	(705.)	1.	145	(578.)	2.			
-50	(801.)	2.	50	(700.)	1.	150	(570.)	2.			
-45	(796.)	2.	55	(694.)	1.	155	(562.)	2.			
-40	(791.)	2.	60	(689.)	1.	160	(553.)	2.			
-35	(786.)	2.	65	(683.)	1.	165	(544.)	5.			
-30	(782.)	2.	70	(677.)	1.	170	(535.)	5.			

Orthobaric Liquid Molar Volume of Methyl isobutyl ether

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
150	(101.5)	0.2	250	(113.7)	0.2	350	(131.7)	0.2	450	(169.)	1.
155	(102.0)	0.2	255	(114.5)	0.2	355	(132.8)	0.2	455	(173.)	1.
160	(102.6)	0.2	260	(115.2)	0.2	360	(134.1)	0.2	460	(176.)	2.
165	(103.1)	0.2	265	(116.0)	0.2	365	(135.3)	0.5	465	(181.)	2.
170	(103.7)	0.2	270	(116.7)	0.2	370	(136.6)	0.5	470	(186.)	2.
175	(104.2)	0.2	275	117.5	0.2	375	(138.0)	0.5	475	(192.)	2.
180	(104.8)	0.2	280	118.3	0.2	380	(139.4)	0.5	480	(199.)	2.
185	(105.4)	0.2	285	119.1	0.2	385	(140.8)	0.5	485	(208.)	5.
190	(106.0)	0.2	290	119.9	0.2	390	(142.3)	0.5	490	(221.)	5.
195	(106.6)	0.2	295	120.8	0.2	395	(143.9)	0.5	495	(242.)	10.
200	(107.2)	0.2	300	121.6	0.2	400	(145.6)	0.5			
205	(107.8)	0.2	305	122.5	0.2	405	(147.3)	0.5			
210	(108.4)	0.2	310	(123.4)	0.2	410	(149.2)	0.5			
215	(109.0)	0.2	315	(124.4)	0.2	415	(151.1)	1.			
220	(109.7)	0.2	320	(125.3)	0.2	420	(153.2)	1.			
225	(110.3)	0.2	325	(126.3)	0.2	425	(155.4)	1.			
230	(111.0)	0.2	330	(127.3)	0.2	430	(157.7)	1.			
235	(111.7)	0.2	335	(128.4)	0.2	435	(160.)	1.			
240	(112.3)	0.2	340	(129.4)	0.2	440	(163.)	1.			
245	(113.0)	0.2	345	(130.5)	0.2	445	(166.)	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.

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|---|--------------------------------|---|---|
| 1 | THORPE,-., RODGER,-., | <i>Phil.Trans.R.Soc.London,A</i> , Vol.189, p.71, 1897. | |
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| 3 | HORSLEY,-., PETRIE,-., | U.S.Patent 2,886,600, 1939. | |
| 4 | SHIKHMAMEDBEKOVA,A.Z., et al., | <i>Dokl.Akad.Nauk Az.SSR</i> , Vol.31, p.10, 1975. | |
| 5 | OBAMA,M., OODERA,Y., et al., | <i>J.Chem.Eng.Data</i> , Vol.30, p.1, 1985. | M |
| 6 | TRC Thermodynamic Tables, | Texas A & M Univ., Loose leaf data sheets extant 1994.* | |

C₅H₁₂O Methyl *tert*-butyl ether; 2-Methoxy-2-methylpropane

CAS Reg. No. 1634-04-4

Mol. Wt. 88.15

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

Critical Temperature	T_c	= 497.1 K	(t_c	= 223.95 °C)
Critical Pressure	p_c	= 3430. kPa	(p_c	= 33.85 atm)
Critical Density	ρ_c	= 266. kg/m ³	(V_c	= 331.39 cm ³ /mol)
Critical Compression Factor	Z_c	= 0.275		

$$N_1 = 1.73995 \quad N_2 = -0.58636 \quad N_3 = 0.00000 \quad N_4 = 0.17846$$

Density at 298.15 K (25 °C)	ρ_{25}	= 735.04 kg/m ³	(V_{25}	= 119.92 cm ³ /mol)
Normal Boiling Point	T_b	= 328.274 K	(t_b	= 55.124 °C)
Melting Point	T_m	= 165.	(t_m	= -108. °C)

Data at Specified Temperatures

$t/^\circ\text{C}$	-109	0	25	55.12	100	200	223.95
T/K	164.15	273.15	298.15	328.27	373.15	473.15	497.10
$\rho/(\text{kg/m}^3)$	(863.99)	760.81	735.04	702.26	(648.30)	(465.04)	(266.00)
$(d\rho/dT)/(\text{kg/m}^3 \text{ K})$	(-0.90)	-1.01	-1.05	-1.13	(-1.29)	(-3.17)	$-\infty$
$V/(\text{cm}^3/\text{mol})$	(102.03)	115.86	119.92	125.52	(135.97)	(189.56)	(331.39)
$(dV/dT)/(\text{cm}^3/\text{mol K})$	(0.11)	0.15	0.17	0.20	(0.27)	(1.29)	∞
Data Quality	(B)	B	B	B	(B)	(B)	(C)
Uncertainty in ρ (kg/m ³)	(2.)	2.	1.	1.	(2.)	(5.)	(20.)
Uncertainty in V (cm ³ /mol)	(0.5)	0.2	0.2	0.2	(0.5)	(2.)	(20.)

Orthobaric Liquid Density of Methyl *tert*-butyl etherUnits: kg/m³ v. °C

t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.	t	ρ	Uncert.
$^\circ\text{C}$	kg/m ³	in ρ	$^\circ\text{C}$	kg/m ³	in ρ	$^\circ\text{C}$	kg/m ³	in ρ	$^\circ\text{C}$	kg/m ³	in ρ
			-25	(786.)	2.	75	679.	1.	175	(529.)	5.
			-20	(781.)	2.	80	673.	1.	180	(518.)	5.
			-15	(776.)	2.	85	667.	2.	185	(506.)	5.
			-10	(771.)	2.	90	661.	2.	190	(494.)	5.
-105	(860.)	2.	-5	(766.)	2.	95	655.	2.	195	(480.)	5.
-100	(856.)	2.	0	761.	2.	100	(648.)	2.	200	(465.)	5.
-95	(851.)	2.	5	756.	2.	105	(642.)	2.	205	(448.)	5.
-90	(847.)	2.	10	751.	2.	110	(635.)	2.	210	(428.)	10.
-85	(842.)	2.	15	745.	1.	115	(628.)	2.	215	(403.)	10.
-80	(838.)	2.	20	740.	1.	120	(621.)	2.	220	(368.)	20.
-75	(833.)	2.	25	735.	1.	125	(614.)	2.			
-70	(828.)	2.	30	730.	1.	130	(607.)	2.			
-65	(824.)	2.	35	724.	1.	135	(599.)	2.			
-60	(819.)	2.	40	719.	1.	140	(592.)	2.			
-55	(814.)	2.	45	714.	1.	145	(584.)	2.			
-50	(810.)	2.	50	708.	1.	150	(575.)	2.			
-45	(805.)	2.	55	702.	1.	155	(567.)	2.			
-40	(800.)	2.	60	697.	1.	160	(558.)	2.			
-35	(795.)	2.	65	691.	1.	165	(549.)	5.			
-30	(790.)	2.	70	685.	1.	170	(539.)	5.			