2.9 Chlorine

Equations for thermodynamic properties have been cited from the IUPAC Table [1], those for transport properties from Miller et al.[2]-[4], and one for surface tension from Miller et al.[5].

2.9.1 Temperature Scale

International practical temperature scale 1968 (IPTS-1968)

2.9.2 The Names of Substance, Library File and Single Shot Program

Name of Substance:	Chlorine
Library File for UNIX:	libjcl2.a
Library File for DOS,Windows95/NT:	JCL2.LIB
Single Shot Program for UNIX:	cl2-ss
Single Shot Program for DOS,Windows95/NT:	CL2–SS.EXE

2.9.3 Important Constants and Others

Molecular Formula:	$C\ell_2$
Relative Molecular Mass:	70.906
Gas Constant:	117.259 J/(kg·K)

Critical Constants:

Critical Pressure:	7.9914×10^6Pa (79.914 bar)
Critical Temperature:	416.956 K (143.806°C)
Critical Specific Volume:	1.7337×10^{-3}m^3/kg

Triple Point:

Pressure:	1.387×10^3 Pa (0.01387 bar)
Temperature:	172.17 K (−100.98°C)

Reference State:

At 1.01325 bar(1 atm) and 25°C(298.15 K), 0 J/(kg·K) is assigned to the specific entropy of the ideal gas. At 25°C(298.15 K), 0 J/kg is assigned to the specific enthalpy of the ideal gas.

2.9.4 Formula

Equation of State:

Equation (21) in a function form of $P = P(\rho, T)$ in reference [1]. Here P=pressure, ρ=density and T=temperature.

Vapor Pressure:

Equation (21) [equation of state] and the Gibbs condition for phase equilibrium in reference [1].

Properties at Vapor-Liquid Equilibrium:

Equation (21) [equation of state] and Gibbs condition for phase equilibrium for specific volume, equation (24) for specific entropy, equation (29) for specific enthalpy and equation (34) for isobaric specific heat, respectively. All of these have been cited from reference [1]. However, the third term in the right side of equation (34)

$$C_p(\rho, T) = C_p^{id}(T) - R + R[\sum_{i=1}^{18} N_i(XC)_i]_0^w + \cdots$$

has been corrected to

$$C_p(\rho, T) = C_p^{id}(T) - R - R[\sum_{i=1}^{18} N_i (XC)_i]_0^w + \cdots$$

Transport Properties:
Thermal conductivity at room pressure from reference [2], viscosity at room pressure from reference [3], and viscosity of saturated liquid from reference [4].

The Other Properties:
Surface tension from reference [5].

References

[1] S.Angus, B.Armstrong and K.M.de Reuck, International Thermodynamic Table of the Fluid State-8, Chlorine, IUPAC, (1974).
[2] J.W.Miller Jr., P.N.Shah and C.L.Yaws, Chem. Eng., 83–24, (1976), p.153.
[3] J.W.Miller Jr., G.R.Schorr and C.L.Yaws, Chem. Eng., 83–24, (1976), p.155.
[4] J.W.Miller Jr., G.R.Schorr and C.L.Yaws, Chem. Eng., 83–24, (1976), p.157.
[5] J.W.Miller Jr. and C.L.Yaws, Chem. Eng., 83–23, (1976), p.127.

Table II–2.9–1 Chlorine Function

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
1	AIPPT(P,T)		
94	AJTPT(P,T)	AJTPT: Joule-Thomson Coefficient [K/Pa] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$0 \leq P \leq 25 \times 10^6$ [Pa] $180 \leq T \leq 900$ [K] $0 \leq P \leq 250$ [bar] $-93.15 \leq T \leq 626.85$ [°C]
8A	AKPD(P)		
8B	AKPDD(P)		
82	AKPT(P,T)	AKPT: Isentropic Exponent [–] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$0 \leq P \leq 25 \times 10^6$ [Pa] $180 \leq T \leq 900$ [K] $0 \leq P \leq 250$ [bar] $-93.15 \leq T \leq 626.85$ [°C]
8C	AKTD(T)		
8D	AKTDD(T)		
2	ALAPP(P)	ALAPP: Laplace Coefficient [m] P∗: Pressure [Pa], [bar]	$1.3871 \times 10^3 \leq P < 7.9914 \times 10^6$ [Pa] $13.871 \times 10^{-3} \leq P < 79.914$ [bar]
3	ALAPT(T)	ALAPT: Laplace Coefficient [m] T∗: Temperature [K], [°C]	$172.17 \leq T < 416.956$ [K] $-100.98 \leq T < 143.806$ [°C]
4	ALHP(P)	ALHP: Latent Heat of Vaporization [J/kg] P∗: Pressure [Pa], [bar]	$1.3871 \times 10^3 \leq P \leq 7.9914 \times 10^6$ [Pa] $13.871 \times 10^{-3} \leq P \leq 79.914$ [bar]
5	ALHT(T)	ALHT: Latent Heat of Vaporization [J/kg] T∗: Temperature [K], [°C]	$172.17 \leq T \leq 416.956$ [K] $-100.98 \leq T \leq 143.806$ [°C]
6	ALMPD(P)		
7	ALMPDD(P)		
8	ALMPT(P,T)	ALMPT: Thermal Conductivity at Ordinary Pressure [W/(m·K)] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	P=Dummy $193.15 \leq T \leq 1473.15$ [K] $-80 \leq T \leq 1200$ [°C]
9	ALMTD(T)		
10	ALMTDD(T)		
11	AMUPD(P)	AMUPD: Coefficient of Viscosity of Saturated Liquid [Pa·s] P∗: Pressure [Pa], [bar]	$1.3871 \times 10^3 \leq P \leq 7.9914 \times 10^6$ [Pa] $13.871 \times 10^{-3} \leq P \leq 79.914$ [bar]
12	AMUPDD(P)		
13	AMUPT(P,T)	AMUPT: Coefficient of Viscosity at Ordinary Pressure [Pa·s] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	P=Dummy $73.15 \leq T \leq 1473.15$ [K] $-200 \leq T \leq 1200$ [°C]
14	AMUTD(T)	AMUTD: Coefficient of Viscosity of Saturated Liquid [Pa·s] T∗: Temperature [K], [°C]	$172.17 \leq T \leq 416.956$ [K] $-100.98 \leq T \leq 143.806$ [°C]
15	AMUTDD(T)		
92	BPPT(P,T)	BPPT: Volumetric Coefficient of Expansion [1/K] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$0 \leq P \leq 25 \times 10^6$ [Pa] $180 \leq T \leq 900$ [K] $0 \leq P \leq 250$ [bar] $-93.15 \leq T \leq 626.85$ [°C]
90	BSPT(P,T)	BSPT: Isentropic Compressibility [1/Pa] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$0 \leq P \leq 25 \times 10^6$ [Pa] $180 \leq T \leq 900$ [K] $0 \leq P \leq 250$ [bar] $-93.15 \leq T \leq 626.85$ [°C]
91	BTPT(P,T)	BTPT: Isothermal Compressibility [1/Pa] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$0 \leq P \leq 25 \times 10^6$ [Pa] $180 \leq T \leq 900$ [K] $0 \leq P \leq 250$ [bar] $-93.15 \leq T \leq 626.85$ [°C]

Table II–2.9–1 Chlorine Function (cont'd)

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
93	BVPT(P,T)	BVPT: Pressure Coefficient [1/K] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$0 \leq P \leq 25\times10^6$ [Pa] $180 \leq T \leq 900$ [K] $0 \leq P \leq 250$ [bar] $-93.15 \leq T \leq 626.85$ [°C]
16	CPPD(P)	CPPD: Isobaric Specific Heat of Saturated Liquid [J/(kg·K)] P∗: Pressure [Pa], [bar]	$1.3871\times10^3 \leq P < 7.9914\times10^6$ [Pa] $13.871\times10^{-3} \leq P < 79.914$ [bar]
17	CPPDD(P)	CPPDD: Isobaric Specific Heat of Saturated Vapor [J/(kg·K)] P∗: Pressure [Pa], [bar]	$1.3871\times10^3 \leq P < 7.9914\times10^6$ [Pa] $13.871\times10^{-3} \leq P < 79.914$ [bar]
18	CPPT(P,T)	CPPT: Isobaric Specific Heat [J/(kg·K)] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$0 \leq P \leq 25\times10^6$ [Pa] $180 \leq T \leq 900$ [K] $0 \leq P \leq 250$ [bar] $-93.15 \leq T \leq 626.85$ [°C]
19	CPTD(T)	CPTD: Isobaric Specific Heat of Saturated Liquid [J/(kg·K)] T∗: Temperature [K], [°C]	$172.17 \leq T < 416.956$ [K] $-100.98 \leq T < 143.806$ [°C]
20	CPTDD(T)	CPTDD: Isobaric Specific Heat of Saturated Vapor [J/(kg·K)] T∗: Temperature [K], [°C]	$172.17 \leq T < 416.956$ [K] $-100.98 \leq T < 143.806$ [°C]
21	CRP('A')	CRP: Critical Constants H: 'A'='H': -81.188×10^3 [J/kg] Specific Enthalpy P∗: 'A'='P': 7.9914×10^6 [Pa], 79.914 [bar] Pressure S: 'A'='S': −632.74 [J/(kg·K)] Specific Entropy T∗: 'A'='T': 416.956 [K], 143.806 [°C] Temperature V: 'A'='V': 1.7337×10^{-3} [m^3/kg] Specific Volume	one of 'H', 'P', 'S', 'T' and 'V'
7A	CVPD(P)		
76	CVPDD(P)	CVPDD: Isochoric Specific Heat of Saturated Vapor [J/(kg·K)] P∗: Pressure [Pa], [bar]	$1.3871\times10^3 \leq P \leq 7.9914\times10^6$ [Pa] $13.871\times10^{-3} \leq P \leq 79.914$ [bar]
77	CVPT(P,T)	CVPT: Isochoric Specific Heat [J/(kg·K)] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$0 \leq P \leq 25\times10^6$ [Pa] $180 \leq T \leq 900$ [K] $0 \leq P \leq 250$ [bar] $-93.15 \leq T \leq 626.85$ [°C]
7B	CVTD(T)		
78	CVTDD(T)	CVTDD: Isochoric Specific Heat of Saturated Vapor [J/(kg·K)] T∗: Temperature [K], [°C]	$172.17 \leq T \leq 416.956$ [K] $-100.98 \leq T \leq 143.806$ [°C]
2A	EPSPD(P)		
2B	EPSPDD(P)		
22	EPSPT(P,T)		
2C	EPSTD(T)		
2D	EPSTDD(T)		

Table II–2.9–1 Chlorine Function (cont'd)

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
89	FC('A')	FC: Fundamental Constants M: 'A'='M': 70.906 Relative Molecular Mass R: 'A'='R': 117.259 [J/(kg·K)] Gas Constant	one of 'M' and 'R'
9A	GAMPD(P)		
96	GAMPDD(P)	GAMPDD: Ratio of Specific Heats of Saturated Vapor [–] P∗: Pressure [Pa], [bar]	$1.3871\times10^3 \le P \le 7.9914\times10^6$ [Pa] $13.871\times10^{-3} \le P \le 79.914$ [bar]
95	GAMPT(P,T)	GAMPT: Ratio of Specific Heats [–] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$0 \le P \le 25\times10^6$ [Pa] $180 \le T \le 900$ [K] $0 \le P \le 250$ [bar] $-93.15 \le T \le 626.85$ [°C]
9B	GAMTD(T)		
97	GAMTDD(T)	GAMTDD: Ratio of Specific Heats of Saturated Vapor [J/kg] T∗: Temperature [K], [°C]	$172.17 \le T \le 416.956$ [K] $-100.98 \le T \le 143.806$ [°C]
23	HPD(P)	HPD: Specific Enthalpy of Saturated Liquid [J/kg] P∗: Pressure [Pa], [bar]	$1.3871\times10^3 \le P \le 7.9914\times10^6$ [Pa] $13.871\times10^{-3} \le P \le 79.914$ [bar]
24	HPDD(P)	HPDD: Specific Enthalpy of Saturated Vapor [J/kg] P∗: Pressure [Pa], [bar]	$1.3871\times10^3 \le P \le 7.9914\times10^6$ [Pa] $13.871\times10^{-3} \le P \le 79.914$ [bar]
71	HPS(P,S)	HPS: Specific Enthalpy [J/kg] P∗: Pressure [Pa], [bar] S: Specific Entropy [J/(kg·K)]	$10 \le P \le 25\times10^6$ [Pa] SPT(P,180K)≤S≤ SPT(P,900K) [J/(kg·K)] $0.1\times10^{-3} \le P \le 250$ [bar] SPT(P,−93.15°C)≤S≤ SPT(P,626.95°C) [J/(kg·K)]
25	HPT(P,T)	HPT: Specific Enthalpy [J/kg] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$0 \le P \le 25\times10^6$ [Pa] $180 \le T \le 900$ [K] $0 \le P \le 250$ [bar] $-93.15 \le T \le 626.85$ [°C]
26	HPX(P,X)	HPX: Specific Enthalpy of Mixture [J/kg] P∗: Pressure [Pa], [bar] X: Dryness Fraction [–]	$1.3871\times10^3 \le P \le 7.9914\times10^6$ [Pa] $13.871\times10^{-3} \le P \le 79.914$ [bar] $0 \le X \le 1.0$ [–]
27	HTD(T)	HTD: Specific Enthalpy of Saturated Liquid [J/kg] T∗: Temperature [K], [°C]	$172.17 \le T \le 416.956$ [K] $-100.98 \le T \le 143.806$ [°C]
28	HTDD(T)	HTDD: Specific Enthalpy of Saturated Vapor [J/kg] T∗: Temperature [K], [°C]	$172.17 \le T \le 416.956$ [K] $-100.98 \le T \le 143.806$ [°C]
29	HTX(T,X)	HTX: Specific Enthalpy of Mixture [J/kg] T∗: Temperature [K], [°C] X: Dryness Fraction [–]	$172.17 \le T \le 416.956$ [K] $-100.98 \le T \le 143.806$ [°C] $0 \le X \le 1.0$ [–]
84	IDENTF('A')	IDENTF: CHARACTER TYPE FUNCTION for Package Identification (Length 20) C: 'A'='C': 'CL2' Molecular Formula S: 'A'='S': 'CHLORINE' Name of Substance V: 'A'='V': '10.1' Version Number	one of 'C', 'S' and 'V'
66	PLDT(T)		
68	PMLT(T)		
85	PRPD(P)		
86	PRPDD(P)		

Table II–2.9–1 Chlorine Function (cont'd)

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
81	PRPT(P,T)	PRPT: Prandtl Number at Ordinary Pressure [–] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	P=Dummy 193.15≤T≤900 [K] −80≤T≤626.85 [°C]
87	PRTD(T)		
88	PRTDD(T)		
99	PSBT(T)		
30	PST(T)	PST∗: Saturation Pressure [Pa], [bar] T∗: Temperature [K], [°C]	172.17≤T≤416.956 [K] −100.98≤T≤143.806 [°C]
72	PSTD(T)		
73	PSTDD(T)		
31	SIGP(P)	SIGP: Surface Tension [N/m] P∗: Pressure [Pa], [bar]	$1.3871\times10^{3}\leq P\leq7.9914\times10^{6}$ [Pa] $13.871\times10^{-3}\leq P\leq79.914$ [bar]
32	SIGT(T)	SIGT: Surface Tension [N/m] T∗: Temperature [K], [°C]	172.17≤T≤416.956 [K] −100.98≤T≤143.806 [°C]
33	SPD(P)	SPD: Specific Entropy of Saturated Liquid [J/(kg·K)] P∗: Pressure [Pa], [bar]	$1.3871\times10^{3}\leq P\leq7.9914\times10^{6}$ [Pa] $13.871\times10^{-3}\leq P\leq79.914$ [bar]
34	SPDD(P)	SPDD: Specific Entropy of Saturated Vapor [J/(kg·K)] P∗: Pressure [Pa], [bar]	$1.3871\times10^{3}\leq P\leq7.9914\times10^{6}$ [Pa] $13.871\times10^{-3}\leq P\leq79.914$ [bar]
35	SPT(P,T)	SPT: Specific Entropy [J/(kg·K)] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$10\leq P\leq25\times10^{6}$ [Pa] 180≤T≤900 [K] $0.1\times10^{-3}\leq P\leq250$ [bar] −93.15≤T≤626.85 [°C]
36	SPX(P,X)	SPX: Specific Entropy of Mixture [J/(kg·K)] P∗: Pressure [Pa], [bar] X: Dryness Fraction [–]	$1.3871\times10^{3}\leq P\leq7.9914\times10^{6}$ [Pa] $13.871\times10^{-3}\leq P\leq79.914$ [bar] 0≤X≤1.0 [–]
37	STD(T)	STD: Specific Entropy of Saturated Liquid [J/(kg·K)] T∗: Temperature [K], [°C]	172.17≤T≤416.956 [K] −100.98≤T≤143.806 [°C]
38	STDD(T)	STDD: Specific Entropy of Saturated Vapor [J/(kg·K)] T∗: Temperature [K], [°C]	172.17≤T≤416.956 [K] −100.98≤T≤143.806 [°C]
39	STX(T,X)	STX: Specific Entropy of Mixture [J/(kg·K)] T∗: Temperature [K], [°C] X: Dryness Fraction [–]	172.17≤T≤416.956 [K] −100.98≤T≤143.806 [°C] 0≤X≤1.0 [–]
67	TLDLP(P)		
69	TMLP(P)		
64	TPH(P,H)	TPH∗: Temperature [K], [°C] P∗: Pressure [Pa], [bar] H: Specific Enthalpy [J/kg]	$10\leq P\leq25\times10^{6}$ [Pa] HPT(P,180K)≤H≤ HPT(P,900K) [J/kg] $0.1\times10^{-3}\leq P\leq250$ [bar] HPT(P,−93.15°C)≤H≤ HPT(P,626.95°C) [J/kg]
6H	TPH2(P,H)		
65	TPS(P,S)	TPS∗: Temperature [K], [°C] P∗: Pressure [Pa], [bar] S: Specific Entropy [J/(kg·K)]	$10\leq P\leq25\times10^{6}$ [Pa] SPT(P,180K)≤S≤ SPT(P,900K) [J/(kg·K)] $0.1\times10^{-3}\leq P\leq250$ [bar] SPT(P,−93.15°C)≤S≤ SPT(P,626.95°C) [J/(kg·K)]
6S	TPS2(P,S)		
98	TPSEUP(P)	TPSEUP: Pseudo Boiling Point [K], [°C] P∗: Pressure [Pa], [bar]	$7.9914\times10^{6}<P\leq25\times10^{6}$ [Pa] 79.914<P≤250 [bar]

Table II–2.9–1 Chlorine Function (cont'd)

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
70	TPV(P,V)	TPV∗: Temperature [K], [°C] P∗: Pressure [Pa], [bar] V: Specific Volume [m^3/kg]	$10 \le P \le 25\times10^6$ [Pa] VPT(P,180K)≤V≤ VPT(P,900K) [m^3/kg] $0.1\times10^{-3} \le P \le 250$ [bar] VPT(P,−93.15°C)≤V≤ VPT(P,626.95°C) [m^3/kg]
41	TRPL('A')	TRPL∗: Properties at Triple Point P∗: 'A'='P': 1.3871×10^3 [Pa], 13.871×10^{-3} [bar] Pressure T∗: 'A'='T': 172.170 [K], −100.980 [°C] Temperature	one of 'P' and 'T'
100	TSBP(P)		
40	TSP(P)	TSP∗: Saturation Temperature [K], [°C] P∗: Pressure [Pa], [bar]	$1.3871\times10^3 \le P \le 7.9914\times10^6$ [Pa] $13.871\times10^{-3} \le P \le 79.914$ [bar]
74	TSPD(P)		
75	TSPDD(P)		
42	UPD(P)	UPD: Specific Internal Energy of Saturated Liquid [J/kg] P∗: Pressure [Pa], [bar]	$1.3871\times10^3 \le P \le 7.9914\times10^6$ [Pa] $13.871\times10^{-3} \le P \le 79.914$ [bar]
43	UPDD(P)	UPDD: Specific Internal Energy of Saturated Vapor [J/kg] P∗: Pressure [Pa], [bar]	$1.3871\times10^3 \le P \le 7.9914\times10^6$ [Pa] $13.871\times10^{-3} \le P \le 79.914$ [bar]
79	UPS(P,S)	UPS: Specific Internal Energy [J/kg] P∗: Pressure [Pa], [bar] S: Specific Entropy [J/(kg·K)]	$10 \le P \le 25\times10^6$ [Pa] SPT(P,180K)≤S≤ SPT(P,900K) [J/(kg·K)] $0.1\times10^{-3} \le P \le 250$ [bar] SPT(P,−93.15°C)≤S≤ SPT(P,626.95°C) [J/(kg·K)]
44	UPT(P,T)	UPT: Specific Internal Energy [J/kg] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$0 \le P \le 25\times10^6$ [Pa] 180≤T≤900 [K] 0≤P≤250 [bar] −93.15≤T≤626.85 [°C]
45	UPX(P,X)	UPX: Specific Internal Energy of Mixture [J/kg] P∗: Pressure [Pa], [bar] X: Dryness Fraction [–]	$1.3871\times10^3 \le P \le 7.9914\times10^6$ [Pa] $13.871\times10^{-3} \le P \le 79.914$ [bar] 0≤X≤1.0 [–]
46	UTD(T)	UTD: Specific Internal Energy of Saturated Liquid [J/kg] T∗: Temperature [K], [°C]	172.17≤T≤416.956 [K] −100.98≤T≤143.806 [°C]
47	UTDD(T)	UTDD: Specific Internal Energy of Saturated Vapor [J/kg] T∗: Temperature [K], [°C]	172.17≤T≤416.956 [K] −100.98≤T≤143.806 [°C]
48	UTX(T,X)	UTX: Specific Internal Energy of Mixture [J/kg] T∗: Temperature [K], [°C] X: Dryness Fraction [–]	172.17≤T≤416.956 [K] −100.98≤T≤143.806 [°C] 0≤X≤1.0 [–]
49	VPD(P)	VPD: Specific Volume of Saturated Liquid [m^3/kg] P∗: Pressure [Pa], [bar]	$1.3871\times10^3 \le P \le 7.9914\times10^6$ [Pa] $13.871\times10^{-3} \le P \le 79.914$ [bar]
50	VPDD(P)	VPDD: Specific Volume of Saturated Vapor [m^3/kg] P∗: Pressure [Pa], [bar]	$1.3871\times10^3 \le P \le 7.9914\times10^6$ [Pa] $13.871\times10^{-3} \le P \le 79.914$ [bar]
80	VPS(P,S)	VPS: Specific Volume [m^3/kg] P∗: Pressure [Pa], [bar] S: Specific Entropy [J/(kg·K)]	$10 \le P \le 25\times10^6$ [Pa] SPT(P,180K)≤S≤ SPT(P,900K) [J/(kg·K)] $0.1\times10^{-3} \le P \le 250$ [bar] SPT(P,−93.15°C)≤S≤ SPT(P,626.95°C) [J/(kg·K)]

Table II–2.9–1 Chlorine Function (cont'd)

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
51	VPT(P,T)	VPT: Specific Volume [m^3/kg] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$10 \leq P \leq 25\times10^6$ [Pa] $180 \leq T \leq 900$ [K] $0.1\times10^{-3} \leq P \leq 250$ [bar] $-93.15 \leq T \leq 626.85$ [°C]
52	VPX(P,X)	VPX: Specific Volume of Mixture [m^3/kg] P∗: Pressure [Pa], [bar] X: Dryness Fraction [–]	$1.3871\times10^3 \leq P \leq 7.9914\times10^6$ [Pa] $13.871\times10^{-3} \leq P \leq 79.914$ [bar] $0 \leq X \leq 1.0$ [–]
53	VTD(T)	VTD: Specific Volume of Saturated Liquid [m^3/kg] T∗: Temperature [K], [°C]	$172.17 \leq T \leq 416.956$ [K] $-100.98 \leq T \leq 143.806$ [°C]
54	VTDD(T)	VTDD: Specific Volume of Saturated Vapor [m^3/kg] T∗: Temperature [K], [°C]	$172.17 \leq T \leq 416.956$ [K] $-100.98 \leq T \leq 143.806$ [°C]
55	VTX(T,X)	VTX: Specific Volume of Mixture [m^3/kg] T∗: Temperature [K], [°C] X: Dryness Fraction [–]	$172.17 \leq T \leq 416.956$ [K] $-100.98 \leq T \leq 143.806$ [°C] $0 \leq X \leq 1.0$ [–]
8E	WPD(P)		
8F	WPDD(P)		
83	WPT(P,T)	WPT: Velocity of Sound [m/s] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$0 \leq P \leq 25\times10^6$ [Pa] $180 \leq T \leq 900$ [K] $0 \leq P \leq 250$ [bar] $-93.15 \leq T \leq 626.85$ [°C]
8G	WTD(T)		
8H	WTDD(T)		
56	XPH(P,H)	XPH: Dryness Fraction [–] P∗: Pressure [Pa], [bar] H: Specific Enthalpy of Mixture [J/kg]	$1.3871\times10^3 \leq P < 7.9914\times10^6$ [Pa] $13.871\times10^{-3} \leq P < 79.914$ [bar] HPD(P)≤H≤HPDD(P) [J/kg]
57	XPS(P,S)	XPS: Dryness Fraction [–] P∗: Pressure [Pa], [bar] S: Specific Entropy of Mixture [J/(kg·K)]	$1.3871\times10^3 \leq P < 7.9914\times10^6$ [Pa] $13.871\times10^{-3} \leq P < 79.914$ [bar] SPD(P)≤S≤SPDD(P) [J/(kg·K)]
58	XPU(P,U)	XPU: Dryness Fraction [–] P∗: Pressure [Pa], [bar] U: Specific Internal Energy of Mixture [J/kg]	$1.3871\times10^3 \leq P < 7.9914\times10^6$ [Pa] $13.871\times10^{-3} \leq P < 79.914$ [bar] UPD(P)≤U≤UPDD(P) [J/kg]
59	XPV(P,V)	XPV: Dryness Fraction [–] P∗: Pressure [Pa], [bar] V: Specific Volume of Mixture [m^3/kg]	$1.3871\times10^3 \leq P < 7.9914\times10^6$ [Pa] $13.871\times10^{-3} \leq P < 79.914$ [bar] VPD(P)≤V≤VPDD(P) [m^3/kg]
60	XTH(T,H)	XTH: Dryness Fraction [–] T∗: Temperature [K], [°C] H: Specific Enthalpy of Mixture [J/kg]	$172.17 \leq T < 416.956$ [K] $-100.98 \leq T < 143.806$ [°C] HTD(T)≤H≤HTDD(T) [J/kg]
61	XTS(T,S)	XTS: Dryness Fraction [–] T∗: Temperature [K], [°C] S: Specific Entropy of Mixture [J/(kg·K)]	$172.17 \leq T < 416.956$ [K] $-100.98 \leq T < 143.806$ [°C] STD(T)≤S≤STDD(T) [J/(kg·K)]
62	XTU(T,U)	XTU: Dryness Fraction [–] T∗: Temperature [K], [°C] U: Specific Internal Energy of Mixture [J/kg]	$172.17 \leq T < 416.956$ [K] $-100.98 \leq T < 143.806$ [°C] UTD(T)≤U≤UTDD(T) [J/kg]
63	XTV(T,V)	XTV: Dryness Fraction [–] T∗: Temperature [K], [°C] V: Specific Volume of Mixture [m^3/kg]	$172.17 \leq T < 416.956$ [K] $-100.98 \leq T < 143.806$ [°C] VTD(T)≤V≤VTDD(T) [m^3/kg]

2.10 Nitrogen

Equations for thermodynamic properties have been cited from the IUPAC Tables[1], those for transport properties from Stephan et al.[2], and those for other properties from Jacobsen et al.[3].

2.10.1 Temperature Scale

International practical temperature scale 1968 (IPTS-1968)

2.10.2 The Names of Substance, Library File and Single Shot Program

Name of Substance:	Nitrogen
Library File for UNIX:	libjn2.a
Library File for DOS,Windows95/NT:	JN2.LIB
Single Shot Program for UNIX:	n2-ss
Single Shot Program for DOS,Windows95/NT:	N2–SS.EXE

2.10.3 Important Constants and Others

Molecular Formula:	N_2
Relative Molecular Mass:	28.0134
Gas Constant:	296.8115 J/(kg·K)

Critical Constants:

Critical Pressure:	3.4000×10^6Pa (34.000 bar)
Critical Temperature:	126.20 K (−146.95°C)
Critical Specific Volume:	3.1847×10^{-3}m^3/kg

Triple Point:

Pressure:	0.01253×10^6Pa (0.1253 bar)
Temperature:	63.148 K (−210.002°C)

Reference State:

At 1.01325 bar(1 atm) and 25°C(298.15 K), 0 J/(kg·K) is assigned to the specific entropy of the ideal gas. At 25°C(298.15 K), 0 J/kg is assigned to the specific enthalpy of the ideal gas.

2.10.4 Formula

Equation of State:

Equation (9) in a function form of $P = P(\rho, T)$ in reference [1]. Here P=pressure, ρ=density and T=Temperature.

Vapor Pressure:

Equation (2) in reference [1].

Properties at Vapor-Liquid Equilibrium:

Equations (2) and (9) for specific volume, equation (12) for specific enthalpy, equation (15) for specific entropy and equation (19) for isobaric specific heat, respectively. All of these have been cited from reference [1]. However, the third term in the right side of equation (19),

$$C_p(\rho, T) = C_p^{id}(T) - R + R[\sum_{i=1}^{32} N_i(XC)_i]_0^w + \cdots$$