Measurement of the Thermodynamic Properties of Single Phases. IUPAC Experimental Thermodynamics, Volume VI. Edited by A. R. H. Goodwin, K. N. Marsh, and W. A. Wakeham. Elsevier: Amsterdam, The Netherlands, 2003. 558 pp. $US 230. ISBN 0-444-50931-3.

This text is Volume VI in a seven-volume Experimental Thermodynamics Series produced over a 37-year span by IUPAC's Commission on Thermodynamics. This book and Volume VII (*Measurement of the Thermodynamic Properties of Multiple Phases*) are intended as updates for Volume II (*Experimental Thermodynamics of Non-Reacting Fluids*) published in 1975. Researchers new to the field will derive maximum benefit if they also have access to Volume II; however, access to Volume VI is essential because there have been many significant advances in measurement technology over the last 30 years. Volume VI is important for any experimentalist or engineer needing to measure a thermodynamic property (such as pressure) even if their field of research is not thermodynamics itself. For experimentalists, theoreticians, or simulators working in the fields of metrology, fundamental thermodynamics, or applied thermodynamics, this book is an invaluable reference.

The text has a modular structure with each chapter focusing on a major thermodynamic property (e.g., temperature), methodology (e.g., calorimetry), or region (e.g., extreme conditions). These broad chapters contain several sections often written by different authors so as to encompass the many issues associated with property measurement for all three phases of matter. The style and readability of each section varies with contributions from 42 international experts. The text is generally readable, but there are a few sections (e.g., very high-pressure measurements in solids) that are difficult to read and/or on the verge on being inaccessible to a non-expert. Certain other sections contain a surprisingly high number of typographical errors. Fortunately, these errors do not detract from the quality of the text's substance.

In Chapter 1, the editors describe the history of the series and the motivation for this volume. Their summary of the contents of the remaining chapters also contains a useful discussion of how and why the material in this text differs from that in Volume II. Chapter 2 covers temperature from its thermodynamic origin, to the need for temperature scales, to thermometry at below 1 K and above 2000 K. A detailed discussion and listing of the fixed points used in ITS-90 is given together with a description of thermometry with standard platinum resistors. Radiation thermometry, helium vapor-pressure and gas thermometers, rhodium−iron resistance thermometers, thermocouples, and Johnson noise thermometry are also covered. The chapter contains sufficient detail for metrologists while providing a useful and accessible summary to the general scientist.

Pressure measurement is the topic of Chapter 3. The first section discusses the five main types of electronic pressure transducers: capacitance diaphragms, quartz bourdon tubes, quartz resonant crystals, resonant silicon sensors, and piezoresistive silicon strain gauges. The second section covers the advances in the technology and understanding of piston gauges that has occurred since 1975. Section three covers high-pressure measurements in solids with diamond anvil cells while the final section of Chapter 3 describes techniques for low-pressure measurements including liquid-column manometry, piston gauges, expansion generators, and suitable low-pressure transducers.

The book's shortest chapter is Chapter 4, the first half of which describes the preparation of fluid mixtures with small compositional uncertainties. The second half covers the issues and techniques for obtaining reliable samples of hydrocarbon reservoir fluids. This topic is central to evaluating the economic viability of a resource and to the construction or tuning of the thermodynamic and production models vital in modern field developments. However, the chapter concludes prematurely as a discussion on how the compositions of these samples are analyzed should surely have followed the section on sampling.

Chapters 5 and 6 on density and speed of sound describe powerful experimental techniques that have only developed since about 1980 and were therefore not included in Volume II. Chapter 5 commences with a section on the magnetically coupled buoyancy densimeters that have enabled density metrology to reach levels of unprecedented accuracy. Vibrating tube and vibrating wire densimeters are well-covered, and there are three sections on volume-based methods of density determination such as bellows volumetry, piezometery, and Burnett methods. There is also a substantial discussion of absolute density standards, which covers single-crystal silicon spheres and the liquid standards of water and mercury. Chapter 5 concludes with an industry-focused section on methods of in-situ densimetry for process fluids; these techniques are also often important to single- and multiphase flow metering.

Chapter 6 covers comprehensively the measurement of the speed of sound in gases, liquids, and solids using cavity resonators, variable-path interferometers, and time-of-flight methods. The discussion includes a detailed description of techniques central to acoustic thermometery (not covered in Chapter 2) and also covers issues associated with acoustic transducers. Chapter 6 also includes a very useful section on the thermodynamic properties of isotropic fluids and solids that can be derived from speed of sound measurements.

Chapter 7 on calorimetry focuses only on instruments not described in the review contained in Volume IV (*Solution Calorimetry*, 1994). These include flow calorimetric techniques for measuring enthalpy differences of fluids, AC calorimetry, differential scanning calorimetry, and nanocalorimetry. Chapter 8 is another chapter about mixtures explicity and the application of the techniques described earlier in the text to the determination of excess properties. Gas mixtures and liquid mixtures are treated but the primary focus is experimental techniques for mixtures of inorganic solids.

The measurement of relative dielectric permittivity in gases, liquids, and electrolytes is covered in Chapter 9; refractive index measurements are also covered briefly. These topics were not given a detailed treatment in Volume II. The chapter is particularly useful in that it describes how permittivity measurements lead to other important thermodynamic and/or molecular properties. In Chapter 10, techniques and materials required for measurements under extreme conditions are discussed. Methods for calorimetery at very low temperatures (<1 K) are described first with the next section covering the thermophysical properties that can be measured at high temperatures (1000 to 10000 K) using pulse heating techniques. The final section of Chapter 10 concentrates on the techniques for measuring the thermophysical properties of molten metals.

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The lack of a chapter or section on the measurement of a fluid mixture's composition is the only significant deficiency of the text. Otherwise, it is a comprehensive exposition on the current techniques used to measure a wide range of thermodynamic properties of single phases over a wide range of conditions. It achieves its stated objectives of capturing and preserving the detailed expertise needed for reliable thermodynamic property measurements. The editors note that the capability of performing such measurements throughout the world has decreased in favor of simulation. However, there will always be a need for experiment and, given the current age demographic of researchers in this field, the importance and utility of this text over the coming decade are very likely to increase. This book is therefore a worthwhile investment for both individuals and institutions.

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