

# **THERMODYNAMIC PROPERTIES OF INDIVIDUAL SUBSTANCES**

*Fourth Edition*

## **Volume 1**

Elements O, H(D, T), F, Cl, Br,  
I, He, Ne, Ar, Kr, Xe, Rn, S, N, P,  
and Their Compounds

## **Part Two**

Tables

*Editors*

L. V. Gurvich and I. V. Veys  
Institute for High Temperatures  
USSR Academy of Sciences, Moscow

C. B. Alcock

University of Notre Dame, Notre Dame, Indiana

●HEMISPHERE PUBLISHING CORPORATION

A member of the Taylor & Francis Group  
New York      Washington      Philadelphia      London

# CONTENTS

## INTRODUCTION

xi

---

## LIST OF TABLES

Table No.	Substance	Page No.
1	Electron e	1
2	Oxygen O (g)	3
3	Oxygen positive ion O <sup>+</sup> (g)	5
4	Oxygen negative ion O <sup>-</sup> (g)	7
5	Dioxygen O <sub>2</sub> (g)	9
6	Dioxygen positive ion O <sub>2</sub> <sup>+</sup> (g)	11
7	Dioxygen negative ion O <sub>2</sub> <sup>-</sup> (g)	13
8	Ozone O <sub>3</sub> (g)	15
9	Hydrogen H (g)	16
10	Hydrogen positive ion H <sup>+</sup> (g)	18
11	Hydrogen negative ion H <sup>-</sup> (g)	20
12	Dihydrogen H <sub>2</sub> (g)	22
13	Dihydrogen positive ion H <sub>2</sub> <sup>+</sup> (g)	24
14	Trihydrogen positive ion H <sub>3</sub> <sup>+</sup> (g)	26
15	Hydroxyl OH (g)	28
16	Hydroxyl positive ion OH <sup>+</sup> (g)	30
17	Hydroxyl negative ion OH <sup>-</sup> (g)	32
18	Hydrogen dioxide HO <sub>2</sub> (g)	34
19	Hydrogen dioxide negative ion HO <sub>2</sub> <sup>-</sup> (g)	35
20	Water H <sub>2</sub> O (g)	36
21	Dihydrogen oxide positive ion H <sub>2</sub> O <sup>+</sup> (g)	38
22	Hydrogen peroxide H <sub>2</sub> O <sub>2</sub> (g)	40
23	Trihydrogen oxide positive ion H <sub>3</sub> O <sup>+</sup> (g)	41
24	Deuterium D (g)	43

Table No.	Substance	Page No.
25	Dideuterium D <sub>2</sub> (g)	45
26	Deuterium oxide DO (g)	47
27	Deuterium oxide negative ion DO <sup>-</sup> (g)	48
28	Deuterium dioxide DO <sub>2</sub> (g)	49
29	Deuterium dioxide negative ion DO <sub>2</sub> <sup>-</sup> (g)	50
30	Dideuterium oxide D <sub>2</sub> O (g)	51
31	Dideuterium dioxide D <sub>2</sub> O <sub>2</sub> (g)	52
32	Protium-deuterium HD (g)	53
33	Protium-deuterium oxide HDO (g)	55
34	Protium-deuterium dioxide HDO <sub>2</sub> (g)	56
35	Tritium T (g)	57
36	Ditritium T <sub>2</sub> (g)	59
37	Tritium oxide TO (g)	61
38	Ditritium oxide T <sub>2</sub> O (g)	62
39	Protium-tritium HT (g)	63
40	Protium-tritium oxide HTO (g)	65
41	Deuterium-tritium DT (g)	66
42	Deuterium-tritium oxide DTO (g)	68
43	Fluorine F (g)	69
44	Fluorine negative ion F <sup>-</sup> (g)	71
45	Difluorine F <sub>2</sub> (g)	73
46	Oxygen fluoride FO (g)	75
47	Oxygen difluoride F <sub>2</sub> O (g)	76
48	Hydrogen fluoride HF (g)	77
49	Hydroxyl fluoride HOF (g)	79
50	Deuterium fluoride DF (g)	80
51	Tritium fluoride TF (g)	82
52	Chlorine Cl (g)	84
53	Chlorine negative ion Cl <sup>-</sup> (g)	86
54	Dichlorine Cl <sub>2</sub> (g)	88
55	Chlorine oxide ClO (g)	90
56	Chlorine dioxide ClO <sub>2</sub> (g)	91
57	Dichlorine oxide Cl <sub>2</sub> O (g)	92
58	Hydrogen chloride HCl (g)	93
59	Chlorine hydroxide HOCl (g)	94
60	Deuterium chloride DCl (g)	95
61	Tritium chloride TCl (g)	96
62	Chlorine fluoride ClF (g)	97
63	Chlorine trifluoride ClF <sub>3</sub> (g)	98
64	Chlorine pentafluoride ClF <sub>5</sub> (g)	99
65	Bromine Br (g)	100
66	Bromine negative ion Br <sup>-</sup> (g)	102
67	Dibromine Br <sub>2</sub> (g)	104
68	Bromine oxide BrO (g)	105
69	Hydrogen bromide HBr (g)	106
70	Deuterium bromide DBr (g)	107
71	Tritium bromide TBr (g)	108
72	Bromine fluoride BrF (g)	109

Table No.	Substance	Page No.
73	Bromine trifluoride BrF <sub>3</sub> (g)	110
74	Bromine pentafluoride BrF <sub>5</sub> (g)	111
75	Bromine chloride BrCl (g)	112
76	Iodine I (g)	113
77	Iodine negative ion I <sup>-</sup> (g)	115
78	Diiodine I <sub>2</sub> (g)	117
79	Iodine oxide IO (g)	118
80	Hydrogen iodide HI (g)	119
81	Deuterium iodide DI (g)	120
82	Tritium iodide TI (g)	121
83	Iodine fluoride IF (g)	122
84	Iodine pentafluoride IF <sub>5</sub> (g)	123
85	Iodine heptafluoride IF <sub>7</sub> (g)	124
86	Iodine chloride ICl (g)	125
87	Iodine bromide IBr (g)	126
88	Helium He (g)	127
89	Helium positive ion He <sup>+</sup> (g)	129
90	Neon Ne (g)	131
91	Neon positive ion Ne <sup>+</sup> (g)	133
92	Argon Ar (g)	135
93	Argon positive ion Ar <sup>+</sup> (g)	137
94	Krypton Kr (g)	139
95	Krypton positive ion Kr <sup>+</sup> (g)	141
96	Krypton difluoride KrF <sub>2</sub> (g)	143
97	Xenon Xe (g)	144
98	Xenon positive ion Xe <sup>+</sup> (g)	146
99	Xenon trioxide XeO <sub>3</sub> (g)	148
100	Xenon tetraoxide XeO <sub>4</sub> (g)	149
101	Xenon difluoride XeF <sub>2</sub> (g)	150
102	Xenon tetrafluoride XeF <sub>4</sub> (g)	151
103	Xenon hexafluoride XeF <sub>6</sub> (g)	152
104	Xenon dioxide-difluoride XeO <sub>2</sub> F <sub>2</sub> (g)	153
105	Xenon trioxide-difluoride XeO <sub>3</sub> F <sub>2</sub> (g)	154
106	Xenon oxide-tetrafluoride XeOF <sub>4</sub> (g)	155
107	Radon Rn (g)	156
108	Radon positive ion Rn <sup>+</sup> (g)	158
109	Sulfur S (cr, l)	160
110	Sulfur S (g)	161
111	Sulfur negative ion S <sup>-</sup> (g)	163
112	Disulfur S <sub>2</sub> (g)	165
113	Disulfur negative ion S <sub>2</sub> <sup>-</sup> (g)	166
114	Trisulfur S <sub>3</sub> (g)	167
115	Tetasulfur S <sub>4</sub> (g)	168
116	Pentasulfur S <sub>5</sub> (g)	169
117	Hexasulfur S <sub>6</sub> (g)	170
118	Heptasulfur S <sub>7</sub> (g)	171
119	Octasulfur S <sub>8</sub> (g)	172
120	Sulfur oxide SO (g)	173

Table No.	Substance	Page No.
121	Sulfur oxide negative ion SO <sup>-</sup> (g)	174
122	Sulfur dioxide SO <sub>2</sub> (g)	175
123	Sulfur dioxide negative ion SO <sub>2</sub> <sup>-</sup> (g)	176
124	Sulfur trioxide SO <sub>3</sub> (g)	177
125	Disulfur oxide S <sub>2</sub> O (g)	178
126	Sulfur hydride SH (g)	179
127	Sulfur hydride negative ion SH <sup>-</sup> (g)	180
128	Sulfur dihydride H <sub>2</sub> S (g)	181
129	Sulfuric acid H <sub>2</sub> SO <sub>4</sub> (g)	182
130	Sulfur fluoride SF (g)	183
131	Sulfur fluoride negative ion SF <sup>-</sup> (g)	184
132	Sulfur difluoride SF <sub>2</sub> (g)	185
133	Sulfur trifluoride SF <sub>3</sub> (g)	186
134	Sulfur trifluoride negative ion SF <sub>3</sub> <sup>-</sup> (g)	187
135	Sulfur tetrafluoride SF <sub>4</sub> (g)	188
136	Sulfur pentafluoride SF <sub>5</sub> (g)	189
137	Sulfur pentafluoride negative ion S <sub>5</sub> <sup>-</sup> (g)	190
138	Sulfur hexafluoride SF <sub>6</sub> (g)	191
139	Sulfur oxide-difluoride SOF <sub>2</sub> (g)	192
140	Sulfur dioxide-difluoride SO <sub>2</sub> F <sub>2</sub> (g)	193
141	Nitrogen N (g)	194
142	Nitrogen positive ion N <sup>+</sup> (g)	196
143	Dinitrogen N <sub>2</sub> (g)	198
144	Dinitrogen positive ion N <sub>2</sub> <sup>+</sup> (g)	200
145	Trinitrogen N <sub>3</sub> (g)	202
146	Nitrogen oxide NO (g)	203
147	Nitrogen oxide positive ion NO <sup>+</sup> (g)	205
148	Nitrogen dioxide NO <sub>2</sub> (g)	207
149	Nitrogen dioxide negative ion NO <sub>2</sub> <sup>-</sup> (g)	208
150	Nitrogen trioxide negative ion NO <sub>3</sub> <sup>-</sup> (g)	209
151	Dinitrogen oxide N <sub>2</sub> O (g)	210
152	Dinitrogen trioxide N <sub>2</sub> O <sub>3</sub> (g)	211
153	Dinitrogen tetroxide N <sub>2</sub> O <sub>4</sub> (g)	212
154	Dinitrogen pentoxide N <sub>2</sub> O <sub>5</sub> (g)	213
155	Nitrogen hydride NH (g)	214
156	Nitrogen hydride positive ion NH <sup>+</sup> (g)	216
157	Nitrogen dihydride NH <sub>2</sub> (g)	218
158	Ammonia NH <sub>3</sub> (g)	219
159	Ammonium ion NH <sub>4</sub> <sup>+</sup> (g)	220
160	Dinitrogen dihydride N <sub>2</sub> H <sub>2</sub> (g)	221
161	Trans-dinitrogen dihydride N <sub>2</sub> H <sub>2</sub> [trans] (g)	222
162	Cis-dinitrogen dihydride N <sub>2</sub> H <sub>2</sub> [cis] (g)	223
163	1,1-Dinitrogen dihydride N <sub>2</sub> H <sub>2</sub> [1,1] (g)	224
164	Hydrazine N <sub>2</sub> H <sub>4</sub> (g)	225
165	Trinitrogen hydride HN <sub>3</sub> (g)	226
166	Nitrogen oxide-hydride HNO (g)	227
167	Nitrous acid HNO <sub>2</sub> (g)	228
168	Trans-nitrous acid HNO <sub>2</sub> [trans] (g)	229

Table No.	Substance	Page No.
169	Cis-nitrous acid HNO <sub>2</sub> [cis] (g)	230
170	Nitric acid HNO <sub>3</sub> (g)	231
171	Hydroxylamine NH <sub>2</sub> OH (g)	232
172	Aminyl-nitrite NH <sub>2</sub> NO <sub>2</sub> (g)	233
173	Nitrogen fluoride NF (g)	234
174	Nitrogen difluoride NF <sub>2</sub> (g)	235
175	Nitrogen trifluoride NF <sub>3</sub> (g)	236
176	Dinitrogen difluoride N <sub>2</sub> F <sub>2</sub> (g)	237
177	Cis-dinitrogen difluoride N <sub>2</sub> F <sub>2</sub> [cis] (g)	238
178	Trans-dinitrogen difluoride N <sub>2</sub> F <sub>2</sub> [trans] (g)	239
179	Dinitrogen tetrafluoride N <sub>2</sub> F <sub>4</sub> (g)	240
180	Trans-dinitrogen tetrafluoride N <sub>2</sub> F <sub>4</sub> [trans] (g)	241
181	Gauche-dinitrogen tetrafluoride N <sub>2</sub> F <sub>4</sub> [gauch] (g)	242
182	Nitrogen oxide-fluoride FNO (g)	243
183	Nitrogen dioxide-fluoride FNO <sub>2</sub> (g)	244
184	Nitrogen trioxide-fluoride FNO <sub>3</sub> (g)	245
185	Nitrogen oxide-trifluoride F <sub>3</sub> NO (g)	246
186	Nitrogen hydride-fluoride NHF (g)	247
187	Nitrogen dihydride-fluoride NH <sub>2</sub> F (g)	248
188	Nitrogen hydride-difluoride NHF <sub>2</sub> (g)	249
189	Nitrogen oxide-chloride ClNO (g)	250
190	Nitrogen dioxide-chloride ClNO <sub>2</sub> (g)	251
191	Nitrogen sulfide NS (g)	252
192	Phosphorus P (g)	253
193	Diphosphorus P <sub>2</sub> (g)	255
194	Triphosphorus P <sub>3</sub> (g)	256
195	Tetraphosphorus P <sub>4</sub> (g)	257
196	Phosphorus oxide PO (g)	258
197	Phosphorus oxide negative ion PO <sup>-</sup> (g)	259
198	Phosphorus dioxide PO <sub>2</sub> (g)	260
199	Phosphorus dioxide negative ion PO <sub>2</sub> <sup>-</sup> (g)	261
200	Diphosphorus trioxide P <sub>2</sub> O <sub>3</sub> (g)	262
201	Diphosphorus tetroxide P <sub>2</sub> O <sub>4</sub> (g)	263
202	Diphosphorus pentoxide P <sub>2</sub> O <sub>5</sub> (g)	264
203	Triphosphorus hexoxide P <sub>3</sub> O <sub>6</sub> (g)	265
204	Tetraphosphorus hexoxide P <sub>4</sub> O <sub>6</sub> (g)	266
205	Tetraphosphorus heptoxide P <sub>4</sub> O <sub>7</sub> (g)	267
206	Tetraphosphorus octoxide P <sub>4</sub> O <sub>8</sub> (g)	268
207	Tetraphosphorus nonoxide P <sub>4</sub> O <sub>9</sub> (g)	269
208	Tetraphosphorus decoxide P <sub>4</sub> O <sub>10</sub> (cr, l)	270
209	Tetraphosphorus decoxide P <sub>4</sub> O <sub>10</sub> (g)	271
210	Phosphorus hydride PH (g)	272
211	Phosphorus dihydride PH <sub>2</sub> (g)	273
212	Phosphorus dihydride negative ion PH <sub>2</sub> <sup>-</sup> (g)	274
213	Phosphorus oxide-hydride HPO (g)	275
214	Phosphorus fluoride PF (g)	276
215	Phosphorus difluoride PF <sub>2</sub> (g)	277
216	Phosphorus difluoride negative ion PF <sub>2</sub> <sup>-</sup> (g)	278

Table No.	Substance	Page No.
217	Phosphorus trifluoride $\text{PF}_3$ (g)	279
218	Phosphorus pentafluoride $\text{PF}_5$ (g)	280
219	Phosphorus oxide-trifluoride $\text{POF}_3$ (g)	281
220	Phosphorus chloride $\text{PCl}$ (g)	282
221	Phosphorus dichloride $\text{PCl}_2$ (g)	283
222	Phosphorus dichloride negative ion $\text{PCl}_2^-$ (g)	284
223	Phosphorus trichloride $\text{PCl}_3$ (g)	285
224	Phosphorus pentachloride $\text{PCl}_5$ (g)	286
225	Phosphorus oxide-trichloride $\text{POCl}_3$ (g)	287
226	Phosphorus fluoride-chloride $\text{PFCl}$ (g)	288
227	Phosphorus fluoride chloride negative ion $\text{PFCl}^-$ (g)	289
228	Phosphorus difluoride-chloride $\text{PF}_2\text{Cl}$ (g)	290
229	Phosphorus tetrafluoride-chloride $\text{PF}_4\text{Cl}$ (g)	291
230	Phosphorus fluoride-dichloride $\text{PFCl}_2$ (g)	292
231	Phosphorus trifluoride-dichloride $\text{PF}_3\text{Cl}_2$ (g)	293
232	Phosphorus difluoride-trichloride $\text{PF}_2\text{Cl}_3$ (g)	294
233	Phosphorus fluoride-tetrachloride $\text{PFCl}_4$ (g)	295
234	Phosphorus oxide-difluoride-chloride $\text{POF}_2\text{Cl}$ (g)	296
235	Phosphorus oxide-fluoride-dichloride $\text{POFCl}_2$ (g)	297
236	Phosphorus sulfide $\text{PS}$ (g)	298
237	Phosphorus nitride $\text{PN}$ (g)	299
A.1	Orthohydrogen $\text{H}_2[\text{o}]$ (g)	300
A.2	Parahydrogen $\text{H}_2[\text{p}]$ (g)	301
A.3	Water $\text{H}_2\text{O}$ (cr, l)	302
A.4	Hydrogen peroxide $\text{H}_2\text{O}_2$ (cr, l)	303
A.5	Orthodeuterium $\text{D}_2[\text{o}]$ (g)	304
A.6	Paradeuterium $\text{D}_2[\text{p}]$ (g)	305
A.7	Orthotritium $\text{T}_2[\text{o}]$ (g)	306
A.8	Paratritium $\text{T}_2[\text{p}]$ (g)	307
A.9	Dihydrogen difluoride $\text{H}_2\text{F}_2$ (g)	308
A.10	Trihydrogen trifluoride $\text{H}_3\text{F}_3$ (g)	309
A.11	Tetrahydrogen tetrafluoride $\text{H}_4\text{F}_4$ (g)	310
A.12	Pentahydrogen pentafluoride $\text{H}_5\text{F}_5$ (g)	311
A.13	Hexahydrogen hexafluoride $\text{H}_6\text{F}_6$ (g)	312
A.14	Heptahydrogen heptafluoride $\text{H}_7\text{F}_7$ (g)	313
A.15	Dibromine $\text{Br}_2$ (cr, l)	314
A.16	Diiodine $\text{I}_2$ (cr, l)	315
A.17	Dixenon $\text{Xe}_2$ (g)	317
A.18	Xenon fluoride $\text{XeF}$ (g)	318
A.19	Xenon difluoride $\text{XeF}_2$ (cr, l)	319
A.20	Xenon tetrafluoride $\text{XeF}_4$ (cr, l)	320
A.21	Xenon hexafluoride $\text{XeF}_6$ (cr, l)	321
A.22	Ammonium nitrate $\text{NH}_4\text{NO}_3$ (cr, l)	322
A.23	Ammonium fluoride $\text{NH}_4\text{F}$ (cr, l)	324
A.24	Phosphorus P (cr, white; l)	326