

relative magnitude of the time constants. If the dominant time constant is  $T_1$ , and the other two time constants,  $T_2$  and  $T_3$ , are expressed in terms of  $T_1$

$$T_2 = X T_1, \quad T_3 = Y T_1 \quad (6)$$

then Eq. (1) becomes

$$K_{\max} = \sqrt{1 + \frac{1+X+Y}{XY}} \sqrt{1 + \frac{1+X+Y}{Y}} X \sqrt{1 + \frac{1+X+Y}{X}} Y \quad (7)$$

which depends only on the ratios of the time constants. Second, the maximum gain is the same for two systems with the time constants as the reciprocals of each other. In other words, if  $1, 1/X, 1/Y$  are substituted into Eq (1), Eq. (7) remains the same. Third, the minimum  $K_{\max}$  happens when all three time constants are identical. The corresponding value is 8. Finally,  $K_{\max}$  goes to infinity when any one of the ratios goes to infinity which corresponds to a lower order system, and hence is always stable.

## REFERENCES

1. Harriot, P., *Process Control*, McGraw-Hill, New York, 1964
2. Routh, F. J., *Dynamics of a System of Rigid Bodies*, 3rd ed., Macmillan & Co., Ltd., London, 1877 □

## REVIEW: Liquids

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modynamic properties have been made, including new methods for studying and understanding fluid behavior near critical and tricritical points. On the theoretical side, the 70's and 80's have seen the rapid development of computer simulation methods and perturbation theory, which have placed the interpretation of liquid properties on a much sounder footing. In particular, the use of simulation data to test theories has eliminated the need to guess the intermolecular forces—a serious source of error in almost all of the tests of theories prior to 1970.

The aim and general organization of the book are the same as for the previous edition. The first two chapters give an introduction to liquid properties and their classical thermodynamics, and are similar to those of the last edition. The next chapter covers fluid behavior near the critical point, and has been substantially updated to cover recent developments. The next three chapters cover our experimental knowledge of thermodynamic properties and phase equilibria for liquid mixtures at both low and high pressures. The coverage is similar to that in the last edition, but the material has been reorganized and updated. Welcome additions include the introduction of phase diagrams plotted in terms of field variables (temperature  $T$ ,

pressure  $p$ , and chemical potential  $\mu$  in place of  $T$ ,  $p$ , and  $x$ , where  $x$  is the mole fraction), a section on tricritical points, and the use of the classification scheme of van Konynenburg and Scott in discussing the behavior of fluid mixtures at high pressure. The last two chapters of the book cover the statistical thermodynamics of liquids and liquid mixtures. Much has been added here, particularly on the recent developments on fluids of nonspherical molecules, perturbation theory, and measurements of molecular correlation functions. The chapter on intermolecular forces, present in the last edition, has been removed, although there is a brief discussion on this subject in Chapter 7. The authors conclude that the statistical thermodynamics of mixtures of rigid (*i.e.* non-flexible) neutral molecules has made major advances and is now on a sound footing. The main barrier to progress remains our relative ignorance of intermolecular forces for all but the simplest molecules.

This latest edition of the book will be indispensable to those working on liquid properties. □

## A PICTORIAL APPROACH TO MOLECULAR STRUCTURE AND REACTIVITY

by R. F. Hout, Jr., W. J. Pietro, and W. J. Hehre  
Published by Wiley-Interscience,  
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It is well known that molecular orbital theory and relatively simple symmetry arguments can provide important information about the electronic and geometrical structure of molecules and their chemical reactivity. In this approach, extended molecular orbitals are constructed from hydrogen-like atomic orbital. While the visualization of atomic orbitals is quite easy, the visualization of molecular orbitals can be quite difficult even for relatively simple molecules. This book provides a pictorial representation of high-lying (valence) molecular orbitals for a large number of polyatomic inorganic, organic, and organometallic molecules. The molecular orbitals have been generated using the GAUSSIAN-83 computer program, and in this book photographs taken of a high resolution graphical display of the molecular orbitals are presented. In addition to the filled levels, the lowest-unfilled molecular orbital (LUMO) is also shown for each molecule. This book provides an important source of information for those trying to understand molecular interactions on a fundamental level. □