PROBLEM 3

Bubble Rise

We leave the reader with an intriguing problem that originated with our colleague, Professor (now *Emeritus*) M. Rasin Tek. As shown in Figure 4, a hollow vertical cylinder with *rigid* walls and of height H is closed at both ends and is filled with a volume, V, of an *incompressible* and *non-volatile* oil of density ρ at a uniform temperature T. A gauge registers the pressure at the top of the cylinder.

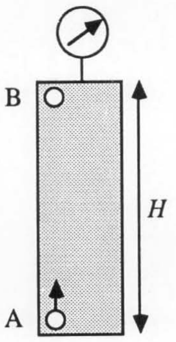

Figure 4. *Bubble rising in liquid in a closed cylinder.*

When a small spherical bubble of volume v initially adheres by surface tension to point A at the bottom of the cylinder, the *absolute* pressure at the top of the cylinder is p_0. The gas in the bubble is ideal, and has a molecular weight of M. The bubble is liberated by tapping on the cylinder and rises to point B at the top. Derive an expression in terms of any or all of the specified variables for the new absolute pressure p_1 at the top of the cylinder. Explain your answer carefully!

We leave the reader in suspense, requesting that he or she solve this problem. It is instructive for a fluid mechanics class because it shows that if you proceed methodically, the answer is deceptively simple. And, if you find it too easy, try it for the case when the oil is slightly *compressible,* with an isothermal compressibility β. ❒

ChE ***book review***

CHEMICAL AND PROCESS THERMODYNAMICS
2nd Edition

by B.G. Kyle
Prentice Hall, Inc., Englewood Cliffs, NJ 07632

Reviewed by
E. Dendy Sloan
Colorado School of Mines

In this useful second edition, the author has avoided an encyclopedic "drink-of-water-from-a-fire-hydrant" approach to thermodynamics in favor of pedagogical digestion. The examples and problems with each chapter are well conceived, and a complete solutions manual is available. The text nomenclature and topic-ordering will seem familiar to professors teaching the topic.

Modern aspects of the book involve applications of classically stated fundamentals to environmental control, electrolytes, biochemicals, and electronic materials. Material on Jacobians, stability, and complex chemical equilibria go beyond topics found in many undergraduate texts.

A major asset of the book is its treatment of fluid properties. The author has eschewed the use of three-parameter corresponding states, providing graphic visualization of changes in compressibility and residual properties as a function of reduced temperature and pressure. An IBM-compatible floppy disk program (*ca.* 4000 lines) in the endpapers enables more accurate calculation of pure fluid properties (other than vapor pressure) through the Peng-Robinson equation of state (EOS).

A second major asset is the treatment of phase equilibria. After a brief treatment of principles, the author goes straight to applications, with advanced topics relegated to a later chapter. For example, in the first chapter on phase equilibria principles the author gives examples of activity coefficient hand calculations to optimize van Laar and Margules parameters, but a floppy disk program (*ca.* 5000 lines) is provided to either optimize or use Wilson equation parameters. Regular solution and UNIFAC treatments are delayed until the third chapter on phase equilibria.

The floppy disk programs represent one approach to introduce students to the foundations of ubiquitous flowsheeting programs in the profession. As such, a reader might wish for the unifying device of a Peng-Robinson EOS program applied to mixtures so that, for example, students could observe relative inaccuracies of an EOS versus activity coefficients for mixtures of alcohol+water or those of hydrocarbons.

Summing up, this book is a welcome addition for students learning undergraduate thermodynamics. If the author included an extension to molecular exposition and a final chapter on statistical thermodynamics, the book might also be a foundation to address the dearth of introductory graduate texts. ❒