

A UNITED STATES  
DEPARTMENT OF  
COMMERCE  
PUBLICATION

National Bureau of Standards  
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NBS TECHNICAL NOTE 383

DEC 22 1969



# A Bibliography of Thermophysical Properties of Air from 0 to 300 K

U.S. DEPARTMENT OF COMMERCE  
NATIONAL BUREAU OF STANDARDS

## NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards<sup>1</sup> was established by an act of Congress March 3, 1901. Today, in addition to serving as the Nation's central measurement laboratory, the Bureau is a principal focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. To this end the Bureau conducts research and provides central national services in four broad program areas. These are: (1) basic measurements and standards, (2) materials measurements and standards, (3) technological measurements and standards, and (4) transfer of technology.

The Bureau comprises the Institute for Basic Standards, the Institute for Materials Research, the Institute for Applied Technology, the Center for Radiation Research, the Center for Computer Sciences and Technology, and the Office for Information Programs.

**THE INSTITUTE FOR BASIC STANDARDS** provides the central basis within the United States of a complete and consistent system of physical measurement; coordinates that system with measurement systems of other nations; and furnishes essential services leading to accurate and uniform physical measurements throughout the Nation's scientific community, industry, and commerce. The Institute consists of an Office of Measurement Services and the following technical divisions:

Applied Mathematics—Electricity—Metrology—Mechanics—Heat—Atomic and Molecular Physics—Radio Physics<sup>2</sup>—Radio Engineering<sup>2</sup>—Time and Frequency<sup>2</sup>—Astrophysics<sup>2</sup>—Cryogenics.<sup>2</sup>

**THE INSTITUTE FOR MATERIALS RESEARCH** conducts materials research leading to improved methods of measurement standards, and data on the properties of well-characterized materials needed by industry, commerce, educational institutions, and Government; develops, produces, and distributes standard reference materials; relates the physical and chemical properties of materials to their behavior and their interaction with their environments; and provides advisory and research services to other Government agencies. The Institute consists of an Office of Standard Reference Materials and the following divisions:

Analytical Chemistry—Polymers—Metallurgy—Inorganic Materials—Physical Chemistry.

**THE INSTITUTE FOR APPLIED TECHNOLOGY** provides technical services to promote the use of available technology and to facilitate technological innovation in industry and Government; cooperates with public and private organizations in the development of technological standards, and test methodologies; and provides advisory and research services for Federal, state, and local government agencies. The Institute consists of the following technical divisions and offices:

Engineering Standards—Weights and Measures—Invention and Innovation—Vehicle Systems Research—Product Evaluation—Building Research—Instrument Shops—Measurement Engineering—Electronic Technology—Technical Analysis.

**THE CENTER FOR RADIATION RESEARCH** engages in research, measurement, and application of radiation to the solution of Bureau mission problems and the problems of other agencies and institutions. The Center consists of the following divisions:

Reactor Radiation—Linac Radiation—Nuclear Radiation—Applied Radiation.

**THE CENTER FOR COMPUTER SCIENCES AND TECHNOLOGY** conducts research and provides technical services designed to aid Government agencies in the selection, acquisition, and effective use of automatic data processing equipment; and serves as the principal focus for the development of Federal standards for automatic data processing equipment, techniques, and computer languages. The Center consists of the following offices and divisions:

Information Processing Standards—Computer Information—Computer Services—Systems Development—Information Processing Technology.

**THE OFFICE FOR INFORMATION PROGRAMS** promotes optimum dissemination and accessibility of scientific information generated within NBS and other agencies of the Federal government; promotes the development of the National Standard Reference Data System and a system of information analysis centers dealing with the broader aspects of the National Measurement System, and provides appropriate services to ensure that the NBS staff has optimum accessibility to the scientific information of the world. The Office consists of the following organizational units:

Office of Standard Reference Data—Clearinghouse for Federal Scientific and Technical Information—Office of Technical Information and Publications—Library—Office of Public Information—Office of International Relations.

<sup>1</sup> Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.

<sup>2</sup> Located at Boulder, Colorado 80302.

<sup>3</sup> Located at 5285 Port Royal Road, Springfield, Virginia 22151.

UNITED STATES DEPARTMENT OF COMMERCE  
Maurice H. Stans, Secretary  
NATIONAL BUREAU OF STANDARDS ● Lewis M. Branscomb, Director



## TECHNICAL NOTE 383

ISSUED OCTOBER 1969

Nat. Bur. Stand. (U.S.), Tech. Note 383, 121 pages (Oct. 1969)  
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### **A Bibliography of Thermophysical Properties of Air from 0 to 300 K**

L. A. Hall

Cryogenics Division  
Institute for Basic Standards  
National Bureau of Standards  
Boulder, Colorado 80302

NBS Technical Notes are designed to supplement the Bureau's regular publications program. They provide a means for making available scientific data that are of transient or limited interest. Technical Notes may be listed or referred to in the open literature.



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A BIBLIOGRAPHY OF THERMOPHYSICAL PROPERTIES  
OF AIR FROM 0 TO 300 K<sup>1</sup>

L. A. Hall

References together with an abbreviated abstract are presented for mechanical, thermodynamic, and transport properties \*) of air from 0 to 300 K published up to December 1968. A total of 610 articles have been indexed. Each article has been reviewed and coded with regard to properties studied, type of article (i.e., experimental, theoretical, etc.), and method of presentation of data. The temperature and pressure ranges for each property under consideration are also given. An index has been prepared according to property with four sub-categories: solid, liquid, gas up to 200 K, and gas above 200 K.

\*) density, P-V-T data, compressibility factor, expansivity, compressibility, equation of state, vapor pressure, melting pressure, latent heats, critical points, normal boiling temperature, specific heat, velocity of sound, Joule-Thomson coefficients, entropy, enthalpy, internal energy, Gibbs function, Helmholtz function, thermal conductivity, viscosity, Prandtl number, diffusion coefficients, surface tension, dielectric constant, refractive index

Key words: air; bibliography; equation of state; low temperature; mechanical properties; thermodynamic properties; transport properties

## 1. INTRODUCTION

The Compilation Unit of the Cryogenic Data Center has in its mission the critical evaluation of quantitative information from the world's literature related to the thermophysical properties of materials at cryogenic temperatures and preparation of charts and tables of data for the entire temperature and pressure range. At the outset of the study of a particular material, copies of the documents concerned with the properties are obtained and reviewed. As the task of document accumulation continues, a concentrated effort is made to complete a systematic and thorough literature search on the selected topic and an annotated bibliography is prepared. This bibliography on the properties of air is the fourth such bibliography<sup>2</sup> prepared on the properties of a cryogenic fluid.

---

<sup>1</sup> This study was supported in part by the National Aeronautics and Space Administration, Contract No. R-06-006-046.

<sup>2</sup> Other materials for which similar bibliographies have been prepared are oxygen, argon, and methane.

Primarily, our search was for articles dealing with properties studied in the temperature range 0 to 300 K. Thirteen articles on properties of oxygen-nitrogen mixtures have been included, some presenting values in temperature ranges where experimental air data are missing. A group of 28 documents dealing with thermophysical properties of air at extremely high temperatures (>1000 K) have been referenced in the Appendix. These documents came to our attention during the literature search, but because of the high temperature range, they have not been included in the main body of the bibliography or indexed.

The collection of documents for air began over ten years ago in conjunction with the data compilation presented in the "Compendium."<sup>1</sup> The initial literature search was conducted by the use of various abstracting journals, in particular Chemical Abstracts. Copies of the articles were obtained at that time and reviewed for useful data. From the time of the "Compendium's" publication to the present, the Compilation Unit of the Cryogenic Data Center has been actively acquiring all articles dealing with the thermophysical properties of air at cryogenic temperatures. These articles were entered into our Storage and Retrieval System together with all the other cryogenically oriented documents that have come to our attention by a systematic scanning of the primary journals, and secondary publications such as Chemical Abstracts, Physics Abstracts, NASA STAR, Nuclear Science Abstracts, DDC TAB, and International Aerospace Abstracts. A computer search of the Storage and Retrieval System was the initial source of references for this annotated bibliography. All pertinent documents from the references listed in this search were reviewed and coded. In addition, other articles, which were referenced in these documents, were also obtained, reviewed, and coded. A final Chemical Abstracts search was conducted back to 1907 to bring to our attention any articles which might have been previously overlooked. Seventy articles written before 1900, not already in our files, were not ordered because these were believed to be of historical interest only.

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<sup>1</sup> "A Compendium of the Properties of Materials at Low Temperature (Phase I), Part I. Properties of Fluids," V. J. Johnson, Editor, Wright Air Development Division Technical Report 60-56 (1960), 560 pp., DDC AD 249 777.

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\*) density, P-V-T data, compressibility factor, expansivity, compressibility, equation of state, vapor pressure, melting pressure, latent heats, critical points, normal boiling temperature, specific heat, velocity of sound, Joule-Thomson coefficients, entropy, enthalpy, internal energy, Gibbs function, Helmholtz function, thermal conductivity, viscosity, Prandtl number, diffusion coefficients, surface tension, dielectric constant, refractive index

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## 2. FORMAT FOR LISTING CITATION AND DOCUMENT CONTENTS

The citations have been arranged alphabetically by first author and numbered.<sup>1</sup> Only information from the article which concerns the properties of air was noted in this bibliography. The temperature and pressure ranges were omitted on references to critical points and normal boiling points. In many cases the pressures were not stated in the article. This is most often the case in the study of properties near atmospheric pressure that are essentially temperature-dependent only.

The information given for each citation includes and is ordered as follows:

1. author(s),
2. title (original language) and translated title, if original is in a language other than English,
3. reference (if the same article is published in more than one place, each reference is cited.),
4. properties studied for air, state of substance, temperature and pressure ranges as available,
5. designation as to primary character of article,
  - a. experimental
  - b. theoretical
  - c. compilation<sup>2</sup>
  - d. correlation
  - e. reference book<sup>3</sup>
6. form in which data are reported,
  - a. tabular - tables (number of values)
  - b. graphical
  - c. equations
  - d. apparatus, if described or illustrated

---

<sup>1</sup> Documents obtained too late to be numbered sequentially have been placed alphabetically in the body of the bibliography and given the number of the preceding article immediately followed by a (+) sign. These articles have also been indexed.

<sup>2</sup> In compilations, the bibliography number of the original article from which the data was obtained is listed if the source of the data is mentioned.

<sup>3</sup> In some instances, the amount of data in reference books is not given.

### 3. INDEX OF PROPERTIES

The bibliography is indexed according to property with sub-indexes for the state of the substance; i.e., solid, liquid, gas up to 200 K, and gas above 200 K. The letters E, T, C, and R following each citation number refer to the type of data; i.e., E = experimental, T = theoretical, C = compilation, correlation, calculation, and R = review, discussion, reference work. A few reference books were coded by property only.

1. Density, P-V-T Data, Compressibility Factor . . . . .	5
2. Equation of State, Virial Coefficients . . . . .	6
3. Expansivity and Compressibility . . . . .	6
4. Vapor Pressure (dew point pressure, bubble point pressure) . . .	7
5. Melting Pressure . . . . .	7
6. Latent Heats . . . . .	7
7. Solid-Solid Phase Transition, Melting Range, Boiling Temperatures, Critical Points (plait point, point of contact) . . . . .	7
8. Specific Heat . . . . .	8
9. Velocity of Sound . . . . .	9
10. Joule-Thomson Coefficients, Inversion Curve . . . . .	10
11. Entropy, Enthalpy, Internal Energy, Gibbs Function, Helmholtz Function . . . . .	10
12. Thermal Conductivity . . . . .	11
13. Viscosity . . . . .	12
14. Prandtl Number . . . . .	13
15. Diffusion Coefficient . . . . .	13
16. Surface Tension . . . . .	13
17. Dielectric Constant . . . . .	13
18. Refractive Index . . . . .	14
19. Corresponding States . . . . .	14
20. Intermolecular Potential . . . . .	15
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  - b. graphical
  - c. equations
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17. Dielectric Constant . . . . .	13
18. Refractive Index . . . . .	14
19. Corresponding States . . . . .	14
20. Intermolecular Potential . . . . .	15
21. Documents not Appearing in the Properties Index . . . . .	15

1. DENSITY, P-V-T DATA, COMPRESSIBILITY FACTOR

3 C	4 E	5 E	6 E	7 E	8 E	9 E	10 E	18 C	22 C
31 T	43 E	44 C	60 T	85 C	86 T	88 C	96 C	97 E	102 C
112 C	145 C	146 C	148 C	152 C	174 E	185 C	191 C	192 C	205 E
209 C	210 C	211 C	212 C	218 C	233 C	238 T	243 E	244 E	245 E
246 E	254 C	259 E	265 C	271 C	282 R	284 C	285 R	293 E	299 C
303 E	312 E	314 E	316 T	317 T	318 T	319 E	334 C	337 C	338 C
343 C	368 E	369 E	370 C	378 E	380 C	385 C	386 C	387 C	388 C
391 C	396 E	399 E	400 E	405 C	412 E	415 R	416 R	419 C	420 R
422 R	432 C	445 C	452 E	455 E	456 E	475 C	486 T	502 C	528 E
558 C	559 C	560 T	569 C	570 T	580 C	588 C	589 E	594 E	

SATURATED LIQUID

18 C	43 E	96 C	112 C	265 C	319 E	368 E	502 C	580 C
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SATURATED VAPOR

18 C	102 C	112 C	265 C	319 E	368 E	502 C	580 C
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SOLID - NONE

LIQUID

112 C	259 E	337 C	594 E
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GAS (UP TO 200 DEGREES K)

18 C	31 T	85 C	86 T	88 C	102 C	112 C	185 C	209 C	210 C
218 C	233 C	254 C	259 E	265 C	271 C	285 R	312 E	314 E	334 C
337 C	368 E	370 C	380 C	386 C	387 C	388 C	405 C	412 E	416 R
432 C	445 C	452 E	455 E	456 E	486 T	502 C	528 E	560 T	569 C
588 C	589 E								

GAS (ABOVE 200 DEGREES K)

3 C	4 E	5 E	6 E	7 E	8 E	9 E	10 E	18 C	22 C
31 T	44 C	60 T	85 C	86 T	88 C	96 C	97 E	102 C	112 C
145 C	146 C	148 C	152 C	174 E	185 C	191 C	192 C	205 E	209 C
210 C	211 C	212 C	218 C	233 C	238 T	243 E	244 E	245 E	246 E
254 C	259 E	265 C	271 C	282 R	284 C	285 R	293 E	299 C	303 E
312 E	314 E	316 T	317 T	318 T	334 C	337 C	338 C	343 C	368 E
369 E	370 C	378 E	380 C	385 C	386 C	387 C	388 C	391 C	396 E
399 E	400 E	405 C	412 E	415 R	416 R	419 C	420 R	422 R	432 C
445 C	452 E	455 E	456 E	475 C	486 T	502 C	528 E	558 C	559 C
560 T	569 C	570 T	588 C	589 E					

## 2. EQUATION OF STATE, VIRIAL COEFFICIENTS

18 C	22 C	29 T	31 T	32 T	33 T	34 T	41 T	60 T	73 T
102 C	113 E	114 E	159 T	164 T	167 C	208 T	209 C	223 T	233 C
236 T	237 C	257 T	300 T	304 T	318 T	363 C	368 E	369 E	371 E
380 C	386 C	405 C	417 E	425 C	432 C	470 T	486 T	507 T	560 T
570 T	571 T								

LIQUID

41 T

GAS (UP TO 200 DEGREES K)

18 C	29 T	31 T	32 T	33 T	34 T	41 T	73 T	102 C	159 T
164 T	167 C	208 T	209 C	223 T	233 C	236 T	300 T	363 C	368 E
371 E	380 C	386 C	405 C	425 C	432 C	486 T	507 T	560 T	

GAS (ABOVE 200 DEGREES K)

18 C	22 C	29 T	31 T	32 T	33 T	34 T	41 T	60 T	73 T
102 C	113 E	114 E	159 T	164 T	167 C	208 T	209 C	223 T	233 C
236 T	237 C	257 T	300 T	304 T	318 T	363 C	368 E	369 E	371 E
380 C	386 C	405 C	417 E	425 C	432 C	470 T	486 T	507 T	560 T
570 T	571 T								

## 3. EXPANSIVITY AND COMPRESSIBILITY

71 E    194 R    425 C    452 E

SOLID - NONE

LIQUID - NONE

GAS (UP TO 200 DEGREES K)

194 R    425 C    452 E

GAS (ABOVE 200 DEGREES K)

71 E    425 C    452 E

1. DENSITY, P-V-T DATA, COMPRESSIBILITY FACTOR

3 C	4 E	5 E	6 E	7 E	8 E	9 E	10 E	18 C	22 C
31 T	43 E	44 C	60 T	85 C	86 T	88 C	96 C	97 E	102 C
112 C	145 C	146 C	148 C	152 C	174 E	185 C	191 C	192 C	205 E
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303 E	312 E	314 E	316 T	317 T	318 T	319 E	334 C	337 C	338 C
343 C	368 E	369 E	370 C	378 E	380 C	385 C	386 C	387 C	388 C
391 C	396 E	399 E	400 E	405 C	412 E	415 R	416 R	419 C	420 R
422 R	432 C	445 C	452 E	455 E	456 E	475 C	486 T	502 C	528 E
558 C	559 C	560 T	569 C	570 T	580 C	588 C	589 E	594 E	

SATURATED LIQUID

18 C	43 E	96 C	112 C	265 C	319 E	368 E	502 C	580 C	
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SATURATED VAPOR

18 C	102 C	112 C	265 C	319 E	368 E	502 C	580 C		
------	-------	-------	-------	-------	-------	-------	-------	--	--

SOLID - NONE

LIQUID

112 C	259 E	337 C	594 E						
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GAS (UP TO 200 DEGREES K)

18 C	31 T	85 C	86 T	88 C	102 C	112 C	185 C	209 C	210 C
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## 2. EQUATION OF STATE, VIRIAL COEFFICIENTS

18 C	22 C	29 T	31 T	32 T	33 T	34 T	41 T	60 T	73 T
102 C	113 E	114 E	159 T	164 T	167 C	208 T	209 C	223 T	233 C
236 T	237 C	257 T	300 T	304 T	318 T	363 C	368 E	369 E	371 E
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GAS (UP TO 200 DEGREES K)

18 C	29 T	31 T	32 T	33 T	34 T	41 T	73 T	102 C	159 T
164 T	167 C	208 T	209 C	223 T	233 C	236 T	300 T	363 C	368 E
371 E	380 C	386 C	405 C	425 C	432 C	486 T	507 T	560 T	

GAS (ABOVE 200 DEGREES K)

18 C	22 C	29 T	31 T	32 T	33 T	34 T	41 T	60 T	73 T
102 C	113 E	114 E	159 T	164 T	167 C	208 T	209 C	223 T	233 C
236 T	237 C	257 T	300 T	304 T	318 T	363 C	368 E	369 E	371 E
380 C	386 C	405 C	417 E	425 C	432 C	470 T	486 T	507 T	560 T
570 T	571 T								

## 3. EXPANSIVITY AND COMPRESSIBILITY

71 E    194 R    425 C    452 E

SOLID - NONE

LIQUID - NONE

GAS (UP TO 200 DEGREES K)

194 R    425 C    452 E

GAS (ABOVE 200 DEGREES K)

71 E    425 C    452 E

4. VAPOR PRESSURE (DEW POINT PRESSURE, BUBBLE POINT PRESSURE)

SOLID

70 E 573 E

LIQUID

18 C 70 E 88 C 102 C 112 C 117 E 168 E 259 E 265 C 368 E  
380 C 401 E 415 R 416 R 445 C 466 C 580 C 583 C 584+E 593 E

5. MELTING PRESSURE, FREEZING PRESSURE

88 C

6. LATENT HEATS

HEAT OF VAPORIZATION

35 E 106 E 107 R 112 C 149 E 265 C 331 E 380 C 466 C 489 T  
580 C 583 C 590 E

7. SOLID-SOLID PHASE TRANSITION, MELTING RANGE, BOILING TEMPERATURES,  
CRITICAL POINTS (PLAIT POINT, POINT OF CONTACT)

SOLID-SOLID PHASE TRANSITION

145+E 428+E

MELTING RANGE

428+E

BOILING TEMPERATURES

96 C 109 E 595 E

CRITICAL POINTS

18 C 23 E 80 E 85 C 86 T 112 C 223 T 319 E 320 E 380 C  
386 C 387 C 388 C 408 E 415 R 418 R 420 R 421 R 560 T 566 T  
580 C 596 E

## 8. SPECIFIC HEAT

12 E	16 C	18 C	25 C	28 C	37 E	60 T	63 E	65 C	67 R
80 E	85 C	90 T	91 T	97 E	99 E	102 C	104 E	107 R	112 C
118 C	120 R	123 C	128 C	131 C	133 E	141 C	142 E	143 E	146 C
160 C	167 C	173 C	176 E	181 E	183 C	184 R	193 C	207 E	210 C
211 C	212 C	213 C	217 E	218 C	222 E	224 E	229 E	233 C	234 C
237 C	238 T	241 E	242 E	251 E	252 C	259 E	262 C	265 C	271 C
273 E	274 C	275 C	280 C	281 C	284 C	285 R	297 C	299 C	301 C
302 E	310 C	312 E	314 E	324 E	325 R	326 E	330 E	338 C	340 E
341 E	344 E	345 E	346 T	352 E	358 C	362 C	367 E	370 C	379 E
380 C	389 C	390 R	391 C	392 C	404 C	407 C	408 E	409 E	410 E
411 E	416 R	432 C	445 C	449 C	452 E	453 E	458 E	468 C	472 E
473 E	474 E	480 E	486 T	487 R	488 T	491 E	493 E	494 T	495 E
508 T	512 E	521 C	530 C	533 E	534 E	538 E	559 C	570 T	571 T
576 C	580 C	584+E	588 C	597 E	598 T				

### SATURATED LIQUID

584+E

### SATURATED VAPOR

18 C      85 C      584+E

### IDEAL GAS

102 C    104 E    128 C    210 C    233 C    275 C    380 C    449 C    598 T

### SOLID

330 E

### LIQUID

25 C    107 R    112 C    142 E    259 E    265 C    445 C    508 T    580 C

### GAS (UP TO 200 DEGREES K)

12 E	16 C	18 C	63 E	65 C	80 E	85 C	90 T	91 T	97 E
102 C	107 R	112 C	131 C	141 C	142 E	167 C	176 E	183 C	210 C
218 C	233 C	234 C	262 C	271 C	285 R	297 C	301 C	312 E	314 E
341 E	358 C	370 C	380 C	389 C	410 E	416 R	432 C	445 C	452 E
472 E	473 E	474 E	488 T	530 C	588 C				



4. VAPOR PRESSURE (DEW POINT PRESSURE, BUBBLE POINT PRESSURE)

SOLID

70 E 573 E

LIQUID

18 C 70 E 88 C 102 C 112 C 117 E 168 E 259 E 265 C 368 E  
380 C 401 E 415 R 416 R 445 C 466 C 580 C 583 C 584+E 593 E

5. MELTING PRESSURE, FREEZING PRESSURE

88 C

6. LATENT HEATS

HEAT OF VAPORIZATION

35 E 106 E 107 R 112 C 149 E 265 C 331 E 380 C 466 C 489 T  
580 C 583 C 590 E

7. SOLID-SOLID PHASE TRANSITION, MELTING RANGE, BOILING TEMPERATURES,  
CRITICAL POINTS (PLAIT POINT, POINT OF CONTACT)

SOLID-SOLID PHASE TRANSITION

145+E 428+E

MELTING RANGE

428+E

BOILING TEMPERATURES

96 C 109 E 595 E

CRITICAL POINTS

18 C 23 E 80 E 85 C 86 T 112 C 223 T 319 E 320 E 380 C  
386 C 387 C 388 C 408 E 415 R 418 R 420 R 421 R 560 T 566 T  
580 C 596 E

## 8. SPECIFIC HEAT

12 E	16 C	18 C	25 C	28 C	37 E	60 T	63 E	65 C	67 R
80 E	85 C	90 T	91 T	97 E	99 E	102 C	104 E	107 R	112 C
118 C	120 R	123 C	128 C	131 C	133 E	141 C	142 E	143 E	146 C
160 C	167 C	173 C	176 E	181 E	183 C	184 R	193 C	207 E	210 C
211 C	212 C	213 C	217 E	218 C	222 E	224 E	229 E	233 C	234 C
237 C	238 T	241 E	242 E	251 E	252 C	259 E	262 C	265 C	271 C
273 E	274 C	275 C	280 C	281 C	284 C	285 R	297 C	299 C	301 C
302 E	310 C	312 E	314 E	324 E	325 R	326 E	330 E	338 C	340 E
341 E	344 E	345 E	346 T	352 E	358 C	362 C	367 E	370 C	379 E
380 C	389 C	390 R	391 C	392 C	404 C	407 C	408 E	409 E	410 E
411 E	416 R	432 C	445 C	449 C	452 E	453 E	458 E	468 C	472 E
473 E	474 E	480 E	486 T	487 R	488 T	491 E	493 E	494 T	495 E
508 T	512 E	521 C	530 C	533 E	534 E	538 E	559 C	570 T	571 T
576 C	580 C	584+E	588 C	597 E	598 T				

### SATURATED LIQUID

584+E

### SATURATED VAPOR

18 C      85 C      584+E

### IDEAL GAS

102 C    104 E    128 C    210 C    233 C    275 C    380 C    449 C    598 T

### SOLID

330 E

### LIQUID

25 C    107 R    112 C    142 E    259 E    265 C    445 C    508 T    580 C

### GAS (UP TO 200 DEGREES K)

12 E	16 C	18 C	63 E	65 C	80 E	85 C	90 T	91 T	97 E
102 C	107 R	112 C	131 C	141 C	142 E	167 C	176 E	183 C	210 C
218 C	233 C	234 C	262 C	271 C	285 R	297 C	301 C	312 E	314 E
341 E	358 C	370 C	380 C	389 C	410 E	416 R	432 C	445 C	452 E
472 E	473 E	474 E	488 T	530 C	588 C				

## 8. SPECIFIC HEAT (CONT.)

### GAS (ABOVE 200 DEGREES K)

12 E	16 C	18 C	28 C	37 E	60 T	63 E	65 C	67 R	85 C
90 T	91 T	99 E	102 C	104 E	107 R	112 C	118 C	120 R	123 C
128 C	131 C	133 E	141 C	143 E	146 C	160 C	167 C	173 C	176 E
181 E	183 C	184 R	193 C	207 E	210 C	211 C	212 C	213 C	217 E
218 C	222 E	224 E	229 E	233 C	234 C	237 C	238 T	241 E	242 E
251 E	252 C	262 C	271 C	273 E	274 C	280 C	281 C	284 C	285 R
297 C	299 C	301 C	302 E	310 C	312 E	314 E	324 E	325 R	326 E
338 C	340 E	344 E	345 E	346 T	352 E	358 C	362 C	367 E	370 C
379 E	380 C	389 C	390 R	391 C	392 C	404 C	407 C	408 E	409 E
410 E	411 E	416 R	432 C	445 C	452 E	453 E	458 E	468 C	472 E
473 E	474 E	480 E	486 T	487 R	488 T	491 E	493 E	494 T	495 E
512 E	521 C	530 C	533 E	534 E	538 E	559 C	570 T	571 T	576 C
588 C	597 E								

## 9. VELOCITY OF SOUND

1 E	45 E	49 E	55 E	67 R	76 E	94 E	95 E	97 E	98 E
99 E	102 C	115 E	116 E	120 R	134 E	160 C	190 E	195 E	203 C
204 E	212 C	214 E	221 E	222 E	233 C	237 C	238 T	239 E	249 E
271 C	272 C	282 R	283 E	285 R	308 E	313 E	321 E	324 E	325 R
327 E	340 E	342 E	360 E	370 C	380 C	382 E	385 C	393 E	410 E
423 E	430 E	432 C	442 E	493 E	495 E	496 E	499 E	500 E	501 E
502 C	520 E	522 E	545 E	549 E	552+E	553 E	568 E	586 E	587 E
601 E	603 E								

SOLID - NONE

LIQUID

552+E

### GAS (UP TO 200 DEGREES K)

97 E	102 C	233 C	271 C	285 R	313 E	370 C	380 C	410 E	430 E
432 C	502 C	587 E							

### GAS (ABOVE 200 DEGREES K)

1 E	45 E	49 E	55 E	67 R	76 E	94 E	95 E	97 E	98 E
99 E	102 C	115 E	116 E	120 R	134 E	160 C	190 E	195 E	203 C
204 E	212 C	214 E	221 E	222 E	233 C	237 C	238 T	239 E	249 E
271 C	272 C	282 R	283 E	285 R	308 E	313 E	321 E	324 E	325 R
327 E	340 E	342 E	360 E	370 C	380 C	382 E	385 C	393 E	410 E
423 E	430 E	432 C	442 E	493 E	495 E	496 E	499 E	500 E	501 E
502 C	520 E	522 E	545 E	549 E	553 E	568 E	586 E	587 E	601 E
603 E									

10. JOULE-THOMSON, INVERSION CURVE

15 E	19 E	30 C	60 T	62 E	85 C	105 E	144 E	161 R	218 C
219 C	236 T	250 E	257 T	258 E	261 C	263 E	268 R	299 C	309 R
370 C	380 C	402 E	415 R	416 R	428 E	451 E	452 E	453 E	488 T
592 C									

11. ENTROPY, ENTHALPY, INTERNAL ENERGY,  
GIBBS FUNCTION, HELMHOLTZ FUNCTION

11 E	17 C	18 C	88 C	90 T	91 T	93 R	102 C	107 R	112 C
118 C	131 C	132 C	145 C	146 C	147 C	148 C	152 C	160 C	173 C
185 C	191 C	192 C	210 C	212 C	213 C	218 C	219 C	233 C	237 C
238 T	254 C	259 E	271 C	272 C	274 C	284 C	285 R	286 C	310 C
316 T	323 C	331 E	332 E	334 C	337 C	370 C	380 C	385 C	398 E
405 C	415 R	416 R	425 C	432 C	449 C	450 C	454 E	459 E	462 R
466 C	468 C	476 C	484 R	488 T	498 C	558 C	559 C	569 C	571 T
580 C	583 C	584+E							

IDEAL GAS

102 C	148 C	210 C	233 C	449 C
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SOLID

88 C
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LIQUID

18 C	88 C	107 R	112 C	259 E	337 C	415 R	416 R	462 R	580 C
583 C	584+E								

GAS (UP TO 200 DEGREES K)

17 C	18 C	88 C	90 T	91 T	93 R	102 C	107 R	112 C	131 C
132 C	185 C	210 C	218 C	219 C	233 C	254 C	259 E	271 C	285 R
286 C	323 C	331 E	332 E	334 C	337 C	370 C	380 C	405 C	415 R
416 R	425 C	432 C	462 R	466 C	484 R	488 T	569 C	580 C	583 C
584+E									

GAS (ABOVE 200 DEGREES K)

11 E	17 C	18 C	88 C	90 T	91 T	93 R	102 C	107 R	112 C
118 C	131 C	132 C	145 C	146 C	147 C	148 C	152 C	160 C	173 C
185 C	191 C	192 C	210 C	212 C	213 C	218 C	219 C	233 C	237 C
238 T	254 C	259 E	271 C	272 C	274 C	284 C	285 R	286 C	310 C
316 T	323 C	331 E	332 E	334 C	337 C	370 C	380 C	385 C	398 E
405 C	415 R	416 R	425 C	432 C	450 C	454 E	459 E	466 C	468 C
476 C	484 R	488 T	498 C	558 C	559 C	569 C	571 T	583 C	

8. SPECIFIC HEAT (CONT.)

GAS (ABOVE 200 DEGREES K)

12 E	16 C	18 C	28 C	37 E	60 T	63 E	65 C	67 R	85 C
90 T	91 T	99 E	102 C	104 E	107 R	112 C	118 C	120 R	123 C
128 C	131 C	133 E	141 C	143 E	146 C	160 C	167 C	173 C	176 E
181 E	183 C	184 R	193 C	207 E	210 C	211 C	212 C	213 C	217 E
218 C	222 E	224 E	229 E	233 C	234 C	237 C	238 T	241 E	242 E
251 E	252 C	262 C	271 C	273 E	274 C	280 C	281 C	284 C	285 R
297 C	299 C	301 C	302 E	310 C	312 E	314 E	324 E	325 R	326 E
338 C	340 E	344 E	345 E	346 T	352 E	358 C	362 C	367 E	370 C
379 E	380 C	389 C	390 R	391 C	392 C	404 C	407 C	408 E	409 E
410 E	411 E	416 R	432 C	445 C	452 E	453 E	458 E	468 C	472 E
473 E	474 E	480 E	486 T	487 R	488 T	491 E	493 E	494 T	495 E
512 E	521 C	530 C	533 E	534 E	538 E	559 C	570 T	571 T	576 C
588 C	597 E								

9. VELOCITY OF SOUND

1 E	45 E	49 E	55 E	67 R	76 E	94 E	95 E	97 E	98 E
99 E	102 C	115 E	116 E	120 R	134 E	160 C	190 E	195 E	203 C
204 E	212 C	214 E	221 E	222 E	233 C	237 C	238 T	239 E	249 E
271 C	272 C	282 R	283 E	285 R	308 E	313 E	321 E	324 E	325 R
327 E	340 E	342 E	360 E	370 C	380 C	382 E	385 C	393 E	410 E
423 E	430 E	432 C	442 E	493 E	495 E	496 E	499 E	500 E	501 E
502 C	520 E	522 E	545 E	549 E	552+E	553 E	568 E	586 E	587 E
601 E	603 E								

SOLID - NONE

LIQUID

552+E

GAS (UP TO 200 DEGREES K)

97 E	102 C	233 C	271 C	285 R	313 E	370 C	380 C	410 E	430 E
432 C	502 C	587 E							

GAS (ABOVE 200 DEGREES K)

1 E	45 E	49 E	55 E	67 R	76 E	94 E	95 E	97 E	98 E
99 E	102 C	115 E	116 E	120 R	134 E	160 C	190 E	195 E	203 C
204 E	212 C	214 E	221 E	222 E	233 C	237 C	238 T	239 E	249 E
271 C	272 C	282 R	283 E	285 R	308 E	313 E	321 E	324 E	325 R
327 E	340 E	342 E	360 E	370 C	380 C	382 E	385 C	393 E	410 E
423 E	430 E	432 C	442 E	493 E	495 E	496 E	499 E	500 E	501 E
502 C	520 E	522 E	545 E	549 E	553 E	568 E	586 E	587 E	601 E
603 E									

10. JOULE-THOMSON, INVERSION CURVE

15 E	19 E	30 C	60 T	62 E	85 C	105 E	144 E	161 R	218 C
219 C	236 T	250 E	257 T	258 E	261 C	263 E	268 R	299 C	309 R
370 C	380 C	402 E	415 R	416 R	428 E	451 E	452 E	453 E	488 T
592 C									

11. ENTROPY, ENTHALPY, INTERNAL ENERGY,  
GIBBS FUNCTION, HELMHOLTZ FUNCTION

11 E	17 C	18 C	88 C	90 T	91 T	93 R	102 C	107 R	112 C
118 C	131 C	132 C	145 C	146 C	147 C	148 C	152 C	160 C	173 C
185 C	191 C	192 C	210 C	212 C	213 C	218 C	219 C	233 C	237 C
238 T	254 C	259 E	271 C	272 C	274 C	284 C	285 R	286 C	310 C
316 T	323 C	331 E	332 E	334 C	337 C	370 C	380 C	385 C	398 E
405 C	415 R	416 R	425 C	432 C	449 C	450 C	454 E	459 E	462 R
466 C	468 C	476 C	484 R	488 T	498 C	558 C	559 C	569 C	571 T
580 C	583 C	584+E							

IDEAL GAS

102 C	148 C	210 C	233 C	449 C
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SOLID

88 C
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LIQUID

18 C	88 C	107 R	112 C	259 E	337 C	415 R	416 R	462 R	580 C
583 C	584+E								

GAS (UP TO 200 DEGREES K)

17 C	18 C	88 C	90 T	91 T	93 R	102 C	107 R	112 C	131 C
132 C	185 C	210 C	218 C	219 C	233 C	254 C	259 E	271 C	285 R
286 C	323 C	331 E	332 E	334 C	337 C	370 C	380 C	405 C	415 R
416 R	425 C	432 C	462 R	466 C	484 R	488 T	569 C	580 C	583 C
584+E									

GAS (ABOVE 200 DEGREES K)

11 E	17 C	18 C	88 C	90 T	91 T	93 R	102 C	107 R	112 C
118 C	131 C	132 C	145 C	146 C	147 C	148 C	152 C	160 C	173 C
185 C	191 C	192 C	210 C	212 C	213 C	218 C	219 C	233 C	237 C
238 T	254 C	259 E	271 C	272 C	274 C	284 C	285 R	286 C	310 C
316 T	323 C	331 E	332 E	334 C	337 C	370 C	380 C	385 C	398 E
405 C	415 R	416 R	425 C	432 C	450 C	454 E	459 E	466 C	468 C
476 C	484 R	488 T	498 C	558 C	559 C	569 C	571 T	583 C	

12. THERMAL CONDUCTIVITY

12 E	14 E	41 T	46 E	61 E	64 T	65 C	72 E	73 T	79 C
82 C	84 E	93 R	108 C	111 E	118 C	121 C	122 E	123 C	125 E
139 E	140 E	141 C	162 R	163 E	170 E	171 T	172 E	181 E	186 E
193 C	196 E	197 E	198 E	199 E	200 C	211 C	212 C	227 E	230 E
231 E	232 E	233 C	234 C	236 T	237 C	255 E	256 E	265 C	277 E
278 E	279 E	285 R	297 C	322 E	328 C	329 E	333 R	337 C	338 C
346 T	353 E	359 E	374 E	375 E	377 E	391 C	392 C	394 C	445 C
460 E	464 E	465 E	467 T	468 C	477 E	478 E	479 R	481 E	482 E
483 E	484 R	487 R	488 T	490 E	503 E	504 E	511 C	518 E	519 E
526 E	543 E	544 E	546 E	547 R	555 E	562 E	563 E	564 E	565 E
577 E	578 E	579 E	584 E	585 E	600 E				

SOLID - NONE

LIQUID

41 T 140 E

GAS (UP TO 200 DEGREES K)

12 E	41 T	65 C	73 T	79 C	93 R	108 C	121 C	125 E	139 E
140 E	141 C	163 E	171 T	186 E	233 C	234 C	236 T	265 C	277 E
297 C	328 C	337 C	445 C	479 R	484 R	488 T	511 C	518 E	544 E

GAS (ABOVE 200 DEGREES K)

12 E	14 E	41 T	46 E	61 E	64 T	65 C	72 E	73 T	79 C
82 C	84 E	93 R	108 C	111 E	118 C	121 C	122 E	123 C	125 E
139 E	140 E	141 C	162 R	163 E	170 E	171 T	172 E	181 E	186 E
193 C	196 E	197 E	198 E	199 E	200 C	211 C	212 C	227 E	230 E
231 E	232 E	233 C	234 C	236 T	237 C	255 E	256 E	265 C	277 E
278 E	279 E	285 R	297 C	322 E	328 C	329 E	333 R	337 C	338 C
346 T	353 E	359 E	374 E	375 E	377 E	391 C	392 C	394 C	445 C
460 E	464 E	465 E	467 T	468 C	477 E	478 E	479 R	481 E	482 E
483 E	484 R	487 R	488 T	490 E	503 E	504 E	511 C	518 E	519 E
526 E	543 E	544 E	546 E	547 R	555 E	562 E	563 E	564 E	565 E
577 E	578 E	579 E	584 E	585 E	600 E				

13. VISCOSITY

12 E	13 C	20 E	21 E	26 E	27 E	39 R	40 E	41 T	50 E
51 E	52 C	54 C	56 E	57 E	58 E	59 C	64 T	65 C	66 C
67 R	73 T	77 C	78 C	83 C	87 E	91 T	92 R	93 R	101 E
113 E	114 E	118 C	123 C	127 E	129 R	130 E	141 C	150 E	151 C
153 E	156 E	157 E	158 E	169+E	177 E	178 E	179 E	180 E	181 E
182 C	184 R	187 E	188 E	193 C	201 E	202 E	211 C	212 C	215 R
216 E	233 C	234 C	235 T	236 T	237 C	240 E	247 E	248 E	260 E
262 C	264 T	265 C	266 E	267 E	276 E	285 R	287 E	288 E	289 E
290 E	292 E	293 E	294 E	295 E	296 C	297 C	298 R	305 E	315 E
333 R	336 C	337 C	338 C	346 T	349 E	350 E	351 E	354 E	355 E
356 E	361 E	366 E	373 E	376 C	380 C	381 C	383 E	384 E	391 C
392 C	394 C	424 E	431 C	434 E	435 E	436 E	437 E	438 E	439 E
440 E	441 E	444 E	445 C	447 E	448 E	461 E	477+E	479 R	484 R
485 E	488 T	492 E	509 E	510 C	511 C	524 E	525 E	527 E	531 E
532 C	535 E	536 E	537 E	539 E	540 E	541 E	542 E	545 E	548 E
550 E	551 E	554 E	556 E	557 E	561 C	567 E	572 E	581 E	582 E
591 C									

LIQUID

41 T	59 C	169+E	337 C	383 E	461 E	484 R	550 E
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GAS (UP TO 200 DEGREES K)

12 E	39 R	41 T	59 C	64 T	65 C	66 C	73 T	83 C	91 T
92 R	93 R	101 E	129 R	141 C	150 E	151 C	156 E	158 E	201 E
233 C	234 C	235 T	236 T	262 C	265 C	266 E	267 E	297 C	298 R
337 C	380 C	381 C	445 C	477+E	479 R	484 R	488 T	509 E	511 C
531 E	540 E								

GAS (ABOVE 200 DEGREES K)

12 E	13 C	20 E	21 E	26 E	27 E	39 R	40 E	41 T	50 E
51 E	52 C	54 C	56 E	57 E	58 E	59 C	64 T	65 C	66 C
67 R	73 T	77 C	78 C	83 C	87 E	91 T	92 R	93 R	101 E
113 E	114 E	118 C	123 C	127 E	129 R	130 E	141 C	150 E	151 C
153 E	156 E	157 E	158 E	177 E	178 E	179 E	180 E	181 E	182 C
184 R	187 E	188 E	193 C	201 E	202 E	211 C	212 C	215 R	216 E
233 C	234 C	235 T	236 T	237 C	240 E	247 E	248 E	260 E	262 C
264 T	265 C	266 E	267 E	276 E	285 R	287 E	288 E	289 E	290 E
292 E	293 E	294 E	295 E	296 C	297 C	298 R	305 E	315 E	333 R
336 C	337 C	338 C	346 T	349 E	350 E	351 E	354 E	355 E	356 E
361 E	366 E	373 E	376 C	380 C	381 C	384 E	391 C	392 C	394 C
424 E	431 C	434 E	435 E	436 E	437 E	438 E	439 E	440 E	441 E
444 E	445 C	447 E	448 E	477+E	479 R	484 R	485 E	488 T	492 E
509 E	510 C	511 C	524 E	525 E	527 E	531 E	532 C	535 E	536 E
537 E	539 E	540 E	541 E	542 E	545 E	548 E	551 E	554 E	556 E
557 E	561 C	567 E	572 E	581 E	582 E	591 C			



12. THERMAL CONDUCTIVITY

12 E	14 E	41 T	46 E	61 E	64 T	65 C	72 E	73 T	79 C
82 C	84 E	93 R	108 C	111 E	118 C	121 C	122 E	123 C	125 E
139 E	140 E	141 C	162 R	163 E	170 E	171 T	172 E	181 E	186 E
193 C	196 E	197 E	198 E	199 E	200 C	211 C	212 C	227 E	230 E
231 E	232 E	233 C	234 C	236 T	237 C	255 E	256 E	265 C	277 E
278 E	279 E	285 R	297 C	322 E	328 C	329 E	333 R	337 C	338 C
346 T	353 E	359 E	374 E	375 E	377 E	391 C	392 C	394 C	445 C
460 E	464 E	465 E	467 T	468 C	477 E	478 E	479 R	481 E	482 E
483 E	484 R	487 R	488 T	490 E	503 E	504 E	511 C	518 E	519 E
526 E	543 E	544 E	546 E	547 R	555 E	562 E	563 E	564 E	565 E
577 E	578 E	579 E	584 E	585 E	600 E				

SOLID - NONE

LIQUID

41 T 140 E

GAS (UP TO 200 DEGREES K)

12 E	41 T	65 C	73 T	79 C	93 R	108 C	121 C	125 E	139 E
140 E	141 C	163 E	171 T	186 E	233 C	234 C	236 T	265 C	277 E
297 C	328 C	337 C	445 C	479 R	484 R	488 T	511 C	518 E	544 E

GAS (ABOVE 200 DEGREES K)

12 E	14 E	41 T	46 E	61 E	64 T	65 C	72 E	73 T	79 C
82 C	84 E	93 R	108 C	111 E	118 C	121 C	122 E	123 C	125 E
139 E	140 E	141 C	162 R	163 E	170 E	171 T	172 E	181 E	186 E
193 C	196 E	197 E	198 E	199 E	200 C	211 C	212 C	227 E	230 E
231 E	232 E	233 C	234 C	236 T	237 C	255 E	256 E	265 C	277 E
278 E	279 E	285 R	297 C	322 E	328 C	329 E	333 R	337 C	338 C
346 T	353 E	359 E	374 E	375 E	377 E	391 C	392 C	394 C	445 C
460 E	464 E	465 E	467 T	468 C	477 E	478 E	479 R	481 E	482 E
483 E	484 R	487 R	488 T	490 E	503 E	504 E	511 C	518 E	519 E
526 E	543 E	544 E	546 E	547 R	555 E	562 E	563 E	564 E	565 E
577 E	578 E	579 E	584 E	585 E	600 E				

## 13. VISCOSITY

12 E	13 C	20 E	21 E	26 E	27 E	39 R	40 E	41 T	50 E
51 E	52 C	54 C	56 E	57 E	58 E	59 C	64 T	65 C	66 C
67 R	73 T	77 C	78 C	83 C	87 E	91 T	92 R	93 R	101 E
113 E	114 E	118 C	123 C	127 E	129 R	130 E	141 C	150 E	151 C
153 E	156 E	157 E	158 E	169+E	177 E	178 E	179 E	180 E	181 E
182 C	184 R	187 E	188 E	193 C	201 E	202 E	211 C	212 C	215 R
216 E	233 C	234 C	235 T	236 T	237 C	240 E	247 E	248 E	260 E
262 C	264 T	265 C	266 E	267 E	276 E	285 R	287 E	288 E	289 E
290 E	292 E	293 E	294 E	295 E	296 C	297 C	298 R	305 E	315 E
333 R	336 C	337 C	338 C	346 T	349 E	350 E	351 E	354 E	355 E
356 E	361 E	366 E	373 E	376 C	380 C	381 C	383 E	384 E	391 C
392 C	394 C	424 E	431 C	434 E	435 E	436 E	437 E	438 E	439 E
440 E	441 E	444 E	445 C	447 E	448 E	461 E	477+E	479 R	484 R
485 E	488 T	492 E	509 E	510 C	511 C	524 E	525 E	527 E	531 E
532 C	535 E	536 E	537 E	539 E	540 E	541 E	542 E	545 E	548 E
550 E	551 E	554 E	556 E	557 E	561 C	567 E	572 E	581 E	582 E
591 C									

## LIQUID

41 T    59 C    169+E    337 C    383 E    461 E    484 R    550 E

## GAS (UP TO 200 DEGREES K)

12 E	39 R	41 T	59 C	64 T	65 C	66 C	73 T	83 C	91 T
92 R	93 R	101 E	129 R	141 C	150 E	151 C	156 E	158 E	201 E
233 C	234 C	235 T	236 T	262 C	265 C	266 E	267 E	297 C	298 R
337 C	380 C	381 C	445 C	477+E	479 R	484 R	488 T	509 E	511 C
531 E	540 E								

## GAS (ABOVE 200 DEGREES K)

12 E	13 C	20 E	21 E	26 E	27 E	39 R	40 E	41 T	50 E
51 E	52 C	54 C	56 E	57 E	58 E	59 C	64 T	65 C	66 C
67 R	73 T	77 C	78 C	83 C	87 E	91 T	92 R	93 R	101 E
113 E	114 E	118 C	123 C	127 E	129 R	130 E	141 C	150 E	151 C
153 E	156 E	157 E	158 E	177 E	178 E	179 E	180 E	181 E	182 C
184 R	187 E	188 E	193 C	201 E	202 E	211 C	212 C	215 R	216 E
233 C	234 C	235 T	236 T	237 C	240 E	247 E	248 E	260 E	262 C
264 T	265 C	266 E	267 E	276 E	285 R	287 E	288 E	289 E	290 E
292 E	293 E	294 E	295 E	296 C	297 C	298 R	305 E	315 E	333 R
336 C	337 C	338 C	346 T	349 E	350 E	351 E	354 E	355 E	356 E
361 E	366 E	373 E	376 C	380 C	381 C	384 E	391 C	392 C	394 C
424 E	431 C	434 E	435 E	436 E	437 E	438 E	439 E	440 E	441 E
444 E	445 C	447 E	448 E	477+E	479 R	484 R	485 E	488 T	492 E
509 E	510 C	511 C	524 E	525 E	527 E	531 E	532 C	535 E	536 E
537 E	539 E	540 E	541 E	542 E	545 E	548 E	551 E	554 E	556 E
557 E	561 C	567 E	572 E	581 E	582 E	591 C			

12. THERMAL CONDUCTIVITY

12 E	14 E	41 T	46 E	61 E	64 T	65 C	72 E	73 T	79 C
82 C	84 E	93 R	108 C	111 E	118 C	121 C	122 E	123 C	125 E
139 E	140 E	141 C	162 R	163 E	170 E	171 T	172 E	181 E	186 E
193 C	196 E	197 E	198 E	199 E	200 C	211 C	212 C	227 E	230 E
231 E	232 E	233 C	234 C	236 T	237 C	255 E	256 E	265 C	277 E
278 E	279 E	285 R	297 C	322 E	328 C	329 E	333 R	337 C	338 C
346 T	353 E	359 E	374 E	375 E	377 E	391 C	392 C	394 C	445 C
460 E	464 E	465 E	467 T	468 C	477 E	478 E	479 R	481 E	482 E
483 E	484 R	487 R	488 T	490 E	503 E	504 E	511 C	518 E	519 E
526 E	543 E	544 E	546 E	547 R	555 E	562 E	563 E	564 E	565 E
577 E	578 E	579 E	584 E	585 E	600 E				

SOLID - NONE

LIQUID

41 T 140 E

GAS (UP TO 200 DEGREES K)

12 E	41 T	65 C	73 T	79 C	93 R	108 C	121 C	125 E	139 E
140 E	141 C	163 E	171 T	186 E	233 C	234 C	236 T	265 C	277 E
297 C	328 C	337 C	445 C	479 R	484 R	488 T	511 C	518 E	544 E

GAS (ABOVE 200 DEGREES K)

12 E	14 E	41 T	46 E	61 E	64 T	65 C	72 E	73 T	79 C
82 C	84 E	93 R	108 C	111 E	118 C	121 C	122 E	123 C	125 E
139 E	140 E	141 C	162 R	163 E	170 E	171 T	172 E	181 E	186 E
193 C	196 E	197 E	198 E	199 E	200 C	211 C	212 C	227 E	230 E
231 E	232 E	233 C	234 C	236 T	237 C	255 E	256 E	265 C	277 E
278 E	279 E	285 R	297 C	322 E	328 C	329 E	333 R	337 C	338 C
346 T	353 E	359 E	374 E	375 E	377 E	391 C	392 C	394 C	445 C
460 E	464 E	465 E	467 T	468 C	477 E	478 E	479 R	481 E	482 E
483 E	484 R	487 R	488 T	490 E	503 E	504 E	511 C	518 E	519 E
526 E	543 E	544 E	546 E	547 R	555 E	562 E	563 E	564 E	565 E
577 E	578 E	579 E	584 E	585 E	600 E				

13. VISCOSITY

12 E	13 C	20 E	21 E	26 E	27 E	39 R	40 E	41 T	50 E
51 E	52 C	54 C	56 E	57 E	58 E	59 C	64 T	65 C	66 C
67 R	73 T	77 C	78 C	83 C	87 E	91 T	92 R	93 R	101 E
113 E	114 E	118 C	123 C	127 E	129 R	130 E	141 C	150 E	151 C
153 E	156 E	157 E	158 E	169+E	177 E	178 E	179 E	180 E	181 E
182 C	184 R	187 E	188 E	193 C	201 E	202 E	211 C	212 C	215 R
216 E	233 C	234 C	235 T	236 T	237 C	240 E	247 E	248 E	260 E
262 C	264 T	265 C	266 E	267 E	276 E	285 R	287 E	288 E	289 E
290 E	292 E	293 E	294 E	295 E	296 C	297 C	298 R	305 E	315 E
333 R	336 C	337 C	338 C	346 T	349 E	350 E	351 E	354 E	355 E
356 E	361 E	366 E	373 E	376 C	380 C	381 C	383 E	384 E	391 C
392 C	394 C	424 E	431 C	434 E	435 E	436 E	437 E	438 E	439 E
440 E	441 E	444 E	445 C	447 E	448 E	461 E	477+E	479 R	484 R
485 E	488 T	492 E	509 E	510 C	511 C	524 E	525 E	527 E	531 E
532 C	535 E	536 E	537 E	539 E	540 E	541 E	542 E	545 E	548 E
550 E	551 E	554 E	556 E	557 E	561 C	567 E	572 E	581 E	582 E
591 C									

LIQUID

41 T	59 C	169+E	337 C	383 E	461 E	484 R	550 E		
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GAS (UP TO 200 DEGREES K)

12 E	39 R	41 T	59 C	64 T	65 C	66 C	73 T	83 C	91 T
92 R	93 R	101 E	129 R	141 C	150 E	151 C	156 E	158 E	201 E
233 C	234 C	235 T	236 T	262 C	265 C	266 E	267 E	297 C	298 R
337 C	380 C	381 C	445 C	477+E	479 R	484 R	488 T	509 E	511 C
531 E	540 E								

GAS (ABOVE 200 DEGREES K)

12 E	13 C	20 E	21 E	26 E	27 E	39 R	40 E	41 T	50 E
51 E	52 C	54 C	56 E	57 E	58 E	59 C	64 T	65 C	66 C
67 R	73 T	77 C	78 C	83 C	87 E	91 T	92 R	93 R	101 E
113 E	114 E	118 C	123 C	127 E	129 R	130 E	141 C	150 E	151 C
153 E	156 E	157 E	158 E	177 E	178 E	179 E	180 E	181 E	182 C
184 R	187 E	188 E	193 C	201 E	202 E	211 C	212 C	215 R	216 E
233 C	234 C	235 T	236 T	237 C	240 E	247 E	248 E	260 E	262 C
264 T	265 C	266 E	267 E	276 E	285 R	287 E	288 E	289 E	290 E
292 E	293 E	294 E	295 E	296 C	297 C	298 R	305 E	315 E	333 R
336 C	337 C	338 C	346 T	349 E	350 E	351 E	354 E	355 E	356 E
361 E	366 E	373 E	376 C	380 C	381 C	384 E	391 C	392 C	394 C
424 E	431 C	434 E	435 E	436 E	437 E	438 E	439 E	440 E	441 E
444 E	445 C	447 E	448 E	477+E	479 R	484 R	485 E	488 T	492 E
509 E	510 C	511 C	524 E	525 E	527 E	531 E	532 C	535 E	536 E
537 E	539 E	540 E	541 E	542 E	545 E	548 E	551 E	554 E	556 E
557 E	561 C	567 E	572 E	581 E	582 E	591 C			

14. PRANDTL NUMBER

90 T	93 R	122 E	123 C	124 E	125 E	181 E	212 C	233 C	234 C
255 E	256 E	285 R	297 C	391 C	394 C	488 T			

15. DIFFUSION COEFFICIENT

64 T

16. SURFACE TENSION

NONE

17. DIELECTRIC CONSTANT

42 E	47 E	48 E	68 E	69 E	74 E	75 E	89 E	100 E	119 E
137 E	138 E	154 E	155 E	165 E	175 E	189 E	225 E	226 E	228 E
253 E	269 E	270 E	306 E	307 E	348 E	357 R	364 E	395 E	396 E
397 E	426 E	445 C	446 E	457 E	463 E	505 E	513 E	514 E	515 E
552 E	575 E	599 E	602 E						

SOLID - NONE

LIQUID

119 E 154 E

GAS (UP TO 200 DEGREES K)

446 E

GAS (ABOVE 200 DEGREES K)

42 E	47 E	48 E	68 E	69 E	74 E	75 E	89 E	100 E	137 E
138 E	155 E	165 E	175 E	189 E	225 E	226 E	228 E	253 E	269 E
270 E	306 E	307 E	348 E	357 R	364 E	395 E	396 E	397 E	426 E
445 C	446 E	457 E	463 E	505 E	513 E	514 E	515 E	552 E	575 E
599 E	602 E								

18. REFRACTIVE INDEX

2 E	23 E	24 E	36 E	38 E	53 R	81 E	103 E	110 E	126 C
135 E	136 E	137 E	138 E	166 E	206 E	220 E	282 R	291 E	311 E
335 E	339 E	347 E	365 R	403 E	406 R	413 E	414 E	427 E	429 E
433 R	443 E	471 E	497 E	516 E	517 E	523 R	529 E	574 E	604 E

LIQUID

335 E

GAS (UP TO 200 DEGREES K)

471 E

GAS (ABOVE 200 DEGREES K)

2 E	23 E	24 E	36 E	38 E	53 R	81 E	103 E	110 E	126 C
135 E	136 E	137 E	138 E	166 E	206 E	220 E	282 R	291 E	311 E
339 E	347 E	365 R	403 E	406 R	413 E	414 E	427 E	429 E	433 R
443 E	471 E	497 E	516 E	517 E	523 R	529 E	574 E	604 E	

19. CORRESPONDING STATES

86 T    161 R    469 T    506 T

20. INTERMOLECULAR POTENTIAL

11 E	41 T	64 T	118 C	164 T	208 T	210 C	235 T	236 T	304 T
372 T	566 T								

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 (P = CONSTANT, V = CONSTANT) (GAS) (90 TO 1473 K AND 0 TO 4000  
 BAR), VAPOR PRESSURE (LIQUID), DEW LINE PRESSURES, SPECIFIC  
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 UNTERSUCHUNG UBER DIE LEISTUNGSFAHIGKEIT DER ASSMANNSCHE METHODE  
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- 219 HAUSEN, H.  
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 UBER DIE ISOTHERMEN EINIGER GASE ZWISCHEN 400 DEGREES UND  
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 UBER DIE ISOTHERMEN EINIGER GASE BIS 400 GRAD UND IHRE BEDEUTUNG  
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- 390 NEUMANN, B.  
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- 473 SCHEEL, K. HEUSE, W.  
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- 481 SCHWARZE, W.  
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- 488 SEVASTYANOV, R.M. ZDUNKEVICH, M.D.  
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- 499 STEVENS, E.H.  
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- 523 TILTON, L.W.  
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- 536 TRAUTZ, M. AND MELSTER, A.  
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(SAT. LIQUID, SAT. VAPOR) (85 TO 130 K AND 0 TO 30 ATM),  
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TEMPERATURE AND PRESSURE  
CORRELATION - GRAPHS

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MIXTURES WITH MOLE FRACTIONS OF NITROGEN AND OXYGEN FROM  
0 TO 1.0 AND OF ARGON FROM 0 TO 0.9 -

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 EXPERIMENTAL - TABLE (21 VALUES), GRAPH, APPARATUS
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EXPERIMENTAL - TABLES (115 VALUES)
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BEI CONSTATEM VOLUMEN VON DER TEMPERATUR UND DIE  
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5. APPENDIX A

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## 6. APPENDIX B

This cross-index of bibliography numbers with Cryogenic Data Center accession numbers has been prepared as an aid to Cryogenics Division staff members and others who might want to obtain specific articles from our files. The articles not in our files will have a dash in the accession number column.

Bib. No.	CDC Accession No.	Bib. No.	CDC Accession No.	Bib. No.	CDC Accession No.	Bib. No.	CDC Accession No.
1	20252	41	6959	81	54495	121	30688
2	19799	42	1009	82	33802	122	12788
3	14024	43	405	83	51037	123	14349
4	6912	44	--	84	56296	124	34515
5	8676	45	45273	85	6424	125	45266
6	8716	46	54564	86	54007	126	36794
7	8719	47	14544	87	54008	127	26705
8	13781	48	925	88	43288	128	633
9	28649	49	54009	89	41536	129	43943
10	6912	50	54481	90	998	130	26610
11	5086	51	26808	91	999	131	54523
12	5093	52	26653	92	6061	132	54730
13	35627	53	22253	93	6151	133	54506
14	55222	54	26626	94	54038	134	7171
15	30928	55	6992	95	7062	135	19277
16	30133	56	10784	96	30354	136	795
17	50687	57	25979	97	4902	137	5627
18	13045	58	54168	98	7070	138	54515
19	54477	59	11995	99	--	139	9244
20	27094	60	54478	100	27768	140	10914
21	--	61	45110	101	32164	141	25978
22	25721	62	5603	102	54006	142	6099
23	14543	63	28110	103	19279	143	1238
24	54488	64	9476	104	42280	144	54047
25	13824	65	10880	105	18950	145	54226
26	10658	66	10749	106	985	145+	48428
27	591	67	5600	107	983	146	55231
28	54593	68	26617	108	48451	147	56299
29	11005	69	27952	109	6622	148	12017
30	54479	70	29390	110	54012	149	16093
31	6926	71	3624	111	6323	150	9149
32	6927	72	6174	112	11281	151	37209
33	43270	73	41837	113	36882	152	56298
34	6929	74	14221	114	47125	153	25265
35	13848	75	14279	115	7127	154	14220
36	54492	76	7023	116	54491	155	26607
37	54011	77	26809	117	6243	156	9250
38	41768	78	34450	118	54023	157	11004
39	42364	79	49154	119	45369	158	27184
40	54563	80	37433	120	3142	159	54171
						160	30134

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161	35893	201	19639	241	57149	281	26897
162	6068	202	54028	242	55225	282	--
163	6106	203	35642	243	7324	283	7387
164	225	204	7262	244	801	284	55717
165	5675	205	56297	245	6328	285	54004
166	789	206	54501	246	8704	286	16845
167	42075	207	54171	247	54035	287	54483
168	4225	208	24946	248	11057	288	28655
169	23055	209	67	249	8695	289	54042
169+	6263	210	5938	250	54010	290	32852
170	48300	211	43584	251	26770	291	54493
171	48521	212	34473	252	5997	292	10579
172	26476	213	14578	253	641	293	11832
173	54227	214	7279	254	13017	294	5507
174	54005	215	11058	255	23628	295	6154
175	54482	216	44504	256	34521	296	25055
176	6029	217	54498	257	3276	297	646
177	25264	218	54566	258	332	298	5573
178	54169	219	55226	259	5897	299	21857
179	28646	220	54562	260	27471	300	28650
180	35639	221	6798	261	57142	301	26641
181	55720	222	6808	262	47579	302	6138
182	38568	223	32705	263	18526	303	33792
183	56401	224	5921	264	27521	304	44288
184	6011	225	27168	265	12018	305	26702
185	8660	226	219	266	5394	306	5495
186	25176	227	54597	267	5888	307	14541
187	28605	228	14739	268	464	308	--
188	45661	229	8696	269	--	309	54172
189	34510	230	25963	270	28641	310	5493
190	7250	231	36387	271	35336	311	19291
191	12673	232	56339	272	40670	312	56337
192	54299	233	453	273	26634	313	54521
193	35295	234	5959	274	6393	314	26640
194	442	235	3284	275	275	315	56334
195	31683	236	8700	276	16301	316	28348
196	9435	237	25357	277	214	317	56338
197	54046	238	48897	278	17969	318	29240
198	26630	239	7320	279	5911	319	12245
199	54045	240	26695	280	25965	320	54579
200	8693						

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321	--	361	43156	401	14793	441	27469
322	54048	362	6221	402	54043	442	1122
323	8397	363	55377	403	54510	443	26001
324	54162	364	11959	404	5536	444	45735
325	16877	365	54484	405	54727	445	25732
326	22251	366	28166	406	44044	446	6383
327	54509	367	54512	407	6114	447	54494
328	25237	368	6171	408	54580	448	6269
329	31490	369	663	409	54567	449	53551
330	29585	370	489	410	25911	450	553
331	24467	371	6077	411	55713	451	10448
332	25312	372	23617	412	16099	452	17804
333	6738	373	54499	413	54160	453	38574
334	22257	374	16893	414	40786	454	10328
335	6613	375	17454	415	--	455	9749
336	40405	376	35302	416	--	456	18002
337	6497	377	40751	417	55232	457	27935
338	10748	378	218	418	6049	458	41771
339	40787	379	41785	419	8703	459	8643
340	24318	380	19790	420	--	460	6076
341	24332	381	47200	421	18042	461	5736
342	28168	382	54505	422	--	462	2793
343	20337	383	665	423	7652	463	54487
344	9486	384	43134	424	56464	464	39108
345	43261	385	25314	425	43639	465	6169
346	27514	386	45966	426	33122	466	6268
347	54165	387	50971	427	54502	467	35646
348	--	388	5542	428	54064	468	11021
349	207	389	55714	428+	5525	469	54159
350	25269	390	54596	429	17997	470	8645
351	6385	391	10699	430	6705	471	6097
352	--	392	5432	431	48909	472	5726
353	32837	393	7594	432	9814	473	8110
354	1104	394	7989	433	12539	474	8111
355	10436	395	54164	434	5749	475	41479
356	54013	396	14228	435	16889	476	55227
357	4403	397	33797	436	18015	477	23395
358	485	398	40734	437	26687	477+	17999
359	39327	399	6193	438	27121	478	26734
360	7528	400	26027	439	54039	479	19641
				440	54026	480	8112



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481	16879	521	8710	561	43160	601	7916
482	16880	522	54496	562	56335	602	14226
483	16886	523	54514	563	17968	603	4590
484	14990	524	56300	564	11461	604	54511
485	--	525	26026	565	54489		
486	55711	526	10605	566	45562		
487	24368	527	26011	567	5703		
488	29436	528	26919	568	--		
489	13378	529	54497	569	27378		
490	11825	530	55710	570	--		
491	54594	531	618	571	24298		
492	26708	532	18000	572	54513		
493	6841	533	39339	573	33664		
494	10752	534	18837	574	54595		
495	19306	535	17962	575	6044		
496	27095	536	604	576	--		
497	56336	537	26003	577	592		
498	35649	538	19301	578	723		
499	54503	539	26006	579	19459		
500	35654	540	26745	580	56343		
501	2274	541	26007	581	54516		
502	12704	542	615	582	54517		
503	11669	543	18843	583	730		
504	16898	544	717	584	34445		
505	54508	545	6816	585	6318		
506	6228	546	10739	586	54480		
507	6229	547	55224	587	24344		
508	27104	548	27954	588	6603		
509	26682	549	5758	589	16360		
510	36399	550	47789	590	5692		
511	16317	551	5711	591	374		
512	54518	552	5710	592	54565		
513	56369	552+	3106	593	16369		
514	711	553	6177	594	19184		
515	14542	554	12631	595	19185		
516	10740	555	32864	596	16106		
517	19292	556	17730	597	7907		
518	11061	557	42121	598	52908		
519	46400	558	22220	599	664		
520	--	559	56674	600	47296		
		560	37889				



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