The last section of the course is devoted to applications, especially energy storage and conversion and various important electrochemical processes, e.g. the chlor-alkali industry, aluminum production and the proposed hydrogen economy. Special topics of interest include bioelectrochemistry, membranes, electrodialysis, electrochemical machining, porous electrodes and high energy batteries.

An interesting class project is the technical comparison and economical evaluation of the various processes for chlorine-caustic production: the mercury, diaphragm and the newly developed membrane cells. The environmental impacts of the three processes are discussed at length. A new high current chlorine production process which involves high flow velocities is proposed as an exercise and the students are asked to design the process and to compare it to existing processes.

The novel technique of electrochemical machining is brought as an example of achieving very high rates which were unheard of only 15 years ago. In this technique the negative replica of the cathode is reproduced in the anode piece by high rate anodic dissolution. High current densities in the order of 100 A/cm^2 can be achieved by circulating the electrolyte at high velocities (10 m/s) through a very small gap (0.1-0.5mm). This is an excellent example of incorporating ChE and electrochemistry principles. The students are asked to design an electrochemical machining system using well known heat, mass and momentum transfer correlations, and to evaluate the power consumption.

CONCLUDING REMARKS

INDUSTRIAL ELECTROCHEMICAL processes will no doubt increase in relative importance to other chemical processes in the future. Increasing electrical energy generation relative to petroleum production will favor electrochemical processes and will need new electrochemical storage and conversion methods. Many known electrochemical reactions will be re-examined and improved. New membranes and new electrodes will be developed, and electro-organic chemistry as well as metal production by electrowinning will be expanded. It is anticipated that careful application of electrochemistry to biological problems will provide new solutions and new techniques. It is predicted that biological membrane research will expand. Direct application of electrochemistry to therapeutic situations will increase in the medical profession.

The role of the electrochemical engineer of the future will be to bridge the gap between the scientific discoveries and the yet unkown economic reality of the future. The present trend in electrochemical engineering of better quantitative understanding, better cell design, scale up and optimization insure that we are ready to fulfill the promising future of electrochemistry. □

RECOMMENDED BOOKS

1. Potter, E. C., Electrochemistry, Cleaver Hume Press, London 1956.
2. Newman, J., Electrochemical Systems, Prentice Hall, Englewood Cliffs, N.J. 1973.
3. Bockris, J. O'M, and A. K. N. Reddy, Modern Electrochemistry, Plenum Press, New York 1970.
4. Kortüm, G. F. A., Treatise on Electrochemistry, 2nd ed., Elsevier, Amsterdam, New York, 1965.
5. MacInnes, D. A., The Principles of Electrochemistry, Reinhold, New York, 1939.
6. Delahay, P., Double Layer and Electrode Kinetics, Interscience, New York, 1965.
7. Vetter, K. J., Electrochemical Kinetics, Academic Press, New York, 1967.
8. Mantell, C. L., Electrochemical Engineering, 4th ed., McGraw Hill, New York, 1960.
9. Kuhn, A. T., Industrial Electrochemical Processes, Elsevier, Amsterdam, New York, 1971.
10. Moore, W. J., Physical Chemistry, 4th ed., Ch. 10 & 12, Prentice Hall, Englewood Cliffs, N.J., 1972.
11. Bard, A. J., ed., Encyclopedia of Electrochemistry of Elements, vol. 1, Marcel Dekker, New York, 1973.
12. Hampel, C. A., ed., The Encyclopedia of Electrochemistry, Reinhold, New York, 1964.

ChE book reviews

INTRODUCTION TO MATERIALS SCIENCE (SI EDITION)

by B. R. Schlenker
John Wiley & Sons Australiana Pty, 1974.
364 pages.

Reviewed by C. E. Birchenall, U. of Delaware

In the foreword to this book, Professor Hugh Muir cites the need for all sorts of people to develop a better feeling for material properties and their efficient utilization as justification for introducing materials science into high school curricula. The author chose the contents to match the New South Wales syllabus for one of the four parts of an industrial arts curriculum. The result is a descriptive survey of the wide variety of materials employed in engineering, with fitting emphasis on structure-properties relationships and

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with the various types of instrumentation likely to be found in any industrial or academic polymer laboratory. This is valuable for learning useful techniques for their thesis research and gives them an edge in obtaining future employment after they finish their graduate study.

After completing the sequence of basic courses, students are further encouraged to take other elective courses on specialized topics in polymers. These include "Transport Processes in Polymer Systems", "Organic Synthesis of Polymers", "Polymer Spectroscopy" and "Polymer Morphology".

The Polymer Science and Engineering program is a graduate program only at the present, but undergraduate students interested in polymers can become introduced to the basic aspects of polymer science through two elective courses "Polymeric Materials" and "Polymer Technology". The two laboratory courses mentioned above are also offered to advanced undergraduate students. □

TABLE 1. Graduate Polymer Courses

Introduction to Polymer Science **3 credits, Lecture,** Boerio, **Autumn**

Preparation and Characterization of polymers; addition and condensation, molecular weight averages and distributions.

Physical Properties of Polymeric Materials **3 credits, Lecture,** Roe, **Winter**

Solid state structure-property relationships in polymeric materials. The glass transition, structure of crystalline polymers, thermodynamics of polymer solutions and compatibility.

Polymer Configurations and Rubber-like Elasticity **3 credits, Lecture,** Mark, **Spring or Summer**

Configuration dependent properties and their interpretation; statistics of chain dimensions; network formation in crosslinked polymers; thermodynamics and mechanical properties of rubbers; statistical theories of rubber-like elasticity.

Polymer Engineering **3 credits, Lecture,** Chartoff, **Spring**

Fundamentals of polymer processing; design of processing operations and relation to physical and mechanical behavior in solid and molten states; viscometric measurements and melt elasticity; applied viscoelasticity.

Polymer Characterization **2 credits, Lab,** Boerio, Roe, Chartoff, Mark, **Winter**

Experimental investigations of structure and properties of polymers; molecular weight averages and distributions, thermal and mechanical properties, transitions, and crystallinity.

Polymer Engineering Techniques **2 credits, Lab,** Chartoff, Roe, Boerio, Mark, **Spring**

Measurements of viscoelastic properties, viscosity and flow parameters necessary for design of polymer processing equipment; relations between processing data and polymer molecular structure with applications to quality control.

Special Topics in Polymers **3 credits, Lecture, Staff, Winter or Spring**

Intensive coverage of specific topi csin polymer science and technology at a research level. To be offered irregularly three quarters in each two year period. Future topics will include polymer spectroscopy, transport phenomena in polymer systems, surface properties of polymers, organic synthesis of polymers, polymer spectroscopy, and polymer morphology. Offerings to be coordinated between Chemical Engineering, Materials Science, and Chemistry staff.

BOOK REVIEW: Schlenker

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brief summaries of methods of testing and characterization of materials, and the shaping and fabrication of objects. There are many illustrations, but they are not always intergrated with and explained in the text. Many experiments are suggested; some are self-explanatory, but others are not clear with respect to purpose, procedure or significance. An instructor is necessary to supply guidance—and to protect students and equipment. Some statements are inaccurate or misleading, but they are few and unemphasized among the multitude; not much damage is likely to result.

Professor Muir notes that, in spite of the title, the text is about the phenomenology of materials more than the principles and concepts of materials science. The few gestures toward a quantitative approach include a few mechanical testing equations and a statement of Bragg's law, together with the geometric figure customarily used in its derivation. The use of the lever rule is illustrated, but even this mass conservation principle, using only the simplest linear algebra, is not derived.

Should the study of materials be a part of high school curricula? Surely it is more exciting than bookkeeping, conveys more varied skills than typing, and is a valuable adjunct to shop practice or preparation for the building trades. This book would be a suitable text, although injection of a bit more of the formal structure of materials science might make the subject easier to retain. College-bound students should study science and mathematics in high school so they can learn materials science on a more systematic and quantitative level. □