CONTENTS

INTRODUCTION

Seldom do we find one with both the necessary skills and the enthusiasm to carry on major tabulations of any kind. Fortunately, we have such a combination in Mr. Dreisbach. He has not only tabulated physical chemical data, but he has done extensive collecting, naming, and tabulation for families and genera of insects, especially *Hymenoptera*.

This is his third volume to be entitled "Physical Properties of Chemical Compounds." The earlier volumes appeared as Numbers 15 and 22 of the ADVANCES IN CHEMISTRY SERIES. The present work includes data on the physical properties of 434 aliphatic compounds and 22 miscellaneous compounds and elements. Of these, 22 are tables of improved values for compounds included in volume two (ADVANCES No. 22). This brings the total number of substances treated up to 1421. This volume also includes a combined index to the tables in all three volumes.

The preparation of these tables has stimulated the determination of physical constants in The Dow Chemical Co. and has been responsible, in part, for the formation of the Manufacturing Chemists' Research Advisory Committee on the Properties of Chemical Compounds.

In addition to the tabulation of new and old data on pure compounds, parameters are given for interpolating and extrapolating determined data based on the systematic way in which the properties of compounds vary within a given homologous series.

H. S. NUTTING, Director
Technical Information Services
The Dow Chemical Co.

PHYSICAL PROPERTIES OF CHEMICAL COMPOUNDS—III

The physical properties covered in this book are listed below. Ranges covered are given in parentheses.

Parameters for various empirical equations are tabulated, which permit accurate interpolation and extrapolation of the various properties within the ranges designated.

Where any of the values below are missing, it is because they have never been determined or are patently inaccurate. Where the determined values do not conform to the formulas, tney have been adjusted accordingly and labeled "calculated."

Purity
Freezing point
Vapor pressure (25° C. to crit. temp.)
Liquid density (25° C., approx. 3 atm.)
Vapor density (25° C., approx. 3 atm.)
Refractive index (25° to approx. 60° C.)
Rate of change of boiling point
  with pressure (25° C., to crit. temp.)
Latent heat of fusion
Latent heat of evaporation (25° C., approx. 3 atm.)
Critical values
Compressibility (25° C., approx. 3 atm.)
Viscosity (approx. 0° to 100° C.)
Heat content (approx. 300° to 1000° K.)
Surface tension (20° to 40° C.)
Solubility (25° C.)

To get full value out of this reference work, the editors recommend that the user take the time to become familiar with the definitions that follow.

Definition of Symbols and Parameters Used, with Methods of Calculating the Parameters

Mol. % Pur.: Mole % purity by weight.

F.P.: Freezing point, ° C.

F.P. 100%: Freezing point curve extrapolated to 100% purity.

B.P. 760 mm., 100 mm., etc.: Boiling points at these pressures, ° C.

P_{25}: Pressures at 25° C., in mm.

P_e: Pressure corresponding to temperature t_e in mm.

d^{20}, etc.: Density at 20° C., etc., g./ml.

a, b: Constants of Law of Rectilinear Diameters, $d_V + d_L = a + bt$
d_V = density of the vapor, g./ml.; d_L = density of the liquid, g./ml.

n_D^{20}, etc.: Refractive index for the sodium line at 20° C., etc.

C: Constant of the Eykman equation, $(n_D^2 - 1)/(n_D + 0.4) \times 1/d = C$

MR (obs.): Molal refraction (obs.) $= (n_D^2 - 1)/(n_D^2 + 2) \times M/d =$ MR at 20° C. (M = mol. wt.)

MR (calc.): Molal refraction calculated from atomic refractive indices. See page 8.

$(n_D - d/2)$: Refractivity intercept equals refractive index minus one half the density, both at the same temperature, 20° C.

D: Dielectric constant run at a frequency of 10^5 (cycles/sec.) and at 25° C. unless otherwise noted. When reported as data of The Dow Chemical Co., error about ±0.005. Where Reference 5 is noted, it was obtained by squaring the refractive index at 20° C.

A, B, C: Constants of the Antoine vapor pressure equation for the liquid state, giving P (pressure) in mm. and t (temperature) in ° C. This is in the range between the temperatures as indicated. These temperatures in general are the boiling point at 30 mm. to a T_R of 0.75 to 0.80. See method of obtaining *A, B, C* on page 6.

Antoine equation: $\log P = A - B/(t + C)$

A^*, B^*, K, c, t_k, t_x: Constants of the saturated vapor density equation
$\log d_V(g./ml.) = A^* - B^*/(t + C)$ to the temperature t_k
$\log d_V(g./ml.) = A^* - B^*/(t + C) + K/(1.1\,T_C - 273.2 - t) + c$
from temperature t_k to a reduced temperature, T_R, of 0.92

t_k = Temperature at which it is necessary to change from the simple vapor density equation to the corrected vapor equation in the higher ranges, ° C.

$t_k = t_x + K/c$ and $t_x = (1.1\,T_C - 273.2)$° C.

A^* and B^* where the latent heat at the atmospheric boiling point is available.

$V_g - V_L = (31381.7 \times \Delta Hv \times dt/dp)/T$

Where the latent heat is not available use
$M(\Delta Hv)/T_B = 21.0$ and from this $\Delta Hv = (T_B \times 21.0)/M$
The value 21.0 (or any other value as 21.4, say) is obtained from the nearest related compound which has a latent heat available. Then proceed as in the case where latent heat is available for V_g value at B. P.

Since $d_V = 1/V_g$
$\log d_{V760} = A^* - B^*/(t_B + C)$ at 760 mm.
$\log d_{V30} = A^* - B^*/(t_{30} + C)$ at 30 mm.
Solve for A^*, B^*, since t and d_V at 760 mm. and 30 mm. and C are known.

A′, B′, C′: Constants of the Antoine vapor pressure equation below 30-mm. pressure, covering the temperature range as indicated. See method of obtaining the constants on page 6.

$A'^{\bullet}$, $B'^{\bullet}$: Constants of the vapor density equation below 30 mm. These two values are obtained by using the boiling point at 30 mm. and the pressure at 25° C. (obtained from the values A', B', C') and assuming that at 25° C. the relationship $PV/RT = 1$. Then we have V_g at 25° $C. = RT/MP = 62{,}361 \times (25 + 273.2)/MP$.

Then $dv = 1/Vg$. Inserting these values of vapor density, we then solve the two equations for the values of $A'^{\bullet}$ and $B'^{\bullet}$ as in the case of $A^{\bullet}$ and $B^{\bullet}$.

Ac, Bc, Cc: Constants of the Antoine vapor pressure equation for the liquid state from $T_R = 0.75$ (or a higher T_R as indicated) to the critical temperature. See method of obtaining the constants on page 7.

Cryoscopic Constants, $A°$, $B°$: Cryoscopic constants for calculating mole % purity. See *J. Research Natl. Bur. Standards*, 35 (1945); RP 1676.

t_e° C.: Temperature at which a mole of the vapor occupies 22.414 liters and the vapor is in equilibrium with the liquid, in ° C.

$$t_e = \frac{B^{\bullet}}{(A^{\bullet} - \log dv_e)} - C$$

dt/dp: Rate of change of boiling point with pressure, given by equation $dt/dp = B/[2.3026 \times P \times (A - \log P)^2]$° C./mm. Also $dt/dp = (t + C)^2/2.3\,PB$

ΔHm: Latent heat of fusion in cal./g.

ΔHv: Latent heat of vaporization at the temperature designed, cal./g.

$t_e(d, e)$: The latent heat of vaporization at the temperature t_e as given by the equation $\Delta Hv = d - et$, and indicates the accuracy of this equation at the temperature t_e.

$\Delta Hv/T_e$: Molal latent heat of vaporization at t_e divided by T_e. (Equal to the molal entropy of vaporization at t_e.)

$d, e; d', e'$: Parameters of the latent heat of vaporization equation, ΔHv(cal./g.) $= d - et$. This is valid between the temperatures indicated. It has been found that the latent heat between the boiling point at 30 mm. and the boiling point at 760 mm. is almost a linear function of the temperature. As seen in most cases this equation holds almost to the temperature, t_e. Above and below this the latent heat is not linear with temperature except for short intervals.

d_c: Critical density, g./ml.

v_c: Critical volume, ml./g.

t_c: Critical temperature, ° C. See also page 7.

P_c mm.: Critical pressure in mm. Where this was not obtained from the literature it is calculated as follows (Thomson method, private communication from George W. Thomson): The critical temperature is inserted in the Antoine equation, using the A, B, and C values to calculate the critical pressure. This value is too low. This is then multiplied by 1.07 and is assumed to be the critical pressure. In the great majority of cases, this will agree with determined values to within ±3%. For high boiling compounds this value must be decreased, since in most cases there is somewhat irregular drift with increasing temperature, so this should be continually lowered as the boiling point becomes increasingly higher.

PV/RT: Compressibility at the temperature designated.

$z = PV/RT$

where P = pressure in mm., V = volume in ml./mole, and $R = 62361$.

ΔHc: Heat of combustion, kcal./mole, gas at constant pressure, 298.16° K. or 25° C.

ΔHf: Heat of formation, kcal./mole, liquid at 298.16° K. or 25° C.

ΔFf: Free energy of formation, kcal./mole, liquid at 298.16° K. or 25° C.

η: Kinematic viscosity in centistokes, at temperature designated. The kinematic viscosity is given by the equation
$\log \eta = A^v + B^v/T$
between the temperatures indicated to an accuracy of 1% or better.

B.P. ° C., 30 mm.; *dt/dp; ΔHv; PV/RT:* These values at 30 mm. are calculated from the Antoine equation using *A, B,* and *C.* It has been found that at 30 mm. in almost all Cox Chart Families the ratio *PV/RT* is negligibly different from one. This, then, has been taken as one point (the other point being the B.P. at 760 mm.) from which to calculate $A^\bullet$ and $B^\bullet$, always assuming the compressibility as 1.0000 at 30 mm.

c_p: Specific heat at constant pressure at temperature designated, cal./g. ° K.

c_v: Specific heat at constant volume at temperature designated, cal./g. ° K.

f, g, h, f', g', h': Parameters of the heat content equation for the liquid for the temperature ranges designated, ° K.
c_p (liquid) $= f + gT + hT^2$

m, n, o, m', n', o': Parameters of the heat content equation for the vapor for the temperature ranges designated, ° K.
c_p (vapor) $= m + nT + oT^2$

γ: Surface tension in dynes/cm., at temperature designated.

[*P*]: Parachor at the temperature designated:
$M(\gamma)^{1/4}/(d_L - d_V) = [P]$

[*P*] Sugd.: Parachor from atomic and structural values as given by Sugden. See table. The parachor value for oxygen as hydroxyl (alcohols) in these tables is taken as 15. Sugden gives the values of 20 for oxygen and 30 for oxygen in esters, which does not seem to work for alcohols and phenols.

Exp. L.l.; Exp. L.u.: Explosion limits lower and upper range, % by wt.

Dispersion: Specific dispersion, $10^4(n_F - n_C)/d$, ml./g. at 25° C.
n_F, n_C = refractive index for *F* and *C* lines.
d = density, g./ml.

Flash and Fire Points, ° C.: Cleveland open cup (ASTM D 92-46) if not otherwise designated. Closed cup (ASTM D 56-36) will be designated as such.

M Spec.: Mass Spectrograph.

Ultra V.: Ultraviolet.

X-Ray Dif.: X-Ray Diffraction.

Infrared: Infrared Spectrograph.

Solubility at 25° C., in solvents as designated.

Explanation of methods used for calculating the various parameters in the foregoing:

A, B, C: The *A, B,* and *C* constants, except where given by the API reports, are calculated by means of the Thomson method [*Chem. Revs.* 38, 1–39 (1946)] using the determined boiling points at three different pressures. The three formulas for this are as follows:
$(y_3 - y_2)/(y_2 - y_1) \times (t_2 - t_1)/(t_3 - t_2) = 1 - (t_3 - t_1)/(t_3 + C)$
$B = (y_3 - y_1)/(t_3 - t_1) \times (t_1 + C)(t_3 + C)$
and $A = y_1 + B/(t_1 + C)$
where y_1 y_2, and y_3 are equal to log P_1, log P_2, and log P_3 at temperatures t_1, t_2, and t_3. Unless the data for the three points are *very* accurate, the *C* value can be considerably in error. As a check on this method an empirical formula developed by Thomson (private communication from George W. Thomson) will give a much better value of *C* if the data are much in error. This formula is $C = 239 - 0.19t_B$. The *A* and *B* values can then be readily determined from the two points given, since they are much less critical.

A', B', C' (for pressures below 30 mm.): Applicable when molar heats of vaporization are available at 25° C. and the Antoine equation can be used to obtain the boiling point at 30 mm. Let *A, B, C* be the constants of the usual Antoine equation valid above 30 mm. and let *A', B', C'* be the constants of the Antoine equation sought for below 30 mm. These two equations are taken to give the same value of the pressure-temperatures slope at 30 mm.

$\log 30 = A - B/(t_1 + C) = A' - B'/(t_1 + C')$

$B/(t_1 + C)^2 = B'/(t_1 + C')^2$

Since PV/RT may be assumed to be 1.0000 at t_1, the temperature corresponding to 30 mm., and is also 1.0000 at 25° C., the molar heat of vaporization at 25° C., $M\Delta Hv_2$, is given by

$M\Delta Hv_2 = 2.3026\ RB'\ [(t_2 + 273.2)/(t_2 + C']^2$

where $t_2 = 25°$ C. To solve for A', B', C' let

$g_2 = M\Delta Hv_2/2.3026\ R(t_2 + 273.2)^2 = M\Delta Hv_2/406883$ if $t_2 = 25°$ C.

Since t_1, t_2 and all values on left-hand side of equations above are known, then B' and C' are readily obtained as follows:

$[B'/(t_2 + C')^2][t_1 + C')^2/B'] = g_2(t_1 + C')^2/B' =$ say, h^2

Then $C' = (t_1 - ht_2)/(h - 1)$ and $B' = g_2(t_2 + C')^2$

Also $B' = B[(t_1 + C')/(t_1 + C)]^2$

$A' = \log 30 + B'/(t_1 + C')$ since $P_1 = 30$ mm.

These formulas were developed with the aid of George Thomson.

When heats of vaporization at 25° C. are not known:

In this case the C' value is estimated and A' and B' are calculated from known data. It was noticed that C' has a value approximately 18 higher than C when latent heats at 25° C. are known. By adding this increment to C we have C', then B' from the relation for the first case

$B' = B[(t_{30} + C')/(t_{30} + C)]^2$

and then A' as in first case.

In the case of the alkenes and alkynes the A', B', C' and $A'^{\bullet}\ B'^{\bullet}$ were not calculated by the above method, since the data for these compounds are much less reliable than in the case of the alkanes.

Ac, Bc, Cc: This method was developed by George Thomson [*Chem. Revs.* 38, No. 1, 23 (1946)] and is similar to the one for obtaining A', B', C'. It is assumed that the parameters A, B, C of the Antoine equation are good to a T_R 0.75 or a higher reduced temperature, and this temperature corresponds to the 25° C. in the case of A', B', C', and the critical point corresponds to the 30-mm. point.

$B/(t_1 + C)^2 \times (t_c - t_1)/(y_c - y_1) = 1 + (t_c - t_1)/(t_1 + Cc)$

and $Bc = (y_c - y_1)/(t_c - t_1) \times (t_1 + Cc)(t_c + Cc)$;

$Ac = B/(t_c + Cc) + y_c$

where t_1 ° C. $= T_R$ 0.75, t_c ° C. = critical temperature

$y_1 = \log P$ at t_1, $y_c = \log P_c$

The first equation is used to evaluate *Cc*, the second, *Bc*, and the third, *Ac*.

Association: The association in the vapor phase of organic acids seems to vary inversely as the temperature for some acids, at least for part of the range. In part of the range, and also apparently for some acids over the whole range, the association is fairly constant. The association is given in these sheets by the formula $M_x = p - rt$. For instance, for acetic acid this formula would be $M_x = 2.225 - 0.004085\ t$ from 0° C. to 100° C. From 100° C. to a T_R of 0.92, $M_x = 1.85$. That is to say, the vapor density as calculated by the $A^{\bullet}, B^{\bullet}$ formula would have to be multiplied by this correction factor to take care of the association. Further, if the reciprocal of the density is used as calculated to give volume, it would be necessary to divide by 1.85 to get the actual vapor volume.

t_c: Where the critical temperature has not been determined, it is calculated by Watson's equation:
$T_c/T_c = 0.283(M/d_s)^{0.18}$
where d_s = liquid density, g./ml. at the boiling point, and M = molecular weight. This is used for all hydrocarbons and halohydrocarbons.

f, g, h, m, n, o, etc.: For a short temperature range the equation $C_p = f + gT + hT^2$ reproduces almost exactly determined data. The parameters were set up on the IBM machines using eight determined values where that many or more were available.

The IBM machines were used to set up the Antoine constants from determined data. A preliminary C value was obtained from the equation $C = 239. - 0.19t_B$. A and B were then obtained and new C values either side of the first C used and new A and B values found. In each case above, the boiling points at the experimental pressures were calculated and compared with the determined boiling points.
Actually the value of C was generally obtained from $C = 239. - 0.19t_B$, since the determined values must be *very very* accurate to give better values of C.

Cox Chart Families

1. Fluoroalkanes
2. Chloroalkanes
3. Bromoalkanes
4. Iodoalkanes
5. Haloalkenes
6. Aminoalkanes
7. Cyanoalkanes (alkyl cyanides)
8. Thiaalkanes
9. Dithiaalkanes
10. Aliphatic acids (organic acids)
11. Miscellaneous organic compounds
12. Miscellaneous inorganic compounds

Atomic Refractive Indices Used for Computing Molecular Refractive Index

All values are for the sodium line.

Carbon singly bound and alone	2.592	NO as nitrites	5.91
Carbon singly bound	2.418	NO as nitrosoamine	5.37
Carbon double bond	1.733	NO_2 as alkyl nitrite	7.44
Carbon triple bond	2.398	NO_2 as alkyl nitrate	7.59
Carbon conjugated	1.27	NO_2 as nitroparaffin	6.72
Hydrogen	1.100	NO_2 as nitro aromatic	7.30
Oxygen, hydroxyl	1.525	NO_2 as nitramine	7.51
Oxygen, ethereal	1.643	Fluorine	0.95[a]
Oxygen, ketonic	2.211	Chlorine	5.967
Oxygen, as ester	1.64	Bromine	8.865
Sulfur as SH	7.69	Iodine	13.900
Sulfur as RSR	7.97		
Sulfur as RCNS	7.91		
Sulfur as RSSR	8.11		
Nitrogen			
As aliphatic primary amine	2.45		
As aromatic primary amine	3.21		
As aliphatic secondary amine	2.65		
As aromatic secondary amine	3.59		
As aliphatic tertiary amine	3.00		
As aromatic tertiary amine	4.36		
As hydroxylamine	2.48		
As hydrazine	2.47		
As aliphatic cyanide	3.05		
As aromatic cyanide	3.79		
As aliphatic oxime	3.93		
As primary amide	2.65		
As secondary amide	2.27		
As teritary amide	2.71		

[a] This value for one fluorine atom attached to carbon. The value 1.1 is to be used for each fluorine atom in polyfluorides.

Atomic and Structural Constants for Calculation of Parachor

	Sugden		*Sugden*
CH_2	39.0	Br	68.0
C	4.8	I	91.0
H	17.1	Single bond	—
O	20.0	Double bond	23.2
O (alcohol)	15.0	Triple bond	46.6
O_2 (ester)	60.0	3-Membered ring	16.7
N	12.5	4-Membered ring	11.6
N (nitrile)	14.4	5-Membered ring	8.5
S	48.2	6-Membered ring	6.1
F	25.7	7-Membered ring	—
Cl	54.3	Aliphatic alcohol subtract	6.0

TABLE I. FLUOROALKANES

No. 1

NAME	Fluoromethane	STRUCTURAL FORMULA
		CH_3F

Mole % Pur.	Ref. 3	Molecular Formula CH_3F	Molecular Weight 34.034

		Ref.			Ref.			Ref.
F.P. °C	-141.8	3	dt/dP °C/mm			f | to		
F.P. 100%			25°C			g | °C		
B.P. °C			BP	0.0238	5	h |		
760 mm	-78.35	3	t_e	0.0325	5	f' | to		
100	-108.68	5	30 mm	0.3392	5	g' | °C		
30	-122.19	5	ΔHm cal/g			h' |		
10	-132.50	5				m | to		
1	-149.60	5	ΔHv cal/g			n | °K		
Pressure mm 25°C			25°C			o |		
t_e	514.16	5	30 mm	130.74	5	m' | to		
Density g/ml 20°C	0.5786[a]	3	BP	119.27	5	n' | °K		
d_4^t 25	0.5570[a]	3	t_e	121.23	5	o' |		
30			t_e (d, e)	121.05	5	Surface tension dynes/cm. 20°C		
a	0.6963	5	ΔHv/T_e	21.95	5	γ 30		
b	-0.02311	5	d | -130 to	98.76	5	40		
Ref. Index			e | -70 °C	0.2617	5	Parachor [P]		
n_D 20°C	1.1727[a]	3	d' | to			20°C		
25	1.1674[a]	3	e' | °C			30		
30			d_c g/ml			40		
"C"	0.4124	4	v_c ml/g			Sugd.	81.8	5
MR (Obs.)	6.5392	4	t_c °C			Exp. L. l. %/wt. u.		
MR (Calc.)	6.668	5	P_c mm			Dispersion		
(nD-d/2)	0.8834	4	PV/RT			Flash Point °C		
Dielectric			25°C			Fire Point		
A | 125 to	7.09761	3	30 mm	1.0000	5	M. Spec.		
B | -60 °C	740.218	3	BP	0.9755	5	Ultra V.		
C	253.89	3	t_e	0.9829	5	X-Ray Dif.		
A* | -70 to	1.25564	5	t_c			Infrared		
B* | -90 °C	687.52	5	ΔHc kcal/m			Solubility in [+]		
K			ΔHf			Acetone		
c			ΔFf			Carbon tet.		
t_k | to			Viscosity centistokes			Benzene		
t_x | °C			η °C			Ether		
A' | to						n-Heptane		
B' | °C			B^v | to			Ethanol		
C'			A^v | °C			Water		
A'* to			(B^v) |			Water in		
B'* °C			(A^v) |					
Ac | to			c_p liq. °C					
Bc | t_c °C			c_p vap. °K					
Cc			c_v vap.					
Cryos. A* consts. B*								
t_e °C	-85.14	5						

[a] For the liquid at saturation pressure

[+] grams/100 grams solvent

REFERENCES: 1-Dow 2-API 3-Lit. 4-Calc. from det. data 5-Calc. by formula

SOURCE: MCA

PURIFICATION: MCA

LITERATURE REFERENCES: 3 MCA

No. 2

NAME	Fluoroethane	STRUCTURAL FORMULA
Mole % Pur.	Ref. 3	Molecular Formula C_2H_5F	Molecular Weight 48.060	CH_3CH_2F

		Ref.
F.P. °C	-143.2	3
F.P. 100%		
B.P. °C		
760 mm	-37.70	3
100	-74.58	5
30	-90.89	5
10	-103.28	5
1	-123.75	5
Pressure mm 25°C	6734.	5
t_e	626.19	5
Density g/ml 20°C	0.7182[a]	3
d_4^t 25	0.7062[a]	3
30		
a	0.7741	5
b	-0.00193¼	5
Ref. Index		
n_D 20°C	1.2656[a]	3
25	1.2621[a]	3
30		
"C"	0.5030	4
MR (Obs.)	11.1799	4
MR (Calc.)	11.286	5
(nD-d/2)	0.9065	4
Dielectric		
A -100 to	6.97853	3
B -30 °C	854.211	3
C	246.16	3
A* -92 to	1.2656	3
B* °C	794.90	3
K		
c		
t_k to		
t_x °C		
A' to		
B' °C		
C'		
A'* to		
B'* °C		
Ac to		
Bc t_c °C		
Cc		
Cryos. A°		
consts. B°		
t_e °C	-41.89	5

		Ref.
dt/dP		
°C/mm		
25°C	0.0056	5
BP	0.0291	5
t_e	0.0339	5
30 mm	0.4086	5
ΔHm cal/g		
ΔHv cal/g		
25°C		
30 mm	112.05	5
BP	100.22	5
t_e	101.20	5
t_e (d, e)	101.15	5
$\Delta Hv/T_e$	21.03	5
d to	91.83	5
e °C	0.2224	5
d' to		
e' °C		
d_c g/ml		
v_c ml/g		
t_c °C		
P_c mm		
PV/RT		
25°C		
30 mm	1.0000	5
BP	0.9689	5
t_e	0.9732	5
t_c		
ΔHc kcal/m		
ΔHf		
ΔFf		
Viscosity centistokes		
η °C		
B^v to		
A^v °C		
(B^v) to		
(A^v) °C		
c_p liq. °K		
c_p vap. °K		
c_v vap.		

		Ref.
f to		
g °K		
h		
f' to		
g' °K		
h'		
m to		
n °K		
o		
m' to		
n' °K		
o'		
Surface tension		
dynes/cm. 20°C	9.64	5
γ 30	8.13	5
40	6.74	5
Parachor [P]		
20°C		
30		
40		
Sugd.	120.8	5
Exp. L.1.%/wt. u.		
Dispersion		
Flash Point °C		
Fire Point		
M Spec.		
Ultra V.		
X-Ray Dif.		
Infrared		
Solubility in +		
Acetone		
Carbon tet.		
Bensene		
Ether		
n-Heptane		
Ethanol		
Water		
Water in		

[a] For the liquid at saturation pressure

+ grams/100 grams solvent

REFERENCES: 1-Dow 2-API 3-Lit. 4-Calc. from det. data 5-Calc. by formula

SOURCE: MCA

PURIFICATION: MCA

LITERATURE REFERENCES: 3 MCA

No. 3

NAME	1-Fluoropropane	STRUCTURAL FORMULA
Mole % Pur.	Ref. 3	Molecular Formula C_3H_7F	Molecular Weight 62.086	$(CH_3)(CH_2)_2F$

		Ref.
F. P. °C	-159.0	3
F. P. 100%		
B. P. °C 760 mm	-2.50	3
100	-44.64	5
30	-63.25	5
10	-77.37	5
1	-100.69	5
Pressure mm 25°C	2014.77	5
t_e	725.55	5
Density g/ml 20°C	0.7956[a]	3
d_4^t 25	0.7518[a]	3
30		
a	0.9730	5
b	-0.008559	5
Ref. Index n_D 20°C	1.3115[a]	3
25	1.3091[a]	3
30		
"C"	0.5288	4
MR (Obs.)	15.1044	4
MR (Calc.)	15.904	5
(nD-d/2)	0.9137	4
Dielectric		
A | -70 to	6.9533	3
B | 30 °C	965.18	3
C	239.5	3
A* | -65 to	1.2563	5
B* | 15 °C	899.42	5
K		
c		
t_k | to		
t_x | °C		
A' | to		
B' | °C		
C'		
A'* to		
B'* °C		
Ac | to		
Bc | t_c °C		
Cc		
Cryos. A°		
consts. B°		
t_e °C	-3.67	5

		Ref.
dt/dP °C/mm		
25°C	0.0156	5
BP	0.0333	5
t_e	0.0345	5
30 mm	0.4659	5
ΔHm cal/g		
ΔHv cal/g		
25°C	83.94	5
30 mm	100.88	5
BP	89.41	5
t_e	89.63	5
t_e (d, e)	89.63	5
$\Delta Hv/T_e$	20.65	5
d | -70 to	88.93	5
e | 10 °C	0.1889	5
d' | to		
e' | °C		
d_c g/ml		
v_c ml/g		
t_c °C	179.06	5
P_c mm	47501.35	5
PV/RT		
25°C	0.9377	5
30 mm	1.0000	5
BP	0.9666	5
t_e	0.9677	5
t_c		
ΔHc kcal/m		
ΔHf		
ΔFf		
Viscosity centistokes		
η °C		
B^v | to		
A^v | °C		
(B^v) | to		
(A^v) | °C		
c_p liq. °K		
c_p vap. °K		
c_v vap.		

			Ref.
f	to		
g	°K		
h			
f'	to		
g'	°K		
h'			
m	to		
n	°K		
o			
m'	to		
n'	°K		
o'			
Surface tension dynes/cm. 20°C		17.04	5
σ 30		10.51	5
40		6.03	5
Parachor [P] 20°C			
30			
40			
Sugd.		159.8	5
Exp. L.1.%/wt. u.			
Dispersion			
Flash Point °C			
Fire Point			
M. Spec.			
Ultra V.			
X-Ray Dif.			
Infrared			
Solubility in [+]			
Acetone			
Carbon tet.			
Benzene			
Ether			
n-Heptane			
Ethanol			
Water			
Water in			

[a] For the liquid at saturation pressure

[+] grams/100 grams solvent

REFERENCES: 1-Dow 2-API 3-Lit. 4-Calc. from det. data 5-Calc. by formula

SOURCE: MCA

PURIFICATION: MCA

LITERATURE REFERENCES: 3 MCA

No. 4

NAME	1-Fluorobutane	STRUCTURAL FORMULA
		$CH_3(CH_2)_3F$

Mole % Pur.	Ref. 3	Molecular Formula C_4H_9F	Molecular Weight 76.112

		Ref.
F.P. °C	-134	3
F.P. 100%		
B.P. °C		
760 mm	+32.5	3
100	-14.6	5
30	-35.4	5
10	-51.3	5
1	-77.3	5
Pressure		
mm 25°C	578.33	5
t_e	817.98	5
Density		
g/ml 20°C	0.7789	3
d_4^t 25	0.7727	3
30		
a	0.8041	5
b	-0.001160	5
Ref. Index		
n_D 20°C	1.3396	3
25	1.3376	3
30		
"C"	0.5864	4
MR (Obs.)	20.4608	4
MR (Calc.)	20.522	5
(nD-d/2)	0.9501	4
Dielectric		
A | -40 to	6.9581	3
B | 75 °C	1081.71	3
C	232.8	3
A* | to	1.3162	5
B* | °C	1012.16	5
K		
c		
t_k | to		
t_x | °C		
A' | to		
B' | °C		
C'		
A'* to		
B'* °C		
Ac | to		
Bc | t_c °C		
Cc		
Cryos. A°		
consts. B°		
t_e °C	+34.60	5

		Ref.
dt/dP		
°C/mm		
25°C	0.0156	5
BP	0.0372	5
t_e	0.0351	5
30 mm	0.4659	5
ΔHm cal/g		
ΔHv cal/g		
25°C	83.61	5
30 mm	94.32	5
BP	82.30	5
t_e	81.92	5
t_e (d, e)	81.93	5
$\Delta Hv/T_e$	20.26	5
d | -40 to	88.05	5
e | 40 °C	0.1770	5
d' | to		
e' | °C		
d_c g/ml		
v_c ml/g		
t_c °C		
P_c mm		
PV/RT		
25°C	0.9644	5
30 mm	1.0000	5
BP	0.9574	5
t_e	0.9553	5
t_c		
ΔHc kcal/m		
ΔHf		
ΔFf		
Viscosity centistokes		
η °C		
B^v | to		
A^v | °C		
(B^v) | to		
(A^v) | °C		
c_p liq. °K		
c_p vap. °K		
c_v vap.		

			Ref.
f | to			
g | °K			
h			
f' | to			
g' | °K			
h'			
m | to			
n | °K			
o			
m' | to			
n' | °K			
o'			
Surface tension			
dynes/cm. 20°C	γ	16.95	5
30		15.82	5
40		14.70	5
Parachor [P]			
20°C			
30			
40			
Sugd.		198.8	5
Exp. L.1.%/wt. u.			
Dispersion			
Flash Point °C			
Fire Point			
M Spec.			
Ultra V.			
X-Ray Dif.			
Infrared			
Solubility in +			
Acetone			
Carbon tet.			
Benzene			
Ether			
n-Heptane			
Ethanol			
Water			
Water in			

+ grams/100 grams solvent

REFERENCES: 1-Dow 2-API 3-Lit. 4-Calc. from det. data 5-Calc. by formula

SOURCE: MCA

PURIFICATION: MCA

LITERATURE REFERENCES: 3 MCA

TABLE I. FLUOROALKANES

No. 5

NAME	1-Fluoropentane	STRUCTURAL FORMULA
		$CH_3(CH_2)_4F$

Mole % Pur.	Ref. 3	Molecular Formula $C_5H_{11}F$	Molecular Weight 90.138

		Ref.
F.P. °C	-120.	3
F.P. 100%		
B.P. °C 760 mm	62.8	3
100	11.6	5
30	-11.1	5
10	-28.3	5
1	-56.8	5
Pressure mm 25°C	184.18	5
t_e	899.65	5
Density g/ml 20°C	0.7907	3
d_4^t 25	0.7851	3
30		
a	0.8132	5
b	-0.001086	5
Ref. Index n_D 20°C	1.3591	3
25	1.3571	3
30		
"C"	0.6091	4
MR (Obs.)	25.1026	4
MR (Calc.)	25.140	5
(nD-d/2)	0.9637	4
Dielectric		
A -20 to	6.9857	3
B 100 °C	1190.03	3
C	227.1	3
A* to	1.3870	5
B* °C	1116.51	5
K		
c		
t_k to		
t_x °C		
A' to		
B' °C		
C'		
A'* to		
B'* °C		
Ac to		
Bc t_c °C		
Cc		
Cryos. A* consts. B*		
t_e °C	68.07	5

		Ref.
dt/dP		
°C/mm		
25°C	0.1259	5
BP	0.0404	5
t_e	0.0353	5
30 mm	0.5677	5
ΔHm cal/g		
ΔHv cal/g		
25°C	82.99	5
30 mm	88.89	5
BP	76.93	5
t_e	76.08	5
t_e (d, e)	76.07	5
$\Delta Hv/T_e$	20.10	5
d -15 to	87.10	5
e 75 °C	0.1620	5
d' to		
e' °C		
d_c g/ml		
v_c ml/g		
t_c °C		
P_c mm		
PV/RT		
25°C		
30 mm		
BP		
t_e		
t_c		
ΔHc kcal/m		
ΔHf		
ΔFf		
Viscosity centistokes		
η °C		
B^v to		
A^v °C		
(B^v) to		
(A^v) °C		
c_p liq. °K		
c_p vap. °K		
c_v vap.		

			Ref.
f	to		
g	°K		
h			
f'	to		
g'	°K		
h'			
m	to		
n	°K		
o			
m'	to		
n'	°K		
o'			
Surface tension dynes/cm. 20°C		18.86	5
30		17.78	5
40		16.72	5
Parachor [P] 20°C			
30			
40			
Sugd.		237.8	5
Exp. L. l. %/wt. u.			
Dispersion			
Flash Point °C			
Fire Point			
M. Spec.			
Ultra V.			
X-Ray Dif.			
Infrared			
Solubility in +			
Acetone			
Carbon tet.			
Benzene			
Ether			
n-Heptane			
Ethanol			
Water			
Water in			

+ grams/100 grams solvent

REFERENCES: 1-Dow 2-API 3-Lit. 4-Calc. from det. data 5-Calc. by formula

SOURCE: MCA

PURIFICATION: MCA

LITERATURE REFERENCES: 3 MCA

No. 6

NAME	1-Fluorohexane	STRUCTURAL FORMULA
		$CH_3(CH_2)_5F$

Mole % Pur.	Ref. 3	Molecular Formula $C_6H_{13}F$	Molecular Weight 104.164

		Ref.
F. P. °C	-103.	3
F. P. 100%		
B. P. °C		
760 mm	91.5	3
100	36.7	5
30	12.4	5
10	-6.2	5
1	-36.8	5
Pressure mm 25°C	57.82	5
t_e	976.82	5
Density g/ml 20°C	0.7995	3
d_4^{t} 25	0.7942	3
30		
a	0.8207	5
b	-0.001046	5
Ref. Index n_D 20°C	1.3738	3
25	1.3718	3
30		
"C"	0.6257	4
MR (Obs.)	29.7394	4
MR (Calc.)	29.758	5
(nD-d/2)	0.9740	4
Dielectric		
A 0 to	7.0305	3
B 120 °C	1299.19	3
C	221.6	3
A* 5 to	1.4680	5
B* 115 °C	1222.05	5
K		
c		
t_k to		
t_x °C		
A' to		
B' °C		
C'		
A'* to		
B'* °C		
Ac to		
Bc t_c °C		
Cc		
Cryos. A'		
consts. B'		
t_e °C	99.93	5

		Ref.
dt/dP		
°C/mm		
25°C	0.3516	5
BP	0.0431	5
t_e	0.0354	5
30 mm	0.6098	5
ΔHm cal/g		
ΔHv cal/g		
25°C	83.03	5
30 mm	84.98	5
BP	73.03	5
t_e	71.84	5
t_e (d, e)	71.75	5
$\Delta Hv/T_e$	20.06	5
d to	86.84	5
e °C	0.1510	5
d' to		
e' °C		
d_c g/ml		
v_c ml/g		
t_c °C		
P_c mm		
PV/RT		
25°C	0.9956	5
30 mm	1.0000	5
BP	0.9481	5
t_e	0.9411	5
t_c		
ΔHc kcal/m		
ΔHf		
ΔFf		
Viscosity centistokes		
η °C		
B^v to		
A^v °C		
(B^v) to		
(A^v) °C		
c_p liq. °K		
c_p vap. °K		
c_v vap.		

			Ref.
f to			
g °K			
h			
f' to			
g' °K			
h'			
m to			
n °K			
o			
m' to			
n' °K			
o'			
Surface tension			
dynes/cm. 20°C		20.35	5
γ 30		19.27	5
40		18.23	5
Parachor [P]			
20°C			
30			
40			
Sugd.		276.8	5
Exp. L.1.%/wt. u.			
Dispersion			
Flash Point °C			
Fire Point			
M Spec.			
Ultra V.			
X-Ray Dif.			
Infrared			
Solubility in +			
Acetone			
Carbon tet.			
Benzene			
Ether			
n-Heptane			
Ethanol			
Water			
Water in			

+ grams/100 grams solvent

REFERENCES: 1-Dow 2-API 3-Lit. 4-Calc. from det. data 5-Calc. by formula

SOURCE: MCA

PURIFICATION: MCA

LITERATURE REFERENCES: 3 MCA