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starting point and presented in fair detail the steps. The goal has been to arrive at a point where the student can understand the principles and profitably read the literature connected with that subject.

In reviewing this book, I decided to assess the extent to which Boyd and Phillips achieved their goal. The book is intended for graduate students in chemistry, chemical engineering, and materials science, and a background in physical chemistry and organic chemistry is assumed. According to the authors, however, "Students from an entirely engineering background have been very successful in mastering the subjects covered."

The book begins with a short chapter on polymerization methods as a means of introducing polymer chemistry to the student. Following the introduction, Chapters 2, 3, and 4 cover molecular weight distribution, molecular weight determination, and polymerization kinetics, respectively. Depending on the topic, the authors provide considerable detail by deriving many of the expressions that are simply stated in most polymer textbooks. For example, in Chapter 2, the "most probable" and Shultz-Zimm molecular weight distribution functions are clearly derived. Chapter 3 discusses the various methods of measuring molecular weight that appear in any textbook on this subject. It appears that the authors are most comfortable with light scattering given the amount of space devoted to it.

The presentation of polymerization kinetics in Chapter 4 is very similar to that in other introductory textbooks. One important aspect of free radical polymerization that was not treated here and which is not covered in other textbooks is the composite molecular weight distribution. The instantaneous distribution only provides a snapshot of the polymerization reaction. The effect of conversion on the instantaneous distribution and the integration to obtain the composite distribution are important from a practical point of view. In addition, this material would demonstrate to students how very broad distributions can occur in practice using the free radical mechanism.

In Chapters 5 and 6, the authors do an excellent job of establishing the fundamental principles necessary to understand the properties and behavior of chain molecules. True to their intentions, these chapters provide the detail for graduate students that is sorely lacking in many textbooks on polymer science. Chapter 5 deals primarily with stereochemical configurations, tacticity, and their effects on molecular shape. In Chapter 6, the authors discuss the statistics of disordered chains and distribution functions for end-to-end distances, particularly for the phantom chain.

Chapter 7 discusses the interacting bond model for obtaining average properties of more realistic chains using complex statistical methods. Many readers may find this chapter somewhat tedious to read. The many references to contribu-

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ChE book review

The Science of Polymer Molecules

by Richard H. Boyd and Paul J. Phillips

Cambridge University Press, 40 West 20th Street, New York, NY 1011-4211; \$79.95 (1994)

Reviewed by

Timothy A. Barbari

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Although there are a number of excellent texts for undergraduate courses in polymer science, they do not provide the necessary depth for a graduate course in the subject. There has long been a need for a graduate-level textbook that presents polymer science from a rigorous, molecular approach. Professors Richard H. Boyd (University of Utah) and Paul J. Phillips (University of Tennessee) address that need with this book, *The Science of Polymer Molecules*. The authors' intentions are clear from their own words in the Preface:

We have taken the viewpoint that a textbook should undertake to explain and develop the principles selected and not just present results. For most of the subjects, we have proceeded from a very elementary

densities are 2710 and 7860 kg/m³.^[5] Thus, the sonic velocity in steel is

$$\left(\frac{207 \times 10^9 \text{ Pa}}{7860 \text{ kg/m}^3}\right)^{1/2} = 5132 \text{ m/s}$$

and in aluminum is

$$\left(\frac{69 \times 10^9 \text{ Pa}}{2710 \text{ kg/m}^3}\right)^{1/2} = 5046 \text{ m/s}$$

As mentioned in the solution to Problem 13 above, the more incompressible the medium (the larger the E value), the higher the sonic velocity. But the higher the density of the medium, the lower the sonic velocity—due, presumably, to the closely packed atomic structure of the medium. The examples cited above indicate that one factor might work against the other for two completely different materials.

15. The air inside the container is not in motion and hence its total energy is in the form of internal energy. Once the container is full, this internal energy is supplied by the atmospheric air filling in the container. Therefore, the internal energy of air in the container at the final temperature T_f equals the enthalpy of atmospheric air at 20°C. Or, in equation form

$$c_v T_f = c_p T_{\text{air}}$$

$$\frac{R}{k-1} T_f = \frac{Rk}{k-1} T_{\text{air}}$$

or

$$T_f = k T_{\text{air}} = 1.4(20 + 273) = 410.2 \text{ K} = 137.2^\circ \text{C}$$

Here, R is the gas constant and k is the ratio of specific heats c_v and c_p at constant volume and constant pressure, respectively. Thus, there is a considerable increase in temperature under adiabatic conditions.

16. They need to know the vapor pressure of water at 85°C and the properties of standard atmosphere at different heights. The vapor pressure of water at 85°C is 57.81 kPa from the steam tables. This corresponds to about 4440 m height in the table which gives the properties of the atmosphere (e.g., see Table A.3, The Properties of U.S. Standard Atmosphere, in reference 6).

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ChE letter to the editor

To the Editor:

I appreciate the inclusion of appropriate quotations from my book *The Interpretation and Use of Rate Data. The Rate Process Concept*, revised printing, Hemisphere Publishing Corporation, Washington, DC (1979), in the excellent article by Shacham and Brauner in *Chemical Engineering Education*, **29**(1), p. 22. However, I wish to point out that the ungrammatical phrase in the last sentence of their article, namely, "data justifies," appeared correctly as "data justify" in my book, page 309.

Stuart W. Churchill

*Carl V.S. Patterson Prof. Emeritus
University of Pennsylvania*

REVIEW: Polymer Molecules

Continued from page 93.

tions of one of the authors suggest some personal bias regarding the inclusion of this chapter. In fact, I found no references to this material in the last two chapters. Although I have no argument with the importance of the topics covered in Chapter 7, I suspect that most faculty members using the book for a course will skip over this material unless their research interests lie in this area. To the authors' credit, they do state in the Preface that this chapter "can be studied or not depending on the interests of the reader."

In the final two chapters, the authors apply the principles established in Chapters 5 and 6 to two very important areas: rubber elasticity in Chapter 8 and polymer solutions in Chapter 9. Both of these areas typically receive a few pages each in traditional undergraduate polymer science textbooks. In these treatments, a simplistic physical description is followed by the end result, an equation for students to apply in problems at the end of the chapter. It is refreshing to see more complete descriptions and detailed derivations in both areas. For example, many textbooks are content to give the expression for solvent activity from Flory-Huggins theory as gospel for polymer solutions. In Chapter 9 the authors derive the configurational entropy of mixing for Flory-Huggins theory, discuss the limitations of the theory, and develop newer treatments such as equations of state.

In summary, I recommend *The Science of Polymer Molecules* for consideration as a textbook for a graduate course in polymer science or polymer physical chemistry. Problems are included at the end of each chapter, evidence that the authors were serious about writing a textbook for graduate students in this area. With minor exceptions, *The Science of Polymer Molecules* is presented in a reader-friendly manner that will further motivate students with an interest in macromolecules and their behavior. □