## **Contents**

|      | eword  |          |           |         |       | •            |       |       | •    |         | •   |     | vii  |
|------|--|----------|-----------|---------|-------|--------------|-------|-------|------|---------|-----|-----|------|
| Pref | ace  |          |           |         | •     |              |       |       |      |         | •   |     | ix   |
| Intr | oduction to Volume 6   |          |           |         | •     | •            |       |       |      | •       |     | •   | xiii |
| Gro  | ace  oduction to Volume 6  uping of Materials and List of Figure   | es and 7 | Tables    | •       |       | •            | •     |       |      | •       | •   |     | xvii |
|      |  |          |           |         |       |              |       |       |      |         |     |     |      |
|      |  | ry, Esti |           | , and . | viea  | sureme       | ent   |       |      |         |     |     |      |
| Note | ition  | •        | •         | •       | •     | •            | ٠     | •     | •    | •       | ٠   | ٠   | 1a   |
| Spec | ific Heat of Liquids and Gases . Introduction  | •        | •         | •       | •     | •            |       | •     | •    | •       | •   | •   | 3a   |
| 1.   | Introduction   | •        | •         |         | •     | •            | •     | •     | •    | •       | •   | •   | 3a   |
| 2.   | Definition of Specific Heats .   |          |           |         | ٠     |              | •     |       | ٠    | •       | ٠   | ٠   | 4a   |
| 3.   | Useful Relationships between $C_p$ , $C$   | v and o  | ther T    | hermo   | odyna | amic P       | roper | ties  | •    | •       | •   | •   | 5a   |
|      | A. The Difference between $C_p$ and $C_p$ .  B. The Ratio of $C_p$ over $C_v$ .  | $C_v$ .  | •         |         |       | •            | ٠     | •     | ٠    |         | •   | •   | 5a   |
|      | B. The Ratio of $C_p$ over $C_v$ .   | •        | *         | *0      | •     | •            | ·     | •     | •    | •       | •   | •   | 5a   |
|      | C. General Thermodynamic Relation  | ons for  | $C_p$ and | $C_v$   |       | •            |       | •     |      | •       | •   | •   | 6a   |
| 4.   | Prediction of Zero-Pressure Specific   | Heat o   | f Gase    | es      | •     |              | •     | •     | ٠    | •       | •   | •   | 6a   |
|      | A. General Considerations  B. Statistical Mechanical Definition a. The Phase Space and Phase C b. Boltzmann Statistics     | •        | •         | •       |       | •            | •     | •     | •    | •       |     | •   | 6a   |
|      | B. Statistical Mechanical Definition   | is .     | •         |         | •     | •            | •     | •     | •    | •       |     | •   | 7a   |
|      | a. The Phase Space and Phase C   | Cell     | •         | •       | •     | •            |       | •     | ٠    | •       | •   | •   | 7a   |
|      | b. Boltzmann Statistics  | •        |           | •       |       | ٠            |       | •     | •    |         |     | •   | 8a   |
|      | c. Quantum Weights   |          |           |         |       |              |       | •     | •    | •       |     | •   | 8a   |
|      | <ul><li>c. Quantum Weights</li><li>d. Sum of States—The Partition</li></ul>  | Funct    | ion       | •       |       |              | •     | •     |      |         |     |     | 8a   |
|      | C. Contributions of the Various F  | orms o   | f Ener    | gy to   | the   | Total        | Ener  | gv of | a Mo | olecule | and | the |      |
|      | Specific Heat  | •        |           | •       | •     |              |       |       |      |         | •   | •   | 9a   |
|      | a. Translational Energy  | •        | •         | •       |       |              |       | •     |      |         | •   | •   | 9a   |
|      | b. Electronic Energy (Excited St   | ates)    | •         |         |       | •            | •     |       |      | •       |     |     | 9a   |
|      | <ul><li>c. Vibrational Energy</li><li>d. Vibrational Characteristic Term</li></ul>   | •        | •         | •       |       |              |       |       |      | •       |     |     | 10a  |
|      | d. Vibrational Characteristic Ter  | mperati  | ıre       | •       | ·     |              |       |       |      |         |     |     | 10a  |
|      | e. Rotational Energy   |          | •         |         |       | •            |       |       |      |         |     |     | 10a  |
|      | e. Rotational Energy f. Combined Rotational and Vi   | bration  | al Ene    | rgies   |       |              | •     |       |      |         |     | •   | 11a  |
|      | g. Nuclear Spin Energy h. Summary Experimental Determination of Spec   | •        | •         | •       |       | •            | •     |       |      | •:      | •   |     | 11a  |
|      | h. Summary   |          |           |         | •h    | ) <b>•</b> ( |       |       |      | •       |     |     | 12a  |
| 5.   | Experimental Determination of Spec   | cific He | at of I   | Fluids  | ٠     |              |       |       |      |         |     |     | 12a  |
|      | A. General Considerations B. Choice of the Calorimetric Meth   | •        |           |         |       |              | •     |       |      | •       | •   |     | 12a  |
|      | B. Choice of the Calorimetric Meth   | od .     |           |         |       |              |       | •     |      |         |     |     | 13a  |
|      | C. Standard Reference Materials  |          | •         |         |       |              |       |       |      |         |     |     | 13a  |
|      | D. Brief Description of Typical Cal  | orimete  | rs        |         |       |              |       |       |      |         |     |     | 14a  |
|      | <ul><li>C. Standard Reference Materials</li><li>D. Brief Description of Typical Cal</li><li>a. Direct Methods</li></ul>    |          |           |         |       | 190          |       |       |      |         |     |     | 14a  |
|      | (i) Constant-Flow Calorime   | ter .    |           |         |       |              |       |       | ,    |         |     |     | 14a  |
|      | (ii) Isothermal Drop Calorin   | neter    |           |         |       |              |       |       |      |         |     |     |      |
|      | <ul><li>(ii) Isothermal Drop Calorin</li><li>(iii) Conduction Calorimeter</li><li>(iv) Mixing Method Calorimeter</li></ul> |          | -         |         | •     |              | -     |       |      |         | -   |     | 15a  |
|      | (iv) Mixing Method Calorino  | eter.    |           |         | -     |              | -     |       | •    |         |     | •   | 16a  |
|      | (v) Heat-Exchanger Calorim   |          | •         | -       | -     |              | •     | •     | •    | •       | •   | •   | 168  |

## xvi Contents

| b. Indirect Methods                                | •     | •        |         | •      | •      | •      |          |       |          |              | 16a        |
|--|-------|----------|---------|--------|--------|--------|----------|-------|----------|--------------|------------|
| (i) Isentropic Expansion Method                    |       | •        | •       | •      |        |        |          |       |          |              | 16a        |
| (ii) Velocity of Sound Method .                    |       |          |         |        |        |        |          |       |          |              | 16a        |
| (iii) Joule-Thomson Effect Method                  |       |          |         |        |        |        |          |       |          |              | 16a        |
| References to Text                                 | ٠     |          |         | •      | •      | •      |          | •     | •        | •            | 19a        |
| NI   |       | rical D  | ata     |        |        |        |          |       |          |              |            |
| 170  | шше   | rical D  | ata     |        |        |        |          |       |          |              |            |
| Data Presentation and Related General Informatio   | n     |          |         | •      | •      | •      |          |       |          |              | 23a        |
| 1. Scope of Coverage                               |       | 7.       |         | •      |        | ٠      |          |       |          |              | 23a        |
| 2. Processing and Presentation of Data .           |       |          |         | •      |        | ě      |          |       |          | <b>3.●</b> 3 | 23a        |
| 3. Symbols and Abbreviations used in the Figu      | ıres  | and Ta   | ables   |        |        |        |          |       |          |              | 24a        |
| 4. Convention for Bibliographic Citation.          |       |          |         |        |        |        |          |       |          | •            | 24a        |
| 5. Name, Formula, Molecular Weight, Transiti       |       |          |         |        |        |        |          |       | Eleme    | ents         |            |
| and Compounds                                      |       |          |         |        |        |        |          |       |          |              | 27a        |
| 6. Conversion Factors for Units of Specific He     |       |          |         |        |        |        |          |       |          |              | 27a        |
| Numerical Data on Specific Heat of Nonmetallic Lie | quids | and G    | ases (S | See pr | . xvii | and xv | viii for | detai | led list | ting         |            |
| of entries for each of the following groups of     |       |          |         |        | •      |        | •        | •     |          |              | 1          |
| 1. Elements  |       | (*)      |         |        |        | -      |          |       | 20       | 25)<br>250   | 1          |
| 2. Inorganic Compounds                             |       |          |         |        |        | _      | 051      |       | -        |              | 61         |
| 3. Organic Compounds                               |       |          | _       |        |        | -      |          | ·     |          |              | 113        |
| 4. Mixtures  | Ţ.    |          | ·       | ·      | •      |        |          |       | •        | 1.5          | 293        |
| References to Data Sources                         |       |          |         | •      | •      |        | •        |       |          | •            | 299        |
| respectives to Data Sources                        | •     | •        | ::•     | •      | •      | •      | •        | •     | •        | •            | 4))        |
| M  | ater  | ial Ind  | ex      |        |        |        |          |       |          |              |            |
| Material Index to Specific Heat Companion Volun    | nes 4 | l, 5, an | d 6     | •      |        |        |          |       |          | •            | <b>A</b> 1 |