VISCOSITY OF GASES

Marcia L. Huber

The following table gives the viscosity of some common gases as a function of temperature. Unless otherwise noted, the viscosity values refer to a pressure of 100 kPa (1 bar) or to the saturation vapor pressure if that is less than 100 kPa. The notation *P*=0 indicates that the low-pressure limiting value is given. The difference between the viscosity at 100 kPa and the limiting value is generally less than 2 %. Uncertainties for gases in this table are generally less than 3 %; uncertainty information on specific fluids can be found in the references. Viscosity is given in units of μPa s; note that 1 μPa s = 10^{-5} poise. Substances are listed in the modified Hill order (see Preface).

		Viscosity in μPa s						
		100 K	**200 K**	**300 K**	**400 K**	**500 K**	**600 K**	**Ref.**
	Air	7.1	13.3	18.5	23.1	27.1	30.8	1
Ar	Argon (*P*=0)	8.1	15.9	22.7	28.6	33.9	38.8	2,3*,4*
BF_3	Boron trifluoride		12.3	17.1	21.7	26.1	30.2	5
ClH	Hydrogen chloride			14.6	19.7	24.3		5
F_6S	Sulfur hexafluoride			15.3	19.7	23.8	27.6	6
H_2	Normal hydrogen (*P*=0)	4.1	6.8	8.9	10.9	12.8	14.5	3*,7
	Deuterium (*P*=0)	5.9	9.6	12.6	15.4	17.9	20.3	8
H_2O	Water (*P*=0)			9.8	13.4	17.3	21.4	9
	Deuterium oxide (*P*=0)			10.1	13.8	17.9	22.1	10
H_2S	Hydrogen sulfide (*P*=0)		8.1	12.2	16.4	20.3	24.0	11
H_3N	Ammonia			10.2	13.9	17.7	21.4	12
He	Helium (*P*=0)	9.6	15.1	19.9	24.3	28.3	32.2	13
Kr	Krypton (*P*=0)	8.9	17.3	25.4	32.8	39.4	45.5	14,15*
NO	Nitric oxide		13.8	19.2	23.8	28.0	31.9	5
N_2	Nitrogen (*P*=0)	6.7	12.8	17.8	22.1	25.9	29.4	16,17*
N_2O	Nitrous oxide (*P*=0)		10.0	14.9	19.6	23.9	27.8	18
Ne	Neon (*P*=0)	14.4	24.1	31.9	38.6	44.8	50.6	19
O_2	Oxygen	7.7	14.7	20.7	25.8	30.5	34.7	1
O_2S	Sulfur dioxide		8.6	12.9	17.5	21.7		5
Xe	Xenon (*P*=0)	8.3	15.6	23.2	30.4	37.1	43.4	3*,15*,20
CO	Carbon monoxide	6.7	12.9	17.8	22.1	25.8	29.1	5,17*
CO_2	Carbon dioxide		10.1	15.0	19.6	23.9	27.9	21
$CHCl_3$	Chloroform			10.2	13.7	16.9	20.1	5
CH_4	Methane (*P*=0)	3.9	7.7	11.1	14.2	16.9	19.3	3*,22
CH_4O	Methanol (*P*=0)		6.6	9.7	13.0	16.4	19.8	23
C_2H_2	Acetylene			10.4	13.5	16.5		5
C_2H_4	Ethylene		7.0	10.4	13.6	16.5	19.2	24

* More accurate data covering a restricted temperature range.

C_2H_4O	Ethylene oxide (P=0)		6.4	9.4	12.5	15.7	18.8	25
C_2H_6	Ethane (P=0)	3.3	6.2	9.3	12.2	14.8	17.3	26
C_2H_6O	Ethanol				11.6	14.5	17.0	5
C_3H_8	Propane			8.2	10.8	13.3	15.6	27
C_4H_{10}	*n*-Butane			7.4	9.9	12.2	14.5	28
C_4H_{10}	Isobutane			7.5	9.9	12.2	14.4	29
$C_4H_{10}O$	Diethyl ether			7.6	10.1	12.4		5
C_5H_{12}	*n*-Pentane			6.7	9.2	11.4	13.4	5
C_6H_{14}	*n*-Hexane				8.4	10.4	12.4	30

References

1. Lemmon, E. W., and Jacobsen, R. T, Viscosity and Thermal Conductivity Equations for Nitrogen, Oxygen, Argon, and Air*, Int. J. Thermophys*., 25, 21, 2004.
2. Vogel, E., Jäger, B., Hellmann, R., and Bich, E., *Ab initio* pair potential energy curve for the argon atom pair and thermophysical properties for the dilute argon gas. II. Thermophysical properties for low-density argon, *Mol. Phys.*, 108, 3335, 2010.
3. May, E. F., Berg, R. F., and Moldover, M. R., Reference viscosities of H_2, CH_4, Ar, and Xe at low Densities*, Int. J. Thermophys*., 28, 1085, 2007.
4. Vogel, E., Reference viscosity of argon at low density in the temperature range from 290 K to 680 K, *Int. J. Thermophys*., 31, 447, 2010.
5. Ho, C. Y., Ed., *Properties of Inorganic and Organic Fluids*, *CINDAS Data Series on Materials Properties*, Vol. V-1, Hemisphere Publishing Corp., New York, 1988.
6. Quiñones-Cisneros, S.E., Huber, M.L., and Deiters, U.K., Correlation for the Viscosity of Sulfur Hexafluoride (SF_6) from the Triple Point to 1000 K and Pressures to 50 MPa, *J. Phys. Chem. Ref. Data*, 41, 023102 (2012).
7. Mehl, J. B., Huber, M. L., and Harvey, A. H., *Ab Initio* Transport Coefficients of Gaseous Hydrogen, *Int. J. Thermophys*., 31, 740, 2010.
8. Assael, M. J., Mixafendi, M., and Wakeham, W. A., The viscosity of normal deuterium in the limit of zero density, *J. Phys. Chem. Ref. Data*, 16, 189, 1987.
9. Huber, M. L., R. A. Perkins, R. A., Laesecke, A., Friend, D. G., Sengers, J. V., Assael, M. J., Metaxa, I. M., Vogel, E., Mares, R., and Miyagawa, K., New International Formulation for the Viscosity of Water, *J. Phys. Chem. Ref. Data*, 38, 101, 2009.
10. Hellmann, R. and Bich, E., Transport properties of dilute D_2O vapour from first principles, *Mol. Phys.*, 115, 1057, 2017.
11. Hellmann, R., Bich, E., Vogel, E., and Vesovic, V., Thermophysical Properties of Dilute Hydrogen Sulfide Gas, *J. Chem. Eng. Data*, 57, 1312, 2012.
12. Monogenidou, S.A., Assael, M.J., and Huber, M.L., Reference Correlation of the Viscosity of Ammonia from the Triple Point to 700 K and up to 50 MPa, *J. Phys. Chem. Ref. Data*, 47, 023102, 2018.

13. Cencek, W., Przybytek, M., Komasa, J., Mehl, J.B., Jeziorski, B., and Szalewicz, K., Effects of adiabatic, relativistic, and quantum electrodynamics interactions on the pair potential and thermophysical properties of helium, *J. Chem. Phys*., 136, 224303, 2012.
14. Jäger, B., Hellmann, R., Bich, E., and Vogel, E., State-of-the-art ab initio potential energy curve for the krypton atom pair and thermophysical properties of dilute krypton gas, *J. Chem. Phys*., 144, 114304, 2016.
15. Vogel, E., The Viscosities of Dilute Kr, Xe, and CO_2 Revisited: New Experimental Reference Data at Temperatures from 295 K to 690 K, *Int. J. Thermophys.,* 37, 63, 2016.
16. Hellmann, R., Ab initio potential energy surface for the nitrogen molecule pair and thermophysical properties of nitrogen gas, *Mol. Phys*., 111,387, 2013.
17. Vogel, E., Towards Reference Viscosities of Carbon Monoxide and Nitrogen at Low Density Using Measurements between 290 K and 680 K as well as Theoretically Calculated Viscosities, *Int. J. Thermophys*., 33, 741, 2012.
18. Crusius, J.-P., Hellmann, R., Hassel, E. and Bich, E., Ab initio intermolecular potential energy surface and thermophysical properties of nitrous oxide, *J. Chem. Phys.,* 142, 244307, 2015.
19. Bich, E., Hellmann, R., and Vogel, E., Ab initio potential energy curve for the neon atom pair and thermophysical properties for the dilute neon gas. II. Thermophysical properties for low-density neon, *Mol. Phys.*, 106, 1107, 2008.
20. Hellmann, R., Jäger, B., and Bich, E., State-of-the-art ab initio potential energy curve for the xenon atom pair and related spectroscopic and thermodynamic properties, *J. Chem. Phys.*, 147, 034304, 2017.
21. Laesecke, A., and Muzny, C.D., Reference Correlation for the Viscosity of Carbon Dioxide, *J. Phys. Chem. Ref. Data*, 46, 013107, 2017.
22. Laesecke, A., and Muzny, C.D., Ab Initio Calculated Results Require New Formulations for Properties in the Limit of Zero Density: The Viscosity of Methane (CH_4), *Int. J. Thermophys*., 38, 181, 2017, Erratum: *Int. J. Thermophys*., 39, 52, 2018.
23. Xiang, H.-W., Huber, M. L., and Laesecke, A., A new reference correlation for the viscosity of methanol, *J. Phys. Chem. Ref. Data*, 35, 1597, 2006.
24. Holland, P. M., Eaton, B. E., and Hanley, H. J. M., A Correlation of the Viscosity and Thermal Conductivity Data of Gaseous and Liquid Ethylene, *J. Phys. Chem. Ref. Data,* 12, 917, 1983.
25. Crusius, J.-P., Hellmann, R., Hassel, E. and Bich, E., Intermolecular potential energy surface and thermophysical properties of ethylene oxide, *J. Chem. Phys*., 141, 164322, 2014.
26. Herrmann, S., Hellmann, R., and Vogel, E., Update: Reference Correlation for the Viscosity of Ethane, *J. Phys. Chem. Ref. Data*, 47, 023103, 2018.
27. Vogel, E., and Herrmann, S., New Formulation for the Viscosity of Propane, *J. Phys. Chem. Ref. Data*, 45, 043103, 2016.
28. Herrmann, S., and Vogel, E., New Formulation for the Viscosity of n-Butane, *J. Phys. Chem. Ref. Data*, 47, 013104, 2018.
29. Vogel, E., Kuechenmeister, C., and Bich, E., Viscosity Correlation for Isobutane over Wide Ranges of the Fluid Region, *Int. J. Thermophys*., 21, 343, 2000.

30. Michailidou, E.K., Assael, M.J., Huber, M.L., and Perkins, R.A., Reference Correlation of the Viscosity of *n*-hexane from the Triple Point to 600 K and up to 100 MPa, *J. Phys. Chem. Ref. Data*, 42, 033104, 2013.