

MASTER

MASTER

PB 161557



# Technical Note

*NBS TN* No. 56

*Boulder Laboratories*

---

A BIBLIOGRAPHY  
OF THE  
PHYSICAL EQUILIBRIA AND RELATED PROPERTIES  
OF  
SOME CRYOGENIC SYSTEMS

BY  
THOMAS M. FLYNN



---

U. S. DEPARTMENT OF COMMERCE  
NATIONAL BUREAU OF STANDARDS

## **DISCLAIMER**

**This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.**

---

## **DISCLAIMER**

**Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.**

## THE NATIONAL BUREAU OF STANDARDS

### Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to government agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. Research projects are also performed for other government agencies when the work relates to and supplements the basic program of the Bureau or when the Bureau's unique competence is required. The scope of activities is suggested by the listing of divisions and sections on the inside of the back cover.

### Publications

The results of the Bureau's work take the form of either actual equipment and devices or published papers. These papers appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three periodicals available from the Government Printing Office: The Journal of Research, published in four separate sections, presents complete scientific and technical papers; the Technical News Bulletin presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: Monographs, Applied Mathematics Series, Handbooks, Miscellaneous Publications, and Technical Notes.

Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards (\$1.25) and its Supplement (\$1.50), available from the Superintendent of Documents, Government Printing Office, Washington 25, D.C.

# NATIONAL BUREAU OF STANDARDS

## *Technical Note*

56

May 1960

A Bibliography of the Physical Equilibria  
and Related Properties of Some  
Cryogenic Systems

by

Thomas M. Flynn

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. They are for sale by the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.

DISTRIBUTED BY

UNITED STATES DEPARTMENT OF COMMERCE

OFFICE OF TECHNICAL SERVICES

WASHINGTON 25, D. C.

Price \$1.75

## II

### Contents

|                                         | Page |
|-----------------------------------------|------|
| Abstract . . . . .                      | III  |
| 1. Introduction . . . . .               | 1    |
| 1.1 Purpose . . . . .                   | 1    |
| 1.2 Organization . . . . .              | 2    |
| 1.3 Scope . . . . .                     | 4    |
| 1.4 Acknowledgements . . . . .          | 7    |
| 2. Phenomena Index . . . . .            | 8    |
| 2.1 Hydrogen . . . . .                  | 9    |
| 2.2 Helium . . . . .                    | 13   |
| 2.3 Nitrogen . . . . .                  | 15   |
| 2.4 Carbon Dioxide . . . . .            | 19   |
| 2.5 Carbon Monoxide . . . . .           | 22   |
| 2.6 Methane . . . . .                   | 24   |
| 2.7 Ethane . . . . .                    | 28   |
| 2.8 Propane . . . . .                   | 30   |
| 3. Properties Index . . . . .           | 32   |
| 3.1 Hydrogen . . . . .                  | 33   |
| 3.2 Helium . . . . .                    | 36   |
| 3.3 Nitrogen . . . . .                  | 38   |
| 3.4 Carbon Dioxide . . . . .            | 42   |
| 3.5 Carbon Monoxide . . . . .           | 45   |
| 3.6 Methane . . . . .                   | 47   |
| 3.7 Ethane . . . . .                    | 50   |
| 3.8 Propane . . . . .                   | 52   |
| 4. Bibliography of References . . . . . | 54   |

### III

#### Abstract

A bibliography of approximately 700 references is presented on the physical equilibria and related properties of several important cryogenic systems. The systems considered are the pure components and mixtures of: Hydrogen, Helium, Nitrogen, Carbon Dioxide, Carbon Monoxide, Methane, Ethane, and Propane.

## 1. Introduction

### 1.1 Purpose

Gases to be liquefied are frequently obtained as by-products from some parent source, and may contain very large amounts of impurities. Determining the method of removal of the impurities is difficult since the systems are seldom ideal, and may deviate from some theoretical models by factors of several thousand. Research in the area of physical equilibria attempts to present the problem from a fundamental viewpoint so that accurate predictions and designs can be made.

Any serious effort to predict physical equilibria demands at least two types of information, sine qua non. First, a precise description of the P-V-T behavior of the pure components. Second, a precise description of the mixture: the P-V-T behavior, or the interaction of the different molecular species, and the like.

Information in these categories appears in several forms and in many places in the scientific literature. It is the purpose of this paper to present results of a literature search in this field. The search was intended to discover, as completely as possible, that work in phenomena and properties, experimental and theoretical, related to the physical equilibria of a few selected systems.

The systems selected were those of primary interest in cryogenics. They included the pure components and mixtures of: Hydrogen, Helium, Nitrogen, Carbon Dioxide, Carbon Monoxide, Methane, Ethane, and Propane.

Oxygen and the higher hydrocarbons were deliberately excluded as primary systems since their behavior has already been thoroughly reported in the literature of air separation and petroleum, respectively. They were included, however, as "Other Components" within the primary systems.

## 1.2 Organization

The information is presented in three principal parts:

I. Phenomena, II. Properties, and III. Bibliography of References.

The following outline delineates the arrangement. For the sake of brevity, the sub-headings are given only once in each principal part. They are, of course, repeated for each component.

### Organization Outline

#### I. Phenomena

##### A. Hydrogen

1. Phase equilibria
2. Fugacity, activity
3. Adsorption, on charcoal
4. Adsorption, on silica gel
5. Adsorption, on other adsorbents

##### B. Helium

1. -- 5.

##### C. Nitrogen

1. -- 5.

##### D. Carbon Dioxide

1. -- 5.

##### E. Carbon Monoxide

1. -- 5.

##### F. Methane

1. -- 5.

##### G. Ethane

1. -- 5.

##### H. Propane

1. -- 5.

## II. Properties

### A. Hydrogen

1. P-V-T General
2. Vapor pressure
3. Critical constants, and triple point
4. Compressibility isotherms
5. Density, molar volume (of a condensed phase)
6. Equations of state, general
7. Corresponding states
8. Beattie - Bridgeman
9. Benedict - Webb - Rubin
10. Potential forms, general
11. Virial coefficients
12. Lennard - Jones 6 - 9 potential
13. Lennard - Jones 6 - 12 potential

### B. Helium

1. -- 13.

### C. Nitrogen

1. -- 13.

### D. Carbon Dioxide

1. -- 13.

### E. Carbon Monoxide

1. -- 13.

### F. Methane

1. -- 13.

### G. Ethane

1. -- 13.

## H. Propane

1. -- 13.

## III. Bibliography of References

(Listed alphabetically by first author)

### 1.3 Scope

#### I. Areas Searched

Indexes, when available, were searched under the following headings:

- |                      |                         |
|----------------------|-------------------------|
| 1. acetylene         | 9. helium               |
| 2. adsorbents        | 10. hydrogen            |
| 3. adsorption        | 11. methane             |
| 4. carbon dioxide    | 12. nitrogen            |
| 5. carbon monoxide   | 13. propane             |
| 6. ethane            | 14. propene (propylene) |
| 7. ethene (ethylene) | 15. purification        |
| 8. gases             | 16. solubility          |

The sub groups searched within these general headings were:

1. Analysis: detection, determination, chromatography, mass spectrometry
2. Adsorption: by various agents, of mixtures
3. Absorption
4. Cryostat: cryogenics
5. Distillation

6. Liquefaction: condensation, melting point, solidification
7. Mists: analysis of, formation, separation, supersaturation
8. Physical equilibria: phase diagrams
9. Purification: impurities, separation, removal, drying
10. P-V-T: equations of state, critical constants, compressibility, vapor pressure, specific volume, fugacity
11. Reviews: bibliographies
12. Solubility: dissolved, determination, theory of, laws of
13. Thermodynamic properties

For the years of Chemical Abstracts for which no indexes are available, the following sections were searched:

- a. (1) Apparatus, plant equipment and Unit Operations
- b. (2) General and Physical Chemistry
- c. (6) Inorganic Chemistry
- d. (7) Analytical Chemistry
- e. (13) Miscellaneous and Industrial Products
- f. (22) Petroleum

II. The Abstracts, Indexes, and Lists searched were:

1. Chemical Abstracts, 1907 to date.\*
2. British Chemical Abstracts, 1926 through 1953.
3. FIAT Review of German Science, 1936-1946,  
Vols. 27b (Inorganic Chemistry, Part V;  
Equilibrium Investigation on Inorganic Substances);  
Gas Analysis); and 30a (Physical Chemistry;  
adsorption and desorption).
4. Chemisches Zentralblatt, 1955 only.
5. Doctoral Dissertations accepted by American  
Universities, 1949-1955.
6. Index to American Doctoral Dissertations,  
Combined with Dissertation Abstracts, 1955 to  
date.\*
7. Index to theses accepted for Higher Degrees in  
the Universities of Great Britain and Ireland.  
1951 to date.\*
8. Bibliography of Translations from Russian  
Scientific and Technical Literature. 1953-1956  
(no more published).
9. Translation Monthly. 1955-1958.
10. Monthly List of Russian Accessions. 1948 to  
date.\*
11. Deitz, V. R., Bibliography of Solid Adsorbents,  
1900 to 1942, and 1943 to 1953.
12. Rose, Arthur and Elizabeth, Distillation Literature  
Index and Abstract, 1946 to 1952, and 1953  
to 1954.

\* "to date" means through and including the most recent issue  
available on October 1, 1959.

13. A few selected journals were searched issue by issue from January, 1958, to date, \* since it was possible that these issues had not yet been fully abstracted. The journals searched in this manner were:

- a. A.I.Ch.E. Journal
- b. Chemical Engineering Progress
- c. Industrial and Engineering Chemistry
- d. Journal of the American Chemical Society

#### 1.4 Acknowledgements

This work simply never would have been compiled without the aid of many able persons of the National Bureau of Standards Cryogenic Engineering Laboratory staff. Recognition is due: Mr. D. E. Drayer, who performed the bulk of the search; Mr. A. J. Kidnay for help in compiling and proofing; Mrs. B. E. Douglas for typing the two principal indices; and especially to Mrs. L. E. Merritt for the painstaking and exhausting typing of the bibliography.

The author also wishes to acknowledge the aid of the Cryogenic Engineering Laboratory Data Center, under the direction of Mr. V. J. Johnson. This able group advised the preparation of the primary information retrieval system, and supplied many of the original papers for review.

2.0

Phenomena Index

Phenomenon

Major Component

## HYDROGEN

| Category            | Other Components                                      | References                                             |
|---------------------|-------------------------------------------------------|--------------------------------------------------------|
| Phase<br>Equilibria | Helium                                                | 568                                                    |
|                     | Nitrogen                                              | 17, 88, 169, 205, 226, 227,<br>231, 374, 420, 472, 637 |
|                     | Nitrogen and<br>Carbon Dioxide                        | 2                                                      |
|                     | Nitrogen and<br>Carbon Dioxide and<br>Carbon Monoxide | 3                                                      |
|                     | Nitrogen and<br>Carbon Monoxide                       | 10, 169, 184, 204, 539,<br>637                         |
|                     | Nitrogen and<br>Methane                               | 131, 132, 133, 572                                     |
|                     | Nitrogen and<br>Methane and<br>Carbon Monoxide        | 600                                                    |
|                     | Nitrogen and<br>Methane and<br>Ethane                 | 131, 132, 133                                          |
|                     | Nitrogen and<br>Ethene                                | 435                                                    |
|                     | Carbon Dioxide                                        | 1, 3, 186, 236, 426, 605                               |
|                     | Carbon Dioxide and<br>Nitrogen                        | 2                                                      |

Phenomenon

Major Component

HYDROGEN  
(continued)

| Category                           | Other Components                                      | References                                           |
|------------------------------------|-------------------------------------------------------|------------------------------------------------------|
| Phase<br>Equilibria<br>(continued) | Carbon Dioxide and<br>Nitrogen and<br>Carbon Monoxide | 3                                                    |
|                                    | Carbon Monoxide                                       | 169, 227, 637                                        |
|                                    | Carbon Monoxide and<br>Nitrogen                       | 10, 169, 184, 204, 539,<br>637                       |
|                                    | Carbon Monoxide and<br>Nitrogen and<br>Carbon Dioxide | 3                                                    |
|                                    | Carbon Monoxide and<br>Nitrogen and<br>Methane        | 600                                                  |
|                                    | Methane                                               | 56, 57, 58, 59, 187, 193,<br>194, 207, 226, 227, 653 |
|                                    | Methane and<br>Nitrogen                               | 131, 132, 133, 572                                   |
|                                    | Methane and<br>Nitrogen and<br>Carbon Monoxide        | 600                                                  |
|                                    | Methane and<br>Nitrogen and<br>Ethane                 | 131, 132, 133                                        |
|                                    | Methane and<br>Ethane                                 | 353                                                  |

Phenomenon

Major Component

HYDROGEN  
(continued)

| Category                        | Other Components               | References                                                                                                                     |
|---------------------------------|--------------------------------|--------------------------------------------------------------------------------------------------------------------------------|
| Phase Equilibria<br>(continued) | Methane and Ethane and Propane | 56, 57, 58, 59                                                                                                                 |
|                                 | Methane and Propane            | 56, 57, 58                                                                                                                     |
|                                 | Methane and Propene            | 57, 58                                                                                                                         |
|                                 | Ethane                         | 352, 612, 663                                                                                                                  |
|                                 | Propane                        | 59, 96, 663                                                                                                                    |
|                                 | Propene                        | 59                                                                                                                             |
| Fugacity, Activity              |                                | 605                                                                                                                            |
|                                 | Helium                         | 370                                                                                                                            |
| Adsorption, Charcoal            |                                | 32, 97, 118, 140, 158, 159, 161, 164, 214, 237, 315, 325, 326, 351, 367, 395, 475, 499, 527, 580, 588, 595, 610, 611, 618, 624 |
|                                 | Nitrogen                       | 12                                                                                                                             |
|                                 | Carbon Dioxide                 | 268, 366, 372                                                                                                                  |
| Adsorption, Silica Gel          |                                | 140, 408, 512, 513, 616                                                                                                        |
|                                 | Nitrogen                       | 12, 290                                                                                                                        |

Phenomenon

Major Component

HYDROGEN  
(continued)

| Category                           | Other Components | References                                                              |
|------------------------------------|------------------|-------------------------------------------------------------------------|
| Adsorption,<br>Other<br>Adsorbents |                  | 23, 33, 86, 202, 274, 289,<br>363, 373, 440, 463, 487,<br>489, 622, 623 |

Phenomenon

Major Component

HELIUM

| Category             | Other Components                            | References                                                           |
|----------------------|---------------------------------------------|----------------------------------------------------------------------|
| Phase Equilibria     | Hydrogen                                    | 568                                                                  |
|                      | Nitrogen                                    | 79, 80, 198, 228, 320, 536, 537                                      |
|                      | Nitrogen and Methane and Ethane             | 79, 80, 583                                                          |
|                      | Nitrogen and Methane and Ethane and Propane | 79, 80                                                               |
|                      | Carbon Dioxide                              | 186, 603                                                             |
|                      | Methane                                     | 229, 230                                                             |
|                      | Propane                                     | 604                                                                  |
|                      | Argon                                       | 300, 301                                                             |
| Fugacity, Activity   |                                             | 370                                                                  |
|                      | Nitrogen                                    | 228                                                                  |
| Adsorption, Charcoal |                                             | 118, 127, 159, 181, 192, 238, 297, 396, 403, 551, 615, 620, 621, 626 |
|                      | Nitrogen                                    | 346, 430, 678                                                        |
|                      | Methane                                     | 346                                                                  |

Phenomenon

Major Component

HELIUM  
(continued)

| Category                           | Other Components | References    |
|------------------------------------|------------------|---------------|
| Adsorption,<br>Silica Gel          |                  | 614           |
|                                    | Oxygen           | 345           |
| Adsorption,<br>Other<br>Adsorbents |                  | 206, 312, 386 |

Phenomenon

Major Component

## NITROGEN

| Category            | Other Components                                      | References                                             |
|---------------------|-------------------------------------------------------|--------------------------------------------------------|
| Phase<br>Equilibria | Hydrogen                                              | 17, 88, 169, 205, 226, 227,<br>231, 374, 420, 472, 637 |
|                     | Hydrogen and<br>Carbon Dioxide                        | 2                                                      |
|                     | Hydrogen and<br>Carbon Dioxide and<br>Carbon Monoxide | 3                                                      |
|                     | Hydrogen and<br>Carbon Monoxide                       | 10, 169, 184, 204, 539,<br>637                         |
|                     | Hydrogen and<br>Carbon Monoxide and<br>Methane        | 600                                                    |
|                     | Hydrogen and<br>Methane                               | 131, 132, 133, 572                                     |
|                     | Hydrogen and<br>Methane and<br>Ethane                 | 131, 132, 133                                          |
|                     | Helium                                                | 79, 80, 198, 228, 320, 536,<br>537                     |
|                     | Helium and<br>Methane and<br>Ethane                   | 79, 80, 583                                            |
|                     | Oxygen                                                | 25, 31, 166, 167, 168, 334,<br>341, 497, 498, 534, 538 |
|                     | Oxygen and<br>Argon                                   | 257, 347, 651                                          |

## Major Component

NITROGEN  
(continued)

| Category                        | Other Components                                | References                                               |
|---------------------------------|-------------------------------------------------|----------------------------------------------------------|
| Phase Equilibria<br>(continued) | Carbon Dioxide                                  | 1, 3, 200, 426, 605                                      |
|                                 | Carbon Dioxide and Hydrogen                     | 2                                                        |
|                                 | Carbon Dioxide and Hydrogen and Carbon Monoxide | 3                                                        |
|                                 | Carbon Dioxide and Argon                        | 648                                                      |
|                                 | Carbon Monoxide                                 | 169, 203, 294, 334, 534, 538, 558, 570, 571, 637         |
|                                 | Carbon Monoxide and Hydrogen                    | 10, 169, 184, 204, 539, 637                              |
|                                 | Carbon Monoxide and Hydrogen and Methane        | 600                                                      |
|                                 | Methane                                         | 71, 72, 113, 114, 195, 197, 199, 404, 581, 598, 599, 635 |
|                                 | Methane and Hydrogen                            | 131, 132, 133, 572                                       |
|                                 | Methane and Helium and Ethane                   | 583                                                      |
|                                 | Methane and Ethane                              | 131, 132, 133                                            |

Phenomenon

Major Component

NITROGEN  
(continued)

| Category                           | Other Components                                   | References    |
|------------------------------------|----------------------------------------------------|---------------|
| Phase<br>Equilibria<br>(continued) | Methane and<br>Ethane and<br>Propane and<br>Butane | 584           |
|                                    | Ethane                                             | 137, 176, 507 |
|                                    | Ethene                                             | 137, 606, 607 |
|                                    | Acetylene                                          | 200, 286      |
|                                    | Propane                                            | 635           |
|                                    | Propene                                            | 137, 607      |
|                                    | Butane                                             | 9             |
|                                    | Benzene                                            | 518, 519      |
|                                    | Argon                                              | 163, 196, 277 |
|                                    | Argon and<br>Oxygen                                | 257, 347, 651 |
| Fugacity,<br>Activity              |                                                    | 75, 370       |
|                                    | Helium                                             | 228           |
|                                    | Methane                                            | 75            |
|                                    | Ethane                                             | 492           |

## Phenomenon

## Major Component

NITROGEN  
(continued)

| Category                           | Other Components | References                                                                                                                                                                                       |
|------------------------------------|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Adsorption,<br>Charcoal            |                  | 20, 21, 22, 97, 109, 118,<br>149, 150, 159, 161, 180,<br>201, 215, 218, 275, 278,<br>279, 283, 296, 302, 314,<br>365, 400, 405, 436, 499,<br>508, 511, 525, 527, 595,<br>609, 640, 641, 664, 665 |
|                                    | Hydrogen         | 12                                                                                                                                                                                               |
|                                    | Helium           | 346, 430, 678                                                                                                                                                                                    |
|                                    | Oxygen           | 12                                                                                                                                                                                               |
|                                    | Carbon Dioxide   | 268                                                                                                                                                                                              |
| Adsorption,<br>Silica Gel          |                  | 90, 108, 145, 172, 173,<br>179, 222, 296, 330, 337,<br>376, 480, 565, 589, 616,<br>665                                                                                                           |
|                                    | Hydrogen         | 290                                                                                                                                                                                              |
|                                    | Oxygen           | 345, 366                                                                                                                                                                                         |
|                                    | Carbon Dioxide   | 673                                                                                                                                                                                              |
|                                    | Carbon Monoxide  | 666                                                                                                                                                                                              |
|                                    | Methane          | 666                                                                                                                                                                                              |
| Adsorption,<br>Other<br>Adsorbents |                  | 23, 33, 86, 433, 546, 622,<br>644, 677                                                                                                                                                           |

## Phenomenon

## Major Component

## CARBON DIOXIDE

| Category            | Other Components                                | References                      |
|---------------------|-------------------------------------------------|---------------------------------|
| Phase<br>Equilibria | Hydrogen                                        | 1, 3, 186, 236, 426, 605        |
|                     | Hydrogen and<br>Nitrogen                        | 2                               |
|                     | Hydrogen and<br>Nitrogen and<br>Carbon Monoxide | 3                               |
|                     | Helium                                          | 186, 603                        |
|                     | Nitrogen                                        | 1, 3, 200, 426, 605             |
|                     | Nitrogen and<br>Hydrogen                        | 2                               |
|                     | Oxygen                                          | 200                             |
|                     | Carbon Monoxide                                 | 1, 3                            |
|                     | Carbon Monoxide and<br>Nitrogen                 | 3                               |
|                     | Methane                                         | 170, 171, 500, 605              |
|                     | Ethane                                          | 117, 502, 529                   |
|                     | Ethene                                          | 110, 117, 124, 256, 529,<br>606 |
|                     | Ethene and<br>Propane                           | 564                             |
|                     | Acetylene                                       | 116                             |

Phenomenon

Major Component

CARBON DIOXIDE  
(continued)

| Category                        | Other Components                | References                                                               |
|---------------------------------|---------------------------------|--------------------------------------------------------------------------|
| Phase Equilibria<br>(continued) | Propane                         | 8, 144, 488, 506                                                         |
|                                 | Propane and Ethene              | 564                                                                      |
|                                 | Butane                          | 450, 488                                                                 |
|                                 | Butanes and Higher Hydrocarbons | 406, 407, 470, 488, 575                                                  |
| Fugacity, Activity              |                                 | 152, 375                                                                 |
| Adsorption, Charcoal            |                                 | 67, 208, 215, 217, 278, 279, 367, 368, 499, 511, 516, 525, 526, 595, 609 |
|                                 | Hydrogen                        | 268, 366, 372                                                            |
|                                 | Nitrogen                        | 268                                                                      |
|                                 | Oxygen                          | 268                                                                      |
|                                 | Carbon Monoxide                 | 366                                                                      |
|                                 | Ethene                          | 67, 366                                                                  |
|                                 | Acetylene                       | 557                                                                      |
| Adsorption, Silica Gel          |                                 | 108, 632                                                                 |
|                                 | Nitrogen                        | 673                                                                      |
|                                 | Oxygen                          | 673                                                                      |

Phenomenon

Major Component

CARBON DIOXIDE  
(continued)

| Category                           | Other Components | References    |
|------------------------------------|------------------|---------------|
| Adsorption,<br>Other<br>Adsorbents |                  | 288, 451, 644 |

Phenomenon

Major Component

## CARBON MONOXIDE

| Category             | Other Components                         | References                                       |
|----------------------|------------------------------------------|--------------------------------------------------|
| Phase Equilibria     | Hydrogen                                 | 169, 227, 637                                    |
|                      | Hydrogen and Nitrogen                    | 10, 169, 184, 204, 539, 637                      |
|                      | Hydrogen and Nitrogen and Carbon Dioxide | 3                                                |
|                      | Hydrogen and Nitrogen and Methane        | 600                                              |
|                      | Nitrogen                                 | 169, 203, 294, 334, 534, 538, 558, 570, 571, 637 |
|                      | Nitrogen and Hydrogen                    | 10, 169, 184, 204, 539, 637                      |
|                      | Carbon Dioxide                           | 1, 3                                             |
|                      | Methane                                  | 674                                              |
|                      | Propane                                  | 659                                              |
|                      | Propene                                  | 659                                              |
|                      | Other Hydrocarbons                       | 470, 659                                         |
| Fugacity, Activity   |                                          | 370                                              |
| Adsorption, Charcoal |                                          | 97, 180, 215, 278, 279, 499, 525, 527, 625       |

## Phenomenon

## Major Component

CARBON MONOXIDE  
(continued)

| Category                               | Other Components | References                     |
|----------------------------------------|------------------|--------------------------------|
| Adsorption,<br>Charcoal<br>(continued) | Carbon Dioxide   | 366                            |
| Adsorption,<br>Silica Gel              |                  | 480, 513, 589                  |
|                                        | Nitrogen         | 666                            |
|                                        | Methane          | 666                            |
| Adsorption,<br>Other<br>Adsorbents     |                  | 23, 216, 363, 486, 487,<br>644 |

Phenomenon

Major Component

METHANE

| Category            | Other Components                                | References                                           |
|---------------------|-------------------------------------------------|------------------------------------------------------|
| Phase<br>Equilibria | Hydrogen                                        | 56, 57, 58, 59, 187, 193,<br>194, 207, 226, 227, 653 |
|                     | Hydrogen and<br>Nitrogen                        | 131, 132, 133, 572                                   |
|                     | Hydrogen and<br>Nitrogen and<br>Carbon Monoxide | 600                                                  |
|                     | Hydrogen and<br>Nitrogen and<br>Ethane          | 131, 132, 133                                        |
|                     | Hydrogen and<br>Ethane                          | 353                                                  |
|                     | Hydrogen and<br>Ethene                          | 362                                                  |
|                     | Hydrogen and<br>Propane                         | 56, 57, 58                                           |
|                     | Hydrogen and<br>Propene                         | 56, 57, 58                                           |
|                     | Helium                                          | 229, 230                                             |
|                     | Helium and<br>Nitrogen and<br>Ethane            | 583                                                  |
|                     | Helium and<br>Nitrogen and<br>Hydrocarbons      | 79, 80                                               |

Phenomenon

Major Component

METHANE  
(continued)

| Category                        | Other Components                                | References                                                     |
|---------------------------------|-------------------------------------------------|----------------------------------------------------------------|
| Phase Equilibria<br>(continued) | Nitrogen                                        | 71, 72, 113, 114, 195, 197,<br>199, 404, 581, 598, 599,<br>635 |
|                                 | Nitrogen and<br>Hydrogen                        | 131, 132, 133, 572                                             |
|                                 | Nitrogen and<br>Hydrogen and<br>Carbon Monoxide | 600                                                            |
|                                 | Nitrogen and<br>Hydrogen and<br>Ethane          | 131, 132, 133, 572                                             |
|                                 | Nitrogen and<br>Helium and<br>Ethane            | 583                                                            |
|                                 | Nitrogen and<br>Helium and<br>Hydrocarbons      | 79, 80                                                         |
|                                 | Oxygen                                          | 19, 195                                                        |
|                                 | Carbon Dioxide                                  | 170, 171, 500, 605                                             |
|                                 | Carbon Monoxide                                 | 674                                                            |
|                                 | Ethane                                          | 91, 251, 534, 535, 540,<br>612                                 |
|                                 | Ethane and<br>Hydrogen                          | 353                                                            |

Phenomenon

Major Component

METHANE  
(continued)

| Category                           | Other Components                       | References                                                                                                |
|------------------------------------|----------------------------------------|-----------------------------------------------------------------------------------------------------------|
| Phase<br>Equilibria<br>(continued) | Ethane and<br>Hydrogen and<br>Nitrogen | 131, 132, 133                                                                                             |
|                                    | Ethane and<br>Helium and<br>Nitrogen   | 583                                                                                                       |
|                                    | Ethane and<br>Ethene                   | 246, 441                                                                                                  |
|                                    | Ethene                                 | 243, 245, 361, 441, 639                                                                                   |
|                                    | Ethene and<br>Hydrogen                 | 362                                                                                                       |
|                                    | Propane                                | 7, 251, 504, 544, 545,<br>612, 649                                                                        |
|                                    | Propane and<br>Hydrogen                | 56, 57, 58                                                                                                |
|                                    | Propene and<br>Hydrogen                | 56, 57, 58                                                                                                |
| Fugacity,<br>Activity              |                                        | 75, 370, 547, 605                                                                                         |
|                                    | Nitrogen                               | 75                                                                                                        |
|                                    | Propane                                | 64                                                                                                        |
| Adsorption,<br>Charcoal            |                                        | 32, 76, 183, 214, 215, 218,<br>278, 279, 327, 329, 332,<br>354, 377, 436, 471, 499,<br>511, 609, 645, 650 |

Phenomenon

Major Component

METHANE  
(continued)

| Category                               | Other Components | References         |
|----------------------------------------|------------------|--------------------|
| Adsorption,<br>Charcoal<br>(continued) | Nitrogen         | 12                 |
|                                        | Ethane           | 633                |
|                                        | Propane          | 633, 645           |
|                                        | n - Butane       | 633, 645           |
| Adsorption,<br>Silica Gel              |                  | 354, 480, 513, 614 |
|                                        | Nitrogen         | 666                |
|                                        | Carbon Monoxide  | 666                |
|                                        | Ethane           | 129                |
| Adsorption,<br>Other<br>Adsorbents     |                  | 233, 363, 563      |

Phenomenon

Major Component

ETHANE

| Category            | Other Components                           | References                     |
|---------------------|--------------------------------------------|--------------------------------|
| Phase<br>Equilibria | Hydrogen                                   | 352, 612, 663                  |
|                     | Hydrogen and<br>Nitrogen and<br>Methane    | 131, 132, 133                  |
|                     | Hydrogen and<br>Methane                    | 353                            |
|                     | Hydrogen and<br>Ethene                     | 567                            |
|                     | Hydrogen and<br>Hydrocarbons               | 56, 57, 58, 59                 |
|                     | Nitrogen                                   | 137, 176, 507                  |
|                     | Nitrogen and<br>Helium and<br>Hydrocarbons | 79, 80                         |
|                     | Oxygen                                     | 19, 137                        |
|                     | Carbon Dioxide                             | 117, 502, 529                  |
|                     | Methane                                    | 91, 251, 534, 535, 540,<br>612 |
|                     | Methane and<br>Hydrogen                    | 353                            |
|                     | Methane and<br>Hydrogen and<br>Nitrogen    | 131, 132, 133                  |

Phenomenon

Major Component

ETHANE  
(continued)

| Category                           | Other Components                            | References                                                           |
|------------------------------------|---------------------------------------------|----------------------------------------------------------------------|
| Phase Equilibria<br>(continued)    | Methane and<br>Hydrogen and<br>Hydrocarbons | 57, 58, 59                                                           |
|                                    | Methane and<br>Ethene                       | 246, 441                                                             |
|                                    | Ethene                                      | 253                                                                  |
|                                    | Ethene and<br>Acetylene                     | 397                                                                  |
|                                    | Acetylene                                   | 116                                                                  |
| Fugacity,<br>Activity              |                                             | 492                                                                  |
| Adsorption,<br>Charcoal            |                                             | 97, 183, 218, 278, 279,<br>332, 354, 436, 462, 471,<br>499, 643, 650 |
|                                    | Methane                                     | 633                                                                  |
| Adsorption,<br>Silica Gel          |                                             | 354, 643                                                             |
|                                    | Methane                                     | 129                                                                  |
|                                    | Propane                                     | 642                                                                  |
| Adsorption,<br>Other<br>Adsorbents |                                             | 522, 591                                                             |

## Phenomenon

## Major Component

## PROPANE

| Category             | Other Components                     | References                                           |
|----------------------|--------------------------------------|------------------------------------------------------|
| Phase Equilibria     | Hydrogen                             | 59, 96, 663                                          |
|                      | Hydrogen and Methane                 | 56, 57, 58, 59                                       |
|                      | Helium                               | 604                                                  |
|                      | Helium and Nitrogen and Hydrocarbons | 79, 80                                               |
|                      | Nitrogen                             | 635                                                  |
|                      | Nitrogen and Hydrocarbons            | 584                                                  |
|                      | Oxygen                               | 19                                                   |
|                      | Carbon Dioxide                       | 8, 144, 488, 506                                     |
|                      | Carbon Monoxide                      | 659                                                  |
|                      | Methane                              | 7, 251, 504, 544, 545, 612, 649                      |
|                      | Propene                              | 252, 505                                             |
| Fugacity, Activity   |                                      | 64                                                   |
| Adsorption, Charcoal |                                      | 62, 183, 218, 332, 354, 436, 462, 471, 499, 645, 650 |
|                      | Methane                              | 633, 645                                             |

Phenomenon

Major Component

PROPANE  
(continued)

| Category                               | Other Components | References |
|----------------------------------------|------------------|------------|
| Adsorption,<br>Charcoal<br>(continued) | Propene          | 357        |
|                                        | n - Butane       | 645        |
| Adsorption,<br>Silica Gel              |                  | 354, 515   |
|                                        | Ethane           | 642        |
|                                        | Ethene           | 355        |
|                                        | Propene          | 357        |
| Adsorption,<br>Other<br>Adsorbents     |                  | 591        |

3.0

Properties Index

## Properties

## Major Component

## HYDROGEN

| Category                     | Other Components               | References                                                                                                                                        |
|------------------------------|--------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| P-V-T<br>General             |                                | 235, 262, 291, 292, 656,<br>658, 669                                                                                                              |
|                              | Nitrogen                       | 34, 419, 608                                                                                                                                      |
|                              | Nitrogen and<br>Carbon Dioxide | 338                                                                                                                                               |
|                              | Carbon Dioxide                 | 338                                                                                                                                               |
| Compressibility<br>Isotherms |                                | 4, 6, 34, 35, 52, 85,<br>220, 247, 272, 273, 293,<br>384, 424, 445, 446, 448,<br>452, 456, 477, 560, 576,<br>577, 590, 601, 638, 661,<br>669, 680 |
|                              | Helium                         | 52, 220, 590                                                                                                                                      |
|                              | Nitrogen                       | 34, 35, 60, 209, 338,<br>340, 359, 380, 418, 638,<br>661                                                                                          |
|                              | Nitrogen and<br>Carbon Dioxide | 338, 380                                                                                                                                          |
|                              | Nitrogen and<br>Methane        | 74, 340                                                                                                                                           |
|                              | Carbon Dioxide                 | 338, 380, 636                                                                                                                                     |
|                              | Carbon Monoxide                | 560, 587, 601                                                                                                                                     |
|                              | Methane                        | 207, 340                                                                                                                                          |

## Properties

## Major Component

HYDROGEN  
(continued)

| Category                              | Other Components     | References                                                                        |
|---------------------------------------|----------------------|-----------------------------------------------------------------------------------|
| Compressibility Isotherms (continued) | Methane and Nitrogen | 74, 340                                                                           |
| Vapor Pressure                        |                      | 27, 105, 111, 122, 190, 211, 235, 239, 270, 427, 428, 561, 656, 669               |
| Critical Constants and Triple Point   |                      | 27, 61, 211, 242, 260, 262, 271, 306, 349, 476, 477, 478, 627, 655, 656, 669, 670 |
| Density, Molar Volume                 |                      | 30, 160, 387, 401, 456, 532, 552, 562, 669                                        |
|                                       | Nitrogen             | 75                                                                                |
| Compressibility Factor, Z             |                      | 212, 669, 675                                                                     |
|                                       | Nitrogen             | 34, 60, 543                                                                       |
| Equation of State, General            |                      | 51, 123, 213, 265, 333, 339, 438, 531, 613, 652, 669                              |
|                                       | Nitrogen             | 339, 380, 466                                                                     |
|                                       | Carbon Dioxide       | 339                                                                               |
|                                       | Carbon Monoxide      | 380                                                                               |
| Corresponding States                  |                      | 5, 370                                                                            |

## Properties

## Major Component

HYDROGEN  
(continued)

| Category                        | Other Components                | References                                        |
|---------------------------------|---------------------------------|---------------------------------------------------|
| Beattie-Bridgeman               |                                 | 43, 44, 156, 381, 585                             |
|                                 | Nitrogen                        | 46, 154, 169                                      |
|                                 | Nitrogen and<br>Carbon Monoxide | 169                                               |
|                                 | Carbon Monoxide                 | 46, 169                                           |
| Benedict-Webb-Rubin             |                                 | 17                                                |
| Virial<br>Coefficients          |                                 | 4, 305, 322, 379, 416,<br>417, 429, 444, 553, 619 |
|                                 | Helium                          | 295                                               |
|                                 | Nitrogen                        | 177, 295, 473, 515                                |
|                                 | Carbon Dioxide                  | 136, 177                                          |
|                                 | Carbon Monoxide                 | 295, 473, 515                                     |
|                                 | Methane                         | 177                                               |
| Lennard-Jones<br>6-9 Potential  |                                 | 148                                               |
|                                 | Helium                          | 590                                               |
| Lennard-Jones<br>6-12 Potential |                                 | 148                                               |

## Properties

## Major Component

## HELIUM

| Category                                   | Other Components | References                                                                              |
|--------------------------------------------|------------------|-----------------------------------------------------------------------------------------|
| P-V-T<br>General                           |                  | 16, 235, 306, 438                                                                       |
|                                            | Nitrogen         | 335                                                                                     |
| Compressibility<br>Isotherms               |                  | 6, 85, 92, 98, 115, 272,<br>273, 308, 311, 384, 387,<br>453, 454, 474, 477, 478,<br>660 |
|                                            | Hydrogen         | 52, 220, 590                                                                            |
|                                            | Carbon Dioxide   | 255                                                                                     |
| Vapor<br>Pressure                          |                  | 13, 14, 69, 119, 235, 242,<br>306, 389, 427, 583, 617                                   |
| Critical<br>Constants and<br>Triple Points |                  | 61, 262, 306, 389, 476,<br>477, 478, 623, 627                                           |
| Density,<br>Molar Volume                   |                  | 11, 77, 175, 234, 249,<br>264, 298, 548                                                 |
| Compressibility<br>Factor, Z               |                  | 79, 80, 583                                                                             |
|                                            | Carbon Dioxide   | 254                                                                                     |
| Equation of<br>State,<br>General           |                  | 134, 148, 262, 298, 328,<br>382, 439, 455, 479, 533,<br>555, 681                        |
| Corresponding<br>States                    |                  | 370                                                                                     |

## Properties

## Major Component

HELIUM  
(continued)

| Category                     | Other Components | References                                          |
|------------------------------|------------------|-----------------------------------------------------|
| Beattie-Bridgeman            |                  | 44, 381, 585                                        |
| Virial Coefficients          |                  | 4, 106, 240, 299, 309, 311, 313, 316, 323, 324, 379 |
|                              | Hydrogen         | 295                                                 |
|                              | Nitrogen         | 177, 336                                            |
|                              | Argon            | 295                                                 |
|                              | Carbon Dioxide   | 135, 177, 255, 474                                  |
| Lennard-Jones 6-9 Potential  |                  | 148, 299                                            |
|                              | Hydrogen         | 590                                                 |
|                              | Argon            | 590                                                 |
| Lennard-Jones 6-12 Potential |                  | 148                                                 |

## Properties

## Major Component

## NITROGEN

| Category                     | Other Components               | References                                               |
|------------------------------|--------------------------------|----------------------------------------------------------|
| P-V-T<br>General             |                                | 53, 235, 287, 349, 530                                   |
|                              | Hydrogen                       | 34, 419, 608                                             |
|                              | Hydrogen and<br>Carbon Dioxide | 338                                                      |
|                              | Helium                         | 335                                                      |
|                              | Methane                        | 72                                                       |
|                              | Ethane                         | 176                                                      |
| Compressibility<br>Isotherms |                                | 35, 37, 41, 85, 153, 157,<br>272, 394, 474, 638          |
|                              | Hydrogen                       | 34, 35, 60, 209, 338,<br>340, 359, 380, 418, 638,<br>661 |
|                              | Hydrogen and<br>Carbon Dioxide | 338, 380                                                 |
|                              | Hydrogen and<br>Methane        | 74, 340                                                  |
|                              | Carbon Dioxide                 | 250, 380                                                 |
|                              | Carbon Monoxide                | 597                                                      |
|                              | Methane                        | 318, 340                                                 |
|                              | Methane and<br>Hydrogen        | 74, 340                                                  |

## Properties

## Major Component

NITROGEN  
(continued)

| Category                             | Other Components                                            | References                                                                                                          |
|--------------------------------------|-------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| Vapor Pressure                       |                                                             | 24, 79, 84, 142, 163, 210, 219, 235, 242, 260, 261, 265, 276, 287, 307, 310, 427, 451, 484, 491, 520, 583, 657, 672 |
| Critical Constants and Triple Points |                                                             | 104, 261, 306, 348, 349, 457, 476, 478, 484, 657                                                                    |
| Density, Molar Volume                |                                                             | 75, 84, 160, 387, 532, 566, 667                                                                                     |
|                                      | Hydrogen                                                    | 75                                                                                                                  |
| Compressibility Factor, Z            |                                                             | 34, 79, 80, 125, 265, 370, 421, 438, 477, 484, 528, 583, 667                                                        |
|                                      | Hydrogen                                                    | 34, 60, 543                                                                                                         |
|                                      | Hydrogen and Carbon Dioxide and Carbon Monoxide and Methane | 543                                                                                                                 |
|                                      | Methane                                                     | 73, 587                                                                                                             |
|                                      | Ethane                                                      | 176                                                                                                                 |
|                                      | Ethene                                                      | 248                                                                                                                 |
|                                      | Propane                                                     | 647                                                                                                                 |

## Properties

## Major Component

NITROGEN  
(continued)

| Category                   | Other Components             | References                                                                          |
|----------------------------|------------------------------|-------------------------------------------------------------------------------------|
| Equation of State, General |                              | 265, 266, 321, 331, 383, 388, 421, 432, 433, 465, 467, 477, 480, 555, 582, 629, 667 |
|                            | Hydrogen                     | 339, 380, 466                                                                       |
|                            | Methane                      | 199, 318, 339, 628                                                                  |
| Corresponding States       |                              | 370, 443, 630                                                                       |
| Beattie-Bridgeman          |                              | 44, 153, 480, 585, 586                                                              |
|                            | Hydrogen                     | 46, 169, 154                                                                        |
|                            | Hydrogen and Carbon Monoxide | 169                                                                                 |
|                            | Carbon Monoxide              | 169                                                                                 |
|                            | Methane                      | 45, 46                                                                              |
| Benedict-Webb-Rubin        |                              | 17, 480, 581                                                                        |
|                            | Hydrogen                     | 17                                                                                  |
|                            | Carbon Monoxide              | 558                                                                                 |
| Virial Coefficients        |                              | 106, 304, 305, 379, 443, 474, 581, 654                                              |
|                            | Hydrogen                     | 177, 295, 473, 515                                                                  |

## Properties

## Major Component

NITROGEN  
(continued)

| Category                              | Other Components | References    |
|---------------------------------------|------------------|---------------|
| Virial<br>Coefficients<br>(continued) | Helium           | 177, 336      |
|                                       | Oxygen           | 295           |
|                                       | Carbon Dioxide   | 136, 177, 474 |
|                                       | Methane          | 177           |
| Lennard-Jones<br>6-9 Potential        |                  | 349           |
| Lennard-Jones<br>6-12 Potential       |                  | 221, 519, 592 |

## Properties

## Major Component

## CARBON DIOXIDE

| Category                                   | Other Components         | References                                                 |
|--------------------------------------------|--------------------------|------------------------------------------------------------|
| P-V-T<br>General                           |                          | 235, 414, 496                                              |
|                                            | Hydrogen                 | 338                                                        |
|                                            | Hydrogen and<br>Nitrogen | 338                                                        |
|                                            | Ethane                   | 502                                                        |
|                                            | Ethene and<br>Propane    | 564                                                        |
|                                            | n - Butane               | 450                                                        |
| Vapor<br>Pressure                          |                          | 82, 117, 188, 235, 409,<br>410, 434, 458, 484, 593,<br>676 |
| Critical<br>Constants and<br>Triple Points |                          | 102, 423, 484                                              |
| Compressibility<br>Isotherms               |                          | 39, 40, 107, 247, 258,<br>387, 411, 412, 448, 574          |
|                                            | Hydrogen                 | 338, 380, 636                                              |
|                                            | Hydrogen and<br>Nitrogen | 34, 35, 338, 359, 380,<br>638                              |
|                                            | Helium                   | 255                                                        |
|                                            | Nitrogen                 | 250, 338                                                   |

## Properties

## Major Component

CARBON DIOXIDE  
(continued)

| Category                              | Other Components                                      | References                             |
|---------------------------------------|-------------------------------------------------------|----------------------------------------|
| Compressibility Isotherms (continued) | Nitrogen and Hydrogen                                 | 34, 35, 338, 359, 380, 638             |
| Compressibility Factor, Z             |                                                       | 438, 484                               |
|                                       | Hydrogen and Nitrogen and Carbon Monoxide and Methane | 543                                    |
|                                       | Helium                                                | 254                                    |
|                                       | Methane                                               | 500                                    |
| Equation of State, General            |                                                       | 139, 266, 331, 383, 432, 582, 586, 634 |
|                                       | Hydrogen                                              | 380                                    |
| Corresponding States                  |                                                       | 125                                    |
|                                       | Ethene                                                | 110                                    |
| Beattie-Bridgeman                     |                                                       | 83, 281, 381, 585                      |
| Virial Coefficients                   |                                                       | 126, 136, 304, 371, 379, 553, 592      |
|                                       | Hydrogen                                              | 136, 177                               |
|                                       | Helium                                                | 135, 177, 255, 474                     |

## Properties

## Major Component

CARBON DIOXIDE  
(continued)

| Category                              | Other Components | References    |
|---------------------------------------|------------------|---------------|
| Virial<br>Coefficients<br>(continued) | Nitrogen         | 136, 177, 474 |
|                                       | Oxygen           | 136, 177      |
|                                       | Carbon Monoxide  | 136           |
|                                       | Ethene           | 177           |
| Lennard-Jones<br>6-12 Potential       |                  | 221, 519, 592 |

## Properties

## Major Component

## CARBON MONOXIDE

| Category                                   | Other Components                                              | References                                       |
|--------------------------------------------|---------------------------------------------------------------|--------------------------------------------------|
| P-V-T<br>General                           |                                                               | 182, 235, 530                                    |
| Vapor<br>Pressure                          |                                                               | 120, 143, 235, 241, 265,<br>389, 390, 422, 672   |
| Critical<br>Constants and<br>Triple Points |                                                               | 104, 143, 244, 389, 390,<br>478                  |
| Compressibility<br>Isotherms               |                                                               | 36, 37, 78, 223, 224,<br>258, 394, 476, 560, 574 |
|                                            | Hydrogen                                                      | 560, 587, 601                                    |
|                                            | Nitrogen                                                      | 597                                              |
| Density,<br>Molar Volume                   |                                                               | 104, 157, 160                                    |
|                                            | Methane                                                       | 103                                              |
| Compressibility<br>Factor, Z               |                                                               | 265, 438, 517, 528                               |
|                                            | Hydrogen and<br>Nitrogen and<br>Carbon Dioxide and<br>Methane | 543                                              |
| Equation of<br>State, General              |                                                               | 155, 265, 467, 549                               |
|                                            | Hydrogen                                                      | 339                                              |

## Properties

## Major Component

CARBON MONOXIDE  
(continued)

| Category                     | Other Components      | References         |
|------------------------------|-----------------------|--------------------|
| Corresponding States         |                       | 125, 189, 244, 370 |
| Beattie-Bridgeman            |                       | 381, 549           |
|                              | Hydrogen              | 46, 169            |
|                              | Hydrogen and Nitrogen | 169                |
|                              | Nitrogen              | 169                |
| Benedict-Webb-Rubin          |                       | 549, 558           |
|                              | Nitrogen              | 558                |
| Virial Coefficients          |                       | 391                |
|                              | Hydrogen              | 295, 473, 515      |
|                              | Carbon Dioxide        | 136                |
| Lennard-Jones 6-12 Potential |                       | 221                |

## Properties

## Major Component

## METHANE

| Category                                  | Other Components         | References                                                                                                                |
|-------------------------------------------|--------------------------|---------------------------------------------------------------------------------------------------------------------------|
| P-V-T<br>General                          |                          | 72, 87, 100, 165, 225,<br>232, 319, 342, 468                                                                              |
|                                           | Nitrogen                 | 72                                                                                                                        |
|                                           | Ethane                   | 280                                                                                                                       |
|                                           | Propane                  | 280                                                                                                                       |
|                                           | n - Butane               | 280, 503                                                                                                                  |
| Vapor<br>Pressure                         |                          | 26, 70, 79, 81, 121, 130,<br>178, 241, 259, 303, 317,<br>319, 344, 360, 484, 510,<br>573, 579, 583, 594, 602,<br>672, 679 |
| Critical<br>Constants and<br>Triple Point |                          | 42, 101, 103, 104, 141,<br>178, 225, 244, 317, 319,<br>425, 476, 477, 478, 481,<br>523, 524, 602, 623, 631                |
| Compressibility<br>Isotherms              |                          | 207, 413                                                                                                                  |
|                                           | Hydrogen                 | 207, 340                                                                                                                  |
|                                           | Hydrogen and<br>Nitrogen | 74, 340                                                                                                                   |
|                                           | Nitrogen                 | 318, 340                                                                                                                  |
|                                           | Ethane                   | 415                                                                                                                       |

## Properties

## Major Component

METHANE  
(continued)

| Category                      | Other Components                                                      | References                                     |
|-------------------------------|-----------------------------------------------------------------------|------------------------------------------------|
| Density,<br>Molar Volume      |                                                                       | 121, 263, 387, 393, 431,<br>532, 541, 554, 578 |
|                               | Carbon Monoxide                                                       | 103                                            |
| Compressibility<br>Factor, Z  |                                                                       | 15, 79, 80, 89, 438, 477,<br>484, 583          |
|                               | Hydrogen and<br>Nitrogen and<br>Carbon Dioxide and<br>Carbon Monoxide | 543                                            |
|                               | Nitrogen                                                              | 73, 587                                        |
|                               | Carbon Dioxide                                                        | 500                                            |
|                               | Ethane                                                                | 587                                            |
|                               | n - Butane                                                            | 587                                            |
| Equation of<br>State, General |                                                                       | 258, 331, 383, 432, 464,<br>467, 477           |
|                               | Nitrogen                                                              | 199, 318, 339, 628                             |
| Corresponding<br>States       |                                                                       | 225, 251, 285, 461, 586                        |
| Beattie-<br>Bridgeman         |                                                                       | 43, 44, 381, 519, 585                          |
|                               | Nitrogen                                                              | 45, 46                                         |
| Benedict-<br>Webb-Rubin       |                                                                       | 54, 55, 459, 560, 461,<br>482, 483, 581        |

## Properties

## Major Component

METHANE  
(continued)

| Category                        | Other Components | References         |
|---------------------------------|------------------|--------------------|
| Virial<br>Coefficients          |                  | 304, 485, 556, 587 |
|                                 | Hydrogen         | 177                |
|                                 | Nitrogen         | 177                |
| Lennard-Jones<br>6-12 Potential |                  | 221                |

## Properties

## Major Component

## ETHANE

| Category                                  | Other Components | References                                                              |
|-------------------------------------------|------------------|-------------------------------------------------------------------------|
| P-V-T<br>General                          |                  | 100, 232                                                                |
|                                           | Nitrogen         | 176                                                                     |
|                                           | Carbon Dioxide   | 502                                                                     |
|                                           | Methane          | 280                                                                     |
|                                           | Propene          | 378, 402, 494                                                           |
| Vapor<br>Pressure                         |                  | 79, 94, 95, 117, 130, 151,<br>178, 360, 364, 490, 583,<br>593, 594, 679 |
| Critical<br>Constants and<br>Triple Point |                  | 42, 50, 102, 524                                                        |
| Compressibility<br>Isotherms              |                  | 38, 47, 49, 146, 501                                                    |
|                                           | Methane          | 415                                                                     |
|                                           | Propene          | 378, 493, 494                                                           |
| Density,<br>Molar Volume                  |                  | 263, 578                                                                |
| Compressibility<br>Factor, Z              |                  | 79, 80, 333                                                             |
|                                           | Nitrogen         | 176                                                                     |
|                                           | Methane          | 587                                                                     |

## Properties

## Major Component

ETHANE  
(continued)

| Category                   | Other Components | References                            |
|----------------------------|------------------|---------------------------------------|
| Equation of State, General |                  | 47, 139, 162, 258, 331, 383, 549, 629 |
| Corresponding States       |                  | 18, 110, 125, 284, 461, 586           |
| Beattie-Bridgeman          |                  | 381, 549, 585                         |
| Benedict-Webb-Rubin        |                  | 54, 55, 459, 460, 461, 482, 549       |
| Virial Coefficients        |                  | 521                                   |

## Properties

## Major Component

## PROPANE

| Category                            | Other Components          | References                                    |
|-------------------------------------|---------------------------|-----------------------------------------------|
| P-V-T<br>General                    |                           | 232                                           |
|                                     | Carbon Dioxide and Ethane | 564                                           |
|                                     | Methane                   | 280                                           |
|                                     | Propene                   | 505                                           |
| Vapor Pressure                      |                           | 79, 93, 95, 151, 178, 191, 360, 593, 594, 679 |
| Critical Constants and Triple Point |                           | 138, 178, 343, 369, 523, 524                  |
| Compressibility Isotherms           | Propene                   | 358                                           |
| Density, Molar Volume               |                           | 263, 385, 578                                 |
| Compressibility Factor, Z           |                           | 79, 80, 191                                   |
|                                     | Nitrogen                  | 647                                           |
| Equation of State, General          |                           | 258, 331, 383                                 |
| Corresponding States                |                           | 18, 125, 284, 461                             |

## Properties

## Major Component

PROPANE  
(continued)

| Category                | Other Components | References            |
|-------------------------|------------------|-----------------------|
| Beattie-<br>Bridgeman   |                  | 48, 381, 585          |
| Benedict-<br>Webb-Rubin |                  | 54, 55, 459, 461, 482 |

4.0

## Bibliography of References

## BIBLIOGRAPHY

1. Abdulaev, Ya. A.; Phase Relations in Mixtures of Carbon Dioxide with Hydrogen, Nitrogen, and Carbon Monoxide  
J. Phys. Chem. (U.S.S.R.) 13, 986-8 (1939)
2. Abdulaev, Ya. A.; Investigating the Solubility of a Hydrogen-Nitrogen Mixture in Liquid Carbon Dioxide  
J. Applied Chem. (U.S.S.R.) 14, 302-4 (1941)
3. Abdulaev, Ya. A.; Equilibrium in the Liquid Carbon Dioxide System in the Presence of Technical Gases  
J. Chem. Ind. (U.S.S.R.) 16, no. 2, 37-40 (1939)
4. Agt, F. van, and Onnes, H. K.; The Compressibility of Hydrogen and Helium Between 90 and 14°K  
Communs. Kamerlingh Onnes Lab. Univ. Leiden 176b (1925)
5. Agt, F. van; The Behavior of Hydrogen Relative to the Law of Corresponding States  
Communs. Kamerlingh Onnes Lab. Univ. Leiden 176c (1925)
6. Agt, F. van, and Onnes, H. K.; Isotherms of Monatomic Substances and of Their Binary Mixtures XXI. The Compressibility of Hydrogen and Helium between 90 and 14°K  
Verslag. Akad. Wetenschappen Amsterdam 34, 625-37 (1925)
7. Akers, W. W., Burns, J. F., and Fairchild, W. R.; Low-Temperature Phase Equilibria. Methane-Propane System  
Ind. Eng. Chem. 46, 2531-34 (1954)
8. Akers, W. W., Kelley, R. E., and Lipscomb, T. G.; Low-Temperature Phase Equilibria. Carbon Dioxide-Propane System  
Ind. Eng. Chem. 46, 2535-6 (1954)
9. Akers, W. W., Attwell, L. L., and Robinson, J. A.; Volumetric and Phase Behavior of Nitrogen-Hydrocarbon Systems. Nitrogen-Butane System  
Ind. Eng. Chem. 46, 2539-40 (1954)
10. Akers, W. W., and Eubanks, L. S.; Vapor-Liquid Equilibrium in the System Hydrogen-Nitrogen-Carbon Monoxide  
Proc. Cryogenic Eng. Conf., 2nd, Boulder, Colo., 1957, 275-93

11. Akin, S. W.; The Thermodynamic Properties of Helium  
Trans. ASME 72, 751-57 (Dec. 1954)
12. Alekseev, V. N.; Separation of Mixtures of Gases by  
Adsorption  
J. Applied Chem. (U.S.S.R.) 12, 996-1005 (1939)
13. Ambler, E., and Hudson, R. P.; Examination of the Helium  
Vapor-Pressure Scale of Temperature Using a Magnetic  
Thermometer  
J. Research Nat. Bur. Standards 56, 99-104 (1956)
14. Ambler, E., and Hudson, R. P.; Examination of the 1955  
Helium Vapor-Pressure Scale of Temperature  
J. Research Nat. Bur. Standards 57, 23-25 (1956)
15. Anon.; Pacific Coast Gas Association; Gas Engineer's  
Handbook  
McGraw-Hill Book Co., Inc., New York (1934)
16. Anon.; Bibliography of Gas Properties  
Trans. ASME 894, 901 (1949)
17. Anon.; Hydrocarbon Research Inc., Final Report to the  
U.S.A.E.C., Low Temperature Heavy Water Plant, Contract  
No. AT(30-1)-810, NYO-889 (3-15-51)
18. Anon.; Engineering Data Book, NGSMA, 7th ed., Tulsa,  
Okla., (1957)
19. Anon.; Safety in Air and Ammonia Plants  
Chem. Eng. Prog. 55, no. 6, 54-64 (1959)
20. Antropoff, A. V.; Adsorption of Nitrogen by Charcoal at High  
Pressures  
Z. Elektrochem. 39, 616 (1933)
21. Antropoff, A. V., Steinberg, F., Kalthof, F., Schmitz, L.,  
and Schaeben, R.; The Adsorption of Argon and of Nitrogen  
on Active Charcoal from the Lowest to the Highest Pressures  
Z. Elektrochem. 42, 554-7 (1936)

22. Antropoff, A. V., Propfe, H. A., Weil, K., Kalthoff, F., Schmitz, L., and Cronenthal, G. R.; Investigations of Adsorption of Gases from Very Small to Very High Pressures. III. Adsorption Isotherms of the Noble Gases and of Nitrogen at Pressures Below Atmospheric  
Kolloid Z. 129, 1-10 (1952)
23. Armbruster, M. H., and Austin, J. E.; The Adsorption of Gases on Smooth Surfaces of Steel; Argon, Neon, Hydrogen, Nitrogen, Carbon Monoxide, and Carbon Dioxide.  
J. Am. Chem. Soc. 66, 159-71 (1944)
24. Armstrong, G. T.; Vapor Pressure of Nitrogen  
J. Research Nat. Bur. Standards 53, 263 (1954)
25. Armstrong, G. T., Goldstein, J. M., and Roberts, D. E.; Liquid-Vapor Phase Equilibrium in Solutions of Oxygen and Nitrogen at Pressures below one Atmosphere  
J. Research Nat. Bur. Standards 55, 265-77 (1955)
26. Armstrong, G. T., Brickwedde, F. G., and Scott, R. B.; Vapor Pressures of the Methanes  
J. Research Nat. Bur. Standards 55, 39 (1955)
27. Arnold, R. D., and Hoge, H. J.; A Test of the Ideal Solution Laws for Hydrogen, Hydrogen-Deuteride, and Deuterium. Vapor Pressures and Critical Constants of the Individual Components.  
J. Chem. Phys. 18, 1295 (1950)
28. Aroyan, H. J.; Vapor Liquid Equilibrium in the Hydrogen-n Butane system; 75 to - 200<sup>o</sup>F, and 300 to 8000 psia  
Ph.D. Thesis, University of Michigan, Ann Arbor, Mich.; Univ. Microfilms (1950)
29. Aroyan, H. J., and Katz, D. L.; Low Temperature Vapor Liquid Equilibrium in the Hydrogen-n Butane System  
Ind. Eng. Chem. 43, 188 (1951)
30. Augustin, H.; Density of Liquid Hydrogen, Index of Refraction and Dispersion of Liquid Hydrogen in Liquid Nitrogen  
Ann. Physik 46, 419 (1915)

31. Baly, R.; On the Distillation of Air, and the Composition of the Gaseous and Liquid Phases  
Phil. Mag. (V), 49, 517 (1900)
32. Barrer, R. M.; Interaction of Hydrogen with Micro-Crystalline Charcoal, II. Activated Sorption of Hydrogen and Methane by Carbon  
Proc. Roy. Soc. 149A, 231-269 (1935)
33. Barrer, R. M. and Robins, A. B.; Sorption of Mixtures, II. Equilibria Between Binary Gas Mixtures and Some Zeolites  
Trans. Farady Soc. 49, 929-39 (1953)
34. Bartlett, E. P.; Compressibility Isotherms of Hydrogen, Nitrogen, and Mixtures of These Gases at  $0^{\circ}$  and Pressures to 1000 Atmospheres  
J. Am. Chem. Soc. 49, 687-701 (1927)
35. Bartlett, E. P., Cupples, H. L., and Tremearne, T. H.; Compressibility Isotherms of Hydrogen, Nitrogen, and a 3:1 Mixture of These Gases at Temperatures Between  $0^{\circ}$  and  $400^{\circ}$  and at Pressures to 1000 Atmospheres  
J. Am. Chem. Soc. 50, 1275-88 (1928)
36. Bartlett, E. P., Hetherington, H. C., Kvalnes, H. M., and Tremearne, T. H.; Compressibility Isotherms of Carbon Monoxide at Temperatures from  $-70^{\circ}$  to  $200^{\circ}$  and at Pressures to 1000 Atmospheres  
J. Am. Chem. Soc. 52, 1374-82 (1930)
37. Batuecas, T., Schlatter, C. and Maverick, G.; Compressibility of Gases at  $0^{\circ}$  and Below One Atmosphere, and Their Divergence from Avagadro's Law, IV. Carbon Monoxide and Nitrogen  
J. Chim. Phys. 26, 548-555 (1929)
38. Batuecas, T.; Compressibility of Certain Gases at Low Pressures  
J. Chim. Phys. 31, 65-75 (1934)
39. Batuecas, T., and Malde, G. G.; Compressibility and Deviation from Boyle's Law of Carbon Dioxide at  $0^{\circ}$  to one Atmosphere  
Anales Real Soc. Espan. Fis. Quim. (Madrid) 49B, 405-10 (1953)

40. Batuecas, T. and Losa, C. G.; Compressibility and Deviation from Boyle's Law of Carbon Dioxide Gas at 0° Between 0 and one Atmosphere, II.  
Anales Real Soc. Espan. Fis. Quim. (Madrid) 50B, 845-50 (1954)
41. Baxter, G. P., and Starkweather, H. W.; The Density, Compressibility and Atomic Weight of Nitrogen  
Proc. Nat. Acad. Sci. 12, 703-7 (1926)
42. Beall, I. M.; Physical and Thermodynamic Properties of Methane and Ethane  
Refiner Nat. Gasoline Mfr. 14, No. 5, 232-4 (1935)
43. Beattie, J. A., and Bridgeman, O. C.; A New Equation of State for Fluids  
Proc. Am. Acad. Arts and Sci. 63, 229-308 (1928)
44. Beattie, J. A., and Bridgeman, O. C.; A New Equation of State for Fluids. II. Application to Helium, Neon, Hydrogen, Nitrogen, Oxygen, Air and Methane. III. The Normal Densities and Compressibilities of Several Gases at 0°C  
J. Am. Chem. Soc. 50, 3133-8 (1928)
45. Beattie, J. A.; An Equation of State for Gaseous Mixtures I. Application to Mixtures of Methane and Nitrogen  
J. Am. Chem. Soc. 51, 19-30 (1929)
46. Beattie, J. A., and Ikehara, S.; An Equation of State for Gas Mixtures II. A Study of the Methods of Combination of the Constants of the Beattie - Bridgeman Equation of State  
Proc. Am. Acad. Arts and Sci. 64, 127-76 (1930)
47. Beattie, J. A., Hadlock, C. and Poffenberger, N.; Compressibility of, and An Equation of State for, Gaseous Ethane  
J. Chem. Phys. 3, 93-6 (1935)
48. Beattie, J. A., Kay, W. C. and Kaminsky, J.; Compressibility of and Equation of State for Gaseous Propane  
J. Am. Chem. Soc. 59, 1589-90 (1937)

49. Beattie, J. A., Su, G. J. and Simard, G. L.; The Compressibility of Gaseous Ethane in the High Density Region  
J. Am. Chem. Soc. 61, 926-7 (1939)
50. Beattie, J. A., Su, G. J. and Simard, G. L.; The Critical Constants of Ethane  
J. Am. Chem. Soc. 61, 924-5 (1939)
51. Beenakker, J. J. and Varekamp, F. H.; Equation of State of Hydrogen and Isotopes Below 20° K  
Inst. Internat. du Froid, Annexe 1956-2, 189 (1956)
52. Beenakker, J. J. M., et al; The Isotherms of Hydrogen Isotopes and Their Mixtures with Helium at the Boiling-point of Nitrogen  
Physica 25, 9 (1959)
53. Benedict, M.; Pressure, Volume, Temperature Properties of Nitrogen at High Density. I. Results Obtained with a Weight Piezometer  
J. Am. Chem. Soc. 59, 2224-33 (1937)
54. Benedict, M., Webb, G. B. and Rubin, L. C.; An Empirical Equation for Thermodynamic Properties of Light Hydrocarbons and their Mixtures. I. Methane, Ethane, Propane, N-Butane  
J. Chem. Phys. 8, 334-45 (1940)
55. Benedict, M., Webb, G. B. and Rubin, L. C.; An Empirical Equation for Thermodynamic Properties of Light Hydrocarbons and their Mixtures. Constants for 12 Hydrocarbons  
Chem. Eng. Prog. 47, 419-22 (1951)
56. Benham, A. L.; Vapor Liquid Equilibria of Light Hydrocarbon Systems Containing Hydrogen at Low Temperatures  
Ph.D. Thesis, U. of Mich., 1956
57. Benham, A. L. and Katz, D. L.; Vapor - Liquid Equilibria for Hydrogen - Light Hydrocarbon Systems at Low Temperatures  
A.I.Ch.E. Journal 3, 33-6 (1957)

58. Benham, A. L.; Vapor - Liquid Equilibriums of Light Hydrocarbon Systems Containing Hydrogen at Low Temperatures  
Univ. Microfilms (Ann Arbor, Mich.) Publ. No. 21145, pp. 140
59. Benham, A. L., Katz, D. L. and Williams, R. B.; Phase Behavior of Hydrogen - Light Hydrocarbon Systems  
A. I. Ch. E. Journal 3, 236-41 (1957)
60. Bennett, C. O. and Dodge, B. F.; Compressibilities of Mixtures of Hydrogen and Nitrogen Above 1000 Atmospheres  
Ind. Eng. Chem. 44, 180-5 (1952)
61. Benson, S. W.; Critical Densities and Related Properties of Liquids (Related to Hydrogen, Helium, Neon and Ammonia  
J. Phys. and Colloid Chem. 52, 1060-74 (1948)
62. Berg, C., Fairfield, R. G., Imhoff, D. H. and Multer, H. J.; Hypersortion (Process for Separating Gases)  
Oil Gas J. 47, 95, 97, 130, 132, 135 (1949)
63. Bergeon R.; The Solubility of Solids and Liquids in Compressed Gases  
Genie Chim 79, 139-51 (1958)
64. Bergholm, A.; Vapor - Liquid Equilibria at High Pressure  
Svensk Kem. Tio 63, 233-49 (1951)
65. Bering, B. P., and Serpinskii, V. V.; Adsorption of Mixtures of Gases, II. Adsorption of Ethylene and Propylene on Active Carbon  
Izvest. Akad. Nauk. S.S.S.R., Otdel. Khim. Nauk. 997-1007 (1952)
66. Bering, B. P. and Serpinskii, V. V.; Simultaneous Adsorption of Ethylene and Propylene on Active Carbon  
Doklady Akad. Nauk S.S.S.R. 85, 1065-8 (1952)
67. Bering, B. P. and Serpinskii, V. V.; Adsorption of Mixtures of Gases I. Adsorption of Ethylene and Carbon Dioxide on Active Carbon  
Zhur. Fiz. Khim. 26, 253-69 (1952)

68. Bering, B. P. and Serpinski, V. V.; Adsorption of Mixtures of Gas. II. Adsorption of Ethylene and Propylene on Active Carbon  
Bull. Acad. Sci. U.S.S.R., Div. Chem. Sci. 877-84  
(English translation) (1952)
69. Berman, R. and Swenson, C. A.; Absolute Temperature Scale Between  $4.2^{\circ}$  and  $5.2^{\circ}$  K  
Phys. Rev. 95, 311-14 (1954)
70. Billig, K.; The Calculation of Boiling Points  
Ber. 70B, 157 (1937)
71. Bloomer, O. T. and Parent, J. D.; (Methane - Nitrogen Phase Equilibria)  
Inst. Gas Technol. Res. Bull. No. 17 (1952)
72. Bloomer, O. T. and Parent, J. D.; Liquid - Vapor Phase Behavior of the Methane - Nitrogen System  
Chem. Eng. Prog. Sympos. Ser. 49, No. 6, (1953)
73. Bloomer, O. T., Eakin, B. E., Ellington, R. T. and Gami, D. C.; Thermodynamic Properties of Methane - Nitrogen Mixtures  
Inst. Gas Technol., Res. Bull. No. 21, pp. 51 (1955)
74. Bolshakov, P. and Etherman, A.; The Compressibility of Hydrogen - Nitrogen - Methane Mixtures at High Pressure  
Acta Physicochim. U.R.S.S. 14, 365-70 (1941)
75. Bolshakov, P. E.; Partial Molal Volume, Fugacity, and Activity Coefficients of Nitrogen and Hydrogen in their Mixtures at High Pressure  
Acta Physicochim., U.R.S.S. 20, 259-67 (1945)
76. Bonnetain, L., Duval, X. and Letort, M.; Stepwise Adsorption Isotherms for Methane on Graphite and Various other Solid Adsorbents  
Compt. Rend 234, 1363-6 (1952)
77. Borelius, G.; Equations of State for Liquid Helium  
Arkiv. Fysik 13, 369-78 (1958)

78. Botella, S. G.; Compressibility of Carbon Monoxide at 0°, at Surrounding Temperatures and at Pressure Between 50 and 130 Atmospheres  
Anales Soc. Espan. Fis. Quim. 27, 315-50 (1929)
79. Brandt, L. W., Stroud, L. S. and Bruce, H. E.; An Experimental Study of the Phase Relationships, Dew Points, and Compressibility of Keyes Gas  
Open File Report No. 14, May 1, 1959, Bureau of Mines Helium Activity
80. Brandt, L. W. and Stroud, L.; Thermodynamic Diagrams of Helium Containing Gaseous Systems. I T - H Diagram for Cliffside Gas  
Open File Report No. 8, May 1, 1959, Proj 17A; Bureau of Mines Helium Activity
81. Bratu, E. M.; A General Equation for Calculating the Pressure of Saturated Vapors  
Bull. Inst. Nat'l Cercetari Technol. 2, 36 (1947)
82. Bridgeman, O. C.; A Fixed Point for Calibration of Pressure Gauges. The vapor pressure of carbon dioxide at 0°C  
Chem. Soc. 49, 1174 (1927)
83. Bridgeman, O. C.; Equation of State for Gaseous Carbon Dioxide  
J. Am. Chem. Soc., 49, 1130-1138 (1927)
84. Bridgman, P. W.; Melting Curves and Compressibilities of Nitrogen and Argon  
Proc. Am. Acad. Arts and Sci., 70, 1-32 (1935)
85. Bridgman, P. W.; Compressibility of Five Gases to High Pressures  
Proc. Am. Acad. Arts and Sci., 59, No. 8, 173-211 (1924)
86. Briggs, H. and Cooper, W.; The Adsorption of Gas under Pressure  
Proc. Roy. Soc. Edinburgh 41, 119-27 (1920 - 21)
87. Broon, J.; Methane, Properties, Constants, and Uses  
Chemiker Ztg. 46, 926-7 (1922)

88. Brown, G. M. and Stutzman, L. F.; Low-Temperature Vapor - Liquid Equilibria. II. Equilibrium Constants for Nitrogen, Methane and Ethane at Low Temperatures  
Chem. Eng. Prog. 45, 142-8 (1949)
89. Brown, G. G.; (title not known)  
Proc. Nat. Gas Assoc. (May, 1940)
90. Brunauer, S. and Emmett, P. H.; The Use of Low Temperature van der Waals Adsorption Isotherms in Determining the Surface Areas of Various Adsorbents  
J. Am. Chem. Soc. 59, 2682 (1937)
91. Budenholzer, R. A., Sage, B. H. and Lacey, W. N.; Phase Equilibria in Hydrocarbon Systems  
Ind. Eng. Chem. 31, 1288 (1939)
92. Burnett, E. S.; Compressibility Determinations without Volume Measurements  
Journal of Applied Mechanics, 3, 136-140 (1936)
93. Burrell, G. A. and Robertson, I. W.; Vapor Pressures of Propane, Propylene and N-Butane at Low Temperatures  
J. Am. Chem. Soc., 37, 2188-93 (1915)
94. Burrell, G. A. and Robertson, I. W.; Vapor Pressures of Ethane and Ethylene at Temperatures Below their Normal Boiling Point  
J. Am. Chem. Soc. 37, 1893-902 (1915)
95. Burrell, G. A. and Robertson, I. W.; Vapor Pressures of Various Compounds at Low Temperatures  
Bur. Mines, Tech. Papers 142, pp. 30 (1916)
96. Burriss, W. L., Hsu, N. T., Reamer, H. H. and Sage, B. H.; Phase Behavior of the Hydrogen - Propane System  
Ind. Eng. Chem. 45, 210-13 (1953)
97. Burshtein, R., Levin, P. and Petrov, S.; Activated Adsorption of Gases on Charcoal  
Physik. Z. Sowjetunion 4, 197-211 (1933)

98. Burt, F. P.; Compressibilities of Helium and Neon  
Trans. Faraday Soc. 6, 19-26 (1910)
99. Burwell, R. L., Jr., Smudski, P. A. and May T. P.;  
Ethylene Adsorption Isotherms at  $-183^{\circ}$   
J. Am. Chem. Soc. 69, 1525-9 (1947)
100. Canjar, L.J.; P-V-T and Related Properties for Methane  
Ethane. Pressure - Volume - Temperature and Related  
Properties for Methane and Ethane  
Chem. and Eng. Data Ser. 3, 185-92 (1958)
101. Cardoso, E.; The Critical Constants of Methane  
Arch. Sci. Phys. et Nat. 36, 97-100 (1913)
102. Cardoso, E.; Critical Point  
J. Chim. Phys. 10, 470-96 (1913)
103. Cardoso, E.; Densities of the Coexisting Phases of Methane  
and Carbon Monoxide  
Arch. Sci. Phys. Nat. 39, 403-4 (1915)
104. Cardoso, E.; Critical Points of Nitrogen, Oxygen, Carbon  
Monoxide, and Methane  
J. Chim. Phys. 13, 312-50 (1916)
105. Cath, P. G. and Onnes, H. K.; The Measurement of Low  
Temperatures XXVII. Vapor Pressure of Hydrogen in the  
Neighborhood of the Boiling Point and Between the Boiling  
Point and the Critical Point  
Commun. Kamerlingh Onnes Lab. Univ. Leiden 152a (1917)
106. Cath, P. G. and Onnes, H. K.; Measurement of Very Low  
Temperature XXX. Comparison of the Helium, Argon, Neon,  
Oxygen and Nitrogen Thermometers with Hydrogen Thermo-  
meter Corrections which will Reduce the Indications of These  
Thermometers to the International Scale of Kelvin. The  
Second Coefficient of the Virial for Helium, Argon, Neon,  
Oxygen and Nitrogen Below  $0^{\circ}$   
Arch. Neerl. Sci. 6, 1-30 (1922)
107. Cawood, W. and Patterson, H. S.; Compressibilities of  
Certain Gases at Low Pressures and Various Temperatures  
J.C.S. 619-624 (1933)

108. Chang, Ta-Yu and Tsang, J. -L.; Adsorption of Carbon Dioxide, Methanol, and Nitrogen on Various Silica Gels  
K'o Hsueh T'ung Pao 239-40 (1957)
109. Chaplin, R.; Adsorption of Nitrogen at Low Pressure by Activated Charcoal  
Phil. Mag. (7) 2, 1198-207 (1926)
110. Charnley, A., Cook, D., Ewald, A. H. and Rowlinson, J. S.; Equilibrium of Phases in Solution  
Compt. Rend. Reunion Ann. Auec Comm Thermodynam., Union Intern. Phys. (Paris) 1952, Changements de Phases 111-14
111. Chester, F. P. and Dugbale, J. S.; Melting Curves of Deuterium and Hydrogen  
Phys. Rev. 95, 278-9 (July 1954)
112. Churchill, S. W., Collamore, W. G. and Katz, D. L.; Phase Behavior of the Acetylene - Ethylene System  
Oil Gas J. 41, No. 13, 33-4, 36-7, (1942)
113. Cines, M. R., Roach, J. T., Hogan, R. J. and Roland, C.H.; (Methane - Nitrogen Phase Equilibria)  
Program, A.I.Ch.E., Atlantic City, N. J. (Dec. 24, 1951)
114. Cines, M. R., Roach, J. T., Hogan, R. J. and Roland, C. H.; Nitrogen - Methane Vapor Liquid Equilibria  
Chem. Eng. Prog. Symp. Ser. 49, No. 6, Phase Equilibria
115. Claitor, L. C. and Crawford, D. B.; Thermodynamic Properties of Oxygen Nitrogen, and Air at Low Temperatures  
Trans. ASME 71, 885-95 (1949)
116. Clark, A. M. and Din, F.; Equilibria Between Solid, Liquid, and Gaseous Phases at Low Temperatures Binary Systems  
Acetylene - Carbon Dioxide, Acetylene - Ethylene, and Acetylene - Ethane  
Trans. Faraday Soc. 46, 901-11 (1950)

117. Clark, A. M. and Din, F.; Equilibria Between Solid, Liquid, and Gaseous Phases at Low Temperatures. The System Carbon Dioxide Plus Ethane Plus Ethylene  
Discussions Faraday Soc. No. 15, 202-7 (1953)
118. Claude, G.; Adsorption of Gases by Charcoal at Low Temperatures  
Compt. rend. 158, 861-864 (1914)
119. Clement, J. R., Logan, J. K. and Gaffney, J.; Liquid Helium Vapor Pressure Equation  
Phys. Rev. 100, 743-4 (1955)
120. Clusius, K. and Teske, W.; Vapor Pressures and Vapor - Pressure Constant of Carbon Monoxide  
Z. Physikal Chem., B.6, 135-151 (1929)
121. Clusius, K. and Weigand, K.; Melting Curves of the Gases A, Kr, Xe, CH<sub>4</sub>, CH<sub>4</sub>D, CD<sub>4</sub>, C<sub>2</sub>H<sub>4</sub>, C<sub>2</sub>H<sub>6</sub>, COS, and NH<sub>3</sub> to 200 Atmospheres Pressure  
Z. Physik. Chem. B46, 1-37 (1940)
122. Cohen, K. and Urey, H. C.; Van der Waal's Forces and the Vapor Pressures of Ortho and Para Hydrogen and Ortho and Para Deuterium  
J. Chem. Phys. 7, 157 (1939)
123. Cohen, E. G. D., et al; The Transport Properties and Equation of State of Gaseous Para - and Ortho - Hydrogen and their Mixtures Below 40°K  
Physica 21, 737 (1955)
124. Cook, D. and Longvet - Higgins, H. C.; Application of the Theory of Conformed Solutions to the System Carbon Dioxide-Ethylene  
Proc. Roy. Soc. A209, 28 (1951)
125. Cook, D. and Rowlinson, J. S.; Deviations from the Principle of Corresponding States  
Proc. Roy. Soc. (London) A219, 405-18 (1953)
126. Cook, D.; 2nd Virial Coefficient of Carbon Dioxide at Low Temperatures  
Can. J. Chem. 35, 268-75 (1957)

127. Cook, J. W.; Purification of Helium  
Phys. Rev. (ii), 29, 920 (1927)
128. Cook, M. W. and Hanson, D. N.; Accurate Measurement of  
Gas Solubility  
Rev. Sci. Instr. 28, 370-4 (1957)
129. Coppens, L.; The Separation at Low Temperature of Mixtures  
of Ethane and Methane  
Bull. Soc. Chim. Belg. 41, 525-8 (1932)
130. Copson, R. L. and Frolich, P. K.; Vapor - Pressure Chart  
for Lower Aliphatic Hydrocarbons  
Ind. Eng. Chem. 21, 1116-7 (1929)
131. Cosway, H. F.; Low Temperature Vapor - Liquid Equilibria  
in Ternary and Quaternary Systems Containing Hydrogen,  
Nitrogen, Methane and Ethane  
Ph.D. Thesis, U. of Mich. (1957)
132. Cosway, H. F.; Low - Temperature Vapor - Liquid  
Equilibriums in Ternary and Quaternary Systems Containing  
Hydrogen, Nitrogen, Methane and Ethane  
Univ. Microfilms (Ann Arbor, Mich.) L.C. Card No.  
Mic 58-7704, pp. 179; Disertation Abstr. 19, 1314 (1958)
133. Cosway, H. F. and Katz, D. L.; Low Temperature Vapor -  
Liquid Equilibria in Ternary and Quaternary Systems  
Containing Hydrogen, Nitrogen, Methane and Ethane  
A.I.Ch.E. Journal 5, 46 (1959)
134. Cottrell, T. L.; Equations of State, Physical Properties, and  
Thermodynamic Transformation of Intermolecular Repulsive  
Forces  
Discussions Faraday Soc. 22, 10-16 (1956)
135. Cottrell, T. L. and Hamilton, R. A.; 2nd Virial Coefficient  
of Gases and Mixtures I. Carbon Dioxide and Helium Mixtures  
Trans. Faraday Soc. 52, 156-60 (1956)

136. Cottrell, T. L., Hamilton, R. A. and Taubinger, R. P.;  
2nd Virial Coefficients of Gases and Mixtures II. Mixtures  
of Carbon Dioxide with Nitrogen, Oxygen, Carbon Monoxide,  
Argon and Hydrogen  
Trans. Faraday Soc. 52, 1310-12 (1956)
137. Cox, A. L. and DeVries, T.; The Solubility of Solid Ethane,  
Ethylene and Propylene in Liquid Nitrogen and Oxygen  
J. Phys. and Colloid Chem. 54, 665-70 (1950)
138. Cox, E. R.; The Physical Constants of Propane  
Petroleum World 31, No. 12, 44-5, 56 (1934)
139. Cramer, F.; An Empirical Equation of State for Extremely  
High Pressures II.  
Chem. Tech. (Berlin) 6, 590-5 (1954)
140. Cremer, E. and Prior, F.; Application of Chromatographic  
Methods to the Separation of Gases and Determination of  
Adsorption Energies  
Z. Elektrochem. 55, 66-70 (1951)
141. Crommelin, C. A.; Triple Point of Methane  
J. Chem. Soc. 104, II, 20 (1913);  
Proc. Akad. Wetenschap. Amsterdam 15, 666 (1912)
142. Crommelin, C. A.; Vapor Pressure of Nitrogen Between  
Critical Point and Boiling Point  
Verslag K. Akad. Wetenschappen 23, 991-4 (1914)
143. Crommelin, C., Bijleveld, W. J. and Brown, E. G.;  
Vapour Tensions, Critical Point, and Triple Point of Carbon  
Monoxide  
Proc. K. Akad. Wetensch. Amsterdam, 34, 1314-1317 (1931)
144. Cullen, E. J. and Kobe, K. A.; Benedict Equation of State:  
Application to Vapor - Liquid Equilibria  
A.I.Ch.E. Journal 1, 452-5 (1955)
145. Damkohler, G.; Adsorption of Mixtures of Nitrogen and Argon  
Z. Physikal. Chem., B 23, 69-88, (1933)

146. Danneel, H. and Stoltzenberg, H.; The Compressibility of Ethylene  
Z. Angew. Chem. 42, 1121-3 (1929)
147. Dean, M. R. and Tooke, J. W.; Vapor Liquid Equilibria in Three Hydrogen - Paraffin Systems  
Ind. Eng. Chem. 38, 389-93 (1946)
148. DeBoer, J.; Equation of State of Gases at Low Temperature  
Physica 24, 590-597 (1958)
149. Deitz, V. R. and Gleysteen, L. F.; Determination of Carbon and Hydrogen in Bone Black and Chars  
J. Research Natl. Bur. Stds. 28, 795 (1942)
150. Deitz, V. R. and Gleysteen, L. F.; Surface Available to Nitrogen on Bone Black and Other Carbonaceous Adsorbents  
J. Research Natl. Bur. Stds., 29, 191 (1942)
151. Delaplace, R.; Vapor Pressure of Gaseous Hydrocarbons at Low Temperatures  
Compt. Rend. 204, 493-5 (1937)
152. Deming, W. E. and Deming, L. S.; Some Physical Properties of Compressed Gases. VI. The Fugacity of Carbon Dioxide  
Phys. Rev. 56, 108-12 (1939)
153. Deming, W. E. and Shupe, L. E.; Constants of the Beattie - Bridgeman Equation of State with Bartlett's P-V-T Data on Nitrogen  
J. Am. Chem. Soc., 52, 1382-1389 (1930)
154. Deming, W. E. and Shupe, L. E.; The Beattie - Bridgeman Equation of State and Bartlett's P-V-T Data on a 3:1 Hydrogen-Nitrogen Mixture  
J. Am. Chem. Soc. 53, 860-9 (1931)
155. Deming, W. E. and Shupe, L. E.; Physical Properties of Compressed Gases. II. Carbon Monoxide  
Physical Rev. (ii), 38, 2245-2264; (1931)

156. Deming, W. E. and Shupe, L. E.; Constants of the Beattie-Bridgeman Equation of State with Bartlett's P-V-T Data on Hydrogen  
J. Am. Chem. Soc., 53, 843-49 (1931)
157. Deming, W. E. and Shupe, L. E.; Some Physical Properties of Compressed Gases III. Hydrogen, also Nitrogen and Carbon Monoxide  
Phys. Rev. 40, 848-59 (1932)
158. DeSorbo, W., Milton, R. M. and Andrews, D. H.; New Cryogenic Methods of Using Liquid Hydrogen  
Chem. Rev. 39, 403-17 (1946)
159. Dewar, J.; The Adsorption and Thermal Evolution of Gases Occuluded in Charcoal at Low Temperatures. Adsorption of Hydrogen, Nitrogen, Oxygen, Argon, Helium, Electrolytic Gas, Carbonic Oxide and Oxygen, Carbonic Oxide, at 0° K and -185° C by Charcoal  
Proc. Roy. Soc. (London A74,) 122-127 (1904)
160. Dewar, J.; The Densities of Solid Oxygen, Nitrogen, Hydrogen, Argon, Carbon Monoxide, etc.  
Proc. Roy. Soc. A73, 251 (1904)
161. Dewar, James; Studies on Charcoal and Liquid Air  
Chem. News 97, 4-8, 16-19 (1908)
162. DiCio, A.; Application of the Paoluzi Equation to Ethane Idrocarburi 5, No. 11, 17-18 (1956)
163. Din, F., Goldman, K. and Monroe, A. G.; Solid-Liquid Equilibriums of the Systems Argon - Nitrogen and Argon - Oxygen  
Congr. Intern. Froid, 9<sup>e</sup>, Paris, 1955, Compt. Rend. Trav. Comm. I et II, 1003-10
164. Dingenen, W. van and Itterbeek A. van; Measurements of the Adsorption of Light and Heavy Hydrogen on Charcoal Between 90 and 17° K  
Physica 6, 49-58 (1939)

165. Dinglinger, G.; Determination of Specific Volumes of Carbon Dioxide, Propane and Methane  
Chem. - Ztg. 80, 135-8 (1956)
166. Dodge, B. F.; Isotherms and Isobars for Air\*Separation Studies  
Chem. Metall. Engng. 35, No. 10 622 (1928)
167. Dodge, B. F. and Davis, H. W.; Vapor Pressure of Liquid Oxygen and Nitrogen  
J. Am. Chem. Soc. 49, 610-20 (1927)
168. Dodge, B. F. and Dunbar, A.; Investigation of the Co-existing Liquid and Vapor Phases of Solutions of Oxygen and Nitrogen  
J. Am. Chem. Soc. 49, 591 (1927)
169. Dokoupil, Z., Soest, G. van and Swenker, M.D.P.; The Equilibrium Between the Solid Phase and the Gas Phase of the Systems Hydrogen - Nitrogen, Hydrogen - Carbon Monoxide, and Hydrogen - Nitrogen - Carbon Monoxide  
Appl. Sci. Research A5, 182-241 (1955)
170. Donnelly, H. G.; Two - Phase and Three - Phase Equilibria in the System Carbon Dioxide - Methane  
Univ. Microfilms (Ann Arbor, Mich.) Pub. No. 3741, pp. 290  
Dissertation Abstrs. 12, 461 (1952)
171. Donnelly, H. G.; Phase Equilibria in the Carbon Dioxide - Methane System  
Ind. Eng. Chem. 46, 511-17 (1954)
172. Dreving, V. P., Kiselev, A. V. and Likhacheva, O. A.; Adsorption of Nitrogen Vapor on Silica Gel at Low Temperatures  
Zhurnal Fizicheskoi Khimii 25, (6): 710-18, (1951)
173. Dreving, V. P., Kiselev, A. V. and Likhacheva, O. A.; The Absolute Isotherms for the Adsorption of Nitrogen Vapor on Silica Gel, Alumino - Silica Gel, and Barium Sulfate  
Doklady, Akad. Nauk U.S.S.R. 82, 277-80 (1952)
174. Dubinin, M. M. and Zaverina, E. D.; Adsorption of Gases by Active Carbons  
Doklady Akad. Nauk U.S.S.R. 72, 319-22 (1950)

175. Dugdale, J. S. and Simon, F. E.; Thermodynamic Properties of Melting and Solid Helium  
Proc. Roy. Soc. (London) A218, 291-310 (1953)
176. Eakin, B. E., Ellington, R. T. and Gami, D. C.; Physical-Chemical Properties of Ethane - Nitrogen Mixtures  
Inst. Gas Technol. Research Bull. 26, pp. 40 (1955)
177. Edwards, A. E. and Roseveare, W. E.; The Second Virial Coefficient of Gaseous Mixtures  
J. Am. Chem. Soc. 64, 2816-19 (1942)
178. Egloff, G.; Physical Constants of Hydrocarbons, 7-10, 16-19  
Reinhold Publishing Corp., N. Y. (1953)
179. Egorow, M. M., Egorova, T. S., Krasil'nikov, K. G. and Kiselev, V. F.; Effects of the Nature of Silica Gel or Quartz Surface on Their Adsorption Properties II. Water, Methane and Nitrogen Adsorption by Silica Gel in Different Hydration Stages  
Zhur. Fiz. Khim. 32, 2624-33 (1958)
180. Ehrlich, G., Hicmott, T. W. and Hudda, F. G.; The Low-Temperature Chemisorption of Nitrogen and Carbon Monoxide  
J. Chem. Phys. 28, 506-7 (1958)
181. Ermolin, M. G.; Method of Quantitative Separation of Helium-Neon Mixture  
Trudy Radievogo Inst. Im. V. G. Khlopina 6, 119-38 (1957)
182. Estreicher T. and Bobotek, J.; The Behavior of Carbon Monoxide at Low Temperatures  
Bull. Intern. Acad. Sci. Cracovie 1913, A, 451-62
183. Etherington, L. D., Haney, R. E. D., Herbst, W. A. and Scheeline, H. W.; Adsorption Phase Equilibrium Correlations. Light-Hydrocarbon Vapors on Activated Charcoal  
A.I.Ch.E. Journal 2, 65-70 (1956)
184. Eubanks, L. S.; Vapor-Liquid Equilibrium in the System Hydrogen - Nitrogen - Carbon Monoxide  
Ph. D. Thesis, Rice Inst., (1956)

185. Evans, R. B., III and Watson, G. M.; Compressibility Factors of n-Butane Mixtures in the Gas Phase  
Chem. and Eng. Data Ser. 1, No. 1, 67-71 (1956)
186. Ewald, A. H.; Solubility of Solids in Gases. III. Solubility of Solid Xenon and Solid Carbon Dioxide  
Trans. Faraday Soc. 51, 347-56 (1955)
187. Ewell, R. H., Harrison, J. M. and Berg, L.; Azeotropic Distillation  
Ind. Eng. Chem. 36, No. 10, 871 (1944)
188. Falck, E.; Theoretical Determination of the Vapor Pressure of Liquid and Solid Carbon Dioxide  
Physik Z., 9, 433-7 (1908)
189. Fales, H. A. and Shapiro, C. S.; Thermodynamic Properties of Substances III Vapor Volumes as Functions of Reduced Temperature Alone  
J. Am. Chem. Soc. 62, 393-406 (1940)
190. Farjas, Adalbert, Orthohydrogen, Parahydrogen and Heavy Hydrogen, (Cambridge University Press, 1935)
191. Farrington, F. S. and Sage, B. H.; Volumetric Behavior of Propene  
Ind. Eng. Chem. 41, 1734-7 (1949)
192. Fastovski, V. G. and Girskaia, L. A.; Adsorption of Neon and Helium  
J. Chem. Ind. Russ. 14, 358-361 (1937)
193. Fastovski, V. G. and Gonikberg, M. G.; Solubility of Gases in Liquids at Low Temperature and High Pressure III. Solubility of Hydrogen in Liquid Methane  
Acta Physicochim. (U.S.S.R.) 12, 488 (1940)
194. Fastovski, V. G. and Gonikberg, M. G.; Solubility of Gases in Liquids at Low Temperatures and High Pressure  
J. Phys. Chem. Russ. 14, 427-28 (1940)
195. Fastovski, V. G. and Krestinskii, YU. A.; Solubility of Solid Methane in Liquid Nitrogen and Oxygen  
J. Phys. Chem. (U.S.S.R.) 15, 525-31 (1941)

196. Fastovski, V. G., Petrovskii, Yu. V. and Lenin, V. I.; Investigation of the Argon - Nitrogen Liquid - and Vapor - Phase Equilibrium. II.  
Zhur. Fiz. Khim. 30, 76-8 (1956)
197. Fastovski, V. G. and Petrovskii, Yu. V.; Liquid and Vapor Equilibriums in the Nitrogen - Methane System  
Zhur. Fiz. Khim. 31, 2317-20 (1957)
198. Fedoritenko, A. and Ruhemann, M.; Equilibrium Diagram of Helium - Nitrogen Mixtures  
Tech. Phys. (U.S.S.R.) 4, 36-43 (1937)
199. Fedorova, M. F.; Binary Mixtures of Substances Melting at Low Temperatures  
J. Exptl. Theoret. Phys. (U.S.S.R.) 8, 425-35 (1938)
200. Fedorova, M. F.; Solubility of Acetylene and Carbon Dioxide in Liquid Nitrogen and Liquid Oxygen  
J. Phys. Chem. (U.S.S.R.) 14, 422-6 (1940)
201. Fejes, P. and Schay, G.; Adsorption and Desorption of Nitrogen on Charcoal  
Acta Chim. Acad. Sci. Hung. 14, 439-52 (1958)
202. Firth, J. B.; Sorption of Hydrogen by Palladium at Low Temperatures  
J. Chem. Soc. 117, 171-83 (1920)
203. Fischer, V.; The Analysis of a Mixture of Carbon Monoxide, Nitrogen and Hydrogen  
Tech. Mech. Thermodynamik 1, 268-76 (1930)
204. Fischer, V.; Equilibrium Isotherms and Isobars of Carbon Monoxide - Nitrogen - Hydrogen Mixtures  
Ann. Physik 31, 531-9 (1938)
205. Fischer, V.; Thermodynamics of the Nitrogen - Hydrogen Mixtures  
Ann. Physik, (v), 39, 273-280 (1941)
206. Frederikse, H.P.R. and Gorter, C. J.; Investigations on the Adsorption of Helium at Very Low Temperatures  
Physica 16, 402-18 (1950)

207. Freeth, F. A. and Verschoyle, T. T. H.; Physical Constants of the Methane - Hydrogen System  
Proc. Roy. Soc. (London) A130, 453-63 (1931)
208. Freundlich, H.; Adsorption and Occlusion  
Z. Physik. Chem. 61, 249, (1908)
209. Friedman, A. S.; PVT Relationships of Gaseous, Hydrogen, Nitrogen and Hydrogen - Nitrogen Mixtures  
Ph.D. Thesis, Ohio St. Univ. (1950)
210. Friedman, A. S. and White, D.; The Vapor Pressure of Liquid Nitrogen  
J. Am. Chem. Soc. 72, 3931-32 (1950)
211. Friedman, A. S., White, D. and Johnston, H. L.; Critical Constants, Boiling Points, Triple Point Constants and Vapor Pressure of the Six Isotropic Hydrogen Molecules Based on a Simple Mass Relationship  
J. Chem. Phys. 19, 126-7 (1951)
212. Friedman, A. S.; The Thermodynamic and Transport Properties of Liquid Hydrogen and Its Isotopes. Part II. Compressibility Factors, Viscosity, Dielectric Constant and Surface Tension  
NBS Report 3282, May 1, 1954
213. Friedman, A. S. and Oppenheim, I.; Equation of State of Hydrogen Isotopes at Intermediate Densities  
Phys. Rev. 98, 258 (1955)
214. Frolich, P. K. and White, A.; Adsorption of Methane and Hydrogen on Charcoal at High Pressure  
Ind. Eng. Chem. 22, 1058-60 (1930)
215. Ganguli, A.; The Adsorption of Gases by Solids  
J. Phys. Chem. 34, 665-8 (1930)
216. Garner, W. E. and Maggs, J.; Adsorption of Carbon Monoxide on Zinc Oxide  
Trans. Faraday Soc. 32, 1744-8 (1936)

217. Geddes, A. E. M.; Adsorption of Carbon Dioxide by Charcoal  
Ann. Physik, 29, 797-808 (1909)
218. Georgiev, Ts.O.; Adsorption of Hydrocarbon Gases on Active Charcoal  
Trudy Moskov. Khim. Tekhnol. Inst. Im. D. I. Mendeleeva 25, 170-7 (1957)
219. Gerold, E.; Density, Refractive Index and Dispersion of Gaseous Nitrogen at its Boiling Point  
Ann. Physik 65, 82-96 (1921)
220. Gibby, C. W., Tanner, C. C. and Masson, I.; The Pressure of Gaseous Mixtures II. Helium and Hydrogen and Their Intermolecular Forces  
Proc. Roy. Soc. (London) A122, 283-304 (1929)
221. Gibert, R. and Dognin, A.; The Calculation of the Force Constants of Lennard - Jones Potentials  
Compt. Rend. 246, 2607-9 (1958)
222. Gleysteen and Deitz; Hysteresis in the Physical Adsorption of Nitrogen on Bone Char and Other Adsorbents  
J. Research Nat. Bur. Standards 35, 285 (1945)
223. Goig, S.; The Compressibility of Carbon Monoxide at  $0^{\circ}$  and Above 50 Atmospheres  
Compt. Rend. 189, 246-8 (1929)
224. Goig, S.; Compressibility of Carbon Monoxide at  $0^{\circ}$  and Ordinary Temperature Between 50 and 150 Atmospheres  
J. Chim. Phys. 27, 212-235 (1930)
225. Goldhammer, D. A.; Studies in the Theory of Corresponding States  
Z. Physik. Chem. 71, 577-624 (1910)
226. Gonikberg, M. G.; Regular Solutions of Gases in Liquids I. Regular Solutions of Hydrogen  
J. Phys. Chem. (U.S.S.R.) 14, 582-8 (1940)

227. Gonikberg, M. G.; Regular Solutions of Gases in Liquids. II. More Concentrated Solutions of Hydrogen at High Pressures Acta Physicochim (U.S.S.R.) 12, 921-30 (1940)
228. Gonikberg, M. G. and Fastovskii, V. G.; Solubility of Gases in Liquids at Low Temperatures and High Pressures II. Solubility of Helium in Liquid Nitrogen at Temperatures From 78.0 to 109.0° K and at Pressures up to 295 Atmospheres Acta Physicochim (U.S.S.R.) 12, 67-72 (1940)
229. Gonikberg, M. G. and Fastovskii, V. G.; Solubility of Gases in Liquids at Low Temperatures and High Pressures. IV. Solubility of Helium in Liquid Methane at 90.3 and 106.0° K and at Pressures up to 160 Atmospheres Acta Physicochim. (U.S.S.R.) 13, 399-404 (1940)
230. Gonikberg, M. G. and Fastovskii, V. G.; The Solubility of Gases in Liquids at Low Temperatures and High Pressures. IV. The Solubility of Helium in Liquid Methane at Temperatures of 90.3° K and 106° K and Pressures up to 160 Atmospheres Foreign Petroleum Tech. 9, 214-19 (1941)
231. Gonikberg, M. G., Fastovskii, V. G. and Gurvitsch, J. G.; Solubility of Gases in Liquids at Low Temperatures and High Pressures I. Solubility of Hydrogen in Liquid Nitrogen at 79-109° K and at Pressures up to 190 Atmospheres Acta Physicochim (U.S.S.R.) 11, 865-882 (1939)
232. Gore, T. L., Davis, P. C. and Kurata, F.; Phase and Volumetric Behavior of Natural Gases at Low Temperatures Petroleum Transactions, AIME, 195, 279-284 (1952)
233. Granquist, W. T.; Adsorption of Methane on Fuller's Earth Ind. Eng. Chem. 42, 2572-5 (1950)
234. Grassmann, P.; Properties of Liquid and Solid Helium Viertel Jahrsschr. Naturforsch. Ges. Zurich 102, No. 3, 61-87 (1957)
235. Gratch, S.; Vapor Pressure, Specific Volume, P-V-T Data for Hydrogen, Nitrogen, Oxygen, Carbon Monoxide, Carbon Dioxide, Air, Helium, Argon, Mercury Trans. ASME 70, 631-40 (Aug. 1948)

236. Greco, G., Casale, C. and Negri, G.; Liquid - Vapor Equilibria at Elevated Pressures of One Component in the Presence of Noncondensable Components  
Compt. Rend. 27<sup>e</sup> Congr. Intern. Chim. Ind. (Brussels) 1954; 2; Industrie Chim. Belge 20, Spec. No. 251- (1955)
237. Greene, S. A., Moberg, M. L. and Wilson, E. M.; Separation of Gases by Gas Adsorption Chromatography  
Anal. Chem. 28, 1369-70 (1956)
238. Greyson, J. and Aston, J. G.; The Heats of Adsorption of Helium and Neon on Graphitized Carbon Black  
J. Phys. Chem. 61, 610-13 (1957)
239. Grilly, E. R.; The Vapor Pressures of Hydrogen, Deuterium and Tritium up to 3 Atmospheres  
J. Am. Chem. Soc. 43, 843 (1951)
240. Gropper, L.; Calculation of the 2nd Virial Coefficient of Helium Gas for the Lowest Measured Temperature.  
Phys. Rev. 55, 1095-7 (1939)
241. Groth, V. W., Ihle, H. and Murrenhoff, A.; Determination of the Temperature Dependence of the Vapor Pressure Relations  
Z. Naturforsch 9a, 895-6 (1954)
242. Guertler, W. and Prani, M.; The Melting Points of the Pure Elements  
Z. Metallk. 11, 1-7 (1919)
243. Guggenheim, E. A.; The Statistical Mechanics of Regular Solutions  
Proc. Roy. Soc. A148, 305 (1935)
244. Guggenheim, E. A.; The Principle of Corresponding States  
J. Chem. Phys. 13, 253-6 (1945)
245. Guter, M., Newitt, D. M. and Ruhemann, M.; Two - Phase Equilibrium in Binary and Ternary Systems. II. The System Methane - Ethylene  
Proc. Roy. Soc. (London), A176, 140-6 (1940)

246. Guter, M., Newitt, D. M., and Runemann, M.; Two - Phase Equilibrium in Binary and Ternary Systems. III. The System Methane - Ethane - Ethylene  
Proc. Roy. Soc. (London) A176, 146-52 (1940)
247. Guye, P. A., and Batuecas, T.; The Compressibility of Several Gases at 0° and up to One Atmosphere, and the Deviation From Avagadro's Law. I. Oxygen, Hydrogen and Carbon Dioxide  
Helvetica Chim. Acta 5, 532-43 (1922)
248. Hagenbach, W. P., and Comings, E. W.; P-V-T Relations of Nitrogen and Ethylene Mixtures at High Pressures  
Ind. Eng. Chem. 45, 606-9 (1953)
249. Ham, N. S.; The Properties of Liquid Helium  
Roy. Australian Chem. Inst. J. and Proc. 17, 272-283 (1950)
250. Haney, R. E. D., and Bliss, H.; Compressibilities of Nitrogen-Carbon Dioxide Mixtures  
Ind. Eng. Chem. 36, 985-9 (1944)
251. Hanson, G. H., Rzasa, M. J., and Brown, G. G.; Equilibrium Constants for Methane in Paraffin Mixtures  
Ind. Eng. Chem. 37, 1216-17 (1945)
252. Hanson, G. H., Hogan, R. J., Nelson, W. T., and Cines, M. R.; Propylene-Propane System-Vapor-Liquid Equilibrium Relationships  
Ind. Eng. Chem. 44, 604-9 (1952)
253. Hanson, G. H., Hogan, R. J., Ruehlen, F. N., and Cines, M. R.; Ethane-Ethylene System; Vapor-Liquid Equilibria at 0°, -40°, and -100°F  
Chem. Eng. Prog. Symposium Ser. 49, No. 6, Phase-Equilibria-Collected Research Papers for 1953, 37-44 (1953)
254. Harper, R. C., Jr.; Compressibility Factors of Gaseous Mixtures of Carbon Dioxide and Helium  
Univ. Microfilms (Ann Arbor, Mich.) Publ. No. 17232, pp. 52

255. Harper, R. C., Jr., and Miller, J. G.; Compressibility of Gases. II. Mixtures of Carbon Dioxide and Helium at 30°  
J. Chem. Phys. 27, 36-9 (1957)
256. Haselden, G. G., Newitt, D. M., and Shah, S. M.; Two - Phase Equilibrium in Binary and Ternary Systems. V. Carbon Dioxide - Ethylene  
Proc. Roy. Soc. (London) A209, 1-14 (1951)
257. Hausen, H.; Rectification of Ternary Mixtures, Especially Oxygen - Nitrogen - Argon Mixtures  
Forsch. Ingenieurw. 6A, 9-22 (1935)
258. Havlicek, V.; The Coefficients of Compressibility for Gases  
Strojirenstvi 8, 903-4 and Inclosure (1958)
259. Henning, F., and Stock, A.; Saturation Pressure of Some Vapors Between 10° and -181°  
Z. Physik 4, 226-44 (1921)
260. Henning, F., and Heuse, W.; A New Determination of the Normal Boiling Points of Oxygen, Nitrogen and Hydrogen  
Z. Physik 23, 105-16 (1924)
261. Henning, F.; The Gas and Resistance Thermometer in the Temperature Region of Liquid Hydrogen and Nitrogen  
Z. Physik 40, 775 (1926)
262. Herz, W.; Uber das b der van der Waalsschne Gleichung  
On the b of the Van der Waals Equation  
Z. Electrochem. 29, 527-30 (1923)
263. Heuse, W.; Molecular Volumes of Hydrocarbons and Other Compounds at Low Temperature  
Z. Physik. Chem. 147, 266-74 (1930)
264. Hewlett, C. W.; Physical Properties of Liquid Helium  
Gen. Elec. Rev. 49, 42-7 (1946)
265. Hilsenrath, J. (Editor); Tables of Thermal Properties of Gases  
Natl. Bur. Standards (U.S.) Circ. 564, 201-53 (1955)

266. Himpan, J.; A New Thermodynamic Equation of State for Gases and Liquids  
Monatsh. 84, 787-97 (1953)
267. Hiraoka, H.; The Fugacities of Steam and Acetylene at High Pressures  
Rev. Phys. Chem. Japan 26, 52-5 (1956)
268. Hitz, K., Scheller, W., and Treadwell, W. D.; The Mixed Adsorption of Hydrogen, Oxygen, and Nitrogen with Carbon Dioxide on Linden Charcoal  
Helv. Chim. Acta 34, 1783-90 (1951)
269. Hogan, R. J., Nelson, W. T., Hanson, G. H., and Cines, M. R.; Ethane - Ethylene - Acetylene System. Vapor - Liquid Equilibrium Data at  $-35^{\circ}$ ,  $0^{\circ}$ , and  $40^{\circ}$  F  
Ind. Eng. Chem. 47, 2210-15 (1955)
270. Hoge, H. J. and Arnold, R. D.; Vapor Pressures of Hydrogen, Deuterium, and Hydrogen Deuteride and the Dew - Point Pressures of Their Mixtures  
J. Research, NBS 47, 63 (1951)
271. Hoge, H. J., and Lassiter, J. W.; Critical Temperatures, Pressures, and Volumes of; Hydrogen, Deuterium and Hydrogen Deuteride.  
J. Research NBS 47, 75 (1951)
272. Holborn, L., and Otto, J.; The Isotherms of Various Gases Between  $400^{\circ}$  and  $-183^{\circ}$   
Z. Physik 33, 1-12 (1925)
273. Holborn, L., and Otto, J.; Isotherms of Helium, Hydrogen, and Heon Below  $-200^{\circ}$   
Z. Physik 38, 359-67 (1926)
274. Hollings, H., and Griffith, R. H.; Activated Adsorption of Hydrogen  
Nature 129, 834 (1932)
275. Holmes, J., and Emmett, P. H.; Investigation of Low-Temperature Nitrogen Adsorption at High Relative Pressures  
J. Phys. and Colloid Chem. 51, 1262-76 (1947)

276. Holst, G.; The Vapor Pressure of Oxygen and Nitrogen  
Proc. Akad. Wetenschappen 18, 829-39 (1916)
277. Holst, G., and Hamburger, L.; Investigation of the Equilibrium Liquid-Vapor of the System Argon - Nitrogen  
Proc. Akad. Wetenschappen 18, 872 (1916)
278. Homfray, I. F.; Adsorption of Gases by Charcoal  
Z. Physik, Chem. 74, 129-201 (1910)
279. Homfray, I. F.; Adsorption of Gases by Charcoal  
Proc. Roy. Soc. (London) A84, 99-106 (1910)
280. Hough, E. W., and Sage, B. H.; Volumetric Behavior in Several Gaseous Hydrocarbon Solutions  
Chem. Revs. 44, 193-204 (1949)
281. Houghton, G., McLean, A. M., and Ritchie, P. D.; Compressibility, Fugacity, and Water Solubility of Carbon Dioxide in the Region 0-36 Atmosphere and 0-100°  
Chem. Eng. Sci. 6, 132-7 (1957)
282. Hughes, E. E., and Gordon, R., Jr.; Detection of Acetylene in Air in Concentrations from 10 Parts Per Billion to 10 Parts Per Million  
Anal. Chem. 31, 94-8 (1959)
283. Husung, E.; Adsorption of Gases and Gas Mixtures by Special Charcoals  
Z. Tech. Physik 17, 289-301 (1936)
284. Hutchinson, A. J. L.; A System of Process Calculations for Light Hydrocarbons. I.  
Petroleum Refiner 29, 83-9 (1950)
285. Hutchinson, A. J. L.; A System of Process Calculations for Light Hydrocarbons. II. Equilibrium Consideration  
Petroleum Refiner 29, 117-22 (1950)
286. Ishkin, I. P., and Burbo, P. Z.; Solubility of Solid Acetylene and Carbon Dioxide in Liquid Oxygen, Nitrogen, and Oxygen-Nitrogen Mixtures  
J. Phys. Chem. (U.S.S.R.) 13, 1337-9 (1939)

287. Ishkin, I. P., and Kaganer, M. G.; Investigation of Thermodynamic Properties of Air and Nitrogen at Low Temperatures Under Pressure. II. Thermodynamic Diagrams of State for Air and Nitrogen  
Soviet Phys. Tech. Phys. 1, 2263-71 (1956)
288. Jelinek, R. V.; Adsorption of Binary Gas Mixtures of Carbon Dioxide and Hydrocarbons  
Univ. Microfilms (Ann Arbor, Mich.) Publ. No. 15741
289. Johnson, M. C.; An Analysis of Hydrogen Adsorption Phenomena  
Trans. Faraday Soc. 29, 1139-55 (1933)
290. Johnson, V. J.; Removal of Nitrogen from Hydrogen with Silica Gel at Low Temperatures  
Proc. Cryogenic Eng. Conf., 2nd, Boulder 1957, 11-18
291. Johnston, H. L., and White, D.; Pressure - Volume - Temperature Relationships of Gaseous Normal Hydrogen from its Boiling Point to Room Temperature from 0-200 Atmospheres  
Trans. ASME 72, 785-7 (1950)
292. Johnston, H. L., White, D., Wirth, H., Swanson, C., Jensen, L. H., and Friedman, A. S.; Gaseous Data of State II, the P-V-T Relationships of Gaseous Normal Hydrogen from the Critical Temperature to Room Temperature and up to 200 Atmosphere Pressures  
T.R. 264-25 Ohio State Cry. Lab. (Nov. 25, 1953)
293. Johnston, H. L., Keller, W. E., and Friedman, A. S.; The Compressibility of Liquid Normal Hydrogen from the Boiling Point to the Critical Point at Pressures up to 100 Atmospheres  
J. Am. Chem. Soc. 76, 1482-6 (1954)
294. Juschkevitsch, N. F., and Torotscheschnikov, N. J.; Liquid and Gaseous Phases in the System Nitrogen - Carbon Monoxide  
J. Chem. Ind. Russ. 13, 1273-83 (1936)
295. Justi, E.; Thermodynamics of Real Gas Mixtures  
Forsch. Gebiete Ingenieurw. 15, 18-21 (1944)

296. Kaganer, M. G.; Adsorption Isotherms of Nitrogen at Low Pressures  
Doklady Akad. Nauk U.S.S.R. 122, 416-19 (1958)
297. Kanda, E.; The Adsorption of Helium on Charcoal Below 78°K, and Thermometry of Low Temperatures  
Bull. Chem. Soc. Japan 13, 241-6 (1938)
298. Kane, G.; Equation of State of Solid Helium  
J. Chem. Phys. 9, 568-70 (1941)
299. Kaneka, S., and Kihara, T.; Second Virial Coefficient of Helium from the Square-Well Potential  
J. Phys. Soc. Japan 11, 471-3 (1956)
300. Karasz, F. E., and Halsey, G. D., Jr.; Solubility of Helium and Neon in Liquid Argon. An Approximation to the Entropy of Lattice Vacancy Formation in Liquid Argon  
J. Chem. Phys. 29, 173-9 (1958)
301. Karasz, F. E.; Solubility of Helium and Neon in Liquid Argon  
Univ. Microfilms (Ann Arbor, Mich.) L. C. Card No. Mic 58-2139, pp. 90 Dissertation Abstr. 18, 1996 (1958)
302. Karnaukhov, A. P., Kiselev, A. V., and Khrapova, E. V.; Adsorption of Nitrogen Vapors on Carbon Black  
Doklady AN U.S.S.R. 92, No. 2: 361-4 (1953)
303. Karwat, E.; Vapor Pressure of Solid Hydrogen Chloride, Methane, and Ammonia  
Z. Physik. Chem. 112, 486-90 (1924)
304. Kazavchinskii, Ya. Z.; A Method of Determining the Constants for the Virial Form of the Equation of State for a Real Gas  
Doklady Akad. Nauk U.S.S.R. 95, 1005-8 (1954)
305. Keesom, W. H.; Second Virial Coefficient for Diatomic Gases  
Proc. Akad. Wetenschappen 15, 417-31 (1913)
306. Keesom, W. H.; Thermodynamic Investigations Including Triple Point and Critical Magnitudes of Oxygen, Argon, Nitrogen, Neon, Hydrogen and Helium  
Onnes-Festschrift 1922, 89-163 (1922)

307. Keesom, W. H., and Lismann, J. H. C.; Melting Curve of Nitrogen to 110 KG/CM<sup>2</sup>  
Physica 1, 735-738 (1934)
308. Keesom, W. H., and Kraak, H. H.; The Compressibility of Helium Gas Between 2.6° and 4.2° K  
Commun. Kamerlingh Onnes Lab. Univ. Leiden Commun No. 234e (1935)
309. Keesom, W. H., and Van Santen, J. J. M.; The Second Virial Coefficient of Helium  
7th Congr. Intern. Froid, 1st Comm. Intern., Rapports et Commun. 1-5 (June 1936)
310. Keesom, W. H., and Bijl, A.; Determination of the Vapor Pressure of Liquid Nitrogen Below one Atmosphere and of Solid Nitrogen. B. Boiling Point and Triple Point of Nitrogen  
Physica 4, 305-10 (1937)
311. Keesom, W. H., and Walstra, W. K.; Isotherms of Helium at Liquid - Helium Temperatures  
Physica 6, 1146 (1939)
312. Keesom, W. H., and Schweers, J.; Measurements of the Adsorption of Helium on Solidified Layers of Some Gases  
Physica 8, 1032-43 (1941)
313. Keesom, W. N., and Walstra, W. K.; The Second Virial Coefficient of Helium at Temperatures of Liquid and Solid Hydrogen  
Physica 13, 225-30 (1947)
314. Keier, N. P., and Roginskii, S. Z.; The Properties of Broadly Heterogeneous Surfaces as Shown by the Study of the Adsorption of Oxygen and Hydrogen on Activated Charcoal  
Problemy Kinetiki i Kataliza 7, Statisticheskii Yavleniya v Geterogen - Sistemakh 410-35 (1949)
315. Keiar, N. P., and Roginskii, S. Z.; The Kinetics of Desorption of Activated Adsorbed Hydrogen  
Zhurnal Fizicheskoi Khimii 23(8); 897-916 (1949)
316. Keller, W. E.; Second Virial Coefficients of Helium<sup>3</sup> - Helium<sup>4</sup> Mixtures Between 2 and 4° K  
Phys. Rev. 100, 1021-2 (1955)

317. Keyes, F. G., Taylor, R. S., and Smith, L. B.; The Thermodynamic Properties of Methane  
J. Math. Phys., Mass. Inst. Tech. 1, 211-42 (1922)
318. Keyes, F. G., and Burks, H. B.; Equation of State for Finary Mixtures of Methane and Nitrogen  
J. Am. Chem. Soc. 50, 1100-6 (1928)
319. Keyes, F. G.; Vapor Pressure, Specific Volumes and P-V-T Data for Water, Ammonia, Methane and Eithylene  
Trans. ASME 70, 641-4 (1948)
320. Kharakhorin, F. F.; The Phase Relations in Systems of Liquefied Gases. I. The Binary Mixture Nitrogen - Helium  
Foreign Petroleum Tech. 9, 397-410 (1941)
321. Kigoshi, K.; Fusion and State Equations of Simple Liquids  
Bull. Soc. Japan 23, 236-44 (1950)
322. Kihara, Taro, et al, Virial Coefficients and Intermolecular Potential of Small, Non-Spherical Molecules (Hydrogen),  
J. Phys. Soc. Japan 11, 362-6 (1956)
323. Kilpatrick, J. E., et al; Second Virial Coefficients of Helium<sup>3</sup> and Helium<sup>4</sup>  
Phys. Rev. 94, 1103-10 (1954)
324. Kilpatrick, J. E., et al; Second Virial Coefficients of Helium from the Exp-Six Potential  
Phys. Rev. 97, 9-12 (1955)
325. Kingman, F. E. T.; Adsorption of Hydrogen on Charcoal  
Nature 127, 742 (1931)
326. Kingman, F. E. T.; Adsorption of Hydrogen by Charcoal  
Trans. Faraday Soc. 28, 269-72 (1932)
327. Kirillov, I. P., and Rakhlin, E. S.; Adsorption of Methane by Charcoal  
J. Applied Chem. (U.S.S.R.) 19, 511-16 (1946)
328. Kirkwood, J. G., and Keyes, F. G.; The Equation of State of Helium  
Phys. Rev. 37, 832-40 (1931)

329. Kiselev, A. V., et al; Adsorption of Methane on Carbon Black and Coal Above and Below Critical Temperature Doklady AN U.S.S.R. 111, 129-32 (1956)
330. Kirshenbaum, I., and Grover, R. K.; Low-Temperature Nitrogen Adsorption Studies of Silica Gel J. Am. Chem. Soc. 70, 1282-3 (1948)
331. Kobe, K. A., and Rosenberg, H. E.; The Wohl Equation of State Applied to Light Hydrocarbons Petroleum Engr. 23, No. 11 35-8 (1951)
332. Koble, R. A., and Corrigan, T. E.; Adsorption Isotherms for Pure Hydrocarbons Ind. Eng. Chem. 44, 383-7 (1952)
333. Kogan, V. S., Lazarev, B. G., and Bulatova, R. B.; State Diagram of the Hydrogen - Deuterium System Zhur. Eksptl. I. Teoret. Fiz. 34, 238-40 (1958)
334. Komarov, P., Likhter, A., and Rueman, M.; The Diagrams of State of Mixtures Fusing at Low Temperatures Systems Nitrogen - Oxygen and Nitrogen - Carbon Monoxide J. Tech. Phys. (U.S.S.R.) 5, 1723-8 (1935)
335. Kramer, G. M.; P-V-T Behavior of Mixture of Helium and Nitrogen at 30° Univ. Microfilms (Ann Arbor, Mich.) Publ. No. 23611
336. Kramer, G. M., and Miller, J. G.; Compressibility of Gases III. The Second and Third Virial Coefficients of Mixtures of Helium and Nitrogen at 30° J. Phys. Chem. 61, 785-8 (1957)
337. Krasil'nikov, K. G., et al; Low Temperature Adsorption of Nitrogen on Thermally Dehydrated Silica Gel and Alumogel Samples Zhur. Fiz. Khim. 31, 1448-54 (1957)
338. Kritscheveskii, I. R., and Markov, V. P.; The Compressibility of Gas Mixtures I. The P-V-T Data for Binary and Ternary Mixtures of Hydrogen, Nitrogen and Carbon Dioxide Acta Physicochim. U.S.S.R. 12, 59-66 (1940)

339. Kritscheveskii, I. R., and Kazarnovskii, Ya. S.; An Equation of State for Gaseous Mixtures  
Acta Physicochim U.S.S.R. 10, 217-44 (1939)
340. Kritscheveskii, I. R., and Levchenko, G. T.; Compressibility of Gas Mixtures II. P-V-T Data for Binary and Ternary Mixtures of Methane, Nitrogen and Hydrogen  
Acta Physicochim U.S.S.R. 14, 271-8 (1941)
341. Kritscheveskii, I. R., and Tarocheshnikov, N. S.; Thermodynamics of the Liquid-Gas Equilibrium in the Nitrogen - Oxygen System  
Z. Physik. Chem. A176, 338-46 (1936)
342. Kvalnes, H. N., and Gaddy, V. L.; The Compressibility Isotherms of Methane at Pressures to 1000 Atmospheres and at Temperatures from -70 to 200°  
J. Am. Chem. Soc. 53, 394 (1931)
343. Lacey, W. N., and Sage, B. H.; Properties of Pure Propane  
Petroleum World 31, No. 12 37-41 (1934)
344. Lamb, A. B., and Roper, E. E.; The Vapor Pressures of Certain Unsaturated Hydrocarbons  
J. Am. Chem. Soc. 62, 806-1940)
345. Lambert, B., and Heaven, H. S.; Gas - Solid Equilibria VI. Adsorption from Binary Gas Mixtures by Silica Gel  
Proc. Roy. Soc. (London) A153, 584-600 (1936)
346. Lang, R. J.; The Purification of Helium  
Trans. Roy. Soc. Can 17, Sec. III, 181-8 (1923)
347. Latimer, R. E.; Vapor - Liquid Equilibriums of Nitrogen - Argon - Oxygen Mixtures  
A.I.Ch.E. Journal 3, 75-82 (1957)
348. Lee, J. F.; Specific Heat of Gases at the Critical Point  
Z. Angew. Math. u Phys. 4, 401-4 (1953)
349. Lennard-Jones, J. E.; The Molecule Fields of Hydrogen, Nitrogen, and Neon  
Proc. Roy. Soc. (London) 112, 214-29 (1926)

350. Lenoir, J. M., and Hipkin, H. G.; Equilibrium Ratios of Hydrogen and the Critical Locus of Hydrogen - Paraffin Mixtures  
A.I.Ch.E. Journal 3, 318 (1957)
351. Lepointe, R.; Heat of Adsorption of Gases by Charcoal at  $-183^{\circ}\text{C}$   
J. Phys. Radium 7, 469-72 (1936)
352. Levitskaya, E., and Pryannikov, K.; Equilibrium Between Liquid and Vapor in the Binary System of Hydrogen and Ethane  
J. Tech. Phys. (U.S.S.R.) 9, 1849-53 (1939)
353. Levitskaya, E. P.; Equilibrium of Liquid-Gas in the Triple System: Ethane - Methane - Hydrogen  
J. Tech. Phys. (U.S.S.R.) 11, 197-204 (1941)
354. Lewis, W. K., Gilliland, E. R., Chertow, B., and Caoogan, W. P.; Adsorption Equilibria. Pure Gas Isotherms  
Ind. Eng. Chem. 42, 1326-32 (1950)
355. Lewis, W. K., Gilliland, E. R., Chertow, B., and Bareis, O.; Vapor - Adsorbate Equilibrium III. The Effect of Temperature on the Binary Systems Ethylene - Propane, Ethylene - Propylene over Silica Gel  
J. Am. Chem. Soc. 72, 1160-3 (1950)
356. Lewis, W. K., Gilliland, E. R., Chertow, B., and Milliken, W.; Vapor - Adsorbate Equilibrium II. Acetylene - Ethylene on Activated Carbon and on Silica Gel  
J. Am. Chem. Soc. 72, 1157-9 (1950)
357. Lewis, W. K., Gilliland, E. R., Chertow, B., and Hoffman, W. H.; Vapor - Adsorbate Equilibrium I. Propane - Propylene on Activated Carbon and on Silica Gel  
J. Am. Chem. Soc. 72, 1153-7 (1950)
358. Li, K., and Canjar, L. N.; Propane - Propylene Mixtures  
A.I.Ch.E. Journal 2, 448-50 (1956)

359. Lialine, L., Hestermans, P., and Deffet, L.; Determination of the Compressibility of a Hydrogen - Nitrogen Mixture by a Method Suitable for the Study of Industrial Gases  
Proc. Conf. Thermodynamic and Transport Properties Fluids, London (Pub. 1958) 43-7 (1957)
360. Liang, S. C.; Low Vapor Pressure Measurements and Thermal Transpiration  
J. Phys. Chem. 56, 660 (1952)
361. Likhter, A. I., and Tikhonovich, N. P.; Equilibrium Between Vapor and Liquid in the System Ethylene - Hydrogen  
J. Tech. Phys. (U.S.S.R.) 9, 1916-22 (1939)
362. Likhter, A. I., and Tikhonovich, N. P.; The Equilibrium Vapor - Liquid in the System Ethylene - Methane - Hydrogen II.  
J. Tech. Phys. (U.S.S.R.) 10, 1201 (1940)
363. Livingston, M. K.; The Cross-Sectional Areas of Molecules Adsorbed on Solid Surfaces. ( $H_2$ ,  $D_2$ ,  $CH_4$ ,  $C_2H_2$ ,  $C_2H_6$ , 1-Butane,  $N-C_4H_{10}$ ,  $C_3H_8$ ,  $n-C_7H_{16}$ ,  $NH_3$ ,  $O_2$ ,  $H_2O$ ,  $C_2H_5OH$ ,  $CO$ ,  $CO_2$ ,  $N_2$ ,  $Ne$ ,  $CS_2$ ,  $CHFCl_2$ ,  $C_2H_5Cl$ ,  $Ar$ ,  $Kr$ )  
J. Colloid Sci. 4, 447-58 (1949)
364. Loomis, A. G., and Walters, J. E.; The Vapor Pressure of Ethane Near the Normal B. P.  
J. Am. Chem. Soc. 48, 2051-5 (1926)
365. Lopez-Gonzales, Carpenter and Dietz; Adsorption of Nitrogen on Carbon Adsorbents at Low Pressures Between  $69^\circ$  and  $90^\circ K$   
J. Research NBS 55, 11 (1955)
366. Lorenz, R., and Wiedbrauck, E.; Adsorption Equilibria of Mixtures of Two Gases  
Z. Anorg. Allgen. Chem. 143, 268-76 (1925)
367. Lowry, H. H., and Morgan, S. O.; The Adsorption of Gases by Graphitic Carbon  
J. Phys. Chem. 29, 1105-15 (1925)

368. Lowry, H. H., and Olmstead, P. S.; The Adsorption of Gases by Solids with Special Reference to the Adsorption of Carbon Dioxide by Charcoal  
J. Phys. Chem. 31, 1601-26 (1927)
369. Ludwig, E. H. B.; Propane, Butane and Pentane, the "Liquid Gases"  
Z. Osterr. Ver. Gas - Wasserfach 74, 121-9, 132-5 (1934)
370. Lydersen, A. L., Greenkorn, R. A., and Hougen, O. A.; Generalized Thermodynamic Properties of Fluids  
Eng. Expt. Station Rpt No. 4, Univ. of Wisconsin, (1955)
371. Mac Cormack, K. E., and Schneider, W. G.; Compressibility of Gases at High Temperatures IV. Carbon Dioxide in the Temperature Range  $0^{\circ}$  -  $600^{\circ}$  and Pressures up to 50 Atmospheres  
J. Chem. Phys. 18, 1269-72 (1950)
372. Magnus, A., and Roth, N.; Adsorption VII. The Adsorption of Carbon Dioxide - Hydrogen Mixtures on Wood Charcoal  
Z. Anorg. Allgem. Chem. 150, 311-25 (1926)
373. Maidanovskaya, L. G., Panfilov, I. A., and Zakharova, R. O.; Adsorption of Hydrogen and Some Electrolytes on Iron Oxide  
Uchenye Zapiski Tomsk. Gosudarst. Univ. 1955, No. 26, 93-102; Referat Zhur. Khim. 1956, Abstr. No. 57687
374. Maimoni - Biblarz, Arturo; Vapor Liquid Equilibria in the System Hydrogen - Nitrogen  
Ph.D. Thesis, U. of Calif., Berkeley (1956)
375. Majumdar, A. J., and Roy, R.; Fugacities and Free Energies of Carbon Dioxide at High Pressures and Temperatures  
Geochim et Cosmochim Acta 10, 311-15 (1956)
376. Malanchuk, M. and Stuart, E. B.; Effect of Heat Treatment on Silica Gel  
Ind. Eng. Chem. 50, 1207-10 (1958)

377. Mamedaliev, Yu. G., and Kuliev, A. M.; The Separation of Pure Methane from Hydrocarbon Gas Mixtures by Means of Selective Adsorption  
J. Applied Chem. (U.S.S.R.) 13, 738-42 (1940)
378. Marchman, H., and Prengle, H. W., Jr.; Compressibility of Ethane Propylene Vapor Mixtures  
Ind. Eng. Chem. 42, 2371 (1950)
379. Margenau, H.; The Second Virial Coefficient for Gases: A Critical Comparison Between Theoretical and Experimental Results  
Phys. Rev. 36, 1782-90 (1930)
380. Markov. V. P.; Compressibility of Gaseous Mixtures II. Verification of the Equation of State for Gaseous Mixtures  
J. Phys. Chem. (U.S.S.R.) 15, 410-15 (1941)
381. Maron, S. H., and Turnbull, D.; Equation of State for Gases at High Pressures Involving only Critical Constants  
J. Am. Chem. Soc. 64, 2195-8 (1942)
382. Marshak, R. E., Morse, P. M., and York, H.; Equation of State of Hydrogen, Helium, and Russell Mixtures at High Temperatures and Pressures  
Astro Phys. J. 111, 214-20 (1950)
383. Maslan, F., and Aberth, E.; Equation of State for Liquids  
J. Chem. Phys. 19, 658-9 (1951)
384. Maslan, F. D., and Littman, T. M.; Compressibility Chart for Hydrogen and Inert Gases  
Ind. Eng. Chem. 45, 1566-8 (1953)
385. Massie, D. S., and Whytlaw-Gray, R.; The Normal Density of Propane and Its Expansion Coefficients Between 0° and 20°  
J. Chem. Soc. 2874-7 (1949)
386. Mastrangelo, S. V. R., and Aston, J. G.; Thermodynamic Data and Some Notes on the Nature of Absorbed Helium  
J. Chem. Phys. 19, 1370-5 (Nov. 1951)

387. Mathias, E.; Study of Density Curves at Low Temperatures  
Onnes-Festschrift 165-96 (1922)  
Physik. Ber. 4, 701-2 (1923)
388. Mathias, E., and Crommelin, C. A.; Work Done in the  
Leiden Cryogenic Lab. Concerning the Equation of State of  
Argon, Neon and Hydrogen Between the 3rd and 4th Intern.  
Cong. of Refrigeration  
Proc. 4th Intern. Congr. Refrig. 1, 89-106a (1924)
389. Mathias, E., and Crommelin, C. A.; Carbon Monoxide and  
Helium  
Ann. Physik 5, 137-66 (1936)
390. Mathias, E., and Crommelin, C. A.; The Rectilinear  
Diameter of Carbon Monoxide  
7th Congr. Intern. Froid, 1st Comm. Intern., Rapporte et  
Commun. June 1936, 96-102 (1936)
391. Mathot, V., Staveley, L. A. K., Young, J. A., and  
Parsonage, N. G.; Thermodynamic Properties of the System  
Methane - Carbon Monoxide at 90.67°K  
Trans. Farady Soc. 52, 1488-1500 (1956)
392. Matsui, R., Ito, Y., Yasui, E., and Susuki, H.; Detection of  
Acetylene, Hydrocarbons, and Carbon Dioxide in Liquid  
Lxygen  
Kogyo Kasaku Zasshi 60, 413-17 (1957)
393. Matthews, C. S., and Hurd, C. O.; Thermodynamic  
Properties of Methane  
Trans. Am. Inst. Chem. Engrs. 42, 55 (1946)
394. Maverick, S., and Schlatter, C.; Compressibility at 0° and  
Below 1 Atmosphere and the Deviation from the Law of  
Avogadro of Several Gases  
J. Chim. Phys. 27, 36-43, 44-53 (1930)
395. McBain, J. W.; The Mechanism of the Adsorption of  
Hydrogen by Carbon  
Z. Physik. Chem. 68, 471-97

396. McBain, J. W., and Britton, G. T.; The Nature of the Sorption by Charcoal of Gases and Vapors Under Great Pressure  
J. Am. Chem. Soc. 52, 2198-222 (1930)
397. McCurdy, J. L., and Katz, D. L.; Phase Equilibria in the System Ethane - Ethylene - Acetylene  
Ind. Eng. Chem. 36, 674-80 (1944)
398. McCurdy, J. L., and Katz, D. L.; Phase Equilibria in the Systems Propylene - Acetylene and Propane - Acetylene  
Oil Gas J. 43, 102-4 (1945)
399. McDermot, H. L., Arnell, J. C., and Lawton, B. E.; Charcoal Sorption Studies. III. The Adsorption of Ethylene and Perfluoroethylene by an Activated Charcoal  
Can. J. Chem. 33, 320-9 (1955)
400. McDermot, H. L., and Lawton, B. E.; Adsorption of Nitrogen by Carbon Black and Graphite  
Can. J. Chem. 34, 769-74 (1956)
401. McGaw, H. D.; The Density and Compressibility of Solid Hydrogen and Deuterium at 4.2°K  
Phil. Mag. 28, 129 (1939)
402. McKay, R. A., Reamer, H. H., Sage, B. H., and Lacey, W. N.; Volumetric and Phase Behavior in the Ethane - Propylene System  
Ind. Eng. Chem. 43, 2112-17 (1951)
403. McLean, S.; The Adsorption of Helium by Charcoal  
Trans. Roy. Soc. Canada 12, (III), 79-81 (1918)
404. McTaggart, H. A., and Edwards, E.; Composition of the Vapor and Liquid Phases of the System Methane - Nitrogen  
Trans. Roy. Soc. Can., 13, Sect. iii, 57-66 (1919)
405. Medek, J.; Gas Adsorption on the Surface of Solids  
Paliva 34, 292-8 (1954)

406. Meldrum, A. H., and Nielsen, R. F.; A Study of 3-Phase Equilibria for Carbon Dioxide - Hydrocarbon Mixtures Penna. State Univ., 18th Tech. Conf. on Petroleum Production, Mineral Inds. Expt. Sta. Bull. No. 64, 9-28 (1954)
407. Meldrum, A. H., and Nielsen, R. F.; Three-Phase Equilibria for Carbon Dioxide - Hydrocarbon Mixtures Producers Monthly 19, No. 10, 22-35 (1955)
408. Melkonian, G. A., and Reys, B.; Isotope Displacement by Absorption and Desorption on Silica Gels at Low Temperatures and Pressures Z. Elektrochem. 58, 616-19 (1954)
409. Meyers, C. H., and Van Dusen, M. S.; Vapor Pressure of Liquid Carbon Dioxide Refrigerating Eng. 13, 180-4 (1926)
410. Meyers, C. H., and Van Dusen, M. S.; The Vapor Pressure of Liquid and Solid Carbon Dioxide J. Research NBS 10, 381-412 (1933)
411. Michels, A., Michels, Mrs. C., and Wouters, H.; Isotherms of Carbon Dioxide Between 70 and 3000 Atmospheres (Amagat Densities Between 200 and 600) Proc. Roy. Soc. (London) A153, 214-24 (1935)
412. Michels, A., and Michels, Mrs. C.; Isotherms of Carbon Dioxide Between 0° and 150° and Pressures from 16 to 250 Atmospheres (Amagat Densities 18 - 206) Proc. Roy. Soc. (London) A153, 201-14 (1935)
413. Michels, A., and Nederbragt, G. W.; Isotherms of Methane Between 0° and 150° and Densities 19 and 53 Amagat (Pressures Between 20 and 80 Atmospheres) Physica 2, 1000-2 (1935)
414. Michels, A., Bijl, A., and Michels, C.; Thermodynamic Properties of Carbon Dioxide Between 25 and 150°; C up to 3000 Atmospheres Proc. Roy. Soc. (London) A160, 376 (1937)

415. Michels, A., and Nederbragt, G. W.; Isotherms of Methane-Ethane at  $0^{\circ}$ ,  $25^{\circ}$ , and  $50^{\circ}$  up to 60 Atmospheres  
Physica 6, 656-62 (1939)
416. Michels, A., and Goudekot, M.; Compressibility of Hydrogen Between  $0^{\circ}$  and  $150^{\circ}$  up to 3000 Atmospheres  
Physica 8, 353-9 (1941)
417. Michels, A., and Goudekot, M.; Compressibilities of Deuterium Between  $0^{\circ}$  and  $150^{\circ}$  up to 3000 Atmospheres  
Physica 8, 353-9 (1941)
418. Michels, A., and Wassenaar, T.; Isotherms of Argon Nitrogen - Hydrogen Mixture Between 0 and  $150^{\circ}$  up to 340 Atmospheres  
Applied Sci. Research 1A, 258-62 (1949)
419. Michels, A., deGroot, S. R., and Lunbeck, R. J.; Thermodynamic Functions of Argon Nitrogen - Hydrogen Mixture Between  $0^{\circ}$  and  $300^{\circ}$  up to 1000 Atmospheres  
Applied Sci. Research 1A, 378-86 (1949)
420. Michels, A., Skelton, G. F., and Dumoulin, E. L.; Gas-Liquid Phase Equilibrium in the System Ammonia - Hydrogen - Nitrogen  
Physica 16, 831-38 (1950)
421. Michels, A., Lunbeck, R. J., and Wolkers, G. J.; Thermodynamic Properties of Nitrogen as Functions of Density and Temperature Between  $-125^{\circ}$  and  $+150^{\circ}$  C and Densities up to 760 Amagat  
Physica 17, 801-16 (1951)
422. Michels, A., Wassenaar, T., and Zwietering, Th. N.; The Vapor Pressure of Carbon Monoxide  
Physica 18, 160-2 (1952)
423. Michels, A., Wassenaar, T., Slayters, Th., and Graaff, W. D.; Triple Points of Carbon Dioxide and of Argon as Fixed Points for the Calibration of Thermometers  
Physica 23, 89-94 (1957)

424. Michels, A., deGraff, W., et al; Compressibility Isotherms of Hydrogen and Deuterium at Temperatures Between  $-175^{\circ}\text{C}$  and  $+150^{\circ}\text{C}$  (at Densities up to 960 Amagat)  
*Physica* 25, 25-42 (1959)
425. Millar, R. W.; Specific Heats of Polyatomic Gases at Low Temperatures  
*J. Am. Chem. Soc.* 45, 874-81 (1923)
426. Mills, J. R., and Miller, F. J. L.; Liquefaction of Carbon Dioxide  
*Can. Chem. Process Inds.* 29, 651-3 (1945)
427. Mills, R. L., and Grilly, E. K.; Melting Curves of Helium 3, Helium 4, Hydrogen, Deuterium, Neon, Nitrogen, and Oxygen up to  $3500\text{ Kg/cm}^2$   
*Phys. Rev.* 99, 480-86 (1955)
428. Mills, R. L., and Grilly, E. R.; Melting Curves of Hydrogen, Deuterium, and Tritium up to  $3500\text{ Kg/cm}^2$   
*Phys. Rev.* 101, No. 4, 1246-7 (1956)
429. Miyako, R.; Viscosity and Second Virial Coefficients of Gaseous Hydrogen at Low Temperatures  
*Proc. Phys. Math. Soc. Japan* 24, 852-63 (1942)
430. Moore, R. B.; Helium-History, Properties, and Commercial Development. The Uses of Charcoal in Helium Purification  
*J. Franklin Inst.* 191, 183-4 (1921)
431. Mooy, H. H.; On the Crystal Structure of Methane  
*Comm. Kamerlingh Onnes Phys. Lab. Univ. Leiden* 213d (1931)
432. Mori, Y.; The Perfect Gas and the Equation of State of Real Gases  
*J. Sci. Research Inst. (Tokyo)* 48, 272-9 (1954)
433. Morrison, J. A., Drain, H. E., and Dugdale, J. S.; Phase Transitions in Multi Molecular Layers of Adsorbed Nitrogen  
*Can. J. Chem.* 30, 890-903 (1952)

434. Moss, S. A.; General Law for Vapor Pressure III - Vapor Pressure of Carbon Dioxide  
Phys. Rev. 26, 439-47 (1908)
435. Mulders, E. M. J., and Scheffer, F. E. C.; Analysis of Mixtures of Hydrogen, Methane and Ethane  
Rec. Trav. Chim. 49, 1057-65 (1930)
436. Nay, M. A., and Morrison, J. L.; The Molecular Adsorption Areas of Hydrocarbon Gases on Charcoal  
Can. J. Research 27B, 205-14 (1949)
437. Nelson, E. E., and Bonnell, W. S.; Solubility of Hydrogen in Nitrogen - Butane  
Ind. Eng. Chem. 35, 204 (1943)
438. Nelson, L. C., and Obert, E. F.; Generalized P-V-T Properties of Gases  
Trans. Am. Soc. Mech. Engrs. 76, 1057-66 (1954)
439. Neusser, E.; The van der Waals Equation for Rare Gases  
Physik. Z. 33, 76-81 (1932)
440. Neven, P., and Van Tiggelen, A.; Quantitative Adsorption of Hydrogen  
Bull. Soc. Chim. Belg. 61, 328-29 (1952)
441. Newitt, D. M., Ruhemann, M., and Guter, M.; Two Phase Equilibrium in Binary and Ternary Systems II. The System Methane - Ethylene III. The System Methane - Ethane - Ethylene  
Proc. Roy. Soc. 176A, 140 (1940)
442. Newitt, D. M., and Ruhemann, M.; Two Phase Equilibrium in Binary and Ternary Systems IV. The System Ethylene - Propylene  
Proc. Roy. Soc. 178A, 506 (1941)
443. Nijhoff, G. P.; Comparison of Nitrogen and Oxygen According to the Law of Corresponding States  
Comm. Phys. Lab. Univ. Leiden, Suppl., 64, 49-52 (1929)

444. Nijhoff, G. P.; The Second Virial Coefficient of Helium and Hydrogen  
Comm. Phys. Lab. Univ. Leiden, Suppl., 64, 17-27 (1929)
445. Nijhoff, G. P., and Keesom, W. H.; Isotherms of Hydrogen at Temperatures of  $0^{\circ}$  and  $+100^{\circ}$  C  
Commun. Phys. Lab. Univ. Leiden Commun. No. 188d (1927)
446. Nijhoff, G. P., and Keesom, W. H.; Isotherms of Hydrogen at Temperatures from  $-225.5^{\circ}$  to  $-248.3^{\circ}$  C and Pressures from 1.6 to 4.2 Atmospheres  
Commun. Phys. Lab. Univ. Leiden Commun. No. 188e (1928)
447. Nodop, G.; Gas Chromatographic Analysis of Very Pure Ethylene  
Z. Anal. Chem. 164, 120-7 (1958)
448. Oishi, J.;  $0^{\circ}$  and  $100^{\circ}$  Isotherms of Helium, Hydrogen, Neon, Argon, Air and Carbon Dioxide at Pressures Below 2 Atmospheres, and Absolute Temperature,  $0^{\circ}$  C  
J. Sci. Research Inst. (Tokyo) 43, 220-31 (June 1949)
449. Olds, R. H., Sage, B. H., and Lacey, W. N.; Methane - Isobutane System  
Ind. Eng. Chem. 34, 1008 (1942)
450. Olds, R. H., Reamer, H. H., Sage, B. H., and Lacey, W. N.; Phase Equilibria in Hydrocarbon Systems. The Nitrogen - Butane and Carbon Dioxide System  
Ind. Eng. Chem. 41, 475 (1949)
451. Oliphant, M. L.; Selective Adsorption from Gaseous Mixtures by a Mercury Surface Formed in the Mixture  
Phil. Mag. 6, 422-33 (1928)
452. Onnes, H. K., and Braak, C.; Isotherms of Hydrogen Between  $-104^{\circ}$  C and  $217^{\circ}$  C  
Communs. Phys. Lab. Univ. Leiden No. 97a (1906);  
99a, 100a (1907)
453. Onnes, H. K.; Isotherms of Helium at  $-253^{\circ}$  C and  $-259^{\circ}$  C  
Proc. Acad. Amsterdam, 10, 741-2 (1908)

454. Onnes, H. K.; Isotherms of Helium,  $+100^{\circ}\text{C}$  to  $-217^{\circ}\text{C}$   
Proc. Acad. Amsterdam 10, 445-50 (1908)
455. Onnes, H. K.; Investigations Carried Out in the Low  
Temperature Laboratory at Leiden  
Chem. Ztg. 34, 1373-4 (1910)
456. Onnes, H. K., and Crommelin, C. A.; Isotherms of Dia-  
tomic Substances and Their Binary Mixtures. XIII. Liquid  
Densities of Hydrogen Between the Boiling Point and the  
Triple Point; Contraction of Hydrogen on Freezing  
Communs. Phys. Lab. Univ. Leiden No. 137a (1913)
457. Onnes, H. K., Dorsman, C., and Holst, G.; Vapor Pressure  
and Critical Point of Oxygen and Nitrogen  
Verslag K. Akad. Wetenschappen 23, 982-5 (1914)
458. Onnes, H. K., and Weber, S.; Vapor Pressure of Substances  
of Low Critical Temperature at Low Temperatures  
Verslag Akad. Wetenschappen 22, 226-39 (1914)
459. Opfell, J. B.; A Detailed Study in the Application of the  
Benedict Equation to One Component Systems  
Ph.D. Thesis, California Tech. (1954)
460. Opfell, J. B., Schlinger, W. G., and Sage, B. H.; Benedict  
Equation of State - Applied to Methane, Ethane, M-Butane,  
and N-Propane  
Ind. Eng. Chem. 46, 1286-91 (1954)
461. Opfell, J. B., Sage, B. H., and Pitzer, K. S.; Application of  
Benedict Equation to Theorem of Corresponding States  
Ind. Eng. Chem. 48, 2069-76 (1956)
462. Ore, F., and Moulton, R. W.; Adsorption of Binary Hydro-  
carbon Mixtures on Activated Charcoal  
Trend in Eng. 7, No. 1., 24-9 (1955)
463. Paal, C., and Hartman, W.; Gaseometric Determination of  
Hydrogen by Catalytic Absorption  
Ber. 43, 243-58 (1910)

464. Paoluzi, G.; New Equation of State Applied to Methane Idrocarburi 5, No. 8, 31-2 (1956)
465. Paoluzi, G.; A New Equation of State Ricerca Sci. 25, 567-75 (1955)
466. Paoluzi, G.; The Equation of State for Gaseous Mixtures Chim. e Ind. (Milan) 39, 350-3 (1957)
467. Paoluzi, G.; New Isothermal Constant for Gases Ann. Geofis. (Rome) 10, 241-5 (1957)
468. Pavlovich, N. V., and Timrot, D. L.; Experimental Investigation of P V T Values of Gaseous and Liquid Methane Teploenergetika 5, No. 4, 69-75 (1958)
469. Pearce, J. N., and Johnstone, H. F.; Adsorption of the Vapors of Methane and Its Chlorine Derivatives by Charcoal J. Phys. Chem. 34, 1260-79 (1930)
470. Peter, S., and Weinert, M.; Solybility of Hydrogen, Carbon Monoxide, Carbon Dioxide, and Water Vapor in Liquid Hydrocarbons Z. Physik. Chem. (Frankfurt) N. F. 5, 114-21 (1955)
471. Peters, K., and Proksch, E.; The Kinetics of Adsorption of Gases Near Their Critical Temperature Z. Elektrochem. 61, 1241-6 (1957)
472. Petit, P.; Solybility of Nitrogen in Hydrogen Below the Critical Temperature of Nitrogen Compt. Rend. 246, 1171-2 (1957)
473. Peuss, J., and Beenakker, J. J. M.; Bestimmung Der Zweiten Virial Kochhizienten Biz von Gas Mischen Physica 22, 869-79 (1952)
474. Pfefferle, W. C., Jr., Goff, J. A., and Miller, J. G.; Compressibility of Gases. I. The Burnett Method An Improved Method of Treatment of Data. Extension of the Method to Gas Mixtures J. Chem. Phys. 23, 509-13 (1955)

475. Phillips, T. D.; Adsorption of Hydrogen  
Phys. Rev. 45, 215 (1934)
476. Pickering, S. R.; A Review of the Critical Constants of Various Gases  
J. Phys. Chem. 28, 97 (1924)
477. Pickering, S. F.; Compressibilities of Gases  
NBS, Miscellaneous Publ. No. 71 (Nov. 21, 1925)
478. Pickering, S. F.; A Review of the Literature Relating to the Critical Constants of Various Gases  
Nat. Bur. Standards Sci. Paper No. 541, 597-629 (1926)
479. Pietrusky, K.; Helium  
Chem. - Ztg. 61, 661-2 (1937)
480. Pietsch, H.; Determination of Very Small Amounts of Oxygen, Carbon Monoxide, Methane and Nitrogen in Purest Ethylene by Adsorption Chromatography  
Erdol v. Kohle 11, 157-9 (1958)
481. Pietsch, E., and Wilcke, G.; The Ionization Potential of Methane  
Z. Physik 43, 342-53 (1927)
482. Pings, C. J., Jr.; I. An Orthogonal Polynomial Equation of State. II. Application of the Benedict Equation of State to Methane - N-Pentane System  
Ph.D. Thesis California Tech. 1955
483. Pings, C. J., Jr., and Sage, B. H.; Benedict Equation of State - Methane-Pentane System  
Chem. and Eng. Data Ser. 1, No. 1, 56-62 (A56)
484. Pitzer, K. S., Lippman, D. F., Curl, J. R. F., Huggens, C. M., and Petersen, D. E.; Volumetric and Thermodynamic Properties of Fluids. II. Compressibility Factor, Vapor Pressure, and Entropy of Vaporization  
J. Am. Chem. Soc. 77 3433-40 (1955)
485. Pitzer, K. S.; Volumetric and Thermodynamic Properties of Fluids I. Theoretical Basis and Virial Coefficients  
J. Am. Chem. Soc. 77, 3427-33 (1955)

486. Piutti, A.; Adsorption of Carbon Monoxide  
Rend. Accad. Sci. Napoli 28, 91 (1922: Giorn. Chim. Ind.  
Applicata 5, 70-3 (1923)
487. Podgurski, H. H., and Emmett, P. H.; The Adsorption of  
Hydrogen and Carbon Monoxide on Iron Surfaces  
J. Phys. Chem. 57, 159-64 (1953)
488. Poettmann, F. H., and Katz, D. L.; Phase Behavior of  
Binary Carbon Dioxide - Paraffin Systems  
Ind. Eng. Chem. 37, 847-53 (1945)
489. Pollard, F. H.; The Adsorption of Carbon Monoxide and  
Hydrogen by Platinized Asbestos  
J. Phys. Chem. 27, 356-75 (1923)
490. Porter, F.; Vapour Pressures and Specific Volumes of  
Saturated Ethane Vapour  
J. Am. Chem. Soc. 48, 2055-58 (1926)
491. Porter, F.; High Vapour Pressures of Nitrogen  
J. Am. Chem. Soc. 48, 2059-60 (1926)
492. Prausnitz, J. M.; Fugacities in Simple Gas Mixtures  
Chem. Eng. Sci. 6, 112-15 (1957)
493. Prengle, H. W., Jr.; The Compressibility and Critical  
Constants of Propylene Vapor, the Compressibility of Ethane -  
Propylene  
Ph.D. Thesis: Carnegie Tech., (1949)
494. Prengle, H. W., Jr., and Marchman, H.; Compressibility of  
Ethane - Propylene Vapor Mixtures  
Ind. Eng. Chem. 42, 2371-4 (1950)
495. Price, A. R.; Low Temperature Vapor Liquid Equilibrium in  
Light Hydrocarbon Mixtures: Methane, Ethane and Propane  
Ph.D. Thesis; Rice Inst., (1957)
496. Price, D.; Thermodynamic Functions of Carbon Dioxide -  
Joule-Thompson Coefficient, Isochofic Heat Capacity, and  
Isentropic Behavior at 100 to 1000 and 50 to 1400 Bars  
Chem. and Eng. Data Ser. 1, No. 1, 83-6 (1956)

497. Prihotiko, A.; Absorption by Solid Mixtures of Oxygen - Nitrogen and Oxygen - Argon Between 2800 and 2400  
J. Exptl. Theoret. Phys. (U.S.S.R.) 8, 671-81 (1938)
498. Prihotiko, A., and Yaunel, A.; Investigations of Solid Mixtures of Oxygen and Nitrogen  
Acta. Physiochim. U.S.S.R. 11, 865-82 (1939)
499. Ray, G. C., and Box, E. O., Jr.; Adsorption of Gases on Activated Charcoal  
Ind. Eng. Chem. 42, 1315-18 (1950)
500. Reamer, H. H., Olds, R. H., Sage, B. H., and Lacey, W. N; Phase Equilibria in Hydrocarbon Systems. Methane - Carbon Dioxide System in the Gaseous Region  
Ind. Eng. Chem. 36, 88-90 (1944)
501. Reamer, H. H., Olds, R. H., Sage, B. H., and Lacey, W. N; Phase Equilibria in Hydrocarbon Systems. Volumetric Behaviour of Ethane  
Ind. Eng. Chem. 36, 956-58 (1944)
502. Reamer, H. H., Olds, R. H., Sage, B. H., and Lacey, W. N; Phase Equilibria in Hydrocarbon Systems. XLV. Volumetric Behavior of Ethane - Carbon Dioxide System  
Ind. Eng. Chem. 37, 688-91 (1945)
503. Reamer, H. H., Korpi, K. J., Sage, B. H., and Lacey, W. N; Phase Equilibria in Hydrocarbon Systems. Volumetric Behavior of Methane - Butane System at Higher Pressures  
Ind. Eng. Chem. 39, 206-9 (1947)
504. Reamer, H. H., Sage, B. H., and Lacey, W. N.; Phase Equilibria in Hydrocarbon Systems. Volumetric and Phase Behavior of the Methane - Propane System  
Ind. Eng. Chem. 42, 534-9 (1950)
505. Reamer, H. H., and Sage, B. H.; Volumetric and Phase Behavior of Propylene - Propane System  
Ind. Eng. Chem. 43, 1628-34 (1951)

506. Reamer, H. H., Sage, B. H., and Lacey, W. N.; Phase Equilibria in Hydrocarbon Systems. Volumetric and Phase Behavior of the Propane - Carbon Dioxide System  
Ind. Eng. Chem. 43, 2515-20 (1951)
507. Reamer, H. H., Selleck, F. T., Sage, B. H., and Lacey, W. N.; Phase Equilibria in Hydrocarbon Systems. Volumetric Behavior of the Nitrogen - Ethane System  
Ind. Eng. Chem. 44, 198-201 (1952)
508. Regak, N. Ya., and Smirnov, N. I.; A Study of Adsorption Processes. II. Adsorption of Unsaturated Gases by Activated Charcoal  
Zhur. Priklad. Khim. 28, 433-6 (1955)
509. Reimann, A. L.; Clean-Up of Various Gases by Magnesium, Calcium, and Borium  
Phil. Mag. 18, 1117-32 (1934)
510. Reis, Christof; Determination of the Heat of Vaporization of Saturated Hydrocarbons from the Vapor-Pressure Curves  
Chem. Tech. (Berlin) 1, 11-18 (1949)
511. Remy, H., and Hene, W.; The Adsorption of Gases by Active Charcoal  
Kolloid. Z. 61, 314-22 (1932)
512. Reyerson, L. H.; The Adsorption of Hydrogen by Silica Gel at Elevated Temperatures  
J. Am. Chem. Soc. 55, 3105-8 (1933)
513. Reyerson, L. H., and Swearingen, L. E.; Adsorption of Gases by Metallized Silica Gels  
J. Phys. Chem. 31, 88-101 (1927)
514. Reyerson, L. H., and Cines, M. R.; Adsorption of Propane and Propylene by Silica Gel and Metallized Silica Gel  
J. Phys. Chem. 46, 1060-8 (1942)
515. Reuss, J., and Beenakker, J. J. M.; Determination of the Second Virial Coefficient  $B_{12}$  for Mixtures of Gases  
Physica 22, 869 (1956); Leiden Comm. Suppl. No. 110e

516. Richardson, L. B.; Adsorption of Carbon Dioxide and Ammonia by Charcoal  
J. Am. Chem. Soc. 39, 1828-48 (1917)
517. Robin, Stephane; Study of the Solubility of Phenanthrene in Nitrogen Components up to 1200 kg/cm<sup>2</sup>; Effect of Temperature  
Compt. Rend. 231, 218-20 (1950)
518. Robin, S., and Vodar, B.; Interpretations of Some Measurements of Solubility in Compressed Gases  
J. Phys. Radium 13, 264-70 (1952)
519. Robin, S., and Vodar, B.; Solubility in Compressed Gases  
Discussions Faraday Soc. No. 15, 233-8 (1953)
520. Robinson, D. W.; An Experimental Determination of the Melting Curves of Argon and Nitrogen into the 10,000 Atmospheres Region  
Proc. Roy. Soc. (London) A225, 393-405 (1954)
521. Roper, E. E.; The Second Virial Coefficient of Ethane  
J. Chem. Phys. 8, 290 (1940)
522. Ross, S., and Winkler, W.; Physical Adsorption V; Two Dimensional Condensation of Ethane on Surfaces of Solids at 90°K  
J. Am. Chem. Soc. 76, 2637-40 (1954)
523. Rossini, F. D., et al; Selected Values of the Properties of Hydrocarbons  
NBS Cir. 461 (1947)
524. Rossini, F. D., et al; Selected Values of Physical and Thermodynamic Properties of Hydrocarbons and Related Compounds  
(Book) Carnegie Press (1953)
525. Rowe, H.; The Adsorption of Gases by Activated Charcoal at Very Low Pressures I. At Air Temperature  
Phil. Mag. 1, 109-31 (1926)

526. Rowe, H.; Adsorption of Carbon Dioxide by Activated Coconut Charcoal  
Phil. Mag. 1, 659-70 (1926)
527. Rowe, H.; The Adsorption of Gases by Activated Charcoal at Very Low Pressures II. At  $-183^{\circ}\text{C}$   
Phil. Mag. 1, 1042-54 (1926)
528. Rowlinson, J. S.; Reduced Equation of State  
Trans. Faraday Soc. 51, 1317-26 (1955)
529. Rowlinson, J. S., and Sutton, J. R.; The Statistical Thermodynamics of Solutions of Non-Spherical Molecules II. Liquid Vapor Equilibrium and the Formation of Azeotropes  
Proc. Roy. Soc. A229, 396 (1955)
530. Rozen, A. M.; The Calculations of Thermodynamic Quantities from Experimental P-V-T Data  
Zhur. Fiz. Khim. 27, 178-93 (1953)
531. Rozen, A. M.; Method of Deviation Coefficients in the Technical Thermodynamics of High Pressure  
J. Phys. Chem. (U.S.S.R.) 19, 469-84 (1945)
532. Rudenko, N. S.; Molecular Weight, Density and Viscosity of Liquefied Gases  
Zhur. Tekh. Fiz. 18, 1123-6 (1948)
533. Rudolf, G.; The Noble Gases and the Equation of State  
Ann. Physik. 29, 251-79 (1909)
534. Ruhemann, M.; Equilibrium Curves of Low-Melting Mixtures  
Physikal. Z. Soviet Union 67-82 Spec. No. (June 1936)
535. Ruhemann, M.; Two-Phase Equilibrium in Binary and Ternary Systems. I. The System Methane - Ethane  
Proc. Roy. Soc. (London) A171, 121-36 (1939)
536. Ruhemann, M., and Fedoritenko, A.; Equilibrium Diagrams of Helium - Nitrogen Mixtures  
Tech. Phys. U.S.S.R. 4, 36 (1939)

537. Ruhemann, M., and Fedoritenko, A.; The Use of the I-X Diagram (Heat Content vs. Composition) in the Separation of Helium and Nitrogen  
J. Chem. Ind. (U.S.S.R.) 14, 28-31 (1937)
538. Ruhemann, M., Likhter, A., and Komarov, P.; The Phase Diagram of Low-Melting Mixtures. II. The Melting Diagram of Oxygen - Nitrogen and the Phase Diagram of Nitrogen -  
Physik. Z. Soviet Union 8, 326-36 (1935)
539. Ruhemann, M., and Zinn, N.; The System Hydrogen - Nitrogen - Carbon Monoxide and the Scrubbing out of Carbon Monoxide  
Physik. Z. Soviet Union 12, 389-403 (1937)
540. Sage, B. H., and Lacey, W. N.; Phase Equilibria in Hydrocarbon Systems. The Methane - Ethane System in the Gaseous Region  
Ind. Eng. Chem. 31, 1497-1509 (1939)
541. Sage, B. H., and Lacey, W. N.; The Partial Volume and Its Significance  
Calif. Oil World 34, No. 22, 31-2, 34-5; No. 23, 16-17, 32 (1941)
542. Sage, B. H., and Lacey, W. N.; The Fugacity of Propene and 1-Butene  
Petroleum Refiner 29, No. 10, 123-7 (1950)
543. Sage, B. H., Olds, R. H., and Lacey, W. N.; Two Gaseous Mixtures Containing Hydrogen and Nitrogen Thermodynamic Properties  
Ind. Eng. Chem. 40, 1453-9 (1948)
544. Sage, B. H., Lacey, W. N., and Schaafsma, J. G.; Phase Equilibria in Hydrocarbon Systems. II. Methane - Propene System  
Ind. Eng. Chem. 26, 214-17 (1934)
545. Sage, B. H., Schaafsma, J. G., and Lacey, W. N.; Phase Equilibria in Hydrocarbon Systems V. Pressure - Volume - Temperature Relations and Thermal Properties of Propane  
Ind. Eng. Chem. 26, 1218 (1934)

546. Salvi, G., and Fiumara, A.; Absorption in the Measurement of Surface Area of Pourous Solids  
Riv. Combustibili 7, 345-91 (1953)
547. Snaiev, L. G.; Fugacity of Vaporous and Liquid Methane  
Org. Chem. Ind. (U.S.S.R.) 5, 350-3 (1938)
548. Satterly, J.; Physical Properties of Solid and Liquid Helium  
Rev. Modern Phys. 8, 347-57 (1936)
549. Saurel, J. R.; Equations of State and the Thermodynamic Properties of Compressed Gases  
Genie Chim. 79, 12-22, 44-51 (1958)
550. Savvina, IA. D., and Velikovskii, A. S.; Equilibrium Constants of Methane and Hydrocarbons of Various Groups in Binary Systems  
Gaz. Prom. No. 2: 26-30 (1957)  
Russ. Acces 10, No. 3, 702 (1957)
551. Schaeffer, W. D., Smith, W. R., and Wendell, C. B.; The Adsorption of Helium on Carbon Black at Liquid Helium Temperatures  
J. Am. Chem. Soc. 71, 863-7 (1949)
552. Schaefer, C. A., and Thodos, G.; Reduced Density Correlation for Hydrogen: Liquid and Gaseous States  
A.I.Ch.E. Journal 5, 155 (1959)
553. Schafer, K.; The Second Virial Coefficient of the Different Modifications of Light and Heavy Hydrogen I. Experimental Determination  
Z. Physik. Chem. B36, 85-104 (1937)
554. Schallamach, A.; X-Ray Investigation of the Structure Transition of Methane at the Lambda Point  
Proc. Roy. Soc. (London) A171, 569 (1939)
555. Schames, L.; Direct Relationship of Equation of State and Internal Friction of Nitrogen, Helium, Neon, Hydrogen, Air, Argon, and Oxygen  
Physik. Z. 32, 16-20 (1931)

556. Schamp, H. W., Jr., Mason, E. A., Richardson, A. C. B., and Altman, A.; Compressibility and Intermolecular Forces in Gases: Methane  
Phys. Fluids 1, 329-37 (1958)
557. Schay, G., Szekely, Gy., and Szigetvary, G.; Adsorption of Gas Mixtures II. New Chromatographic Method for Determination of Mixed Adsorption; Adsorption of Carbon Dioxide-Acetylene Mixtures on Charcoal  
Acta Chim. Acad. Sci. Hung 12, 309-23 (1957)
558. Schiller, F. C., and Canjar, L. N.; An Equation of State for Carbon Monoxide Vapor - Liquid Equilibria for the Nitrogen - Carbon Monoxide System  
Chem. Eng. Prog. Symposium Ser. 49, No. 7, Appl. Thermodynamics 67-72 (1953)
559. Schneider, W. G., and Maass, O.; Phase Equilibria in the Two-Component System: Ethylene - Propylene, in the Critical-Temperature Region  
Can. J. Research 19, 231-40 (1941)
560. Scott, G. A.; Isotherms of Hydrogen, Carbon Monoxide, and Their Mixtures  
Proc. Roy. Soc. (London) A125, 330-44 (1929)
561. Scott, R. B., Brickwedde, F. G., Urey, H. C., and Wahl, M. H.; The Vapor Pressures and Derived Thermal Properties of Hydrogen and Deuterium  
J. Chem. Phys. 2, 454 (1934)
562. Scott, R. B., and Brickwedde, F. G.; Molecular Volumes and Expansivities of Liquid Normal Hydrogen and Parahydrogen  
J. Research NBS 19, 237 (1937)
563. Seeliger, R.; The Absorption of Gases by Crystals  
Physik. Z. 22, 563 (1921)
564. Shearn, R. B.; The Volumetric and Phase Behavior of the Propane - Ethylene - Carbon Dioxide System  
Ph.D. Thesis, Birmingham (1955)

565. Shull, C. G., Elkin, P. B., and Roess, L. C.; Physical Studies of Gen Microstructure  
J. Am. Chem. Soc. 70, 1410-14 (1948)
566. Simon, F., Ruhemann, M., and Edwards, W. A. M.; Melting Point Curves of Hydrogen, Neon, Nitrogen and Argon  
Z. Phys. Chem. 6, 331 (1929)
567. Smith, H. A., and Vaughan, W. E.; Ethane - Ethylene - Hydrogen Equilibrium  
J. Chem. Physics 3, 341-3 (1935)
568. Smith, S. R.; I. Gas-Liquid Phase Equilibria in the System Helium - Hydrogen. II. Development of Mass Spectrometer Techniques for Analysis of Helium - Hydrogen and Their Isotopes  
Ph.D. Thesis, Ohio State (1952)
569. Steacie, E. W. R., and Stovel, H. V.; Rate of Adsorption of Ethylene by Silica Gel and Nickel  
J. Chem. Phys. 2, 581-4 (1934)
570. Steckel, F.; Dew and Boiling Points for Mixtures of Nitrogen with Carbon Monoxide at Pressures up to 17 Atmospheres  
J. Tech. Phys. (U.S.S.R.) 6, 137-40 (1936)
571. Steckel, F.; Dew-and Boiling-Point Curves of Nitrogen - Carbon Monoxide Mixtures up to 17 Atmospheres  
Physik. Z. Soviet Union 8, 337-41 (1935)
572. Steckel, F., and Tsin, N. M.; Determination of the Component Diagram for the Liquid-Gas System Methane - Nitrogen - Hydrogen  
J. Chem. Ind. (U.S.S.R.) 16, No. 8, 24-8 (1939)
573. Sterne, T. E.; The Vapor Pressure Constant of Methane  
Phys. Rev. 42, 556-64 (1932)
574. Stevenson, R.; Compressions and Solid Phases of Carbon Dioxide, Carbon Disulfide, Carbonyl Sulfide, Oxygen, and Carbon Monoxide at Low Temperatures  
J. Chem. Phys. 27, 673-5 (1957)

575. Stewart, W. C., and Nielsen, R. F.; Phase Equilibria for Mixtures of Carbon Dioxide and Several Normal Saturated Hydrocarbons  
Penna. State Univ., State Coll., Pa., Mineral Inds. Expt. Sta. Bull. 62, 9-18 Seventeenth Tech. Conf. on Petroleum Production (1953)
576. Stewart, J. W., and Swenson, C. A.; Compression to 10,000 Atmospheres of Solid Nitrogen and Oxygen at 4.2° K  
Phys. Rev. 94, 1069-70 (1954)
577. Stewart, J. W.; Compressibilities of Some Solidified Gases at Low Temperature  
Phys. Rev. 97, 578-82 (1955)
578. Stewart, J. W., and LaRock, R. I.; Compression and Densities of 4 Solidified Hydrocarbons and Carbon Tetrafluoride at 77° K  
J. Chem. Phys. 28, 425-7 (1958)
579. Stock, A., Henning, F., and Kuss, E.; Vapor Pressure Tables for Determinations Between +25° and -185°  
Ber. 54B, 1119-29 (1921)
580. Storfer, E.; Heterogeneous Catalysis. I. Activated Adsorption of Hydrogen on Charcoal  
Z. Elektrochem. 41, 198-204 (1935)
581. Stotler, H. H., and Benedict, M.; Correlation of Nitrogen - Methane Vapor - Liquid Equilibria by Equation of State  
Chem. Eng. Prog. Sympos. Ser. 49, No. 6, Phase - Equilibria, Coll. Res. Papers for 1953, 25-36 (1953)
582. Strehlow, R. A.; Method of Extrapolating Equation-of-State Data to Higher Temperatures  
J. Chem. Phys. 23, 1562 (1955)
583. Stroud, L., Miller, J. E., and Brandt, H. W.; An Experimental Study of the Phase Relationships of a Typical Helium Conservation Gas  
Open File Supplement, Bur. Mines, (August 6, 1959)

584. Stutzman, L. F., and Brown, G. F.; Low Temperature Vapor-Liquid Equilibrium I.; Phase Equilibrium in Natural Gas at Low Temperatures  
Chem. Eng. Prog. 45, 139 (1949)
585. Su, G. J., and Chang, C. H.; Generalized Beattie - Bridgeman Equation of State for Real Gases  
J. Am. Chem. Soc. 68, 1080-3 (1946)
586. Su, G. J., and Chang, C. H.; Generalized Equation of State of Real Gases  
Ind. Eng. Chem. 38, 800-2 (1946)
587. Su, G. J., Huang, P. H., and Chang, Y. M.; The Compressibilities of Gas Mixtures  
J. Am. Chem. Soc. 68, 1403-4 (1946)
588. Swenson, C. A.; The Catalysis of the Ortho-Para Conversion in Liquid Hydrogen  
J. Chem. Phys. 18, 520-2 (1950)
589. Szulcyewski, D. H.; Gas Chromatographic Separation of Some Permanent Gases on Silica Gel at Reduced Temperatures  
Anal. Chem. 29, 1541 (1957)
590. Tanner, C. C., and Masson, I.; The Pressure of Gaseous Mixtures III.  
Proc. Roy. Soc. (London) A126, 268-88 (1930)
591. Taramasso, M.; Vapor - Phase Chromatography of Gaseous Hydrocarbons  
Ricerca Sic. 26, 887-8 (1956)
592. Thomas, W.; Second Virial Coefficients of Argon, Krypton, Xenon, Nitrogen and Carbon Dioxide in the 0 to 1200 Temperature Region  
Z. Physik 147, 92-8 (1957)
593. Tickner, A. W., and Lossing, F. P.; Mass Spectrometer Measurements of Low Vapor Pressures  
J. Chem. Phys. 18, 148 (1950)

594. Tickner, A. W., and Lossing, F. P.; Measurements of Low Vapor Pressure by Means of a Mass Spectrometer  
J. Phys. and Colloid Chem. 55, 733 (1951)
595. Titov, A.; The Adsorption of Gases on Charcoal  
Z. Physik. Chem. 74, 641-78 (1910)
596. Torocheshnikov, N. S.; Isotherms and Isobars of the Nitrogen - Carbon Monoxide System  
Journ. Techn. Phys. (Russian) 7, 1107 (1937)
597. Torocheshnikov, N. S.; Isotherms and Isobars of the Nitrogen - Carbon Monoxide System  
Tech. Phys. U.S.S.R. 4, No. 5, 365-9 (1937)
598. Torocheshnikov, N. S., and Levius, L. A.; Liquid-Vapor Equilibrium in the System Nitrogen - Methane  
J. Chem. Ind. (U.S.S.R.) 16, No. 1, 19-22 (1939)
599. Torocheshnikov, N. S., and Levius, M.; Liquid Vapor Equilibrium in the System Nitrogen - Methane  
Zh. Khim. Prom. 18, No. 5, 7 (1941)
600. Torocheshnikov, N. S., and Sernenova, V. A.; Equilibrium Liquid-Vapor in the System Hydrogen - Methane - Nitrogen - Carbon Monoxide  
Trudy Moxkov. Khim. - Tekhnol. Inst. No. 18, 115-17 (1954)
601. Townend, D. T. A., and Bhatt, L. A.; Isotherms of Hydrogen, Carbon Monoxide and Their Mixture  
Proc. Roy. Soc. (London) A134, 502-12 (1931)
602. Trautz, M., and Badstubner, W.; Calculation of the Specific Heats of Gases from Vapor-Pressure Cruves  
Ann. Physik. 8, No. 5, 185-202 (1931)
603. Tsiklis, D. S.; Limited Mutual Solubility of Gases Under High Pressure in the Systems Helium - Ammonia and Helium - Carbon Dioxide  
Doklady Akad. Nauk U.S.S.R. 86, 1159-61 (1952)

604. Tsiklis, D. S.; Limited Mutual Solubilities of Gases at High Pressure in the Helium - Propane System  
Doklady Akad. Nauk U.S.S.R. 101, 129-30 (1955)
605. Tsiklis, D. S.; Heterogeneous Equilibria in Binary Systems  
J. Phys. Chem. (U.S.S.R.) 20, 181-8 (1946)
606. Tsiklis, D. S.; Heterogeneous Equilibria in Binary Systems  
Systems Ethylene - Carbon Dioxide and Ethylene - Nitrogen  
J. Phys. Chem. (U.S.S.R.) 21, 355-9 (1947)
607. Tsin, N. M.; Solubility of Ethylene and Propylene in Liquid Nitrogen and Liquid Oxygen  
J. Phys. Chem. Russ. 14, 418-21 (1940)
608. Trzeciak, Max; P V T Relationships of Gaseous Normal Deuterium and Three Hydrogen - Nitrogen Mixtures  
Ph.D. Thesis, Ohio State Univ. (1954)
609. Turvizumi, A.; Porous Structure of Active Carbons. IV. Adsorption of Nitrogen, Methane, Carbon Dioxide, and Ethylene  
Nippon Kagaku Zasshi 80, 221-4 (1959)
610. Ubbelohde, A. R.; Kinetics of Adsorption Processes. III. Influence of Nuclear Spin on Sorption of Hydrogen on Charcoal  
Trans. Faraday Soc. 28, 291-9 (1932)
611. Ubbelohde, A. R., and Egerton, A.; The Kinetics of Adsorption Processes  
Proc. Roy. Soc. (London) A134, 512-23 (1931)
612. Uehara, K.; Gas Mixtures of Low Hydrocarbons. II. Solubilities of Hydrogen and Methane in Liquid Ethane  
J. Chem. Soc. Japan 53, 931-2 (1932)
613. Uhlenbeck, G. E., and Beth, E.; Quantum Theory of the Nonideal Gas. I. Deviations from the Classical Theory  
Physica 3, 729-45 (1936)
614. Urry, W. D.; Adsorption with Silica Gel at Low Temperatures  
J. Phys. Chem. 36, 1831-45 (1932)

615. Vagin, E. Y., and Zhukhovitskii, A. A. Theory of Thermal Separation of Gas Mixtures by the Adsorption Method  
Doklady Akad. Nauk U.S.S.R. 94, 273-6 (1954)
616. Van Der Waarden, M., and Scheffer, F. E. C.; Adsorption of Nitrogen, Hydrogen and Their Mixtures on Silica Gel  
Rec. Trav. Chim. Phys - Bas, 71, 689-98 (1952)
617. Van Dijk, H., and Shoenberg, D.; Tables of Vapor Pressure of Liquid Helium  
Nature 164, 151 (1949)
618. Van Dingenen, W., and Van Itterbeek, A.; Measurements of the Adsorption of Light and Heavy Hydrogen on Charcoal Between  $90^{\circ}$  and  $17^{\circ}$  K  
Physica 6, 49-58 (1939)
619. Van Itterbeek, A.; The Dependency of  $C_p/C_v$  on Pressure for Hydrogen Gas Deduced from Measurements of the Velocity of Sound at Liquid - Hydrogen Temperatures  
Commun. Phys. Lab. Univ. Leiden, Supp. 70b, 7-12 (1932)
620. Van Itterbeek, A., Van Dingenen, W., and Borghs, J.; Measurements of the Adsorption of Helium Gas on Active Charcoal Between  $4.22^{\circ}$  K and  $1.78^{\circ}$  K  
Physica 6, 951-60 (1939)
621. Van Itterbeek, A., Van Dingenen, W., and Borghs, J.; Adsorption of Helium Gas on Active Charcoal Between  $4.2^{\circ}$  and  $1.78^{\circ}$  K  
Nature 144, 249 (1939)
622. Van Itterbeek, A., and Borghs, J.; The Van der Waals Adsorption of Gases  
Z. Physik. Chem. B50, 128-42 (1942)
623. Van Itterbeek, A., and Vereycken, W.; Further Experiments on the Simon Desorption Method Between Temperatures of  $90$  and  $40^{\circ}$  K  
Physica 3, 954-8 (1936)
624. Van Itterbeek, A., and Van Dingenen, W.; Determination of Adsorption Isotherms of Hydrogen on Charcoal Between  $90$  and  $50^{\circ}$  K, in Connection with Desorption Experiments  
Physica 4, 389-402 (1937)

625. Van Itterbeek, A., and Van Dingenen, W.: Adsorption Isotherms and Heats of Adsorption of Oxygen and Carbon Monoxide on Charcoal in the Temperature Range 50 to 90°K  
*Physica* 4, 1169-80 (1937)
626. Van Itterbeek, A., and Van Ginenen, W.; Adsorption Isotherms and Heats of Adsorption of Helium on Charcoal Between 20 and 6°K. New Desorption Experiments  
*Physica* 5, 529-40 (1938)
627. Van Laar, J. J.; The Critical Density of Hydrogen, Helium and Neon  
*Chem. Weekblad.* 16, 1557-64 (1919)
628. Van Lerberghe, B., and Schouls, G.; Characteristic Equation of a Binary Mixture of Gases  
*Bull. Sci. Acad. Roy. Belg.* 15, 583-9 (1929)
629. Van Ness, H. C.; Use of the Redlich and Kwong Equation of State in Calculating Thermodynamic Properties of Gases from Experimental Compressibility Data  
*A.I.Ch.E. Journal* 1, 100-4 (1955)
630. Van Urk, A. T.; Behaviour of Nitrogen According to the Law of Corresponding States  
*Proc. Fourth Intern. Congress Refrigeration* 1, 79-80A  
Leiden Comm. No. 169 (1924)
631. Varshni, Y. P., and Srivastave, S. N.; Additive Function of Critical Pressures  
*Sci. and Culture (Calcutta)* 19, 308 (1953)
632. Vasil'ev, B. N., Bering, B. P., Dubinin, M. M., and Serpinskii, V. V.; Adsorption at High Pressures  
*Doklady Akad. Nauk U.S.S.R.* 114, 131 (1957)
633. Uehara, K.; The Gas Mixtures of Lower Hydrocarbons. V. Adsorption of the Gas Mixtures  
*J. Chem. Soc. Japan* 60, 1149-58 (1939)
634. Veinik, A. I.; The Equation of State of Argon Gas  
*Doklady Akad. Nauk Bloruss U.S.S.R.* 1, No. 1, 7-11 (1957)

635. Vellinger, E., and Pons, E.; The Solubility of Nitrogen in Liquid Methane and Propane  
Compt. Rend. 217, 689-91 (1943)
636. Verschaffelt, J. E.; Researches on the Compressibility and Condensation of Mixtures of Carbon Dioxide and Hydrogen  
Arch. Neerland. Sci. Inact. Nat. 11, 358 (1906)
637. Verschoyle, T. T. H.; The Ternary System: Carbon Mono-oxide - Nitrogen - Hydrogen and the Component Binary Systems Between Temperatures of  $-185^{\circ}$  and  $-215^{\circ}$  and Between Pressures of 0 and 225 Atmospheres  
Trans. Roy. Soc. (London) A230, 189-220 (1931)
638. Verschoyle, T. T. H.; Isotherms of Hydrogen, Nitrogen, and Hydrogen - Nitrogen Mixtures at  $0^{\circ}$  and  $20^{\circ}$  up to a Pressure of 200 Atmospheres
639. Volova, L. M.; Equilibrium of Coexisting Liquid and Gas Phases in the Binary System Methane - Ethylene  
J. Phys. Chem. (U.S.S.R.) 14, 268-76 (1940)
640. Von Antropoff, A., Propfe, H. A., Weil, K., Kalthoff, F., Schmitz, L., and Von Cronenthal, G. R. H.; Adsorption of Gases at Lowest to Highest Pressures III. Adsorption Isotherms of the Rare Gases and Nitrogen at Pressures Below Atmospheric  
Kolloidzshr 129, 1-10 (1952)
641. Von Antropoff, A., Propfe, H. A., Weil, K., Kalthoff, F., Schmitz, L., and Von Cronenthal, G. R. H.; Adsorption of Gases at Lowest to Highest Pressures. IV. Adsorption Isotherms of Argon and Nitrogen up to Pressures of 400 kg/cm<sup>2</sup>  
Kolloidzshr 129, 11-19 (1952)
642. Vyakhirev, D. A., Bruk, A. I., and Guglina, S. A.; Volumetric - Chromatographic Method of Gas Analysis  
Doklady Akad. Nauk U.S.S.R. 90, 577-9 (1953)
643. Vyakhiren, D. A., and Reshetnikova, L. E.; Chromatographic Study of Static Ethane Adsorption  
Uchenye Zapiski Gor'kovsk, Univ. 1953, No. 24, 191-209, Referat, Zhur. Khim, 1955 No. 7254

644. Wagener, S.; Adsorption Measurements at Very Low Pressures. II.  
J. Phys. Chem. 61, 267-71 (1957)
645. Walters, C. J.; Charcoal Adsorption Equilibria for Light Hydrocarbons  
Ind. Eng. Chem. 47, 2544-7 (1955)
646. Wang, D. I. J.; Vapor - Liquid Equilibria Studies on the System Argon - Oxygen  
Proc. of 1957 Cryog. Engr. Conf. 294, (1957)
647. Watson, G. M., Stevens, A. B., Evans, R. B., III, and Hodges, D., Jr.; Compressibility Factors of Nitrogen - Propane Mixtures in the Gas Phase  
Ind. Eng. Chem 46, 362-4 (1954)
648. Webster, T. J.; The Influence of Pressure on the Equilibria Between Carbon Dioxide and Air  
Proc. Roy. Soc. London A214, 61-71 (1951)
649. Weinaug, C. F., and Katz, D. L.; Surface Tensions of Methane - Propane Mixtures  
Ind. Eng. Chem. 35, 239 (1943)
650. Weingaertner, E.; Sorption Equilibria of Methane, Ethane and Propane with Active Carbon Above and Below the Critical Temperature  
Z. Elektrochem 42, 599-606 (1936)
651. Weishaupr, J.; Determination of the Phase Equilibria of Nitrogen - Argon - Oxygen Mixtures at a Pressure of 1000 Tarc. (1000 mm Hg)  
Angrew. Chem. B20, 321-6 (1948)
652. Weiss, P.; Equation of State of Fluids. Negative Internal Pressure at High Temperature  
Compt. Rend. 200, 1700-2 (1935)
653. Wenzel, L. A.; Low - Temperature Distillation  
Chem. Eng. Prog. 53, 272-7 (1957)

654. White, David; Second Virial Coefficients of Non Polar Binary Gas Mixtures  
Bull. Eng. Expt. Stat. Ohio State Univ. (June 12, 1952)
655. White, D., Friedman, A. S., and Johnston, H. L.; Direct Determination of the Critical Temperature and Critical Pressure of Normal Hydrogen  
J. Am. Chem. Soc. 72, 3565 (1950)
656. White, D., Friedman, A. S., and Johnston, H. L.; The Vapor Pressure of Normal Hydrogen from the Boiling Point to the Critical Point  
J. Am. Chem. Soc. 72, 3927-30 (1950)
657. White, D., Friedman, A. S., and Johnston, H. L.; The Critical Temperature and Critical Pressure of Nitrogen  
J. Am. Chem. Soc. 73, 5713-15 (1951)
658. White, D., Friedman, A. S., and Johnston, H. L.; Low Pressure P-V-T Data of Gaseous Hydrogen from the Boiling Point to Room Temperature  
T.R. 264-12 (1951) Cry. Lab., Ohio State Univ.
659. Widdoes, L. C., and Katz, D. L.; Vapor-Liquid Equilibrium Constants for Carbon Monoxide  
Ind. Eng. Chem. 40, 1742-6 (1948)
660. Wiebe, R., Gaddy, V. L., and Heins, C., Jr.; Compressibility Isotherms of Helium at Temperatures from  $-70^{\circ}$  to  $200^{\circ}$  and at Pressures to 1000 Atmospheres  
J. Am. Chem. Soc. 53, 1721-5 (1931)
661. Wiebe, R., and Gaddy, V. L.; The Compressibilities of Hydrogen and Four Mixtures of Hydrogen and Nitrogen at  $0^{\circ}$ ,  $25^{\circ}$ ,  $50^{\circ}$ ,  $100^{\circ}$ ,  $200^{\circ}$ , and  $300^{\circ}$  and to 1000 Atmospheres  
J. Am. Chem. Soc. 60, 2300-3 (1938)
662. Williams, George B., Jr.; P V T Relationships and Phase Equilibria in the System Ethylene - N-Butane  
Ph.D. Thesis U. of Mich. (1949)
663. Williams, R. B., and Katz, D. L.; Vapor - Liquid Equilibria in Binary Systems. Hydrogen with Ethylene, Ethane, Propylene and Propane  
Ind. Eng. Chem. 46, 2512-20 (1954)

664. Wilson, R. E.; Adsorption of Nitrogen and Oxygen by Charcoal  
Phys. Rev. 16, 8-16 (1920)
665. Winkler, O.; Absorption of Gases at Low Pressure by Active Carbon and Silica Gel  
Z. Tech. Physik 14, 319-332 (1933)
666. Wirth, H.; Separation of Gases by Sorption Processes. II.  
Monatsh. 84, 741-50 (1953)
667. Woolley, H. W.; Thermodynamic Properties of Gaseous Nitrogen  
Natl. Bur. Standards (U.S.) Report 2287 (March 1953)
668. Woolley, H. W.; Vapor Pressure of Parahydrogen and Orthohydrogen Mixtures  
Natl. Bur. Standards Report 3253 (April 15, 1954)
669. Woolley, H. W., Scott, R. B., and Brickwedde, F. G.;  
Compilation of Thermal Properties of Hydrogen in Its Various Isotopic and Ortho-Para Modifications  
J. Research NBS 41, 379 (1948)
670. Woolsey, G.; Critical Constants of the Inert Gases and of Hydrogen Compounds Having the Same Number of Electrons per Molecule  
J. Am. Chem. Soc. 59, 1577-8 (1937)
671. Wroblewski, M. S. de; Sur les Proprietes die gas des marais liquide et sur son employe comme refrigerant  
On the Properties of Liquid Methane and Its Use as a Refrigerant  
Compt. Rend. 99, 136-9 (1994)
672. Wylie, L. M.; The Vapor Pressure of Solid Argon, Carbon Monoxide, Methane, Nitrogen, and Oxygen from Their Triple Points to the Boiling Point of Hydrogen  
M. S. Thesis, Georiga Inst. of Tech. (1958)
673. Yasui, E., and Suzuki, H.; Determination of Small Amounts of Hydrocarbons and Carbon Dioxide Contained in Air, Oxygen, or Nitrogen by Use of Silica Gel Under Cooling with Liquid Oxygen  
Kogyo Kagaku Zasshi 60, 260-5 (1957)

674. Young, J. A.; Some Thermodynamic Studies of Binary Liquid Mixtures of Carbon Monoxide and Methane  
B. Sc. Thesis, Oxford, New College (1954)
675. Zaalishvili, Sh. D.; A Modified Theorem of Corresponding States for Gas Mixtures and Its Test on Hydrocarbon Mixtures II.  
Zhur. Fiz. Khim. 26, 970-6 (1952)
676. Zelany, J., and Smith, R. H.; Vapor Pressures of Carbon Dioxide at Low Temperatures  
Phys. Rev. 24, 42 (1907)
677. Zickermann, C.; Adsorption of Gases on Solid Surfaces at Low Temperatures  
Z. Physik 88, 43-54 (1934)
678. Zielinski, E.; Separation of Helium - Neon - Nitrogen Mixtures by a Combination Adsorption and Desorption Method  
Przemyst Chem. 13, 642-6 (1957)
679. Ziegler, W. T.; The Vapor Pressure of Some Hydrocarbons in the Liquid and Solid State at Low Temperatures  
NBS Tech. Note No. 4, PB 151363 (1959)
680. Zlunitsyn, S. A., and Rudenko, N. S.; Compressibility of Hydrogen at Low Temperatures  
J. Exptl. Theoret. Phys. (U.S.S.R.) 16, 776-9 (1946)
681. Zwanzig, R. W., Kirkwood, J. G., Stripp, K. F., and Oppenheim, I.; Errata: Radial Distribution Functions and the Equation of State of Monatomic Fluids  
J. Chem. Phys. 22, 1625 (1954)