PN AAU-177

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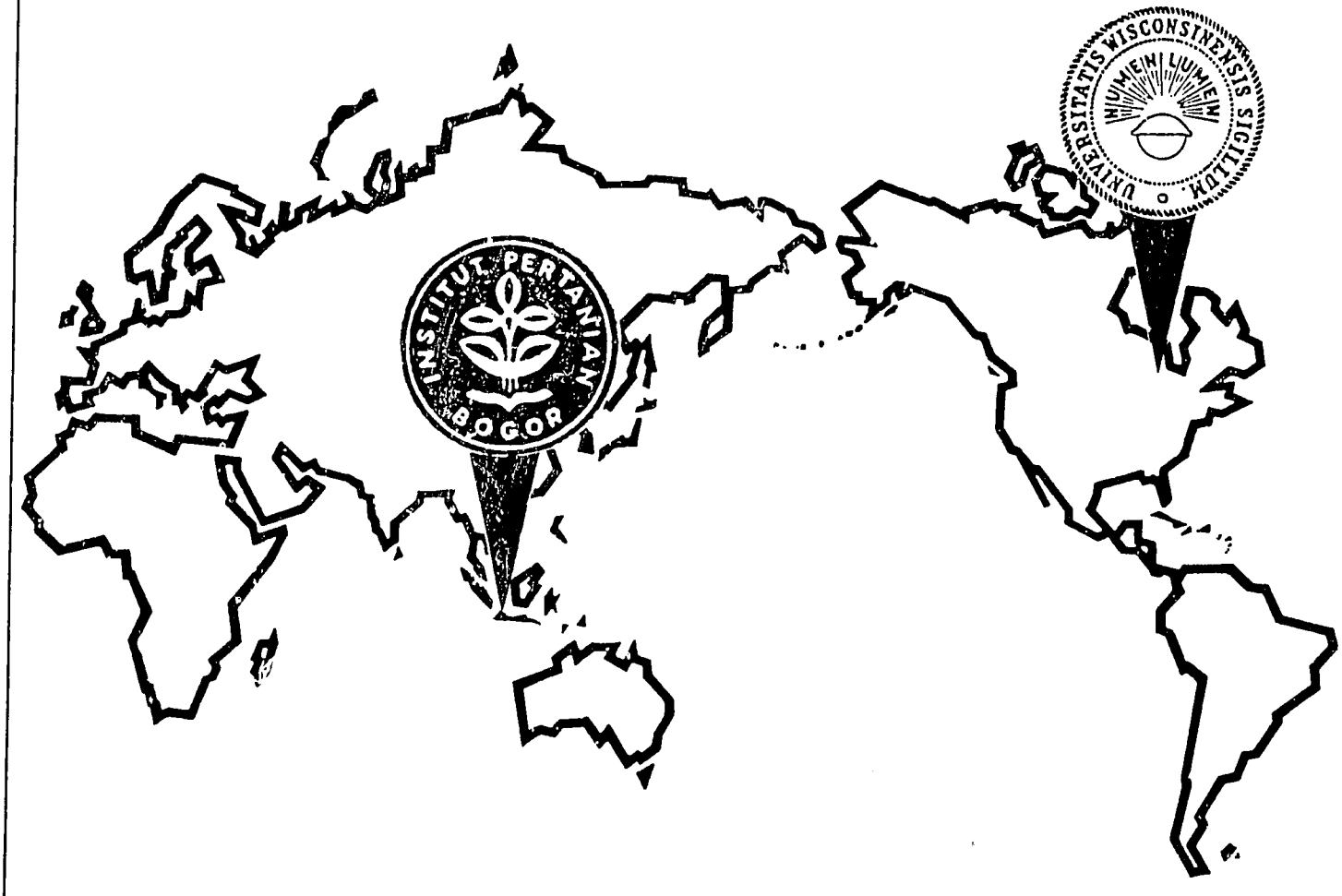

Aid Project 497-0290

Report No. 41
Kean/O'Leary

A RECOMMENDED SARJANA CURRICULUM IN CHEMISTRY/BIOCHEMISTRY FOR INSTITUT PERTANIAN BOGOR

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IPB/UW Graduate Education Project
July-August 1984

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ACKNOWLEDGMENT

We would like to thank our many friends and colleagues in Bogor for their assistance in preparing this report, particularly John Murdock, Norman Azwar, Anwar Nur, and the faculty of the Department of Chemistry and Biochemistry. We also thank our colleagues in Madison who took over our duties in our absence and gave us the freedom to come to Bogor.

SUMMARY OF RECOMMENDATIONS

1. Institut Pertanian Bogor should proceed with the establishment of a Sarjana (S_1) program in chemistry and biochemistry. The first part of the program will be uniform for all students. During the last three semesters, students interested in chemistry or biochemistry will be able to concentrate in their own field.
2. A four-year cycle of activities is recommended in order to develop the program.
3. Arrangements should begin immediately to acquire equipment and facilities required for the program.
4. Continuing acquisition of equipment and supplies will be required to support the program and to provide facilities needed for research activities.
5. Staff size must be increased in the next five years to provide enough manpower to teach the courses in the Sarjana program.
6. Advanced training activities in Indonesia and in the U.S. for current and new IPB staff should be continued.
7. All chemistry/biochemistry staff should participate in the development of the Sarjana program. All staff should participate in the Kimia Dasar program.
8. A curriculum committee composed of chemistry/biochemistry staff should be appointed to oversee the development of the Sarjana program. They should communicate with the full staff at regular intervals.

9. In order to provide for the development of new courses in the Sarjana program, release time should be provided to staff at the rate of one semester half-time released per semester of course to be developed.
10. In the development of a detailed curriculum, maximum flexibility should be allowed in order to permit students to proceed through the program at their own best rates.
11. A book and journal collection in the IPB Library should be established to support the program. Continuing subscriptions to a small set of journals should be provided.
12. A translation program should be started in order to provide necessary textbooks and laboratory materials for the chemistry/biochemistry program. Translation activities should be coordinated with similar activities at other Indonesian universities.
13. A regular sequence of program evaluations should be conducted, using information gathered from students, from staff, and from outside reviewers.

INTRODUCTION

As part of our visits to Institut Pertanian Bogor in January, 1983 and July-August, 1984, we were asked to make recommendations concerning the development of a Sarjana (S_1) curriculum in chemistry and biochemistry. During our first visit, we made trips to the University of Indonesia, Gadja Mada University and Bandung Institute of Technology, where we talked to chemists and obtained information about S_1 curricula in chemistry at those institutions. We also talked to many IPB staff to get background on the current state of science education at IPB.

At the end of our first visit (January, 1983) we wrote a preliminary report and made a series of recommendations for the creation of an S_1 program in chemistry at IPB ("Observations and Recommendations Concerning Creation of a Sarjana (S_1) Program in Chemistry at Institut Pertanian Bogor," IPB/UW Graduate Education Project Report No. 21). Our report dealt particularly with manpower needs and facilities needs that would have to be met prior to the establishment of a full S_1 program. We will not repeat those observations and recommendations except to repeat our belief that staff training and staff size must be high priorities for a successful program (see particularly recommendations 1, 4, 5, 7, and 8).

In the 18 months since our first visit, progress has been made in reaching the desired level of staff training, though much still remains to be done. The number of staff remains a serious problem, particularly considering the heavy load of service courses provided by

The Department of Chemistry. The recommendations concerning staffing that were made in our previous report remain valid.

In this report we present a detailed outline of the proposed Sarjana program in chemistry and biochemistry. This includes a listing of the courses to be taught, a description of their content, suggestions for the accompanying laboratories, and a recommended schedule for development of the program.

Departmental Structure Just prior to our return to Bogor in July, 1984, the Ministry of Education decreed that the Department of Biochemistry would be joined with the Department of Chemistry into a new, expanded Department of Chemistry, with the expectation that the Department(s) would thus be strengthened. As with any such merger, this one is likely to have both advantages and disadvantages. In our previous report we recommended that the two departments work together to create a core curriculum at the S_1 level that could be used both by chemistry majors and by biochemistry majors. The feasibility of such a plan is much increased by the merger of the two departments. At the same time, it is important that both groups be able to offer advanced-level courses to their own students.

We do not presume to understand the details of Indonesian higher education well enough to recommend whether this union should be considered permanent--this choice must ultimately be left to the members of the Department(s). However, we hope that past differences of opinion can be overcome and that both faculties can work together to create a strong program.

It is important that the new Department establish a sense of trust and respect between the chemists and the biochemists. We especially recommend that a strong departmental structure be established. The faculty should meet regularly, and they should be kept informed concerning administrative decisions that affect them. Further, all staff must have a voice in decisions made by the Jurusan.

UNDERGRADUATE (S_1) CHEMICAL EDUCATION IN THE U.S.

In this section we will describe the general pattern of undergraduate chemistry programs in the U.S.A. in order to provide a possible system for comparison with the developing system of chemical education in Indonesia. Of course, a number of aspects of the U.S. system are probably not appropriate for Indonesian education, but the general outline may be useful.

After 12 years of primary and secondary school, an American student is qualified to enter a college or university. The student is then about 18 years old. In secondary school, he or she probably had one year of chemistry, one year of physics, and 3 or 4 years of mathematics (sometimes including an introduction to calculus).

Although colleges and universities vary somewhat in their requirements for an undergraduate degree, the following represents a summary of a typical college program.

Most undergraduate programs require four years of full-time study to complete. Each "year" consists of two semesters, each of length approximately 16 weeks. One "credit" in the American system is generally equivalent to one class hour or three laboratory hours a week for one semester. The student will also spend about two hours outside of class for each credit hour. In fact, the amount of outside time varies widely, sometimes running up to twice the expected time for particularly difficult courses.

In order to graduate, the student must accumulate at least 120 credits. Thus, in a 4-year program the average load is 15 credits (4

or 5 courses) per semester. Of this total of 120 credits, only about 40 will be in the student's major field. The remainder will be in auxiliary technical fields (such as mathematics and physics for a chemistry major) and in general subjects (language, history, literature, social science). Thus, American science curricula at the undergraduate level generally contain less science than their Indonesian equivalents.

The curriculum for students majoring in chemistry in the U.S. has been strongly influenced by the American Chemical Society, the professional society of chemists in the U.S. Although the Society has no official role in determining curricula (that is, it has no role that has been required by the U.S. Government), most chemistry professors are members of the Society, and it has had a strong, though unofficial influence.*

College chemistry curricula typically require 2-4 semesters of college mathematics (at least through calculus, and in some cases more than that), and 2-3 semesters of calculus-based physics (these courses are a prerequisite for courses in physical chemistry). Of the approximately 40 credits required in chemistry at typical American universities, 32 are in required courses and only 8 are in elective chemistry courses. Only in the last year does the student have any real choice of courses. Laboratory work is emphasized; the average

*See "Undergraduate Professional Education in Chemistry: Guidelines and Evaluation Procedures", American Chemical Society, 1983, and "Guide to Chemical Education in the U.S. for Foreign Students", American Chemical Society, 1981.

student takes one or two laboratory courses each semester. The treatment of many topics, particularly in the advanced courses, tends to be highly mathematical, with liberal application of principles from calculus. The following breakdown by year describes a typical program:

Year 1: A two-semester course in general chemistry, with laboratory. This course is somewhat more mathematical than the corresponding Indonesian course. The major subject areas are:

1. Introduction to units and measurement
2. Properties of matter, including physical and chemical changes
3. Structure of the atom
4. Molecular structure
5. States of matter
6. Solutions
7. Thermodynamics and kinetics
8. Chemical equilibrium
9. Electrochemistry
10. Descriptive phenomena (this section is highly variable)
11. Carbon chemistry
12. Nuclear chemistry

At the same time, the student is also taking mathematics, physics, and a variety of non-technical subjects.

Year 2: First semester: Analytical chemistry and quantitative analysis. This course builds on many of the issues introduced during the first-year course, particularly those issues having a highly mathematical foundation. Topics generally include:

1. Data treatment
2. Chemical equilibrium
3. Acid-base theory, pH
4. Electrode potentials and oxidation-reduction reactions
5. Stoichiometric calculations
6. Gravimetric methods
7. Titrimetric methods
8. Potentiometric measurements
9. Photometric and spectrophotometric measurements
10. Separations
11. Other electroanalytical and spectrochemical methods

The laboratory is a very strong component of this course, giving students practice in making careful measurements. This laboratory course is generally not strongly oriented toward instrumentation. Simple pH meters and spectrometers are, however, used.

The second semester of the second year is taken up with the first part of a two-semester introduction to organic chemistry. This course is rather uniform among various universities. It is concerned with the structures and reactions of carbon-containing substances. The course is generally organized according to functional groups, but reaction mechanisms are emphasized. The accompanying laboratory course covers purification and identification of organic compounds, organic synthesis, and spectroscopy, particularly nmr and IR.

Year 3: During the first semester the student takes the second semester of the two-semester organic chemistry course that was started the previous semester.

During this year the student also starts a two-semester sequence in physical chemistry. The course is generally highly mathematical and makes great demand of students' time. Most students say that these are the most difficult courses they take. Of the total of two semesters, about half of one semester is taken up with thermodynamics and half of one semester with quantum mechanics. Other topics (emphasis varies) include spectroscopy, statistical mechanics, solutions, colligative properties, and kinetics

The accompanying laboratory course is highly instrumental and highly individualized. It is a sort of pre-research course in which the students must design and perform their own experiments using a variety of modern instrumentation (spectrophometers, calorimeters, ultracentrifuges, stopped-flow equipment, etc.).

Year 4: Most students take a one-semester survey course in inorganic chemistry. There is not such a logical progression of topics in this course as in organic chemistry. Topics covered often include molecular structure, advanced acid-base chemistry, coordination chemistry, organo-metallic chemistry, catalysis, mechanisms, and other topics. There is usually no lab.

Most students also take a course in instrumental analysis. This is a continuation of the second-year course in quantitative analysis with additional emphasis on instrumentation. The course is laboratory-oriented and includes various kinds of spectroscopy, nmr, electrochemistry, chromatography, etc., as well as a liberal amount of electronics and computer-control.

Electives include advanced organic chemistry (synthesis, mechanisms, or spectroscopy, depending on the institution), advanced physical chemistry, biochemistry, and senior research. Some schools require senior research, but not all.

Several contrasts with Indonesian programs are worth noting. First, there is no requirement for a course in biochemistry (though some universities offer a separate major in biochemistry; see below). Second, there is a shortage of "relevant" courses--environmental chemistry, agricultural chemistry, medical pharmaceutical chemistry, etc. Third, there is generally no seminar requirement. The amount of descriptive material in the American curriculum is rather small.

Biochemistry Programs. A number of American universities now offer an undergraduate major in biochemistry. During their first two years, these students take the same courses as the chemistry majors, including general chemistry, quantitative analysis, and organic chemistry. They often take one semester of physical chemistry that is different from the course offered to chemistry majors. They also take about 4 courses in biology.

During their third and fourth years, these students take 3-5 courses in biochemistry, often including general biochemistry, molecular biology, vitamins and hormones, plant biochemistry, and other subjects. One or two semesters of laboratory work in biochemistry are included in the curriculum.

UNDERGRADUATE EDUCATION PROGRAMS IN CHEMISTRY IN INDONESIA

The following observations are based on visits we made in January, 1983, to the University of Indonesia (UI), Bandung Institute of Technology (ITB), and Gadja Mada University (UGM), as well as on a reading of the publications of those three jurusan kimia. Our limited observations may have led to some inaccuracies in our report.

In general, the S_1 programs in chemistry in Indonesia contain a much later amount of chemistry than their American counterparts, about 100 out of 144 credits required for graduation are in chemistry.

We were also told that there is a tendency in Indonesia for S_1 chemistry programs to take longer than the expected time. All three faculties reported that students were having trouble finishing within the maximum time (7 years) allowed by the Ministry of Education.

It is possible that one key to this scheduling problem is the course load of Indonesian chemistry students. Most students are taking 5 science and math courses each semester, including 2 or more laboratory courses. This is a heavy load by any standard, and may be a key to the problem.

A comparison of course requirements at the three Indonesian universities visited and at a typical American university are given in Table I. In addition to the requirements noted, all 3 Indonesian universities require 2 semesters of physics (with at least 1 semester of laboratory work) and 4 semesters of mathematics.

Table I: Undergraduate (S_1) chemistry curricula in the U.S. and in Indonesia. The U.S. curriculum is a typical four-year program. Numbers given are the number of semesters of courses required in each area. The last column (IPB) is the recommended course offering for Institut Pertanian Bogor.

	Number of semesters of courses required				
Area of Chemistry	USA	UI	UGM	ITB	IPB
General	2	2	2	2	2
Organic	2	3	4	4	4
Analytical	2	5	4	5	4
Physical	2	6	6	6	3
Inorganic	1	2	0	1	1
Biochemistry	0	1	1	1	2
Seminar	0	2	2	2	2
Thesis	2	2	2	2	2
Options	2	6		5	4

Generally, the three Indonesian curricula agree on a number of points: a year of general chemistry, followed by 3 or 4 semesters of organic chemistry, 4 or 5 semesters of analytical chemistry, 6 semesters of physical chemistry, a semester of biochemistry, 2 semesters of seminar, and 2 of thesis research. In terms of semesters, these are roughly twice the number of semesters required by the American curriculum. However, note that the balance among the various areas of chemistry is similar in the two curricula.

THE RECOMMENDED CURRICULUM

Here we begin a detailed discussion of the recommended Sarjana curriculum in chemistry and biochemistry. Our recommendations are based on a number of factors:

1. The requirements of the Ministry of Education.
2. Requirements and needs of IPB.
3. The model of U.S. programs.
4. Other Indonesian programs.
5. The differing needs of students having different career goals, with particular attention to the differences between chemistry and biochemistry.
6. The scarcity of trained manpower and the necessity of optimizing the use of this resource.
7. The scarcity of economic resources (money, equipment, chemicals, supplies) and the necessity of careful planning in this area.

We present these recommendations with the request that the reader understand the limits of our own experience: We have spent many years in the American educational system, but only a few months in the Indonesian educational system. We hope we have done no serious injustices to either system. We hope that these suggestions may serve as a starting point for the establishment of a successful program.

Chemistry and Biochemistry Although it might be best to create two curricula--one in chemistry, and one in biochemistry--it seems to us

that the needs of IPB are best served by a combined program in chemistry and biochemistry. In this program, the students in both areas take the same set of "core" courses in their first three years. In their third and fourth years, their paths diverge, depending on whether they are interested in chemistry or biochemistry. It seems to us that the recent Ministry of Education directive that combined the departments of chemistry and biochemistry suggests that such a program is desirable. The new, united Department should be able to generate a strong program of this type.

GOALS OF THE CHEMISTRY/BIOCHEMISTRY CURRICULUM

We assume that the goal of this curriculum is to train IPB students at the Sarjana level for careers in the agricultural, chemical, pharmaceutical, and chemical manufacturing industries, for careers in government agencies, for careers in analytical laboratories, for careers in education (both at the secondary and tertiary level), as well as for further education either in Indonesia or overseas. The curriculum should emphasize skill in the theory and understanding of chemistry as well as skill in laboratory practice. These skills should encompass five basic areas:

1. organic chemistry
2. physical chemistry
3. biochemistry
4. analytical chemistry
5. inorganic chemistry

STUDENTS ENTERING THE CURRICULUM

Students entering this curriculum will be graduates of an Indonesian secondary school (SMA) and will have taken three years of chemistry and at least three years of mathematics there. Students will also have completed the compulsory first-year Sarjana program at Institut Pertanian Bogor, including one year of chemistry, one year of mathematics, and one semester of physics.

Initially, it would probably be reasonable to plan for an incoming class of about 25 students. This would keep lecture and laboratory sections at a reasonable size, and by the fourth year, the class would probably be reduced to about 12--probably the largest number that could be accommodated in research in the first years of operation of the program.

Chemistry is not currently a popular subject among students, either in the United States or in Indonesia. Many students have had bad experiences with chemistry in secondary school; they find chemistry frustrating and uninteresting. How are we to attract interested and capable students to a Sarjana program in chemistry? Kimia Dasar is probably the answer. If students find this course interesting and rewarding, their interest in chemistry may be increased. If they find the laboratory exercises exciting, they will be interested in further laboratory work.

In every class in Kimia Dasar there are a small number of students (perhaps only one or two) who show by their examination performance that they are particularly capable of doing chemistry. The chemistry

staff should make a vigorous effort to recruit these students to become chemistry majors. Most first-year students are pleased if a faculty member takes special interest in them. An early and persuasive approach to talented students might be a good means of building a chemistry program.

These students should be told that the chemistry/biochemistry program is currently being developed, and that they will have a part in that development. Their help and input will be needed in the development of courses and laboratories. They will receive an extra education by virtue of their work on the planning of the Sarjana program.

GENERAL DESCRIPTION OF THE CURRICULUM

All students in the first year of the Sarjana program at IPB take the same set of courses, including a year of chemistry. Our discussion starts with the following year.

The courses can be divided into four groups:

I. A set of "core courses" in the second and third years that will be taken by all students. These courses provide the fundamental basis for all that is to follow. They include 3 semesters of organic chemistry, 2 of quantitative chemistry, 2 of physical chemistry, and 2 of biochemistry, plus a semester of physics and 2 semesters of calculus.

II. A set of more advanced courses required of all students after completion of the "core courses", including a semester of instrumental analysis, a semester of inorganic chemistry, a semester of radiochemistry, a year of chemistry in English, a year of seminar, and a year of thesis.

III. A set of more advanced courses for chemistry majors.

IV. set of more advanced courses for biochemistry majors.

The recommended curriculum is set out in Table II and in Figure 1. Individual courses are described in more detail in Appendix I. Comments on the curriculum, year by year, follow.

Table II. The recommended Sarjana curriculum in chemistry and biochemistry.

Year 1

Standard IPB first-year program, including one year of chemistry

Year 2

First Semester		Second Semester	
Calculus I (STK 201)	4	Calculus II (STK 202)	4
Physics II	3	Physical Chemistry I	3
Organic Chemistry I*	4	Organic Chemistry II*	4
Quantitative Chem. I*	4	Quantitative Chem. II*	4
Biology Elective	3	Biology Elective	3
	18		18

Year 3

First Semester		Second Semester	
Physical Chemistry II*	4	Inorganic Chemistry	3
Organic Chemistry III*	4	Instrumental Analysis*	4
Chemistry in English I	2	Chemistry in English II	2
Biochemistry I*	4	Biochemistry II*	4
Elective	4	Thermodynamics(CHEM)	3
		Required Course(BIO)	3
		Elective	2
	18		18

Year 4

First Semester		Second Semester	
Radiochemistry*	3	Seminar II	1
Seminar I	1	Thesis II*	8
Thesis I*	7	Advanced Chemistry or Biochemistry	9
KKN	4		
Advanced Organic (CHEM)	3		
Advanced Biochemistry (BIO)	3		
	18		18

Notes: *indicates that course includes laboratory. (CHEM) means required only of chemistry students. (BIO) means required only of biochemistry students.

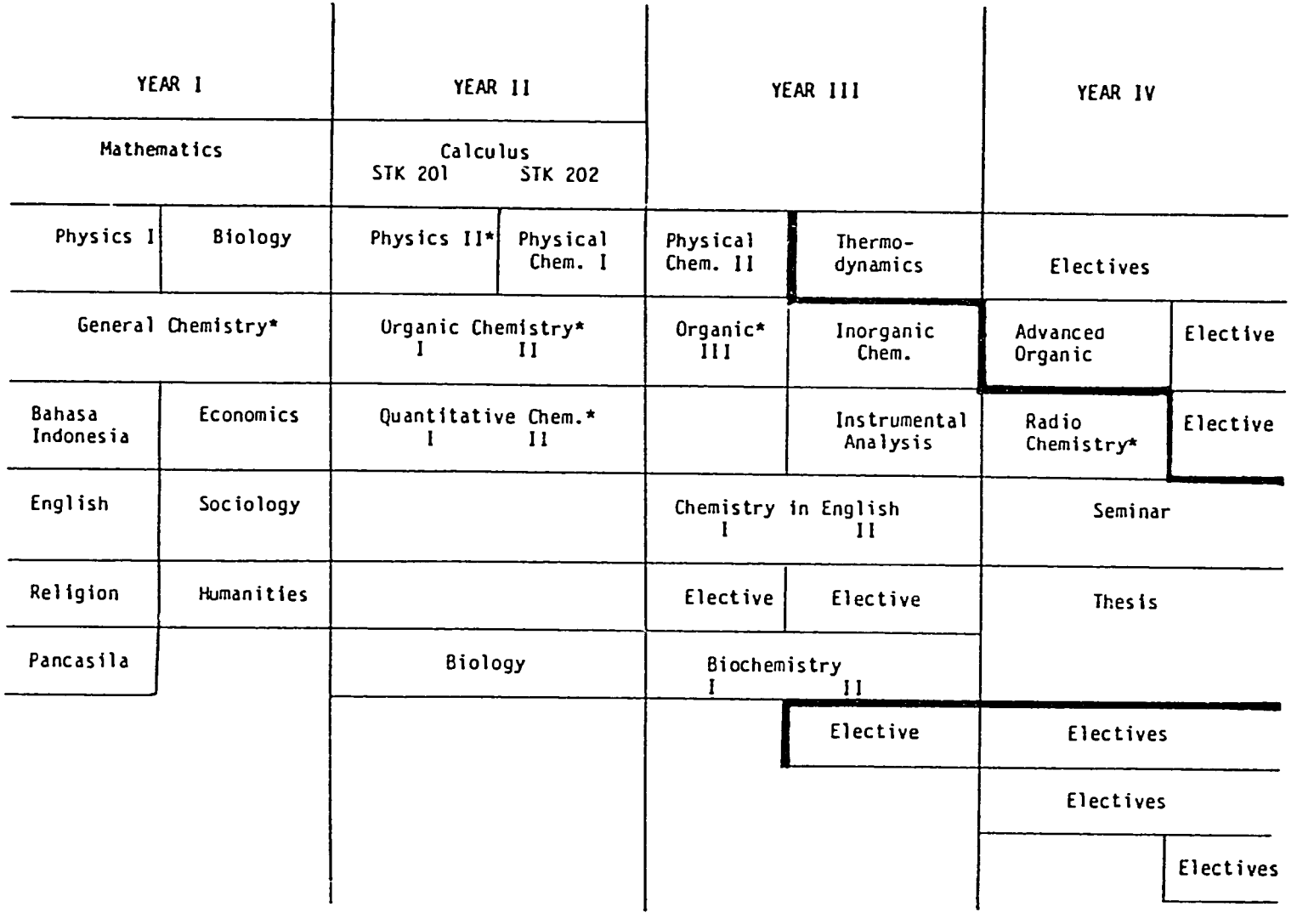

Figure 1. The Chemistry/Biochemistry curriculum. The * indicates that a course includes laboratory. The courses in the center are for all students. The upper right is for Chemistry and the lower right Biochemistry.

Year 2. The first semester includes two courses needed as preparation for physical chemistry: calculus and physics. Also in this semester, is the beginning of a three-semester sequence in organic chemistry. This course is similar to that given in American universities and in other Indonesian universities. The laboratory in this course is rather different from the laboratory portions of the other courses; this one is concerned with the particular skills needed to prepare and manipulate carbon compounds.

The other major course in the first semester is the beginning of a two-semester sequence in quantitative chemistry. This course is generally similar to that given in many U.S. and Indonesian universities, but it is different in detail. There is emphasis on the quantitative (i.e., calculation) aspects of chemistry, with the particular aim of increasing the ability of students to do chemical/mathematical calculations. The laboratory in this course is very important.

A course in biology (to be chosen by the student) completes the semester's work.

The second semester is a continuation of the first, with continuing courses in organic chemistry, quantitative chemistry, calculus, and an additional course in biology. The only new course is the first course in physical chemistry. This course was delayed to the second semester in order that the student could study calculus and physics. The organic chemistry and quantitative chemistry courses both have a laboratory.

The teaching techniques which will be employed in these second-year courses are particularly important. Because of the number of students in the first-year program, the teaching is principally in a lecture format and the exams tend to be multiple-choice or other formats where only the final answer (and not the process of arriving at that answer) counts. At the end of the first year, the problem-solving skills of students are still quite weak.

One of the principal objectives of the quantitative chemistry course is to develop the problem-solving skills of students so that they will comfortably be able to complete more advanced work in chemistry. In order to develop these skills, it is important that the instructor work with the students step by step in working through problems. On exams, it is important that students show their work on each problem and that they be given credit for correct work even when the final answer is incorrect. The instructor in this course should consider the development of appropriate study and problem-solving skills to be one of his/her most important objectives.

A similar recommendation applies to the organic chemistry course: Students must learn to work systematically and carefully with organic structures. The instructor must guide them in the development of this skill. Partial credit must be given on exams for answers that are partially correct.

Year 3. In the first semester, the courses in physical chemistry (now including a laboratory) and organic chemistry (also with laboratory) continue. This organic chemistry course is concerned with the organic chemistry of biological molecules, including amino acids, proteins, carbohydrates, heterocyclic compounds, etc. This semester also begins a two-semester sequence in biochemistry. Because of the agricultural orientation of IPB, we believe that this two-semester course should be required of all students. Although it would be better to postpone the biochemistry course until organic chemistry has been completed, this is not possible, because the two-semester biochemistry course needs to be completed within the third year.

The biochemistry course also includes a laboratory. Unfortunately, students are taking three laboratory courses this semester. This will be a very heavy load. It would be possible to omit the laboratory in one of the three courses, but we do not recommend this.

Also in this semester, there is a course called "Chemistry in English." The purpose of this course is to improve the ability of students to communicate in chemistry using the English language. An elective course (not necessarily technical) completes the curriculum.

In the second semester, the Biochemistry course and the Chemistry in English course continue. There is also an advanced course in instrumental analysis, in which the student learns the operation and maintenance of a variety of modern analytical instruments. It is important that students take this course prior to the beginning of research in the fourth year.

In this semester, all students take a one-semester course in inorganic chemistry. Chemistry students take a course in thermodynamics. Biochemistry students take an advanced course in biochemistry (the content of this course has not been determined). All students take one elective course.

Year 4. The curriculum for the first semester must be arranged to allow for the required KKN. All students take a course in radiochemistry (principles and practice of performing experiments with radioactive isotopes). Students begin a two-semester "Seminar," as is common in Indonesian universities.

Chemistry students are required to take an advanced course in organic chemistry. Biochemistry students must take an advanced course in biochemistry.

During this semester and the next, students spend about half of their time (7-8 credits per semester) on research for a thesis. This work is done under direction of a member of the faculty, using the instrumentation and equipment available in the various laboratories. It should be noted that this research program is expensive in terms of faculty time; appropriate recognition must be given to faculty for participating in these research activities.

The second semester is composed of seminar, thesis, and three additional courses in advanced chemistry or biochemistry. The content of these advanced courses has not been clearly defined at the present time. This issue is discussed in more detail below.

Advanced Elective Courses. In addition to the specific courses which have been described above, students should be required to take a number of elective courses in chemistry or biochemistry in their fourth year. Probably 4 courses should be required. We leave the final decision on that to the IPB staff.

At this level, separate courses should be offered for chemistry majors and for biochemistry majors. However, there is no reason why a chemistry major should be prohibited from taking a biochemistry course, or vice versa.

The development of courses at this level is a long-term project. The courses are relatively advanced, and thus they require a lot of staff time for development. We would expect that development of a full set of courses at this level might take as long as 6-8 years. In the first years of operation of the curriculum, it may be possible only to offer the absolute minimum number of courses. In that case, students will have almost no choice of advanced courses--they must simply take those that are offered. As new courses are developed, more options will become available.

The nature of the courses which are developed at this level will depend on the knowledge and interests of the staff. A course in a particular area is obviously most easily developed by a specialist in that area.

In Appendix II we list some possible courses that might be offered. This list is illustrative, not complete. It is based on courses in the U.S. and in other Indonesian universities, as well as on

our own feelings about what might be useful in an Indonesian curriculum. It is possible that some courses offered by other jurusan (especially biology, veterinary medicine, food science) may be appropriate for chemistry and biochemistry students.

IPB staff must also make a decision on whether specific advanced courses should be required of all students, or whether students should be free to choose. We favor the latter possibility. An appropriate requirement would be, for example, for biochemistry students, "four advanced courses in biochemistry."

Relation of This Curriculum to Requirements of the Ministry of Education. After this curriculum document was completed and presented to Jurusan Kimia at Institut Pertanian Bogor, we became aware that several of our suggestions were at variance with Ministry requirements. Some of this problem has occurred because we were unaware of Ministry requirements. Some of this has occurred because existing IPB courses do not provide the required number of credits. Necessary changes have not yet been made in the proposed curriculum, but they are outlined below.

1. Matematika dasar. Our curriculum contains 4 more credits (SKS) than are required. However, we believe that given the nature of modern chemistry, this level of mathematical preparation is important, and we would urge that it be left in. This level of mathematical preparation corresponds to that required in American universities.

2. Fisika dasar. Ministry requirements are 8 SKS, whereas our proposal contains only 6 SKS. In order to meet this requirement, both the existing first-year physics course and the pending second-year course must be increased from 3 to 4 SKS.

3. Kimia dasar. Ministry requirements are 8 SKS, whereas the current IPB courses are only 6 SKS. Thus, both these existing courses need to be increased by one SKS each.

4. Quantitative chemistry. Ministry requirements are 12 SKS. If our course 'Instrumental analysis' is included in the total, then our total is 12 SKS. Otherwise, it will be necessary to add a third course in introductory quantitative chemistry.

5. Kimia fisika. Our curriculum contains two courses, 3 SKS each, whereas the Ministry requirement is for 12 SKS. We suggest increasing each course to 4 SKS and adding a third semester.

6. Kimia organik. Our curriculum is two credits short in the second and third years. However, if the advanced organic chemistry course in year 4 is included, the requirements are met

7. Biokimia. Our curriculum contains two SKS more than the required minimum, but we believe that this is appropriate for IPB.

8. Kinetika dan mekanisme. This is often a part of the physical chemistry course. However, according to Ministry requirements, it needs to be included as a separate course. This would presumably be done in the fourth year and would decrease the number of electives.
9. Molecular structure and spectroscopy. This course is closely related to physical chemistry. According to Ministry requirements, we need to add it, presumably in the fourth year.
10. Statistika. This course needs to be added.
11. Literature kimia. The proposed third-year course covers this subject as well as needed English-language instruction. We recommend that the course be given as suggested, even though it exceeds Ministry requirements.

The net result of all these changes will be to increase the number of required courses in the fourth year and decrease the number of electives. Finally, we should note that it is not clear whether enough flexibility can be created within the curriculum to allow for a separate major in biochemistry, as we have suggested. However, we would recommend that this be done if at all possible.

Relationship to Other Jurusan. Building a strong curriculum in chemistry and biochemistry at IPB will be beneficial not only to the Chemistry Department, but to other Jurusan as well. A number of the courses which will be developed as part of the chemistry program will

also be useful to students in other disciplines. For example, organic chemistry is likely to be useful to students in food chemistry, biology, veterinary medicine, agronomy, and other curricula which depend on chemical foundations of life. Students whose curriculum involves many measurements may find the quantitative chemistry course useful. Students in the life sciences may find the biochemistry course appropriate. A second year of chemistry is likely to be useful to many students.

The Problem of Timing. Students choose to become chemistry or biochemistry majors because chemistry and biochemistry will allow them to enter the professions they want to enter. They also choose these fields because chemistry is "easy" for them--students for whom chemistry is very difficult tend to migrate to less quantitative areas. Thus, we hope that the students who become chemistry and biochemistry majors will be more interested and more capable in this area than is the student body as a whole.

However, even for these selected students, chemistry is a difficult and time-consuming subject. In addition, there is a heavy load of laboratory work in this curriculum.

This brings us to a serious problem. Each semester, students are expected to enroll in 18 credit hours of courses. Is this realistic? What happens if students fall behind? Is it possible to rearrange the curriculum so that more time is available?

We have been told that chemistry students at other Indonesian universities do not finish their curriculum in four years. In fact,

most students are unable to finish in five years, and many take as long as seven. We fear that unless very dramatic steps are taken, the same thing may happen at IPB.

We have tried to account for this problem in our curriculum design. Thus, we have been careful to restrict the level of particularly difficult courses in any semester. Alas, given the 18 hour per semester requirement, this is very difficult. We have also tried to restrict the number of laboratory courses in each semester. Laboratory courses are very time-consuming compared to the number of credits that a student earns.

We do not believe that most students will be able to finish this curriculum in four years. We urge that IPB staff maintain flexibility in order to allow students to progress through the curriculum at their own pace. In this spirit, we have rearranged the four-year curriculum into a five-year curriculum containing the same number of credits and courses. This is shown in Figure II. This particular rearrangement is not unique; several other possibilities exist. However, it should be noted that many advanced courses have prerequisites; these should be carefully observed.

Figure 2. The five-year version of the chemistry/biochemistry curriculum. The required first-year courses are not shown.

YEAR II	YEAR III		YEAR IV		YEAR V
Calculus	Physics	Physical Chemistry	Physical* Chemistry	Instrumental* Analysis	Electives
Organic Chemistry*	Organic*	Inorganic Chemistry	Advanced Organic	Thermo-dynamics	
Quantitative* Chemistry			Radio* Chemistry	Elective	
Biology	Biochemistry*		Elective	Thesis?*	Thesis*
	Electives		Chemistry in English I II		Seminar
			Electives		Electives

STAFF DEVELOPMENT

The full operation of a Sarjana program in chemistry and biochemistry will require a substantial investment of both human and economic resources. Full operation of this program will require the development of more than 20 new courses. Many of these courses include laboratories (experiments are always time-consuming to develop), and most courses will require the translation of materials that are not currently available in Bahasa Indonesia.

When the program is in full operation and has its full complement of students at all levels, each semester there will be about 12 courses offered that are not currently being taught. If a typical instructor teaches two courses, this means that the full-time work of at least six individuals will be required to maintain the program. In addition to this, staff time will be required to supervise thesis projects in the fourth year.

Another manpower component that must be considered is the manpower to operate laboratories. Each semester, about five laboratory courses will be taught. Staff supervision of these courses is very time-consuming. Staff should be given extra incentives for the work they will do in the laboratory. In addition, a system should be designed whereby advanced students serve as assistants in the lower-level chemistry courses. This teaching experience is valuable for students. It can also be a great help to the staff. Funds need to be available for this purpose.

Staff Size. Previous reports have recommended that the size of the chemistry faculty be increased by 10-15 people over the next 8 years. We support that recommendation. Without such an increase in size, the manpower will not be available to develop an adequate curriculum.

Relationship of Sarjana Program to Kimia Dasar. Chemistry departments everywhere must teach a heavy load of service courses. The continuing need to teach Kimia Dasar to all first-year students at IPB will continue to take the time of many staff. We strongly recommend that Kimia Dasar not be reduced to one semester, even though this would save staff time.

An important question that will arise during the development of the Sarjana program is the division of labor between the first-year courses and the professional chemistry/biochemistry courses. We believe that all staff should participate in both programs. This probably means that each year, staff will divide their time approximately equally between the two activities. Economic incentives must be found that will encourage staff to participate in the professional program.

Self-Government. It is important that all members of the Jurusan have a part in the development of the Sarjana program. It is also important that there be good communication among the staff and good communication between staff and administration. It is important that staff feel a sense of interest and responsibility in the curriculum.

We recommend that a "Coordinating Committee" within the Jurusan be established to work on the development of the curriculum. This committee (of perhaps 5 members) would be able to coordinate the activities of various individuals who are working to prepare sections of the program. They would also report on their progress to the faculty at regular intervals.

Staff Training. As noted in our previous report, advanced courses in chemistry and biochemistry are difficult for students and difficult for teachers. Teachers must be specialists in order to teach these courses easily. Additional staff training will be an important part of the development of the curriculum.

Significant progress has been made in this area within the last year. Three Indonesian chemists will shortly be returning to Bogor from the U.S., and one more will follow within a year. Several staff currently in Bogor are working part-time on advanced degrees. These activities should continue, and a long-term commitment must be made to increasing the proportion of Ph.D. holders within the Jurusan.

We would like to repeat our previous recommendation on this subject:

> "Within the first 8 years of operation of the curriculum, at least 50 percent of the chemistry staff should have training in chemistry at either the M.S. or Ph.D. level."

CURRICULUM DEVELOPMENT

The development of a Sarjana program in chemistry and biochemistry is going to consume both time and resources. Unless time and resources are available prior to the time the first students are admitted, the program will not be successful. Unless continuing support is provided during the first years of operation of the program, the program will not continue to succeed. Thus, we recommend that during this initial period the Sarjana program in chemistry and biochemistry be designated as a "special program" and that special funding be sought for program development.

Development of Courses. Prior to the first time each new course is offered, someone must spend time developing the materials necessary for the course, including:

1. Identifying an appropriate textbook and translating it into Bahasa Indonesia if necessary.
2. Writing a detailed syllabus and lecture notes for the course. Designing problem sets and other handouts.
3. Developing laboratory experiments for courses where a laboratory is included. Even though many experiments can be adapted from other texts, time will be required to test the experiments and to develop instructions in Bahasa Indonesia.

Staff release time and appropriate economic incentives are going to be required in order to assure the proper development of these materials. The development of a one-semester course is likely to require about half-time work by one individual for a full semester prior to the first time the course is offered. Thus, we recommend that the development of the curriculum be spread over a period of three or four years and that staff be given release time for course development at the rate of one semester of half-time release time per semester of course to be developed.

A possible timetable for curriculum development is given in the next section.

A Timetable for Curriculum Development. As noted above, we recommend that one semester of half-time release time be given to a staff member for the development of each one-semester course. A possible timetable for development of the chemistry/biochemistry program is given below.

Year 1: Three individuals need to be given half-time release time for the year in order to develop materials required for Organic Chemistry I, II, and perhaps III, Physical Chemistry I and II (development of the latter could be deferred to year 2), and Quantitative Chemistry I and II. Equipment must be purchased to support the laboratories in these courses.

Year 2: This is the most difficult year in the development of the curriculum. The first students enter the curriculum, taking Organic Chemistry, Quantitative Chemistry, and Physical Chemistry. Another three individuals must have half-time release time for the year in

order to develop the courses in Biochemistry, Instrumental Analysis, Advanced Inorganic Chemistry, Chemistry in English, and Thermodynamics. If staff were available, preparations could also begin for the advanced (fourth year) courses. Equipment and supplies for the third-year courses must also be purchased.

Year 3: The first group of students enters the third-year curriculum. A new group enters the second-year curriculum. The optional and required courses for the fourth year must be developed. Again, three individuals must have half-time release time for these activities.

The fourth-year elective courses should be developed gradually over a period of three or four years at a rate of 2-4 courses per year. In this year it will also be necessary to prepare for the fourth-year thesis projects. Potential projects and potential research sponsors must be identified, and provisions must be made for the required experimental work.

Year 4: This is the first year of full operation of the program. By now, three groups of students will be enrolled. At the end of this year, the first group of students should graduate. All required courses should be operational by this time, and the first set of elective courses should have been developed. Development of further elective courses will continue over the next few years.

Priorities for Course and Laboratory Development The development of lecture materials and the development of laboratory materials must go together. A suggested sequence of course development is:

1. organic chemistry, quantitative chemistry
2. physical chemistry
3. biochemistry, chemistry in English
4. instrumental analysis, inorganic chemistry, radiochemistry
5. thesis
6. advanced courses in chemistry and biochemistry

ORGANIZATION AND MANAGEMENT OF LABORATORY FACILITIES

Appropriate laboratory facilities are an integral part of every chemistry and biochemistry department. The practical skills which students learn in the laboratory are an important part of their education. The curriculum designed here includes two laboratory courses every semester, and it is expected that all students in the curriculum will spend at least two half-days per week in the laboratory.

In this section, we are concerned with the physical organization of the laboratories: How many laboratories there must be, what equipment is required, etc.

The curriculum we have designed required that there be three separate laboratories set aside for the Sarjana program in chemistry/biochemistry:

1. The organic chemistry laboratory, to be used for all laboratory courses in organic chemistry.
2. The quantitative chemistry laboratory, to be used for laboratory courses in quantitative chemistry, physical chemistry, and instrumental analysis.
3. The biochemistry laboratory, to be used for all laboratory courses in biochemistry.

In most semesters, each laboratory will be used for more than one course. For example, in the first semester each year the quantitative chemistry laboratory will be used for the first-semester quantitative chemistry course and for the physical chemistry laboratory. In the

second semester, this laboratory will be used for the second-semester quantitative chemistry course and for the instrumental analysis course. It is also expected that these laboratories will be used by students for their thesis research.

Laboratory periods are generally 3-5 hours long, with the more advanced courses having longer periods. Thus, it may be possible to accommodate two groups of students in each laboratory each day, if necessary. Ideally, each laboratory should be able to accommodate about 25 students at a time, although for the third and fourth year students at a time, although for the third and fourth year courses it would be better if no more than 12 students were in the laboratory at one time (otherwise, the cost of equipment becomes prohibitive).

In the following sections we discuss the three laboratories separately: facilities, equipment, and management. We have tried to make some general estimates of costs for the instrumentation recommended for these laboratories. Prices given are approximate current US costs in US$, and the costs in Indonesia will undoubtedly be higher.

It is also important to note that initial costs for equipment are not the only costs for this laboratory program. Instrument maintenance and repair will be a continuing cost. Chemicals, supplies, and glassware must be replenished at regular intervals. Thus, a regular budget for laboratories will be needed.

The Organic Chemistry Laboratory. Modern organic chemistry laboratory practice requires that laboratories be well-ventilated and have good hoods, in order to minimize contact with toxic vapors. Fire hazards are always present in organic chemistry laboratories, and the use of Bunsen burners or other open flames is to be avoided if at all possible.

Each student will require a drawer or kit of glassware, including several sizes of round-bottom flasks, beakers, condensers, adapters, etc. Earlier laboratory practice involved use of corks to connect various pieces of equipment. This has largely been replaced by the use of "standard taper" glassware with ground-glass joints. though more expensive than the older equipment, such equipment is useful in the organic laboratory in order to familiarize the student with the kinds of glassware he/she will later encountered in research or in industry. Student laboratory kits are available for perhaps $150 each.

The question of instrumentation for the organic chemistry laboratory is a difficult one. It would be nice to have infrared spectroscopy, NMR spectroscopy, gas chromatography. etc., available for students in this laboratory, but it is not economically feasible. Instead, such instrumentation has been assigned to the quantitative chemistry laboratory. It is expected that certain equipment could be borrowed on a short-term basis for use in the organic chemistry laboratory.

In Table III we give our recommendations for the equipment that should be included in the organic chemistry laboratory. This amount of equipment should be adequate for 12 students.

The organic chemistry laboratory is particularly expensive with regard to expendable chemicals and supplies. Students always break glassware. Solvents such as ethanol, acetone, ether, chloroform, etc., as well as raw materials for syntheses, are used up very rapidly.

The Quantitative Chemistry Laboratory. This laboratory is the most expensive because it will become the central laboratory for chemical analysis and will house most of the modern instrumentation that the Department acquires. The laboratory will be used by students in the second-year quantitative chemistry course, who require relatively unsophisticated equipment, as well as by students in physical chemistry laboratory and instrumental analysis laboratory both of which require substantial amounts of equipment. The list of equipment given in Table IV is intended for 12 students. If more students are to be accommodated at one time, additional glassware, balances, pH meters, and single-beam spectrophometers would be required.

As additional funds become available, it would be desirable to acquire additional equipment, including a higher field nuclear magnetic resonance spectrometer (cost perhaps $100,000), a mass spectrometer ($100,000-200,000), a high-pressure liquid chromatograph ($20,000), an electron-spin-resonance spectrometer ($100,000), a better infrared spectrometer ($20,000), a fluorescence spectrometer ($20,000), and perhaps other instruments as well. However, none of these are seen as being central to the Sarjana program at the present time.

The Biochemistry Laboratory. Recommended equipment for setting up the laboratory in biochemistry is listed in Table V. The principal major item that is not included is a scintillation counter ($20,000).

Purchase of Laboratory Equipment. The investment required for the three chemistry laboratories is large. Fortunately, this investment could easily be spread over two years. In the first year (the year before the first students are admitted to the program) equipment would be purchased for the organic chemistry laboratory, plus the first half of the equipment for the quantitative chemistry. The balance of the equipment could be purchased in the following year.

Table III: Recommended equipment for the organic chemistry laboratory.

Number	Description	Unit Cost	Total Cost
12	student laboratory glassware kits	$150	$1,800
3	melting point apparatus--Mel-Temp or equivalent	400	1,200
6	Variacs (variable transformers) for heating baths. (baths are made from a crystallizing dish, Nicrome wire, and mineral oil)	100	600
3	single-beam balances (precision ± .1 g)	100	300
6	magnetic stirring motors	150	900
12	other glassware	100	1,200
1	initial inventory of chemicals and other supplies	10,000	10,000
		Approximate total cost	$16,000

Table IV: Recommended equipment for the quantitative chemistry laboratory.

Number	Description	Unit Cost	Total Cost
12	student glassware, including beakers, flasks, pipets, burettes, volumetric flasks crucibles, etc.	$ 300	$ 3600
3	single-beam (±0.1g)	100	300
3	analytical balances (Sartorius Series 2400 or equivalent, ±0.1mg)	1,500	4,500
3	single-beam spectrometer--Spectronic 20 or equivalent	1,200	3,600
3	ovens for drying samples	600	1,800
1	scanning double-beam spectrophotometer	8,000	8,000
2	constant-temperature bath	1,000	2,000
2	infrared spectrometer	6,000	12,000
1	nuclear magnetic resonance spectrometer(student instrument operating at 30-40 mHz)	30,000	30,000
2	gas chromatograph	5,000	5,000
4	pH meter	1,500	6,000
1	polarimeter	3,000	3,000
1	refractometer	2,000	2,000
6	magnetic stirrers	150	900
1	flame photometer	20,000	20,000
1	initial inventory of chemicals and other supplies	10,000	10,000
		Approximate total cost	$112,700

Table V: Recommended equipment for the biochemistry laboratory

Number	Description	Unit Cost	Total Cost
2	refrigerated centrifuge and accessories	$ 8,000	$16,000
1	recording spectrophotometer	8,000	8,000
1	electrophoresis equipment	3,000	3,000
3	single-beam balances	100	300
2	triple-beam balances	100	200
2	analytical balances	1,500	3,000
4	magnetic stirring hot plates	150	600
1	tissue homogenizer	500	500
1	Gilson differential respirometer---student model	3,000	3,000
2	constant temperature baths	1,000	2,000
1	autoclave	2,000	2,000
1	incubator	3,000	3,000
3	pH meters	1,500	4,500
12	student glassware	200	2,400
1	chromatography glassware--columns, test tubes, etc.	2,000	2,000
4	fraction collectors	2,000	8,000
1	initial inventory of chemicals	10,000	10,000
		Approximate total cost	$68,500

TEXTBOOKS AND OTHER MATERIALS

Our conversations with colleagues at IPB and at other Indonesian universities, together with our own observations of students, indicate that it is necessary for textbooks and related materials to be available in Bahasa Indonesia. It might be possible to use English-language materials in one or more advanced courses, but certainly all of the fundamental courses will need materials in Bahasa Indonesia.

Of the texts which we have recommended for the IPB Sarjana curriculum in chemistry and biochemistry, only the Day and Underwood text for the quantitative chemistry course is currently available in Bahasa Indonesia, to our knowledge. The Alberty and Daniels physical chemistry book is available in Bahasa Indonesia, but, as noted elsewhere, we do not recommend that that book be used. The same is true of the Fessenden and Fessenden organic chemistry text.

We recommended in our previous report that a cooperative effort be established among Indonesian universities in order to translate important English-language textbooks. Both Gadja Mada and Bandung have active translation programs, and we recommend that efforts be made to cooperate in those activities. In Table VI we list the texts that need to be translated into Bahasa Indonesia in order to begin the Sarjana program.

Table VI: Needed translation activities

Year 2:

Morrison and Boyd, "Organic Chemistry", 4th Edition

Barrow, "Physical Chemistry for the Life Sciences", 2nd edition

Laboratory materials for organic chemistry and quantitative chemistry

Year 3:

Baldwin, "Biological Chemistry"

Huheey, "Inorganic Chemistry" 2nd edition

Willard, Merritt, Dean, and Settle, "Instrumental Methods of Analysis", 6th edition

Klotz and Rosenberg, "Thermodynamics" (?)

Laboratory Materials

Year 4:

Advanced organic chemistry books

Other biochemistry books

Other texts for advanced courses

DEVELOPMENT OF A CHEMISTRY LABORATORY

A collection of chemistry and biochemistry books and journals will serve several functions for IPB students and staff:

1. It can provide additional information for students in courses and laboratories. For example, physical constants for compounds used in laboratory experiments, extra readings for courses, etc.
2. It can give students exposure to the chemical literature so that in their future professional work they will be able to use reference materials.
3. It can be used to provide background information needed for writing a thesis.
4. It can be used by teachers in preparing lectures and laboratory experiments.

Chemistry and biochemistry are dynamic, rapidly-changing fields. Unlike in some fields, scientific advances in chemistry and biochemistry rapidly appear in introductory courses in the subject. Thus, current textbooks and reference materials are an important part of the total curriculum.

As we have recommended previously, IPB must establish and maintain a small collection of chemistry and biochemistry books and journals as part of the Sarjana curriculum. An ongoing budget must be provided for this, in order to maintain subscriptions to important journals and to provide for the continuing purchase of new books.

The books and journals to be included in the library collection must be chosen with care. A relatively complete chemistry library (primarily intended for research purposes) now costs over $200,000 per year to maintain. Such an investment is not appropriate for IPB.

The principal sections of the collection are:

1. Standard reference books, including handbooks containing physical and chemical properties of compounds, books containing detailed descriptions of standard chemical and biochemical procedures, books describing methods of analysis, etc.
2. A variety of standard chemistry textbooks, including both S_1 and S_2 level books.
3. A small collection of more advanced monographs in fields of particular interest (e.g., food chemistry, protein and colloid chemistry, natural products chemistry, environmental chemistry, etc.).
4. A small collection of significant chemistry journals, including both journals describing original research (Journal of the American Chemical Society, Journal of Biological Chemistry, etc.) and review journals (Annual Review of Biochemistry, Quarterly Reviews, Advances in Protein Chemistry, etc.).

EVALUATION

Evaluation of the chemistry curriculum must be done at regular intervals (at least yearly). Such evaluations will not answer the question: "Is this curriculum good or bad." Rather, the evaluation should identify the specific strengths and weaknesses of the curriculum. It is especially important to evaluate individual courses when they are given for the first several times. New courses always contain parts which are not successful. Evaluations at the conclusion of the course (or perhaps even during the course) can identify ways to improve the course.

At least three levels of evaluation should be considered: student evaluation, staff evaluation, and evaluation by persons outside the department.

Student Evaluation University teachers sometimes feel that students should not be asked to evaluate their courses. They feel that only the teachers know enough about the subject to decide what and how the subjects should be taught. Further, they feel that students should always accept the courses as given and should not have the opportunity to criticize courses.

However, we feel that university teachers receive many benefits when they ask students for information about their courses. As the "recipients" of a curriculum, students are in a unique position to identify strengths and weaknesses of courses or an entire curriculum. Thus, students can help their teachers find those areas which are most in need of change.

When asking students to evaluate a course, choose the questions to give specific information. Avoid true-false type questions such as "Did you like this course (yes or no)?" Such questions are of no use in making improvements because they are not specific. They do not tell you WHY the student liked or didn't like the course. Examples of more specific questions follow:

"My previous courses had prepared me adequately for this course."

"The laboratory work helped me to understand the lectures."

"I was able to do most of the assigned problems."

Students can be asked to check answer scales or rank items in order to give more quantifiable information. For example, in response to the statement "I was able to do most of the assigned problems," students could be asked to check one of the following categories:"

always____ often____ occasionally____ seldom____ never____

"Open ended" questions give valuable information because they permit students to identify problem areas which teachers may not be aware of. For example:

"What I liked most about this course was:"

and

"What I liked least about this course was:"

Interpretation of student responses to both forced choice and open ended questions will require judgment by faculty. For example, if only one student says "The textbook was terrible and didn't help me learn", you might decide that the text is probably adequate for most students. However, if half of your class makes that same comment, the

text may need improvement. Thus, it is the pattern of responses rather than individual responses which give you information.

It can be difficult to design an evaluation document which gives you the information you desire. Upon our return to the United States, we will send to IPB several different versions of questionnaires which have been used in obtaining course information. Members of Jurusan Kimia at IPB should freely adapt these to fit the situation at IPB. We have found that although students occasionally give a bad rating to a course because they perceive it to be too hard or unfair, most of the time, student responses have been useful in planning course improvements.

Student evaluation of an overall curriculum is more difficult to obtain. It is much more difficult to design and use a questionnaire for entire curricula than for individual courses. We recommend that such information be obtained in interviews with students perhaps at the end of each school year or at graduation. If students are reluctant to offer criticisms to their professors, offer them the opportunity to comment, anonymously and in writing, on which courses they felt were especially hard, whether they encountered scheduling difficulties for chemistry or biochemistry courses, etc.

Evaluation By Teaching Staff The initial success of the curriculum will depend on cooperation among members of the staff in determining the strengths and weaknesses of recently initiated courses. All members of the staff should participate in the evaluation. This includes both part time and full time, temporary and permanent staff.

However, curriculum decisions based on the evaluation results should be the responsibility of the permanent staff of the Jurusan.

Evaluation questions for the entire curriculum should include such questions as:

> What courses were particularly difficult for students? Why?
>
> What subjects within the curriculum need more (less) emphasis?
>
> What changes are needed in the scheduling of courses or laboratories to minimize conflicts and maximize use of facilities?
>
> What additional facilities (books, laboratory equipment, etc.) are needed to carry out the existing curriculum?

At the individual course level, questions might include the following:

> Were students adequately prepared for this course?
>
> Do students leave this course prepared for the next course? How do I know this?
>
> Which topics in this course did students learn well, adequately, inadequately?
>
> What actions can I take to improve student learning in the weak topics?

A small group of staff should be selected by the Jurusan to form a Curriculum Committee. The purpose of this committee is to develop and recommend to the Jurusan a practical set of evaluation questions on which to base future improvements. These evaluation questions should relate directly to the goals and specific objectives of the Sarjana program in Chemistry and Biochemistry. After discussion by the Jurusan, the evaluation questions which are selected should be established as the usual framework for yearly evaluations of the curriculum especially during the development years.

External Evaluations It is sometimes difficult for those within a Department to identify important strengths and weaknesses. Thus, examination of a curriculum by others external to IPB can be helpful in curriculum development and revision. Other chemistry faculty at other Indonesian universities could be asked to offer suggestions and identify strengths and weaknesses.

We, ourselves, have a continuing interest in the development of a strong program in chemistry and biochemistry at IPB. It is probable that in connection with our activities at Andalas University, we will be in Indonesia for extended periods during the next several years. We would welcome the opportunity to participate in the evaluation of the Jurusan Kimia as it develops.

APPENDIX I

Detailed descriptions of courses in the required section of the Sarjana curriculum in chemistry and biochemistry.

CALCULUS

Stk 201, 202. These courses currently exist and would presumably be appropriate for chemistry/biochemistry students.

PHYSICS

This course is currently under development.

BIOLOGY

Any of several introductory biology courses would be appropriate. The student is expected to take one of these courses in the third semester, and one in the fourth.

QUANTITATIVE CHEMISTRY I, II

Schedule: A two-semester course, 4 credits each semester. Each semester there are 2 hours of lecture, 1 hour of discussion/problem solving, and 3-4 hours of laboratory.

Required of all chemistry and biochemistry students.

Purpose:

1. The development of ability to solve quantitative problems in chemistry.
2. To learn about important types of chemical measurement methods.
3. Familiarization with common laboratory equipment, including balances, pipets, burettes, pH meters, filtering crucibles, chromatography equipment, and photometers.

4. To develop laboratory skills in making quantitative measurements.

Text: R.A. Day and A.L. Underwood, "Quantitative Analysis," 4th edition, Prentice-Hall, 1980, and the accompanying laboratory manual. This text is available in Bahasa Indonesia. The laboratory manual put out by the University of Wisconsin chemistry department may also be useful.

Prerequisites:

Successful completion of a year of general chemistry.

Outline of Content:

I. Solutions: concentration, units of concentration, dilution, making solutions, the mole (Ch 1 in Day and Underwood, and additional material)

II. Statistics of measurements (Ch.2)

III. Chemical stoichiometry: the mole, balancing equations, working mole problems, reactions in solution, introduction to titration methods (Ch. 3, 4)

IV. Introduction to gravimetric methods: weighing, use of balances, precipitation, manipulation of precipitates (Ch.4)

V. Chemical equilibrium: general equilibrium concepts, definition and determination of equilibrium constants, equilibria in solution, activity coefficients (ch.5)

VI. Acid-base chemistry: definitions, pH, autoprotolysis of water, weak acids and bases, buffers, indicators, titrations, titration curves, polyprotic acids and bases (Ch. 5, 6, 7)

VII. Complex formation: definition and determination of equilibrium constants for complex formation, titration methods, EDTA (Ch.8)

VIII. Solutions: solubility, solubility equilibria and solubility product, precipitation titrations (Ch. 9)

IX. Electrochemistry: half-cells, half-reactions, balancing oxidation-reduction equations, oxidation numbers, standard redox table, spontaneous and nonspontaneous reactions, Nernst equation, concentration cells, salt bridges, batteries (Ch 10, 11)

X. Electrochemical measurements: standard electrodes, redox indicators, laboratory oxidizing and reducing agents (Ch. 10, 11)

XI. Potentiometry, other electrochemical methods: indicator electrodes, the glass electrode, measurement of pH, potentiometric titrations, electroysls, coulometry, polarography, the dropping-mercury electrode, amperometric titrations (some selection of topics in this chapter will probably have to be made) (Ch. 12, 13)

XII. Introduction to spectroscopy: the electromagnetic spectrum, optics, photomultipliers, interaction of light with molecules, infrared spectroscopy (may be deferred to organic chemistry), uv/visible spectroscopy, Beer's law, multicomponent analyses, titrations, fluorescence (Ch. 14)

XIII. Emission spectroscopy: flame photometry, atomic absorption (optional) (Ch. 15)

XIV. Solubility-based methods of separation: partition coefficients, solvent extraction, multiple extractions, countercurrent distribution (Ch. 16)

XV. Gas chromatography: theory of chromatography, applications of gas chromatography, mechanics of gas chromatography, practical separations, qualitative and quantitative analysis (Ch. 17)

XVI. Liquid chromatography: absorption, ion exchange, gel filtration, high-performance liquid chromatography (Ch.18)

Laboratory:

Experiments selected from Day and Underwood or elsewhere to coordinate with the lecture material. Experiments to include experience with analytical balances, pH meters, spectrophotometers, gas chromatographs, other chromatography equipment if available, electrochemical systems.

Comments: This is a standard second-year course in most U.S. universities; it sometimes occupies one semester, and sometimes two. For IPB, it is recommended that the amount of quantitative material in the first half of the course be increased over that offered in U.S. courses. This material deserves special emphasis, with particular attention to the development of problem-solving techniques. The development of careful laboratory techniques in this course is also the key to future success in chemistry.

Options for consideration:

1. Condense the course to one semester. Not recommended.
2. Expand to three lectures per week and/or drop the discussion session. Not recommended.
3. Separate the laboratory course from the lecture course. Combine the laboratory course with the physical chemistry laboratory and offer a separate two-year course in laboratory procedures and measurements. Not recommended because of the close connection between lecture and laboratory in this course.

ORGANIC CHEMISTRY I, II, II

Schedule: A three-semester course, 4 credits each semester. Each semester 3 hours of lecture and 3-4 hours of laboratory per week. To be taken in the second year.

Required of all chemistry and biochemistry students.

Purpose:
1. To develop fluency in recognizing and interpreting the structures of organic compounds.
2. To learn the standard reactions of organic chemistry.
3. To learn why and how organic reactions occur (i.e., reaction mechanisms).
4. To learn methods for synthesizing organic molecules.
5. To learn the organic chemistry necessary to understand biological processes.

Text: Morrison and Boyd, "Organic Chemistry," 4th Edition, and study guide.*

Prerequisites:

Successful completion of two semesters of general chemistry.

Outline of content:

Course I: Alkanes, alkenes, halides, and basic organic structural chemistry (Chapters 1-9 in Morrison and Boyd), except Chapter 17).

Course II: Oxygen compounds, alkynes, aromatics, etc.(Chapters 10-21 in Morrison and Boyd, except Chapter 17).

Course III: Amines, phenols, aryl halides, carbanions, spectroscopy, fats, carbohydrates, amino acids, polynuclear aromatic compounds, heterocycles (Chapters 17, 22-35 in Morrison and Boyd).

Outline of laboratory:

Course I: Analysis and purification of organic compounds, including melting points, boiling points, distillation, recrystallization, extraction of natural products, simple chromatography, and separation of mixtures.

*The text by Fessenden and Fessenden is already available in translation. This is an adequate book, but it is not as good as Morrison and Boyd. Translation of the latter is recommended.

Course II: Preparation and properties of compounds,including Grignard reaction, addition and elimination reactions, esterification, etc.

Course III: Chemical analysis of organic compounds, including chemical analysis of functional groups, qualitative organic analysis, and spectroscopy

Comments: This is the standard second-year course that is taught both in the U.S. and elsewhere in Indonesia. It follows the outline of a number of the standard American and European textbooks. A laboratory course is included in each semester (in some universities, the first semester course has no laboratory).

At some universities, this course is taught in two semesters, rather than three (it is two semesters at UI, at UGM, and in most American universities, but three semesters at ITB). However, in order to give appropriate time to the biochemical topics which are concentrated at the end of the course, three semesters is recommended.

Use of molecular models by students is an important part of this course.

Options for consideration:

1. Condense the course to two semesters by omitting the biochemical topics in the third semester. This is not recommended.
2. Omit the first semester of laboratory work. Change the first semester course from 4 credits to 3 or else offer a compulsory discussion/problem session each week.

PHYSICAL CHEMISTRY I, II

Schedule: A two-semester course, 3 credits first semester and 4 credits second semester. Each semester 3 hours per week of lecture. Second semester, 4 hours per week of laboratory. To be taken by students in their fourth and fifth semesters.

Required of all chemistry and biochemistry students.

Purpose:
1. To gain a basic acquaintance with, and ability to solve problems in thermodynamics.
2. To learn modern theories of the structure and behavior of matter (including pure substances, mixtures, multiphase systems, colloids, and macromolecules).
3. To learn the basic physical theories underlying the properties of biological molecules.
4. To learn in the laboratory modern methods for studying the physical properties of matter.

Text: Barrow, "Physical Chemistry for the Life Sciences, " 2nd ed. An alternative text would be Alberty and Daniels, "Physical Chemistry," 5th edition. This book has the advantage that it is already available in Bahasa Indonesia, and it is a standard and well-written book. However, (see comments below) the emphasis in the book is different from that of the course recommended here.

Prerequisite:

Successful completion of a year of general chemistry, a semester of quantitative chemistry, two semesters of physics, and a semester of calculus.

Outline of Content:

Physics and mathematical background for physical chemistry.

Gas laws. Nonideal gases. Introduction to statistical mechanics.

Thermodynamics: Thermochemistry and heats of reaction. Entropy. Free energy. The laws of thermodynamics.

Chemical equilibrium. Relation to thermodynamics. Electrochemical equilibrium. Acid-base equilibrium. Complex equilibria.

Physical equilibria. Vaporization. Colligative properties.

Transport. Diffusion. Electrophoresis. Viscosity.

Chemical kinetics. Measurement. Rate Equations. Enzyme kinetics. Reaction mechanisms.

Spectroscopy. Quantum mechanics. The Schrödinger equation. Quantum-mechanical basis of spectroscopy.

Molecular structures of solids.

Outline of laboratory:

Laboratory experiments can be selected from Shoemaker, Garland, and Steinfeld, "Experiments in Physical Chemistry," 3rd edition, McGraw-Hill, and from Daniels, Williams, Bender, Alberty, Cornwell, and Harriman, "Experimental Physical Chemistry," 7th edition, McGraw-Hill. Choice of experiments will be dictated by the availability of equipment. It is expected that these experiments will be quantitative and will rely quite heavily on instrumental techniques. This

laboratory is essentially a continuation of the quantitative chemistry laboratory and precedes the laboratory in the course on instrumental analysis.

Comments: As noted earlier, the course in physical chemistry that is part of the U.S. curriculum contains a large dose of statistical mechanics and quantum mechanics. It is recommended that the course be changed to make it more relevant to students whose interests are life sciences and to students in Indonesia. Even so, it is expected that this course will be relatively mathematical and will require a basic knowledge of calculus.

The text by Barrow is not perfect for this course. It would be better to have a text that is slightly more quantitative. At the same time, the text by Alberty and Daniels is probably too quantitative and contains too much quantum mechanics. If the Alberty and Daniels text were used, it would be advisable to extend the course to three semesters and drop the thermodynamics course that is currently offered in the third year.

One semester of laboratory work is recommended. There is not enough time in the curriculum to offer a second semester of laboratory without overloading the students.

Traditional physical chemistry courses are particularly concerned with the behavior of isolated molecules in the gas phase. This is the emphasis in the Alberty and Daniels text. However, the needs of life science students are different: They need detailed treatment of processes in solution, including physical chemistry of solutions,

ionic interactions, protein structures in solution, kinetics in solution, enzyme kinetics, colligative properties, and colloid chemistry.

Options:

1. Use the Alberty and Daniels text.
2. Find another text. This possibility should be considered.
3. Expand the course to three semesters. This would be especially appropriate if the Alberty and Daniels text were used. In this case, the third-year course in thermodynamics (currently required of chemistry students but not of biochemistry students) would be dropped.
4. Offer two semesters of laboratory work. As noted, this would be difficult because of student schedules.

CHEMISTRY IN ENGLISH I, II

Schedule: A two-semester course, 2 credits each semester. Each semester 2 hours of discussion (not lecture) per week. No laboratory. To be taken by students in their third year.

Required of all chemistry and biochemistry students.

Purpose:

1. To develop fluency in written and spoken English.
2. To develop scientific vocabulary in English.
3. To learn to read scientific articles in English.
4. To improve oral communication skills in scientific English.

Text: No text. Material to be collected from a variety of English-language texts and articles.

Prerequisites:

Successful completion of two semesters of organic chemistry and 2 semesters of quantitative chemistry.

Outline of content:

Each class meeting, students will be given a 1-4 page article in English from a chemistry book or journal. Students will be expected to read the article prior to the next class period in order that it can be discussed in the next class period. Students will be expected to develop a technical vocabulary list.

At the beginning, readings will be drawn from first- and second-year English language textbooks in order that the chemistry content will be moderately familiar and students can concentrate on the language. Later, articles will be chosen from technical articles. The Journal of Chemical Education is particularly useful for this purpose.

Articles from current research journals (e.g., The Journal of the American Chemical Society, The Journal of Biological Chemistry, etc.) must be chosen with great care. Even native speakers of English find such articles very difficult to read and understand when they first encounter them.

Over the two semesters, it is expected that students will spend several weeks on each of the five areas of chemistry. It might be useful for a specialist from each area to teach that section, in order that the instructor be quite familiar with the vocabulary in that area.

It is important that classes be kept small. About 10 students would be ideal, and the upper limit should be 25 students. This is a discussion class, and all students must have the opportunity to participate.

During the second semester, each student will be expected to choose a subject area and read 4-6 articles on the subject then present a 10-15 minute report in English on the reading.

Occasional seminars by a native English speaker on a semi-technical level would also be useful.

Comments: Students who are to become members of the scientific community must become fluent in technical English in order that they can easily read and understand the many technical articles in that language. This course will also be useful for students who will later go abroad for further study.

Options:

1. Offer the course for only one semester.
2. Combine the course with the "seminar" course offered in the fourth year. This option is not recommended, because it does not allow enough time for development of English scientific vocabulary.
3. Offer the course for one credit (one class meeting per week) instead of two.

INSTRUMENTAL ANALYSIS

Schedule: A one-semester, four-credit course to be offered in the second semester of the third year. The course includes 2 or 3 lectures each week and one 4-6 hour laboratory period.

Required of all chemistry and biochemistry students.

Purpose:

1. To familiarize students with the principles of electronics and scientific instrumentation.
2. To familiarize students with modern methods of chemical analysis--both theory and practice.
3. To teach students to learn to use modern instruments for chemical analysis.

Text: Willard, Merritt, Dean, and Settle, "Instrumental Methods of Analysis," 6th edition, Wadsworth Publishing Co., 1981.

Prerequisites:

Successful completion of two semesters of physical chemistry, two semesters of quantitative chemistry.

Outline of content:

(order of presentation of topics not critical). Introduction to electronics for scientists. Absorption and emission spectroscopy. Flame spectroscopy. Infrared and raman spectroscopy. Nuclear magnetic resonance. Other optical methods. Gas chromatography. Liquid chromatography. Electrometric methods of analysis. Computer-based instrumentation.

Outline of laboratory:

Experiments selected from the text to coincide with the presentation of topics in the lecture. Students in the laboratory should be divided into small groups, with each group performing a different experiment in a given week. This makes it possible to have an effective laboratory course with a smaller amount of equipment.

Comments: This course is a continuation of the second-year quantitative course. This course relies on principles that the students have learned in physical chemistry. It also includes experiments using most of the standard instruments for chemical analysis.

One of the important aspects of this course is not only to learn to use a variety of instruments, but also to learn about the principles of their operation and to learn about simple repair procedures. It is important that all research scientists understand their own instruments well enough to be able to make simple repairs. This is particularly true in Indonesia, where professional service technicians are often not available. In fact, it would be worth considering whether to offer a separate course in instrument maintenance and repair.

The laboratory work in this course should be considered as essentially the fourth semester of a laboratory sequence in quantitative chemistry. The first two semesters are concerned with quantitative chemistry involving only simple equipment (pipets, balances, pH meters, etc.). The last two semesters are concerned with

instrumentation in modern chemistry. The third semester is concerned with measurement and study of physical and chemical properties by means of modern instrumentation. The last semester is concerned with the instruments themselves--how they work, what their limitations are, and how to fix them.

Options:

1. Extend the course to two semesters. There is certainly enough material to merit this possibility, but because of the number of other courses that students must take, it does not seem advisable.
2. Two lectures a week or three? Two is probably adequate. Long laboratory periods will be necessary because of the complexity of the experiments.
3. Create a separate course in instrument design, repair, and maintenance. This could be offered as an option for students in their fourth year. Even if this course were created, it would still be advisable to discuss instrument maintenance in the instrumental analysis course as well. The instrument design, repair, and maintenance course would probably be attractive to students from a variety of other jurusan.
4. Combine the laboratory in this course with the laboratory in physical chemistry and offer an integrated, two-semester course in instrumental methods in chemistry.

INORGANIC CHEMISTRY

Schedule: A one-semester course, 3 credits. Each week, three hours of lecture. No laboratory. To be taken in the second semester of the third year. Required of chemistry students and biochemistry students.

Purpose:

1. To survey structures, reactions, and mechanisms in modern inorganic chemistry.
2. To discuss the inorganic chemistry of biological processes, including nitrogen fixation, enzyme action, hemes and porphyrins, etc.

Text: Huheey, "Inorganic Chemistry", 3rd edition, Harper and Row

Prerequisite:

Successful completion of the two-semester course in physical chemistry.

Outline of content:

Bonding in inorganic compounds

Acid-base chemistry

Chemistry in solution. Aqueous and nonaqueous solvents.

Coordination chemistry

Bio-inorganic chemistry

Comments: At one time, many first-year chemistry courses contained a lot of descriptive inorganic chemistry. However, in the last 20 years there has been a movement toward more concentration on physical chemistry in the first-year course. As a result, most American

universities now offer a one-semester survey of inorganic chemistry in the third or fourth year. The principal difference between the course described here and the usual American course is the greater emphasis on biological topics in this course. The textbook being recommended is an extremely good and readable book. The alternative text, the one by Cotton and Wilkinson, is much more encyclopaedic, and is very difficult to read. The courses will probably cover only half or two thirds of the Huheey book. The book is large (over 1000 pages) and translation of it represents a formidable task, considering the small number of students who will benefit. Perhaps the English version of the text could be used.

Options:

1. Should this course be required of biochemistry students? It is certainly a useful course, but they also have many other courses to take.
2. Expand the course to two semesters.
3. Include a laboratory. This would be nice, but it is not essential.
4. Build the course around bio-inorganic chemistry. Many of the same topics would be discussed, but the emphasis would be different and a different textbook would be needed.

THERMODYNAMICS

Schedule: A one-semester course, 3 credits, to be offered the second semester of the third year. Three hours of lecture, and no lab.

Required of chemistry students, but not of biochemistry students.

Purpose: To develop fluency in applying the principles of thermodynamics to chemical systems.

Text: Klotz and Rosenberg, "Introduction to thermodynamics" (There is also an existing thermodynamics text in Bahasa Indonesia that has not been examined).

Prerequisites:

Successful completion of two semesters of physical chemistry.

Content: Covers the basics of thermodynamics, continuing on the foundation of thermodynamics that was begun in the physical chemistry course

Comments: This course is similar to courses offered at other Indonesian universities. There is no corresponding course in the U.S., although thermodynamics is given intensive treatment in beginning physical chemistry courses.

Options:

1. Do not offer this course.
2. Expand the physical chemistry course to three semesters and combine it with this course.

ADVANCED ORGANIC CHEMISTRY

The content of this course can be adjusted according to the interests of the staff. Possibilities include natural product chemistry, organic synthesis, organic structure determination, and

physical-organic chemistry. The last topic is often taught in U.S. universities, but it is probably not the best for Indonesia.

RADIOCHEMISTRY

This course should be similar to the course which is currently being taught by Dr. Djokowerjo Sastradipradja.

BIOCHEMISTRY

This one-year course should follow the outline of the Baldwin book currently being translated by Pak Djoko.

SEMINAR

This course will give students an opportunity to discuss their thesis work and get help from other students and staff.

THESIS

Students will spend about half of their time in their last year doing research and preparing a thesis. Careful faculty guidance will be required in order to make this program a success.

APPENDIX II

Outline of some possible optional courses in chemistry and biochemistry for students in the Sarjana program.

Enzymes: This course examines the structure and function of enzymes, including the fundamental chemistry underlying enzyme action. It is important to maintain a clear perspective on the central role of enzymes in biology. Topics to be discussed might include: classification of enzymes, enzyme co-factors and how they work, kinetics and thermodynamics of enzyme action, chemical studies of enzyme models, enzyme inhibitors, and in vivo regulation of enzyme activity. The book on enzymes by Fersht might be a useful text, although the emphasis in this book is strongly chemical.

Organic Chemistry of Natural Products: The aim of this course is to prepare students who will ultimately work on the purification and study of Indonesian natural products. The focus of the course is on the structure identification and the synthesis of these compounds. Subjects to be discussed might include: chemical methods of structure analysis (i.e., classical qualitative organic analysis by functional groups), types of natural products, the biosynthesis of natural products, instrumental methods of structure determination, synthesis of natural products, survey of Indonesian natural products. This subject could be approached in many different ways.

Soil Chemistry: An existing course offered by the Soils Department might be appropriate.

Nutritional Biochemistry: Several excellent courses are offered by the Nutrition Department. One or more of those might be appropriate.

Animal Biochemistry: A current course offered by the School of Veterinary Medicine might be appropriate.

Plant Biochemistry: This course might also be of interest to students in other jurusan. Topics to be covered include: physiology of plant cells, energy production in photosynthesis, carbon assimilation mechanisms, carbohydrate biosynthesis, other aspects of carbon metabolism, nitrogen fixation, nitrogen metabolism, plant nutrition, plant hormones, plant molecular biology. A useful text might be "Introduction to Plant Biochemistry," 2nd edition, by Goodwin and Mercer, Pergamon Press.

Molecular Biology: Students will undoubtedly have an introduction to molecular biology in the introductory course in biochemistry. However, the subject is so important that it deserves a course of its own. Recombinant DNA techniques are becoming very important in many areas of biology. A useful text might be Watson's "Molecular Biology of the Gene".

Chemistry and Biochemistry of Drugs and Pharmaceuticals: This course is concerned with the interaction of foreign compounds with animals and man. A good introductory text in pharmaceutical chemistry or pharmacology would be appropriate.

Modern Methods of Structure Determination of Organic Compounds: This course is concerned with the applications of infrared spectroscopy, nuclear magnetic resonance spectroscopy, mass spectrometry, and other

similar techniques to the determination of structures of organic compounds. This course is especially important for students who will work in the area of natural products chemistry. There is some potential overlap between this course and the course in the chemistry of natural products. If possible, it would be useful to offer a laboratory with this course.

Industrial Organic Chemistry: This course is similar to a course offered at several other Indonesian universities. It is concerned with the chemistry of industrial processes, including industrial methods for the synthesis and purification of compounds, petroleum chemistry, and other types of practical chemistry. This could be a useful course for students who intend to work in the chemical industry.

Chemical Kinetics: The rates of chemical processes are important in many fields. This course is concerned with both the theory and practice of kinetics. Topics to be covered might include: simple reactions in the gas-phase, simple reactions in solution, effect of solvent on reactions, mathematics of complex reaction schemes, steady-state schemes, chain reactions, mathematics of radioactive decay, and enzyme kinetics. A variety of texts are available.

Molecular Spectroscopy: This is a physical chemistry course concerned with the fundamental properties of matter. It is highly dependent on the theories of quantum mechanics and statistical mechanics. The course deals with electronic and vibrational spectra of simple molecules in the gas phase.

Design and Maintenance of Scientific Instruments: This course was mentioned previously in connection with the discussion of the advanced course in instrumental analysis. The purpose of this course is to provide students with the knowledge and skill needed to repair and maintain the various instruments used in chemistry laboratories. It is assumed that before students take this course, they already know how to operate the instruments. The first part of this course is the fundamentals of electronics. The remainder of the course is concerned with specific instruments.

Computer Science: Computer control of scientific instruments is becoming common, particularly in fields such as nuclear magnetic resonance and x-ray crystallography, where extensive data manipulation is required. Students should be exposed to the fundamentals of programming as part of their Sarjana training. A relatively modest computer (e.g., and Apple or IBM personal computered) is adequate for this purpose.

Chromatography: The methods used for separation of organic and inorganic compounds have become increasingly sophisticated. A separate course in separation methods would be useful. This course should include a laboratory.

Analysis of Biological Molecules: A number of the methods which are used for the analysis of biological molecules are different from the methods used for simpler molecules. In addition, some of the standard methods are used in different ways. Topics to be covered here include electrophoresis methods, sedimentation, gel filtration, ion-exchange chromatography, amino acid analysis, paper chromatography, etc. This course should include a laboratory.

Advanced Inorganic Chemistry: This is the second semester of the survey course in inorganicchemistry that is required of all chemistry and biochemistry majors.

Bio-inorganic Chemistry: This course deals with the functioning of metal ions and other inorganic ions in biological systems. Topics might include inorganic chemistry of nitrogen fixation, role of metals in hemes and chlorophylls, coordination chemistry of metals in enzymes, biochemistry of sulfate reduction, etc.

Statistics: Many kinds of research work in chemistry and biochemistry require the application of statistics. Some of the other Indonesian chemistry curricula include a course in statistics. The inclusion of such a course, either as a requirement or as an elective, should also be considered here.

Water Chemistry: This course should deal with both the theoretical and the practical aspects of water quality and water quality improvement. This course may also be of interest to students from other jurusan.

Environmental Chemistry: A survey of environmental chemistry, including air and air pollution, water and water pollution, industrial pollution and its control, economics of environmental science, and related subjects.