Handbook Of Heterogeneous Catalysis

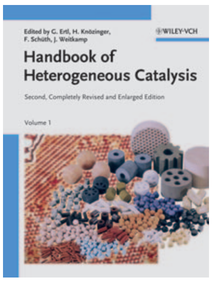
In each of the eight prefaces of this much-awaited handbook, we are reminded of the ubiquitous nature of the subject covered in this compendious collection of authoritative articles. The editors state that in about 85 to 90 percent of all chemical manufacturing processes use is made of a catalyst. Furthermore, in about 80 to 85 percent of all of those catalytic processes, heterogeneous catalysis is employed. A year or so ago, the worldwide trade volume for solid catalysts was estimated to amount to approximately 15 billion US dollars per annum; and the value created by using these catalysts was about a hundred to a thousand times as high. One must not, however, be overawed by the massiveness of these figures: their magnitude alone is not what is significant—otherwise we would construe the manufacture of cement or concrete as equally important—it is the perennial fascination, not to say enigma, of the phenomenon and application of catalysis itself that deeply interest us.

Heterogeneous catalysis, as the editors rightly proclaim, is an interdisciplinary field that demands the cooperation of experts from a multitude of traditional branches of natural and engineering sciences. "*It is based on solid-state chemistry and physics, materials science and surface science but various other disciplines have steadily contributed to an improved understanding of, and progress in, heterogeneous catalysis. Among these are reaction kinetics and mechanisms, theoretical chemistry, solid-state spectroscopy, analytical chemistry and chemical reaction engineering. It is this pronounced interdisciplinary that contributes to the fascination of heterogeneous catalysis.*" Putting it in purely academic terms, we may ask: how is it that molecules impinging upon certain (catalytic) surfaces at velocities of typically 1600 $km\,h^{-1}$ can be converted at those surfaces, with high efficiency and often with spectacular selectivity, into a desired product, whereas the same species impinging upon other (inert) surfaces merely rebound with more or less retention of translational, vibrational and rotational energy? This key question, along with numerous others of a more practical, operational nature, are addressed directly or indirectly in this massive cornucopia, which overflows with the fruits of the labors of numerous practitioners of a subject—namely catalysis generally—which is of ancient lineage and which is a prime determinant in the functioning of civilized, industrial societies.

In this completely revised and significantly enlarged second edition—the first appeared in 1997—not only are the contributions from the first edition updated (a few of them only rather sparsely), but numerous chapters dealing with topics that were not addressed—some had not even appeared over the horizon in 1997—in the first edition. Experts from all over the world have been recruited to provide the ideal vade mecum for the practitioner in heterogeneous catalysis. There are 16 sections in this Handbook, all of which are commendable, and some so thorough and selective that they could serve as stand-alone monographs. This is particularly true of Section 5, which devotes over 315 pages to "Elementary Steps and Mechanisms" with elegant contributions from Freund, Goodman, Dumesic et al., Ertl, Stoltze and Nørskov, Hinrichsen, Knözinger, van Santen and Neurock, Catlow et al., Theodorou, Smit, and others. There are many other praiseworthy contributions for example, on "Biomass Conversion" by Gallezot and Kiennemann (p. 2447), on "Ordered Mesoporous Materials" by Kleitz (p. 178), on "Immobilized Molecular Catalysts" by Anwander (p. 583), and many very timely topics such as "High Throughput Experimentation" by Schüth, and "Polymerization Reactions" by McDaniel. In most of the sections the references cited are fully up-to-date, especially so in Besenbacher's account of scanning probe methods. In others, for example, "Electron-Energy-Loss Spectroscopy" and "Metal Clusters in Zeolites" they are not.

One may cavil at relatively minor errors, policy decisions, or omissions. Why, for example, is Ertl's classic diagram showing the energy profile of the progress of the ammonia synthesis on Fe shown twice (on p. 30, in the elegant section by Davis on "Development of the Science of Catalysis", and on p. 1267 by Marsh et al. on "Single Crystal Surfaces") when its most natural place would have been in Schlögl's monumental and otherwise comprehensive 74-page account of "Ammonia Synthesis" (p. 2501)? I was also puzzled by the fact that Ansorge-Schumacher's fine article on "Immobilization of Biological Catalysts" (p. 644 ff.) is not juxtaposed with the final section (by Horn et al.) on "Reactions on Immobilized Biocatalysts" (p. 3831). The section on "Oxy-functionalization of Alkanes" (p. 3400) is good in dealing with the earlier and later work with complex oxides (on the MI phase for example) but ignores completely what has been achieved with open-structure solids. Minor corrections are called for should there be a future edition of this massive source book. For example, it was Humphry Davy in 1815, not Humphrey Davy in 1817, who discovered that a combustible gas could be oxidized by atmospheric oxygen on the surface of platinum (p. 2266); and Grove's discovery of the fuel cell was not made in 1893 (as claimed on p. 3080) but in 1838.

In a Handbook it is especially important that the reader can locate a topic easily. In general this is



Handbook Of Heterogeneous Catalysis
2., completely revised and enlarged Edition. Vol. 1–8. Edited by G. Ertl, H. Knözinger, F. Schüth, and J. Weitkamp. Wiley-VCH, Weinheim 2008. 3966 pp., hardcover € 1999.00.—
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so—it is certainly easier in the Second Edition than it was in the first. However, I would have liked entries in the Index that are not now there for example, on "caprolactam", "nylon production", and "single-site heterogeneous catalysts" (There are now 125 000 entries in Google on the last of these topics); an author index would also have been helpful. It would also help the reader if the pages covered were included on the spine or cover of each volume.

On balance, the venture is an indisputable success: no laboratory—academic or industrial center—seriously interested in keeping abreast of the vast ramifying corpus of heterogeneous catalysis can afford not to have this series on its shelves. In an age when Wikipedia is instantly accessible online through Google, one wonders what kind of Handbook will be published when the time arrives for a third edition!

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The Periodic Table

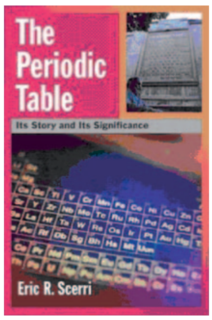
This is a well-written, readable, and interesting book at a quite reasonable price, which will serve the needs of many ordinary chemists, chemistry teachers, and philosophers. The first two-thirds deals with the history and epistemology of the Periodic System of chemical elements and its empirical aspects, in a very effective way. The theoretical chemical aspects in the last third are treated less appropriately.

The classical works on the Periodic System date back three to five decades. J. W. Van Spronsen celebrated a jubilee with *The Periodic System of Chemical Elements* (1969, reviewed in *Angew. Chem*. **1972**, *84*, 1113; *Angew. Chem. Int. Ed. Engl*. **1972**, *11*, 948). E. G. Mazurs systematized the then already 700 diverse *Graphic Representations of the Periodic System During One Hundred Years* (1957, 1974). The publication of individual papers on the Periodic System has boomed in recent years, in particular on the occasion of the 100th anniversary of Dmitrij Mendeleyev's death in 2007. During the intervening years since the earliest publications, the new discipline of the "Philosophy of Chemistry" has matured (with a periodic spiral as its logo, http://ispc.sas. upenn.edu). One of its fathers, Eric Scerri, now presents a suitably enriched monograph. Another important, although less comprehensive, text is R. M. Cahn's *Historische und Philosophische Aspekte des Periodensystems der Chemischen Elemente* (http://www.hyle.org/publications/books/cahn/cahn.pdf, 2002).

A real advantage of the present work is that some unfortunate, but often repeated, statements in chemistry textbooks are here presented more correctly. The author consistently makes a conceptual distinction between the Periodic Law, the Periodic System, and the individual Periodic Tables; also between chemical elements *in* compounds, as *basic* substances, and elementary *simple* substances. He carefully traces the slow birth of the Periodic Tables that occurred over an extended period, with many accoucheurs including Döbereiner, Chancourtois, Meyer, Mendeleyev, and others. He analyzes the more recent developments and the various graphical forms. Concerning the still debated question of whether a new theory is better promoted through the accommodation of many well-known facts or by the verification of some bold predictions (e.g., *Science* **2005**, *307,* 219–221; *308,* 1409–1412), the author proposes a more reasonable compromise. Scerri also does not hide the fact that Mendeleyev's predictions included not only his three spectacular successes (Sc, Ga, Ge) but also many that were simply wrong.

In other respects the author, a chemistry lecturer at the University of California at Los Angeles, adopts the common chemical textbook wisdom. Chemically bound elements are equated with single atoms in vacuum, and also the electronic state is equated with the electronic configuration. Concerning the transition-metal atoms, it is suggested that first the $(n+1)$s orbital is occupied by electrons, and only subsequently the nd shell, although the transition-metal cations have been known since the 1930s to possess only d valence electrons. The author correctly presents some aspects of the nd$-(n+1)$s issue, which is treated notoriously badly in the textbooks, but he still does not reach a correct resolution. Hence, absurd doubts about the fundamental applicability of quantum mechanics to atoms and molecules emerge, which may be appreciated by some chemists and philosophers. Unfortunately, many modern philosophers of chemistry disclaim the power of theoretical physics and quantum chemistry to explain and to deduce many chemical concepts and chemical laws.

This still young century has already produced a significant gain of new insights, relevant to both empirical and quantum-theoretical aspects (see the Essay on page 3404 in this issue). Regrettably, they were too recent to be incorporated into this book, although admittedly, Scerri's earlier contributions, which are integrated into the present book, had decisively influenced the recent advances. The



The Periodic Table
Its Story and Its Significance. By Eric R. Scerri. Oxford University Press, Oxford 2006. 346 pp., hardcover € 29.00.—ISBN 978-0-19-530573-6

