

BOOK REVIEWS

The Theory of Adsorption and Catalysis. By ALFRED CLARK, Academic Press, New York, 1970. x + 418 pp. \$19.50.

In reviewing the book we are constrained to follow the sharp division imposed by the author, that is, to consider the adsorption and catalysis parts separately.

The adsorption part gives, in general, a concise and thorough picture of the present day adsorption theories and thereby fulfills a long-felt need for a similar text. It is indeed, as the title implies, limited to the theoretical aspects of the interaction between gases and solids and all the practical and experimental details are almost entirely omitted. This should not be construed to be a detriment as the adsorption practice is covered adequately in several existing texts.

The subject matter evolves gradually, first by presenting simple models of adsorption and then introducing an ever increasing degree of detail and complexity. It starts from a model of localized adsorption of monoatomic molecules on uniform surfaces, then the adsorbate is made polyatomic or mobile or mutually interacting and the surface—heterogeneous. No rigor is sacrificed and yet the presentation is clear.

One chapter is devoted to the treatment of the physical forces of adsorption, and two, one each for metals and semiconductor adsorbents, to the chemical adsorption forces. The treatment of chemisorptive bonding requires the description of covalent and ionic bonding, ligand fields, theory of metals and semiconductors, magnetism, etc.; and space limitations allow only a very cursory explanation of each facet. Nevertheless, for a reader with a reasonable grounding in physical chemistry, the going is not too arduous. These chapters could possibly have been switched to the beginning of the book so that the reader, or student, starts with the forces that hold the adsorbate and adsorbent together. The adsorption part is concluded with a chapter on the rate of the process.

The adsorption part alone could serve as an excellent basis for a one-term (semester) graduate course given either to physical chemists or chemical engineers interested in catalysis. Whether or

not the author had this objective in mind, he has succeeded where people who teach for a living rarely do.

The second part, theory of catalysis, is the shorter one in spite of the vastly more complicated subject. This fact by itself illustrates the quandary when attempts to theorize are made in heterogeneous catalysis. What is available to the author instead of theories is a series of correlations of catalytic activity operating somewhat in the fashion of a Procrustean bed: whatever observation does not fit is rationalized away. These correlations have only a limited predictive power and are, for the most part, not unique.

A vast amount of data on catalytic processes has been accumulated over the years and correlations by empirical means have been fairly successful. In contrast, the application and development of suitable theories have lagged behind. Even so a digest of theories pertinent to catalysis, as given in the book, should be welcomed by everyone interested in a deeper understanding of catalytic principles. At present, theory and the very successful practice are still far apart. The experimental approach suffers from a general lack of precision. Results from different laboratories are frequently difficult to compare because poorly defined surfaces make a meaningful comparison impossible. Often there are just not enough reliable data available for a crucial test of a theory. Then the theoretical approach involves restrictions introduced by assumptions or approximations along the mathematical route to provide a workable solution. Such simplifications result often in a satisfactory agreement with experiment within a certain region, but in complete disagreement beyond this region. Theoretically derived constants differ, for the most part, from measured values and have to be adjusted empirically. A complete experimental confirmation of certain theories may not be possible at all, as some factors, such as electronic contributions, cannot be measured. Sometimes a distinction between different models cannot be made by experiment as they are described by the same type of mathematical expressions. This large gap between theory and experimental results is pointed out by the book.

The theories are grouped in the usual manner into those where the activity determining factor is structural or geometric and those where it is electronic. There are only a few omissions of the notions used currently in discussing catalytic mechanisms. Such are Horiuti's stoichiometric number and Borekov's correlation between the strength of the oxygen surface bond and the activity of metal oxides in redox reactions, although relations similar to the latter are briefly discussed. The continuity of exposition of the first part is absent in the second, but, given the circumstances, this must be expected.

The list of references, drawn from world sources, permits the reader to consult the pertinent literature when further details are desired. Typographical errors are few, almost all of them found in the author index.

The book, as a whole, is recommended both for the practicing catalytic chemist and for the graduate student tackling problems related to adsorption and catalysis. We can hope, that the at times mathematically demanding treatment, especially of the adsorption, will not discourage the application by the practitioner and that the work will help to narrow the theory-practice gap. The price is on the high side, inflation notwithstanding, but the expenditure, in the opinion of the reviewers, is worthwhile.

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Catalytic Processes and Proven Catalysts. By CHARLES L. THOMAS, Academic Press, New York, 1970. xiv + 284 pp. \$12.50.

This book is a "public" edition of what was for a number of years a private company edition of a "how to do it book" in catalysis. The book is aimed at those scientists and engineers who are concerned with process problems in catalysis. It will be of particular value to individuals who have little or no background in the field and who need orientation in a subject prior to embarking on a

research and development program. The more knowledgeable, and even the expert, will find the book valuable as a quick reference for information outside his immediate field.

The book is an excellent source for finding out what catalyst to use for a particular reaction, manufacturers of individual catalysts (or, if not available, directions for making recommended catalysts) and the ranges for the main catalyst usage parameters such as temperature, pressure, feed rate, catalyst life, (short- and long-range) catalyst poisoning and catalyst regeneration.

Numerous references are included for those who wish to learn more about a particular field. The reference material is summarized at the end of the book under author and subject headings.

There are 22 chapters in the book. All the main areas of catalysis as practiced in the petroleum, chemical, and related industries are covered. Three chapters cover a description of various catalytic reactors, a summary of the scientific and engineering aspects of catalysis including regeneration, descriptions of various catalyst support materials, and directions for obtaining samples of commercial catalyst carriers and supports. Individual chapters are devoted to isomerization, cracking, dehydration, dehydrogenation, reforming, and alkylation; four chapters are devoted to various areas of hydrogenation processes; three chapters are devoted to oxidation; two chapters are devoted to polymerization. Additional separate chapters cover preparation of synthesis gas and hydrogen production, gas purification, and ammonia and methanol production. Twenty-seven miscellaneous processes not covered in other parts of the book are summarized in Chapter 21.

Considering the author's objectives, this reviewer has found the information to be comprehensive and up to date. Not included are the alkali promoted catalysts for the production of synthesis gas and hydrogen from naphtha. This is a recent development of wide usage at the present time.

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