ment of this topic makes the entire book worthwhile because (Wonder of Wonders!) he has included examples and exercises which appear in the text directly after the explanation. Since the answers and explanations appear at the end of the text you can read this chapter and test yourself on the concepts presented as you go.

Programming the 6502 requires a thorough understanding of how the various registers in the microprocessor are organized and exactly what is the function of each. Chapter 2 explains the organization of the 6502 and, in general terms, how it works in enough detail to make programming possible. The minute detail which would lead to a deeper understanding is mercifully omitted. Chapter 3 presents the fundamental techniques necessary for writing a machine language program. Additionally register management, loops and subroutines are discussed. The author uses very simple programs as examples, such as addition and subtraction in both binary and BCD mode, for this purpose as well as more complicated programs such as 16-bit multiplication and division. Only the most simple addressing is used in these programs since the concept is discussed in detail in a later chapter. Again the author makes use of highly instructive exercises to insure that the reader understands vital concepts as he moves through the text.

Chapter 4 is an exhaustive summary of the 6502 instruction set. The first part of the chapter classifies the instructions which follow into five classes and discusses each class in detail. Then each instruction is explained in detail as well as how they may affect flags or can be utilized with various modes of address. I would suggest that the reader go over this chapter the first time with the object of obtaining an overview of the instruction set since the comments about addressing and flags will make little sense at this time. Then as he proceeds through the book he can come back to this chapter for learning greater detail about instructions as needed.

Addressing techniques is the hardest topic, in my opinion, to be mastered in machine language programing. Zaks patiently goes through the various modes available on the 6502 with examples of each in Chapter 5. I found the use of diagrams called data paths extremely helpful in this section (once I figured them out). Again this is a chapter whose broad concepts should be appreciated on a first reading. During actual programming attempts the reader will have to return to this section many times to pick up the details necessary for successful program writing.

Chapters 6 and 7 are concerned with the problem of microprocessor communication with the external world. The 6502, since it is memory mapped, treats memory and I/O ports alike and considers both to be memory. In other words the 6502 does not have separate pins for a read and write signal as do the Z80 or 8080. A write operation to the proper memory location can serve as an output operation, and a read operation from the proper memory location can serve as an input operation. This feature makes the 6502 particularly simple to interface. Zaks discusses in Chapter 6 both the simple task of communication with common I/O devices as well as the more complicated task of dealing with several of these devices through interrupts. The reader should be cautioned here that various microcomputers which utilize the 6502 have been designed with various systems in ROM for handling interrupts. Once you understand how the 6502 handles interrupts it would then be well to see how this is implemented on your own particular machine.

Chapter 7 discusses interfacing hardware mainly the 6520 family of programmable input output chips. These chips are the mainstay of most simple I/O boards. The author refers the reader to the documentation supplied by the manufacturer of these chips for the details of their use. In my experience this will give the reader a valuable exercise in understanding technical jargon which can be at least for a while a most frustrating experience.

The remainder of the book is comprised of valuable chapters on application examples, data structures and program development which allow the reader to put into practice the principles he has presumably learned in the preceding chapters. These chapters are not only valuable to the 6502 programmer but of value to anyone interested in these topics.

One important development in 6502 technology which has occurred since the publication of this book is the introduction of the CMOS (complementary metal-oxide semiconductor) version of the 6502. This chip is pin and software compatible with the earlier versions with the added advantages of lower power consumption and an extended instruction set. Additionally this chip has been changed to iron out some of the minor anomalies which are poorly documented in most of the literature including Programming the 6502. I would suggest that anyone with a serious interest in 6502 programming read and keep an article in BYTE magazine called "The CMOS 6502" by Steven Hendrix (December, 1983) for a complete discussion of the CMOS 6502 as well as the various anomalies of the older version.

On the whole I found Programming the 6502 an excellent learning tool for 6502 machine language programming. A student armed with a good assembler and this book as well as a 6502 can quickly master most of the techniques necessary for successful program writing. As I pointed out in an earlier review in this newsletter, however, the art of programming is best learned by actually sitting down and writing a program. Mr. Zaks has made this chore easier.

*Assistant Professor of Chemistry
University of Alabama in Birmingham, University Station
Birmingham, Alabama 35294

ARTIFICIAL INTELLIGENCE APPLICATIONS IN CHEMISTRY

Edited by Thomas H. Pierce and Bruce A. Hohne American Chemical Society, Washington, DC, 1986, 395 pages, hardbound, $59.95.
Reviewed by Harry E. Pence*

After many years of steady progress, practical applications of

artificial intelligence techniques in Chemistry now seem to be burgeoning. Chemistry is said to be an ideal field for the application of artificial intelligence and expert systems, because there are many situations where decisions are made on the basis of past experience or a set of rules that has been empirically derived. Expert systems catalog these rules in a form that is accessible to a computer, then use this inventory of rules to make decisions.

This book consists of papers presented at a symposium held at the American Chemical Society Meeting at Chicago, Illinois in September of 1985. Like most of the volumes in this ACS series, the articles were submitted as camera-ready copy. The individual papers cross reference each other more than usual and the type is generally quite readable. The index provided seems quite adequate, and each paper includes a bibliography for further reading.

The various papers do a fine job of representing the diversity of effort in this field. The discussion includes not only those few programs that are already available commercially, but also many different types of software that are in various stages of development. Concern has been expressed about the large amounts of programming time required to bring a new expert system to market, and so the reports on the use of rule-making systems to decrease development time may be particularly significant. The use of a rule-maker simplifies the development process both by decreasing the time required and also by decreasing the complexity of the programming process. These systems are already playing an important role in AI development, and they will probably become more prominent as they become more available and better known.

This book will be of primary interest to those who are either currently engaged in chemical AI research or are planning to do so in the near future; however, as more of these systems become commercially available, it is increasingly important for chemistry instructors to be aware of the capabilities of this new technique. Those who are interested in maintaining contact with progress in this field may well find this to be a solid way of doing so.

*Chemistry Department SUNY Oneonta, Oneonta, NY 13820

(See front cover for resulting graphs of the program below.)

```
1   'PROGRAM PHTITRAT BY Dr.R.J.LANCASHIRE DEP'T OF CHEMISTRY UWI, JAMAICA.
100 GOTO 120
110 FOR W=1 TO 5000:NEXT:RETURN
120 CLS:COLOR 5,0
130 ' SET UP RANDOM CONC OF ACID (APPROX .06) AND BASE (APPROX .001)
140 FOR I=1 TO 10*RND(1):A=RND(1):NEXT
150 V1=.09+RND(1)/10:VT=V1
160 MB=.001+RND(1)/10000:MB%=MB*1E+06:MB=MB%/1E+06:MB1=MB/2
170 MA=.06+RND(1)/100:MA%=MA*10000:MA=MA%/10000:MA1=MA/1000
180 VF=500*MB/MA:VF%=VF*100:VF=VF%/100
190 ' IGNORES DILUTION SINCE ONLY 10 cm3 ADDED TO 500 cm3
200 LOCATE 22,4,0:PRINT USING"TITRATION OF ##.####";MA;:PRINT " M STRONG ACID VS
. ";
210 PRINT USING"500 cm3 OF ##.###^^^^";MB;:PRINT " M STRONG BASE";
220 'STAND + BASE
230 LINE(20,164)-(630,164)
240 LINE(100,5)-(100,163):LINE-(104,163):LINE-(104,5):LINE-(100,5)
250 LINE(90,163)-(114,163)
260 ' BURETTE
270 LINE(98,95)-(157,95),2
280 LINE(145,7+VT*10)-(155,7+VT*10),1
290 LINE(145,5)-(145,120):LINE-(148,127)
300 LINE(155,5)-(155,120):LINE-(152,127):LINE-(148,127)
310 LINE(138,110)-(160,112):LINE-(160,115):LINE-(138,117)
320 LINE-(138,110)
330 PAINT(150,11),1,5
340 PAINT(150,120),1,5
350 FOR I=0 TO 10
360 SYMBOL(155,5+I*10),"-"+STR$(I),1,1
370 NEXT
380 'BEAKER
390 LINE(110,115)-(120,110)
400 LINE-(120,162)
410 LINE-(240,162)
420 LINE-(240,110):LINE-(250,115)
430 LINE(120,140)-(240,140)
440 PAINT(122,142),1,5
450 ' STIRRER BAR
460 BAR$="<"+STRING$(3,219)+">"+STRING$(5,8)+" <"+CHR$(219)+"> "
```