
THE PROPERTIES OF GASES AND LIQUIDS

Bruce E. Poling

*Professor of Chemical Engineering
University of Toledo*

John M. Prausnitz

*Professor of Chemical Engineering
University of California at Berkeley*

John P. O'Connell

*Professor of Chemical Engineering
University of Virginia*

Fifth Edition

McGRAW-HILL

New York San Francisco Washington, D.C. Auckland Bogotá
Caracas Lisbon London Madrid Mexico City Milan
Montreal New Delhi San Juan Singapore
Sydney Tokyo Toronto

CONTENTS

Preface vii

Chapter 1 The Estimation of Physical Properties 1.1

- 1-1 Introduction / 1.1
- 1-2 Estimation of Properties / 1.3
- 1-3 Types of Estimation / 1.3
- 1-4 Organization of the Book / 1.6

Chapter 2 Pure Component Constants 2.1

- 2-1 Scope / 2.1
- 2-2 Vapor-Liquid Critical Properties / 2.2
- 2-3 Acentric Factor / 2.23
- 2-4 Boiling and Freezing Points / 2.26
- 2-5 Discussion of Estimation Methods for Pure Component Constants / 2.33
- 2-6 Dipole Moments / 2.34
- 2-7 Availability of Data and Computer Software / 2.35

Chapter 3 Thermodynamic Properties of Ideal Gases 3.1

- 3-1 Scope and Definitions / 3.1
- 3-2 Estimation Methods / 3.5
- 3-3 Method of Joback / 3.6
- 3-4 Method of Constantinou and Gani (CG) / 3.8
- 3-5 Method of Benson [1968; 1969] / 3.14
- 3-6 Discussion and Recommendations / 3.46
- 3-7 Heat of Combustion / 3.47

Chapter 4 Pressure-Volume-Temperature Relationships of Pure Gases and Liquids 4.1

- 4-1 Scope / 4.1
- 4-2 Introduction to Volumetric Properties / 4.1
- 4-3 Corresponding States Principle / 4.5
- 4-4 Equations of State / 4.8
- 4-5 Virial Equation of State / 4.11
- 4-6 Analytical Equations of State / 4.17
- 4-7 Nonanalytic Equations of State / 4.25
- 4-8 Discussion of Equations of State / 4.31
- 4-9 PVT Properties of Liquids—General Considerations / 4.32

- 4-10 Estimation of the Liquid Molar Volume at the Normal Boiling Point / 4.33
- 4-11 Saturated Liquid Densities as a Function of Temperature / 4.35
- 4-12 Compressed Liquid Densities / 4.43

Chapter 5 Pressure-Volume-Temperature Relationships of Mixtures **5.1**

- 5-1 Scope / 5.1
- 5-2 Mixture Properties—General Discussion / 5.2
- 5-3 Corresponding States Principle (CSP): The Pseudocritical Method / 5.5
- 5-4 Virial Equations of State for Mixtures / 5.8
- 5-5 Analytical Equations of State for Mixtures / 5.12
- 5-6 Nonanalytic Equations of State for Mixtures / 5.18
- 5-7 Discussion of Mixture Equations of State / 5.22
- 5-8 Densities of Liquid Mixtures at Their Bubble Point / 5.23
- 5-9 Densities of Compressed Liquid Mixtures / 5.26

Chapter 6 Thermodynamic Properties of Pure Components and Mixtures **6.1**

- 6-1 Scope / 6.1
- 6-2 Fundamental Thermodynamic Relationships for Pure Components / 6.1
- 6-3 Departure Functions for Thermodynamic Properties / 6.4
- 6-4 Evaluation of Departure Functions for Equations of State / 6.6
- 6-5 Heat Capacities of Real Gases / 6.16
- 6-6 Heat Capacities of Liquids / 6.17
- 6-7 Partial Properties and Fugacities of Components in Mixtures / 6.26
- 6-8 True Critical Points of Mixtures / 6.30

Chapter 7 Vapor Pressures and Enthalpies of Vaporization of Pure Fluids **7.1**

- 7-1 Scope / 7.1
- 7-2 Theory / 7.1
- 7-3 Correlation and Extrapolation of Vapor-Pressure Data / 7.3
- 7-4 Ambrose-Walton Corresponding-States Method / 7.7
- 7-5 Riedel Corresponding-States Method / 7.9
- 7-6 Discussion and Recommendations for Vapor-Pressure Estimation and Correlation / 7.11
- 7-7 Enthalpy of Vaporization of Pure Compounds / 7.13
- 7-8 Estimation of ΔH_v from Vapor-Pressure Equations / 7.14
- 7-9 Estimation of ΔH_v from the Law of Corresponding States / 7.16
- 7-10 ΔH_v at the Normal Boiling Point / 7.19
- 7-11 Variation of ΔH_v with Temperature / 7.23
- 7-12 Discussion and Recommendations for Enthalpy of Vaporization / 7.24
- 7-13 Enthalpy of Fusion / 7.25
- 7-14 Enthalpy of Sublimation; Vapor Pressures of Solids / 7.28

Chapter 8 Fluid Phase Equilibria in Multicomponent Systems **8.1**

- 8-1 Scope / 8.1
- 8-2 Thermodynamics of Vapor-Liquid Equilibria / 8.9

8-3	Fugacity of a Pure Liquid / 8.11
8-4	Simplifications in the Vapor-Liquid Equilibrium Relation / 8.12
8-5	Activity Coefficients; Gibbs-Duhem Equation and Excess Gibbs Energy / 8.12
8-6	Calculation of Low-Pressure Binary Vapor-Liquid Equilibria with Activity Coefficients / 8.19
8-7	Effect of Temperature on Low-Pressure Vapor-Liquid Equilibria / 8.22
8-8	Binary Vapor-Liquid Equilibria: Low-Pressure Examples / 8.23
8-9	Multicomponent Vapor-Liquid Equilibria at Low Pressure / 8.32
8-10	Determination of Activity Coefficients / 8.42
8-11	Phase Equilibrium with Henry's Law / 8.111
8-12	Vapor-Liquid Equilibria with Equations of State / 8.120
8-13	Solubilities of Solids in High-Pressure Gases / 8.158
8-14	Liquid-Liquid Equilibria / 8.159
8-15	Phase Equilibria in Polymer Solutions / 8.177
8-16	Solubilities of Solids in Liquids / 8.180
8-17	Aqueous Solutions of Electrolytes / 8.191
8-18	Concluding Remarks / 8.193

Chapter 9 Viscosity

9.1

9-1	Scope / 9.1
9-2	Definitions of Units of Viscosity / 9.1
9-3	Theory of Gas Transport Properties / 9.2
9-4	Estimation of Low-Pressure Gas Viscosity / 9.4
9-5	Viscosities of Gas Mixtures at Low Pressures / 9.15
9-6	Effect of Pressure on the Viscosity of Pure Gases / 9.29
9-7	Viscosity of Gas Mixtures at High Pressures / 9.47
9-8	Liquid Viscosity / 9.51
9-9	Effect of High Pressure on Liquid Viscosity / 9.55
9-10	Effect of Temperature on Liquid Viscosity / 9.56
9-11	Estimation of Low-Temperature Liquid Viscosity / 9.59
9-12	Estimation of Liquid Viscosity at High Temperatures / 9.75
9-13	Liquid Mixture Viscosity / 9.77

Chapter 10 Thermal Conductivity

10.1

10-1	Scope / 10.1
10-2	Theory of Thermal Conductivity / 10.1
10-3	Thermal Conductivities of Polyatomic Gases / 10.2
10-4	Effect of Temperature on the Low-Pressure Thermal Conductivities of Gases / 10.18
10-5	Effect of Pressure on the Thermal Conductivities of Gases / 10.18
10-6	Thermal Conductivities of Low-Pressure Gas Mixtures / 10.29
10-7	Thermal Conductivities of Gas Mixtures at High Pressures / 10.35
10-8	Thermal Conductivities of Liquids / 10.42
10-9	Estimation of the Thermal Conductivities of Pure Liquids / 10.44
10-10	Effect of Temperature on the Thermal Conductivities of Liquids / 10.51
10-11	Effect of Pressure on the Thermal Conductivities of Liquids / 10.52
10-12	Thermal Conductivities of Liquid Mixtures / 10.56

Chapter 11 Diffusion Coefficients

11.1

11-1	Scope / 11.1
------	--------------

11-2	Basic Concepts and Definitions	/ 11.1
11-3	Diffusion Coefficients for Binary Gas Systems at Low Pressures: Prediction from Theory	/ 11.5
11-4	Diffusion Coefficients for Binary Gas Systems at Low Pressures: Empirical Correlations	/ 11.9
11-5	The Effect of Pressure on the Binary Diffusion Coefficients of Gases	/ 11.12
11-6	The Effect of Temperature on Diffusion in Gases	/ 11.19
11-7	Diffusion in Multicomponent Gas Mixtures	/ 11.19
11-8	Diffusion in Liquids: Theory	/ 11.20
11-9	Estimation of Binary Liquid Diffusion Coefficients at Infinite Dilution	/ 11.21
11-10	Concentration Dependence of Binary Liquid Diffusion Coefficients	/ 11.33
11-11	The Effects of Temperature and Pressure on Diffusion in Liquids	/ 11.38
11-12	Diffusion in Multicomponent Liquid Mixtures	/ 11.41
11-13	Diffusion in Electrolyte Solutions	/ 11.43

Chapter 12 Surface Tension

12.1

12-1	Scope	/ 12.1
12-2	Introduction	/ 12.1
12-3	Estimation of Pure-Liquid Surface Tension	/ 12.2
12-4	Variation of Pure-Liquid Surface Tension with Temperature	/ 12.11
12-5	Surface Tensions of Mixtures	/ 12.12

Appendix A Property Data Bank A.1

Appendix B Lennard-Jones Potentials as Determined from Viscosity Data B.1

Appendix C Group Contributions for Multiproperty Methods C.1

Index follows Appendix C