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**Thermal conductivity, viscosity,
isobaric specific heat capacity and
Prandtl number of gases at low
pressure: Halogenated hydrocarbons
– halomethanes**

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THERMAL CONDUCTIVITY, VISCOSITY, ISOBARIC SPECIFIC HEAT CAPACITY AND PRANDTL NUMBER OF GASES AT LOW PRESSURE: HALOGENATED HYDROCARBONS – HALOMETHANES

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Data sheets for each of the gases are given in the following order:-

Formula	Name	Alternative Name(s)
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MONOHALOMETHANES

1.	CH ₃ F	Fluoromethane	Methyl fluoride	Refrigerant 41	11
2.	CH ₃ Cl	Chloromethane	Methyl chloride	Refrigerant 40	12
3.	CH ₃ Br	Bromomethane	Methyl bromide	Refrigerant 40B1	13
4.	CH ₃ I	Iodomethane	Methyl iodide		14

Formula	Name	Alternative Name(s)
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DIHALOMETHANES

5.	CH ₂ F ₂	Difluoromethane	Methylene difluoride	Refrigerant 32	15
6.	CH ₂ ClF	Chlorofluoromethane	Methylene chlorofluoride	Refrigerant 31	16
7.	CH ₂ Cl ₂	Dichloromethane	Methylene dichloride	Refrigerant 30	17
8.	CH ₂ BrCl	Bromochloromethane	Methylene bromochloride	Refrigerant 30B1	18
9.	CH ₂ Br ₂	Dibromomethane	Methylene dibromide	Refrigerant 30B2	19
10.	CH ₂ I ₂	Diiodomethane	Methylene diiodide		20

TRIHALOMETHANES

11.	CHF ₃	Trifluoromethane	Fluoroform	Refrigerant 23	21
12.	CHClF ₂	Chlorodifluoromethane		Refrigerant 22	22
13.	CHBrF ₂	Bromodifluoromethane		Refrigerant 22B1	23
14.	CHCl ₂ F	Dichlorofluoromethane		Refrigerant 21	24
15.	CHCl ₃	Trichloromethane	Chloroform	Refrigerant 20	25
16.	CHBr ₃	Tribromomethane	Bromoform	Refrigerant 20B3	26

TETRAHALOMETHANES

17.	CF ₄	Tetrafluoromethane	Carbon tetrafluoride	Refrigerant 14	27
18.	CClF ₃	Chlorotrifluoromethane		Refrigerant 13	28
19.	CBrF ₃	Bromotrifluoromethane		Refrigerant 13B1	29
20.	CCl ₂ F ₂	Dichlorodifluoromethane		Refrigerant 12	30
21.	CBrClF ₂	Bromochlorodifluoromethane		Refrigerant 12B1	31
22.	CBr ₂ F ₂	Dibromodifluoromethane		Refrigerant 12B2	32
23.	CCl ₃ F	Trichlorofluoromethane		Refrigerant 11	33
24.	CCl ₄	Tetrachloromethane	Carbon tetrachloride	Refrigerant 10	34
25.	CBrCl ₃	Bromotrichloromethane		Refrigerant 10B1	35
26.	CBr ₄	Tetrabromomethane	Carbon tetrabromide	Refrigerant 10B4	36

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THERMAL CONDUCTIVITY, VISCOSITY, ISOBARIC SPECIFIC HEAT CAPACITY AND PRANDTL NUMBER OF GASES AT LOW PRESSURE: HALOGENATED HYDROCARBONS – HALOMETHANES

1. INTRODUCTION

This Item presents in tabular form values of thermal conductivity, viscosity, isobaric specific heat capacity and Prandtl number of the vapours of halomethanes at or below atmospheric pressure. The range covered is from below the normal boiling point to at least 600 K. Previous Data Items in this group were restricted to thermal conductivity but the importance of the Prandtl number for chemical engineering design makes the inclusion of the isobaric specific heat capacity and viscosity desirable.

The data on which these values are based are believed to be the most reliable available and have been reviewed and suitably extended. Sections 4, 5 and 6 describe, respectively, the procedures used to obtain the values of thermal conductivity, viscosity and isobaric specific heat capacity and indicate the effects of pressure. Section 7 gives an explanation of the Tables, the Prandtl number equation and indicates the uncertainties in the values presented.

References to sources of supplementary information are given in Section 8. Appendix A provides a full bibliography of relevant data sources for viscosity, specific heat capacity and thermal conductivity. The data sources for each particular compound are listed with the appropriate table.

2. NOTATION AND UNITS

The units of each property are based on SI units. The SI units of thermal conductivity, viscosity and specific heat capacity are the watt per metre kelvin (W/m K), the newton second per square metre (N s/m²) and the joule per kilogram kelvin (J/kg K) respectively. Convenient units for the properties in this Item are: thermal conductivity, the milliwatt per metre kelvin (mW/m K); viscosity, the micronewton second per square metre (μN s/m²); isobaric specific heat capacity, the kilojoule per kilogram kelvin (kJ/kg K). Conversion factors are given in Section 3. The correlation parameters are not dimensionless but take the units listed in Tables 9.1, 9.2 and 9.3.

b_1, b_2, b_3, b_4	constants for each fluid in Equation (4.1), (5.1), (6.1)	*
c	specific heat capacity	kJ/kg K
M	molecular weight (relative molecular mass)	—
p	pressure	kPa
Pr	Prandtl number	—
T	kelvin temperature	K
t	Celsius temperature, $T - 273.15$	°C
η	dynamic viscosity	μN s/m ²
λ	thermal conductivity	mW/m K

* See footnote at end of this section.

Superscripts

id	denotes ideal gas
(o)	denotes dilute gas

Subscripts

c	denotes value at critical point
p	denotes constant pressure
r	denotes reduced quantity, for example $T_r = T/T_c$.
v	denotes constant volume.

* The units of these constants for thermal conductivity, viscosity and ideal gas heat capacity can be found in Tables 9.1, 9.2 and 9.3 respectively.

3. CONVERSION FACTORS

Thermal conductivity

$$\begin{aligned}
 1 \text{ mW/m K} &= 0.8598 \times 10^{-3} \text{ kcal/m h } ^\circ\text{C} \\
 &= 2.3885 \times 10^{-6} \text{ cal/cm s } ^\circ\text{C} \\
 &= 0.5778 \times 10^{-3} \text{ Chu/ft h } ^\circ\text{C} \\
 &= 0.5778 \times 10^{-3} \text{ Btu/ft h } ^\circ\text{F} \\
 &= 6.9335 \times 10^{-3} \text{ Btu in/ft}^2 \text{ h } ^\circ\text{F}
 \end{aligned}$$

Viscosity

$$\begin{aligned}
 1 \text{ } \mu\text{N s/m}^2 &= 10^{-3} \text{ cP} \\
 &= 145.04 \times 10^{-12} \text{ lbf s/in}^2 \\
 &= 101.972 \times 10^{-9} \text{ kgf s/m}^2 \\
 &= 10^{-6} \text{ kg/m s}
 \end{aligned}$$

Specific heat capacity

$$\begin{aligned}
 1 \text{ kJ/kg K} &= 0.239 \text{ cal/g K} \\
 &= 0.239 \text{ Btu/lb } ^\circ\text{F}
 \end{aligned}$$

Pressure

$$\begin{aligned}
 10^5 \text{ Pa} &= 1 \text{ bar} \\
 &= 14.5038 \text{ lbf/in}^2 \\
 &= 1.0197 \text{ kgf/cm}^2 \\
 &= 0.9869 \text{ atm} \\
 &= 750.062 \text{ mmHg.}
 \end{aligned}$$

4. THERMAL CONDUCTIVITY OF GASES

4.1 Thermal Conductivity at Low Pressure (Dilute Gas)

A comprehensive survey of the literature on the thermal conductivity of gases was prepared with the assistance of the National Engineering Laboratory (NEL), East Kilbride, UK. An attempt has been made

to correlate the data between compounds in the same way as for the alkanes (Reference 25). The theoretical predictions of Svehla (Data Source A1.: 12) have assisted in the case of non-polar compounds, enabling prediction of thermal conductivities over the full temperature range described in Section 1. The polar compounds were not so well predicted as the non-polar compounds and a study of the Eucken factor which, in the units adopted in this Item is given by $\lambda^{(o)}/\eta^{(o)}c_v^{id}$, has assisted in extending the correlation in each case.

Close agreement of the data among the numerous authors and differing methods was found and it was possible to extend the range of results to between at least 333 and 600 K in all cases.

The correlated data are represented by the equation

$$\lambda^{(o)} = b_1 + b_2(1 - T_r) + b_3(1 - T_r)^2 + b_4(1 - T_r)^3. \quad (4.1)$$

The derived values of the constants given in Table 9.1 give the best fits to the data.

Using these values with the values of T_c given in Table 9.1 (References 18, 19, 21), values of $\lambda^{(o)}$ in mW/m K have been calculated at 20 K and at 20 degree Celsius intervals for each compound.

4.2 Effect of Pressure

The thermal conductivity of all gases increases with pressure but the effect is small at low pressures from 0.1 to 1000 kPa (approximately 1% per 100 kPa). At higher pressures it is difficult to generalise. The correlations of Stiel and Thodos (Reference 3) remain the best method of evaluating the pressure effect in terms of the density and critical properties. Data for common and other refrigerants are available in References 10, 16, 17, 20 and in the data sources marked with an asterisk in Appendix A2.

Near the critical point, the thermal conductivity increases asymptotically and at the critical point tends to infinity. This phenomenon, the so-called critical enhancement implies that, in the critical region the thermal conductivity is very sensitive to temperature and pressure and cannot be predicted reliably. As a rough guide, for the subcritical vapour for $0.9 \leq T_r \leq 1$, the critical enhancement takes effect at pressures exceeding $\approx 0.5p_c$ and is greatest at saturation. For example, Data Source A2.: 891 gives tables for R12 that show the thermal conductivity to be 3.8 times its value at atmospheric pressure for the condition $0.93T_c, 0.97p_c$. For values of T_r in the range $1 \leq T_r \leq 1.1$, the thermal conductivity at any specified temperature passes through a maximum at values of $p_r > 1$; the maximum declines and shifts to higher pressures with increasing temperature. A useful discussion of the anomalous behaviour of thermal conductivity near the critical point is given in References 22, 24 and Data Source A2.: 7512.

5. VISCOSITY OF GASES

5.1 Viscosity at Low Pressure (Dilute Gas)

Well-documented and correlated data are available for the major halomethane refrigerants and these data were extended to lower and/or higher temperatures by using the predictions of Svehla (Data Source A1.: 12) based on theoretical considerations. For the other compounds, the Reichenberg method (Reference 12) appeared to give adequate agreement with any available data.

The experimental and estimated dilute gas viscosities are adequately represented by the following equation of the same form as that used for thermal conductivity and it is valid over the same temperature range.

$$\eta^{(o)} = b_1 + b_2(1 - T_r) + b_3(1 - T_r)^2 + b_4(1 - T_r)^3 \quad (5.1)$$

The derived values of the constants given in Table 9.2 give the best fit to the data. Using these values with the value of T_c given in Table 9.2, values of $\eta^{(o)}$ in $\mu\text{N s/m}^2$ have been calculated at 20 K and at 20 degree Celsius intervals for each compound.

5.2 Effect of Pressure

The viscosity of gases increases with pressure, but the effect is small at low pressures (0.1 to 1000 kPa). The correlations of Stiel and Thodos (References 2, 4) may be used to evaluate the pressure effect in terms of the density and critical properties. Near the critical point, however, the pressure effect is greater and cannot be predicted reliably but is less significant than in the case of thermal conductivity.

Data for common and other refrigerants are available in References 10, 16, 17 and 20. Experimental data at various pressures are available for some compounds from Data Source A1.: 10.

6. ISOBARIC SPECIFIC HEAT CAPACITY

6.1 Isobaric Specific Heat Capacity at Low Pressure (Ideal Gas)

The isobaric specific heat capacity approaches the ideal gas value as the pressure tends to zero and these are the values tabulated in this Data Item.

Data for the isobaric specific heat capacity of the ideal gas were taken from Data Source A1.: 27. Over the temperature ranges covered by this Data Item, they can be adequately represented by the following simple polynomial in reduced temperature:

$$c_p^{\text{id}} = b_1 + b_2 T_r + b_3 T_r^2 + b_4 T_r^3 \quad (6.1)$$

The values of the constants given in Table 9.3 were derived from the best fit to the selected data over the given temperature range. Using these values with the value of T_c given in Table 9.3, values of c_p^{id} in kJ/kg K have been calculated at 20 K and at 20 degree Celsius intervals for each compound.

6.2 Effect of Pressure

For non-reacting non-associating vapours, far from the critical point, the effect of pressure is small. At the critical point c_p tends to infinity and large effects in the critical region will occur. Estimates may be obtained from general equations of state such as the Soave-Redlich-Kwong, Lee-Kesler and Peng-Robinson (References 9, 11, 14). Fortran programs for the Soave-Redlich-Kwong and the Peng-Robinson equations may be found in Reference 22. For more accurate calculations, fluid specific equations of state should be used. References to these for chlorodifluoromethane, dichlorodifluoromethane and trichlorofluoromethane may be found in a review article by de Reuck, Craven and Elhassan (Reference 23).

Data are available for common and other refrigerants in References 10, 16, 17 and 20 and equations of state are also discussed in References 10 and 16.

7. EXPLANATION OF TABLES AND THE PRANDTL NUMBER EQUATION

For each compound the constants in Equations (4.1), (5.1) and (6.1) are given in Tables 9.1, 9.2 and 9.3 respectively, together with the critical temperature and the range of applicability. Because of possible decomposition of these compounds the experimental data, where they exist, and the tables are limited to a maximum of 350 °C.

Within the compound tables, values of thermal conductivity and viscosity that are supported by experimental data are presented in bold type. Isobaric specific heat capacity values from Data Source A1.: 27 are also given in bold type.

Experimental data for thermal conductivity from the most reliable individual sources have a repeatability of about ±2%. However, differences in methods and technique increase the uncertainty of the absolute values to ±3% or more. Such reliable data are available for the principal refrigerants.

Although it is considered that the procedure adopted for thermal conductivity keeps the errors in the values presented to a minimum, the user should allow for an uncertainty of ±5% in all values, except those unsupported by experimental data (presented in plain type) where the uncertainty increases to ±10%.

Experimental data for the viscosity of the principal refrigerants have been reviewed, and the reliable data have a repeatability of about ±3%. For values unsupported by experiment the uncertainty is greater. Although it is considered that the procedure adopted here keeps the errors in the values presented to a minimum, the user should allow for an uncertainty of ±5% in all values.

The isobaric specific heat capacity values are based on spectroscopic data. Comparisons with reliable experimental data indicate that the uncertainties are below 1%.

At any specific temperature, the Prandtl number entry was calculated from Equations (4.1), (5.1), (6.1) and the relation

$$Pr^{(o)} = \frac{c_p^{id} \eta^{(o)}}{\lambda^{(o)}} \quad (7.1)$$

No attempt was made to smooth the values thus obtained. Rounding errors, which may affect the last significant figure may produce differences between the tabulated values and those calculated directly from the tabulated entries for thermal conductivity, viscosity and isobaric specific heat capacity.

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The references given are recommended sources of information supplementary to that in this Data Item.

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9. TABLES

TABLE 9.1 Dilute Gas Thermal Conductivity; Constants for Equation (4.1)

Compound	T_c K	b_1 mW/m K	b_2 mW/m K	b_3 mW/m K	b_4 mW/m K	Range of applicability °C	
1. Fluoromethane	312.	16.57	-25.67	10.30	2.03	-73	to 350
2. Chloromethane	416.3	18.98	-32.23	10.06	4.77	-13	to 350
3. Bromomethane	463.	17.50	-28.23	3.82	5.01	-13	to 350
4. Iodomethane	527.	13.20	-18.00	0	0	-13	to 350
5. Difluoromethane	351.5	15.79	-25.08	6.82	6.04	-73	to 350
6. Chlorodifluoromethane	428.	17.92	-30.45	0.91	31.07	-53	to 350
7. Dichloromethane	510.	17.95	-24.05	0	0	-13	to 350
8. Bromochloromethane	560.	16.80	-22.95	-0.04	6.65	7	to 350
9. Dibromomethane	610.	15.66	-22.10	0	0	-13	to 350
10. Diiodomethane	750.	12.88	-15.15	-4.71	7.38	40	to 347
11. Trifluoromethane	299.3	13.59	-17.68	0	0	-93	to 350
12. Chlorodifluoromethane	369.3	14.93	-22.30	2.56	-0.51	-73	to 350
13. Bromodifluoromethane	413.	13.74	-19.19	2.09	3.31	-33	to 350
14. Dichlorodifluoromethane	451.3	16.36	-22.05	0	0	-13	to 350
15. Trichloromethane	536.5	16.89	-21.74	0	0	-13	to 350
16. Tribromomethane	685.	14.20	-18.00	0	0	60	to 347
17. Tetrafluoromethane	227.7	11.13	-16.44	0	0	-153	to 350
18. Chlorotrifluoromethane	302.2	12.75	-18.48	0	0	-93	to 350
19. Bromotrifluoromethane	340.2	13.34	-17.05	0	0	-73	to 350
20. Dichlorodifluoromethane	385.1	14.34	-18.58	0	0	-53	to 350
21. Bromochlorodifluoromethane	426.9	14.64	-21.51	0	0	-33	to 350
22. Dibromodifluoromethane	471.	12.03	-15.49	0	0	-33	to 350
23. Trichlorodifluoromethane	471.2	15.42	-18.49	0	0	7	to 350
24. Tetrachloromethane	556.3	15.11	-18.26	0	0	-13	to 350
25. Bromotrichloromethane	606.	14.06	-14.97	-3.12	2.54	-73	to 350
26. Tetrabromomethane	740.	11.86	-10.83	-4.96	3.13	60	to 327

TABLE 9.2 Dilute Gas Viscosity; Constants for Equation (5.1)

Compound	T_c K	b_1 $\mu\text{N s/m}^2$	b_2 $\mu\text{N s/m}^2$	b_3 $\mu\text{N s/m}^2$	b_4 $\mu\text{N s/m}^2$	Range of applicability °C
1. Fluoromethane	312.	12.06	-12.07	-0.57	0.27	-73 to 350
2. Chloromethane	416.3	15.16	-14.79	-1.23	0.72	-13 to 350
3. Bromomethane	463.	21.13	-20.96	-1.54	0.25	-13 to 350
4. Iodomethane	527.	25.89	-26.06	-1.42	3.17	-13 to 350
5. Difluoromethane	351.5	14.35	-14.10	-1.08	0.34	-73 to 350
6. Chlorofluoromethane	428.	16.53	-15.73	-1.83	0.58	-53 to 350
7. Dichloromethane	510.	17.28	-16.31	-2.30	1.22	-13 to 350
8. Bromochloromethane	560.	22.07	-21.06	-3.14	2.50	7 to 350
9. Dibromomethane	610.	25.03	-23.50	-2.92	1.32	-13 to 350
10. Diiodomethane	750.	30.79	-29.44	-6.28	6.68	40 to 347
11. Trifluoromethane	299.3	14.74	-15.39	-0.84	2.14	-93 to 350
12. Chlorodifluoromethane	369.3	15.86	-13.65	-1.89	-4.51	-73 to 350
13. Bromodifluoromethane	413.	19.35	-18.18	-2.00	0.47	-33 to 350
14. Dichlorofluoromethane	451.3	17.28	-16.12	-1.72	-0.32	-13 to 350
15. Trichloromethane	536.5	18.10	-16.68	-2.98	1.37	-13 to 350
16. Tribromomethane	685.	27.20	-26.13	-5.25	5.74	60 to 347
17. Tetrafluoromethane	227.7	13.64	-12.52	-1.49	-0.06	-153 to 350
18. Chlorotrifluoromethane	302.2	15.12	-13.69	-2.46	-0.45	-93 to 350
19. Bromotrifluoromethane	340.2	17.59	-15.56	-2.91	-0.55	-73 to 350
20. Dichlorodifluoromethane	385.1	16.01	-14.72	-2.25	-0.12	-53 to 350
21. Bromochlorodifluoromethane	426.9	18.13	-17.04	-1.88	0.50	-33 to 350
22. Dibromodifluoromethane	471.	20.64	-19.41	-2.19	0.75	-33 to 350
23. Trichlorofluoromethane	471.2	17.01	-16.09	-2.11	0.91	7 to 350
24. Tetrachloromethane	556.3	17.81	-15.98	-3.34	1.20	-13 to 350
25. Bromotrichloromethane	606.	20.57	-19.33	-2.36	1.06	-73 to 350
26. Tetrabromomethane	740.	28.19	-24.99	-8.79	6.89	60 to 327

TABLE 9.3 Ideal Gas Isobaric Specific Heat Capacity; Constants for Equation (6.1)

Compound	T_c K	b_1 kJ/kg K	b_2 kJ/kg K	b_3 kJ/kg K	b_4 kJ/kg K	Range of applicability °C		
1. Fluoromethane	312.	1.0782	-0.5804	0.8069	-0.1741	-73	to	350
2. Chloromethane	416.3	0.5720	0.0319	0.5521	-0.1824	-13	to	350
3. Bromomethane	463.	0.2786	0.1551	0.2335	-0.0965	-13	to	350
4. Iodomethane	527.	0.1711	0.2135	0.0962	-0.0596	-13	to	350
5. Difluoromethane	351.5	0.5825	-0.0078	0.4616	-0.1299	-73	to	350
6. Chlorodifluoromethane	428.	0.3850	0.3194	0.2473	-0.1103	-53	to	350
7. Dichloromethane	510.	0.2708	0.5943	-0.0130	-0.0602	-13	to	350
8. Bromochloromethane	560.	0.1758	0.4985	-0.1053	-0.0163	7	to	350
9. Dibromomethane	610.	0.1355	0.4308	-0.1289	-0.0042	-13	to	350
10. Diiodomethane	750.	0.0674	0.5014	-0.3676	0.1055	40	to	347
11. Trifluoromethane	299.3	0.2862	0.4476	0.0221	-0.0233	-93	to	350
12. Chlorodifluoromethane	369.3	0.2353	0.5912	-0.0945	-0.0075	-73	to	350
13. Bromodifluoromethane	413.	0.1973	0.4049	-0.0725	-0.0059	-33	to	350
14. Dichlorodifluoromethane	451.3	0.1979	0.7728	-0.2895	0.0374	-13	to	350
15. Trichloromethane	536.5	0.1797	0.9145	-0.5150	0.1115	-13	to	350
16. Tribromomethane	685.	0.1225	0.5156	-0.3988	0.1190	60	to	347
17. Tetrafluoromethane	227.7	0.1384	0.5365	-0.0908	0.0036	-153	to	350
18. Chlorotrifluoromethane	302.2	0.1116	0.7476	-0.2443	0.0296	-93	to	350
19. Bromotrifluoromethane	340.2	0.1169	0.5551	-0.2054	0.0284	-73	to	350
20. Dichlorodifluoromethane	385.1	0.1118	0.9253	-0.4465	0.0804	-53	to	350
21. Bromochlorodifluoromethane	426.9	0.1163	0.7133	-0.3899	0.0800	-33	to	350
22. Dibromodifluoromethane	471.	0.1294	0.5467	-0.3137	0.0668	-33	to	350
23. Trichlorodifluoromethane	471.2	0.1370	1.0383	-0.6621	0.1540	7	to	350
24. Tetrachloromethane	556.3	0.1488	1.1513	-0.9262	0.2662	-13	to	350
25. Bromotrichloromethane	606.	0.1415	0.9284	-0.8276	0.2638	-73	to	350
26. Tetrabromomethane	740.	0.1372	0.5439	-0.5984	0.2326	60	to	327

CH₃F FLUOROMETHANE (METHYL FLUORIDE, REFRIGERANT 41)

$M = 34.03$

$$\lambda^{(o)} \text{ and } \eta^{(o)} = b_1 + b_2 (1 - T_r) + b_3 (1 - T_r)^2 + b_4 (1 - T_r)^3,$$

$$c_p^{\text{id}} = b_1 + b_2 T_r + b_3 T_r^2 + b_4 T_r^3,$$

$$T_r = T/T_c, \quad T = \text{temperature (K)}, \quad T_c = \text{critical temperature} = 312. \text{ K } (= 38.85 \text{ }^\circ\text{C})$$

	b_1	b_2	b_3	b_4	Equation
Thermal conductivity of dilute gas, $\lambda^{(o)}$ (mW/m K)	16.57	-25.67	10.30	2.03	(4.1)
Viscosity of dilute gas, $\eta^{(o)}$ ($\mu\text{N s/m}^2$)	12.06	-12.07	-0.57	0.27	(5.1)
Specific heat capacity of ideal gas, c_p^{id} (kJ/kg K)	1.0782	-0.5804	0.8069	-0.1741	(6.1)

T K	$\lambda^{(o)}$ mW/m K	$\eta^{(o)}$ $\mu\text{N s/m}^2$	c_p^{id} kJ/kg K	$Pr^{(o)}$ -	t °C	$\lambda^{(o)}$ mW/m K	$\eta^{(o)}$ $\mu\text{N s/m}^2$	c_p^{id} kJ/kg K	$Pr^{(o)}$ -
200	8.8	7.7	0.992	0.87	-70	9.0	7.8	0.994	0.87
220	9.9	8.5	1.009	0.86	-50	10.1	8.6	1.012	0.86
240	11.2	9.2	1.030	0.85	-30	11.4	9.4	1.034	0.85
260	12.6	10.0	1.054	0.84	-10	12.8	10.2	1.058	0.84
280	14.0	10.8	1.081	0.83	10	14.3	10.9	1.086	0.83
300	15.6	11.6	1.111	0.83	30	15.9	11.7	1.116	0.83
320	17.2	12.4	1.144	0.82	50	17.5	12.5	1.149	0.82
340	19.0	13.1	1.179	0.82	70	19.2	13.3	1.184	0.82
360	20.8	13.9	1.215	0.81	90	21.0	14.0	1.221	0.81
380	22.6	14.7	1.254	0.81	110	22.9	14.8	1.260	0.81
400	24.6	15.4	1.293	0.81	130	24.9	15.5	1.300	0.81
420	26.6	16.2	1.334	0.81	150	26.9	16.3	1.341	0.81
440	28.7	16.9	1.376	0.81	170	29.0	17.0	1.383	0.81
460	30.8	17.6	1.419	0.81	190	31.2	17.7	1.425	0.81
480	33.1	18.4	1.461	0.81	210	33.4	18.5	1.468	0.81
500	35.3	19.1	1.504	0.81	230	35.7	19.2	1.511	0.81
520	37.7	19.8	1.546	0.81	250	38.0	19.9	1.553	0.81
540	40.0	20.5	1.588	0.81	270	40.4	20.6	1.595	0.81
560	42.5	21.2	1.629	0.81	290	42.8	21.3	1.636	0.81
580	44.9	21.8	1.669	0.81	310	45.3	21.9	1.675	0.81
600	47.4	22.5	1.708	0.81	330	47.8	22.6	1.714	0.81
620	50.0	23.2	1.745	0.81	350	50.4	23.3	1.751	0.81

Data Sources (see Appendix A)

Thermal conductivity - A2.: 778; Reference 15

Viscosity - A1.: 9, 12, 20, 26

Specific heat capacity - A1.: 27