



CLUSTER I

Science  
**Chemistry**

Prepared by Herb Strauss, Lead Discipline Faculty, UC Berkeley

## Summary of Identified Issues

Issues for this year include the following four issues thoroughly explored during the course of the year:

1. Revisions to the CAN descriptors for the first-year Chemistry courses and the need to indicate the expected level of rigor of these courses.
2. Descriptors for Organic Chemistry, agreed on for the first time.
3. Development of a SciGETC or similar GE program that directs students majoring in the sciences to make a timely start on the science and mathematics courses required at the four- year receiving institutions. Discussions involved all the science and engineering groups.
4. Meeting the requirements of the students who are headed towards degrees in nursing. This is the most complex of the discussions since it involves the Chemistry, Biology and Nursing groups and is also intimately connected to certification requirements.

### Issue 1: First-year Chemistry.

CAN descriptors currently exist for the standard science majors freshman chemistry. There has been general agreement as to the content of the course. The discussion addressed sharpening the description of these topics and finding a way to indicate the appropriate level of rigor of the courses. The year-long course is summarized as Chem Sequence A and is the sum of either two semesters (Chem 2 and Chem 4) or of three quarters (Chem 1 plus Chem 3 plus Chem 5). New CAN descriptors have been written for all of these. Chem 1, 2, 3, 4, and 5 have been defined as appropriate divisions of Sequence A. Since the order of topics and approach differ from school to school, each CAN descriptor makes the point that it is best to take the entire sequence at one school.

The CAN descriptor for Sequence A has been expanded to provide a more detailed list of topics that should be part of the curriculum. To indicate level of rigor, reference is made to the guides and sample examinations available from the American Chemical Society (ACS). It is important to note that there is no intention to insist on the exact amount of time that should be given to each topic, nor the order in which the topics are taken up. Similarly the ACS examinations are an indicator only, but may be used to provide sample questions or as examinations as faculty see fit. The ACS Examinations Institute collects statistics and can provide some measure of student achievement. Information on the ACS examinations and guidebooks may be found via the ACS web site or at <http://www.uwm.edu/Dept/chemexams/INTRO/index.html>.

The second sequence of Freshman Chemistry courses is designated CAN Chem Sequence B: General, Organic and Biochemistry for Allied Health Majors. This is a sum of Chem 7, 9 and 11 (quarter sequence) or 6 and 8 (semester sequence). The details have been spelled out in the new CAN descriptor and a reference to the appropriate level of ACS examinations added (unfortunately there is no guide book available from the ACS).

A new Descriptor has also been developed for Quantitative Analysis, CAN Chem 12. (See Chemistry Appendix 1.)

## Issue 2: Organic Chemistry.

CAN descriptors for the courses for second-year Chemistry have been more difficult to write, and this has been a matter for discussion since the beginning of the IMPAC meetings a few years ago. This year, agreement was reached in a number of stages. A number of faculty participants drafted CAN descriptors that focused discussion. It eventually became clear that schools use Organic Chemistry for somewhat different purposes. The community colleges can teach the subject, but are very limited in providing fully instrumented laboratories. CSUs tend to have the instrumentation and would like to have the students use it in the laboratory portion of this course. UC campuses have many more students taking the Chemistry majors' Organic Chemistry course, and so they tend to offer/require additional courses that specifically teach advanced laboratory methods. In the CSUs, the Organic Laboratory is often taken by only a very small number of students and is an introduction to research. At UC, this role is taken by the further courses.

The bottom line is that some of the four-year institutions (UCs and some CSUs) can accept the CC courses, if they are assured of the level at which they are taught, without concern about laboratory instruction on modern instruments. The newly written CAN descriptors will work for transfer to those institutions that offer additional advanced lab courses separated from the Organic Chemistry sequence. On the other hand, the four-year institutions (some CSUs) that use the Organic Sequence to lead into advanced laboratory work without another formal course may not wish to use CAN for the Organic course.

## Issue 3: SciGETC.

It has been widely recognized that the IGETC requirements work well for what they are designed for—satisfying the GE requirements in a manner that is transferable. However, they do not work well for students majoring in the sciences who must start on the all-important introductory courses in science and mathematics in a timely fashion. Science and Engineering curricula require sequences of courses that are interlocked by prerequisites—for example, some specific level of mathematics is required for most science majors. If the mathematics sequence is not started early in the student's college career, the student will inevitably have to spend extra time meeting these requirements before continuing with courses in the major discipline. The SciGETC proposal is an attempt to solve this problem. Discussion has involved all the science and engineering groups and details of the current outline may be found in the Biology Appendix 2 of this report. A major advantage of a SciGETC program will be the guidance it offers to students who are looking for a more definite path to a science or engineering major at a four-year college. SciGETC will need to have enough flexibility to accommodate the different majors in each of the many four-year colleges. Each student should get specific advice from a counselor, but not all students take advantage of this resource. Furthermore many students change their goals as they proceed through their college careers. SciGETC would provide students with a guide for the many requirements of the science and engineering curricula.

## Issue 4: Chemistry for Nursing and Other Health Professions.

There are two basic nursing degrees: an Associate Degree in Nursing, the ADN (two year program), and a Bachelor's Degree in Nursing, BSN (four-year program). CCs tend to teach towards the ADN degree and the CSUs towards the BSN. In UC, only UCLA teaches nursing at the undergraduate level.

Chemistry is required in two different ways: as a Chemistry requirement *per se* and as a prerequisite for the Biology courses required in their own right. The various community colleges teach different versions of Chemistry and Biology, depending on the demand of the different majors at the college. The demand for nursing education varies widely. For example, City College of San Francisco has a large number of nursing students and is able to teach a one-semester course that covers most of the vital topics (one such “Integrated Chemistry Course” has been developed by a committee chaired by James Armstrong—see the Nursing IMPAC Report 2001-2002). This has led to the suggestion that all colleges teach such a one-semester course. However, there are two outstanding problems. The first is that a one-semester course may not satisfy the requirements of the BSN curricula. Thus a student who starts in the ADN program and then switches to a BSN program may have to repeat aspects of Chemistry and Biology. The second problem is that colleges with relatively low nursing student demand do not have the resources and/or demand to teach a separate course and wish to use the two-semester sequence defined as CAN Chem Sequence B (General, Organic and Biochemistry (GOB) for Allied Health Majors) instead. The Chemistry group agrees that if only one semester of the GOB sequence is to be used as a requirement, it should be the second OB semester. In principle, students could place out of the first semester of a GOB course by taking an examination based on a strong high school chemistry course. However, it is acknowledged that many students arrive at college without a strong background in either Chemistry or elementary mathematics, making a route to the degree that involves “testing out” a realistic option for only a few.

### Identified Trends/Future Directions

An increasing number of students wish to major in the Allied Health Sciences and Nursing. This raises issues of the Chemistry requirements for the individual majors. Chemistry departments will be challenged to provide courses suitable for the different majors while, at the same time, upholding standards and facing the expected budget cuts.

The rapid expansion of the knowledge in Biochemistry/Chemical Biology suggests expansion of the curriculum in that direction over time.

Issues involved with safety suggest increased emphasis on environmental analytical and forensic chemistry.

### Comments from Statewide Meetings and the General Field

IMPAC Chemistry Group Meetings

#### Oakland Regional Meeting, October 26, 2002

The Chemistry Group met and arrived at a consensus on a number of issues.

CAN Descriptors: The new descriptors for Chemistry courses were discussed and found to be generally satisfactory. More detailed descriptors of the content of and indication of the skill level expected to result from each course are desirable. To that end, a sentence will be added to each of the applicable CAN descriptors. For Chem Seq A and its component courses: “See the General Chemistry ACS Guide and the General Chemistry ACS Examinations for more detailed information on the possible topics and the appropriate level of this course.” For Chem Seq B and its component courses: “See the General-Organic-Biochemistry ACS examinations for the appropriate level of this course”.

Barriers to transfer: Not all the colleges accepting transfer students interpret the course descriptors the same way. For example, the reasonable requirement that the Organic Chemistry Sequence include nuclear magnetic resonance (NMR) has been interpreted in two different ways.

1. NMR should be discussed in class and examples of interpreting the spectra of unknown compounds should be included as either lecture or laboratory exercises. This interpretation met with general agreement.
2. NMR should be treated as in 1) and, in addition, students need hands-on experience with an actual working NMR machine for the course to be acceptable. This interpretation was considered unreasonable. The problem of monitoring this recommendation will be referred to ICAS.

Nursing: The Chemistry requirement for nursing students was discussed. Possibilities range from no requirement to a one-term requirement to a two-term requirement. The Chemistry Group agrees that the GOB examinations of the ACS provide a reasonable standard for knowledge and achievement in Chemistry for nursing students. However, there was not consensus on a one term or two-term requirement. (N.B. In the discussion with the Nurses Group, it is not clear that they really wish to require any chemistry at all).

#### **Long Beach Regional Meeting, November 16, 2002.**

The notes from the Northern Regional Meeting (Oakland October 26, 2002) were discussed. Many of the same topics are of concern to the Southern group as well.

CAN Descriptors: There was general agreement with the idea that the ACS course outlines and “Guides” and the ACS exams be used to indicate curricula and the appropriate level of courses. The most difficult of the courses to define is Organic Chemistry.

There are two key problems faced by CSU and UC institutions when accepting courses from the community colleges. The first is the specification of arbitrary requirements. The example given at the Northern meeting was the specification that students be given access to an NMR machine as part of the Organic Chemistry Sequence. Many more examples emerged in this meeting, including the requirement that the topics be taught in essentially the same order as in the accepting school. The second problem involved the nominal expertise of the instructors—requiring that an acceptable course be taught by an instructor with a PhD, for example, with an MS degree not acceptable. It was noted at both Regional Meetings that the UCs tends to be more flexible than some of the CSUs in accepting Chemistry credits from the community colleges.

By using the ACS Examinations as criteria to measure knowledge and achievement of students, CC faculty would change the emphasis from the organization of the various courses to an emphasis on the abilities and experiences of the students who have completed the courses.

Laboratory: Requirements for the laboratory were discussed and the point was made that the courses should require that students keep a notebook with write-ups of the experiments.

The question of requirements for nursing majors was discussed. It was agreed that if the requirement for the nurses was only one semester of Chemistry, it should be the Organic Chemistry, Biochemistry semester. The ACS has a number of exams that can serve as

placement exams for the first college chemistry course and also as waivers out of one or more terms of General Chemistry.

In a meeting with the Engineering group, there was discussion of the SciGETC and of the Transfer AA degree. Because of the requirement that science courses be taken in sequence, it is difficult to specify a set of courses that could be completed in the time available to a lower-division student and still be satisfactory for most technical majors.

In a meeting with the Biology group, the Chemistry requirements for Biology courses were discussed. A possible starting point is the new National Academy of Sciences Report: Biology 2010. This report is available at <http://www.nap.edu/books/0309085357/html/>

### **Sacramento Regional Meeting, February 1, 2003**

This was the largest Regional Meeting for the Chemistry group and had participants from the CC, CSUs and UCs. Although many of the participants were familiar with IMPAC, a number were not. Consequently the purpose of IMPAC was briefly discussed.

The notes from the October 26, 2002, meeting were distributed and many of the same topics were discussed. The idea of using the ACS study guides and exams to indicate the level of the Chemistry courses was generally agreed upon.

The difficulty of providing CAN descriptors for the Organic Chemistry sequence was discussed at length. Among the problems are the following: Nominal level of the course—in some colleges both semesters of Organic Chemistry are lower-division, in some they are upper-division, and in some the first semester is lower-division and the second semester is upper-division. Specific requirements were discussed, particularly with respect to the laboratory element. Do we need to define a specific list of topics? What, if anything, should be done when one of the teaching institutions does not have a given piece of laboratory equipment available? Is it sufficient to discuss the use of an instrument without having “hands-on” experience? Is there a criterion of competence that can be used whether or not the course is upper or lower-division? What skills are required that would allow a student to continue taking courses at the next level?

A number of the participants agreed to send a draft to Herb Strauss for distribution and discussion.

### **Chemistry Courses for Nursing Programs: Comments by Faculty Attendees**

**Comments by Tony Wren:** This group agreed that the second semester of the general-organic-biochemistry sequence defined by the ACS exam—GOB (general-organic-biochemistry) was the appropriate course and the appropriate level for the chemistry preparation required by nursing programs. The first semester of this sequence could be skipped if the student has a sufficient background from high school [as originally proposed by James Postma (CSU-Chico) at the 2002 Northern regional meeting last year, and agreed to at the 2002 statewide meeting]. This background could be tested using an ACS high school exam or the California Chemistry Diagnostic Test—also available from the ACS.

**Nini Cardoza:** I would suggest that if some one wanted to challenge Chem 2A, that person should take the ACS GOB exam and be able to pass with a certain agreed upon percentage. In this exam the first section (questions #1-61) are questions that relate to Chem 2A. (The remainder of the booklet includes the organic and biochemistry sections.) If a student could

pass this first part of the exam, I would feel very comfortable allowing that person to take the Chem 2B and by-pass Chem 2A.

In an informal discussion, Shaaron Vogel, the Lead Faculty for the Nursing group, Herb Strauss, and Tony Wren agreed to proceed by providing a copy of the ACS examination to Shaaron as the best indication of what the chemistry faculty thinks appropriate. (Both Tony and Shaaron are at Butte College.)

A joint meeting between the Chemistry, Biology and other groups discussed a science alternative to IGETC. It has been generally agreed that satisfying IGETC leaves a student unprepared to start upper-division work in the sciences or engineering. The science alternative to IGETC will still not satisfy all majors and a student who knows what he/she wants to major in and which institution he/she wants to transfer to should try and meet the specific requirements of that institution. However, many faculty think that a general science alternative to the GE transfer package will be a viable option for students interested in majoring in the sciences and a help to counselors in the CC.

#### **Addendum to Chemistry notes from the IMPAC February 1 Regional Meeting: Nursing**

“Last year, a task force chaired by James Armstrong, Chair of Chemistry at City College of San Francisco undertook the job of developing curricular content of the desired course, drawing upon the experience of those campuses that were already teaching a similar course and upon additional input from faculty in Biology and from the nursing faculty. The work was accomplished largely over the Internet and capped by an extra evening session joint meeting of Nursing, Chemistry, and Biology faculty at the statewide IMPAC meeting.” (2001-02 IMPAC Annual Report, Chemistry Report, William Fink).

“Since we cannot cover a full year of chemistry in a single semester, we are quite ruthless in our treatment of general chemistry topics. Stoichiometry is cut to a bare minimum, gas laws and nuclear chemistry are omitted altogether, you won't find any mention of solubility rules for ionic compounds, and so forth. We also keep our organic section focused on reactions of particular relevance to biological processes—no halogenations of alkenes (or anything else), no arene substitutions, a minimum of nomenclature, and so forth.” (Jim Armstrong)

We now have the alternatives clearly laid out—either something like Jim's one-semester course without prerequisites or the two-semester ACS GOB course with a possible waiving of the first semester.

#### **Pasadena Regional Meeting, March 1, 2003.**

A brief review of previous meetings was presented and then most of the discussion was devoted to the same issues as in the previous meetings. There was general agreement that the ACS exams and study guides provided a good sign posts for college Chemistry courses and that this suggestion should be added to the proposed CAN descriptors.

Organic Chemistry continues to be a problem. The first issue is structural within the California public higher education system. CCs teach only courses identified as lower-division; many CSUs and UCs however teach the same courses as upper-division. A number of the UC campuses use an exam (for example the ACS exam) to test entering students for their mastery of the organic course and then exempt students who pass from having to retake it. A number of the CSUs apparently will not allow students to place out of their upper-

division organic courses. The other hurdle seems to be the laboratory. A new difference among the laboratories was brought up for the first time—the distinction between micro and macro laboratory approaches. Apparently, some transfer institutions insist that a student have both micro and macro lab experience at the CC level in order to credit that student with having passed Organic Chemistry. Similarly, some schools require hands-on experience with certain laboratory instruments. Some faculty from CSU have volunteered to spell out what should be required. In the coming year, IMPAC faculty should develop a specific proposal to move this subject towards resolution.

The perennial issue of the appropriate Chemistry requirement for nurses was discussed briefly. A major problem is that many CCs are too small to have separate courses specifically for nurses. (This problem may well get worse with the current state budget situation). It was mentioned that since many entrants into nursing programs are among the weaker students in mathematics, schemes such as skipping the first term of a two-term sequence are unlikely to work.

A joint meeting with the biologists, physicists and engineers was held to discuss the possibility of a SciGETC. The difficulty of advising students is widely acknowledged, and a detailed plan would be a substantial help.

### **Recommendations for the Discipline**

Continue discussions both within the Discipline and with the connecting Disciplines.

### **Recommendations for Support Courses (if discussed)**

None

### **Topics for Further Discussion**

1. SciGETC or similar scheme to direct CC students who want to continue in the sciences or engineering.
2. Further discussion with the nursing group and with other faculty involved in preparation for professional programs in the Health Sciences.
3. Develop a specific proposal defining any required hands-on experience with certain laboratory instruments for the organic lab.

### **Recommendations Forwarded/to be Forwarded to:**

#### **CAN**

New descriptors for Chem Sequence A and Chem Sequence B and the descriptors for the individual quarters or semesters that make up the sequences are being forwarded to CAN. A set of descriptors for Chem Seq C, Organic Chemistry for Science Majors and its individual quarters or semesters is being forwarded as well.

## CHEMISTRY CAN DESCRIPTORS

*Italics:* new proposed language

~~Strikethrough:~~ deletion of existing CAN description

**CAN Number:** CHEM1

**Title:** General Chemistry for Science Majors, 1<sup>st</sup> Quarter, with Laboratory

**Description:** *The course will consist of a portion of the topics listed under CAN CHEM SEQ A. The laboratory sequence will support the above topics including both qualitative and quantitative experiments, analysis of data and error propagation. It is strongly recommended that CAN CHEM 1, 3, and 5 (CAN CHEM SEQ A) be completed at a single institution before transfer.*

**Prerequisite:** Algebra I and II (Two years of high school algebra. High school chemistry and physics recommended.)

**CAN Number:** CHEM2

**Title:** General Chemistry for Science Majors, 1<sup>st</sup> Semester, with Laboratory

**Description:** ~~A presentation of fundamental principles and concepts of chemistry.~~ *This course will consist of a portion of the topics listed under CAN CHEM SEQ A. The laboratory sequence will support the above topics including both qualitative and quantitative experiments, analysis of data and error propagation. It is strongly recommended that CAN CHEM 2 and 4 (CAN CHEM SEQ A) be completed at a single institution before transfer.*

**Prerequisite:** ~~Prerequisite: 2 years of high school algebra; high school chemistry and physics recommended.~~ Algebra I and II (Two years of high school algebra. High school chemistry and physics recommended.)

**CAN Number:** CHEM3

**Title:** General Chemistry for Science Majors, 2<sup>nd</sup> Quarter, with Laboratory

**Description:** *The course is a continuation of CAN CHEM 1 and will consist of an additional portion of the topics listed under CAN CHEM SEQ A. The laboratory sequence will support the above topics including both qualitative and quantitative experiments, analysis of data and error propagation. It is strongly recommended that CAN CHEM 1, 3, and 5 (CAN CHEM SEQ A) be completed at a single institution before transfer.*

**Prerequisite:** General Chemistry for Science Majors, 1<sup>st</sup> Quarter, with Laboratory, CAN CHEM 1

**CAN Number:** CHEM4

**Title:** General Chemistry for Science Majors, 2<sup>nd</sup> Semester, with Laboratory

**Description:** ~~A continuation of the presentation of fundamental principles and concepts of chemistry.~~ *The course is a continuation of CAN CHEM 2 and will consist of an additional portion of the topics listed under CAN CHEM SEQ A. The laboratory sequence will support the*

*above topics including both qualitative and quantitative experiments, analysis of data and error propagation. It is strongly recommended that CAN CHEM 2 and 4 (CAN CHEM SEQ A) be completed at a single institution before transfer.*

**Prerequisite:** *General Chemistry for Science Majors, 1<sup>st</sup> Semester, with Laboratory, CAN CHEM 2*

**CAN Number:** CHEM5

**Title:** *General Chemistry for Science Majors, 3<sup>rd</sup> Quarter, with Laboratory*

**Description:** *The course is a continuation of CAN CHEM 1 and 3 and will consist of an additional portion of the topics listed under CAN CHEM SEQ A. The laboratory sequence will support the above topics including both qualitative and quantitative experiments, analysis of data and error propagation. It is strongly recommended that CAN CHEM 1, 3, and 5 (CAN CHEM SEQ A) be completed at a single institution before transfer.*

**Prerequisite:** *General Chemistry for Science Majors, 2<sup>nd</sup> Quarter, with Laboratory, CAN CHEM 3*

**CAN Number:** CHEM6

**Title:** *General Chemistry for Allied Health Majors, 1<sup>st</sup> Semester, with Laboratory*

**Description:** ~~A presentation of the principles of chemistry and scientific methods for students who do not plan advanced study in science.~~ *Introduction to the principles of chemistry including physical and chemical changes, energetics, atomic structure, bonding, nomenclature, chemical calculations, chemical reactions (including solubility, neutralization, and oxidation-reduction) gas laws, solutions, acids and bases, pH, equilibrium, and nuclear chemistry. Appropriate for students majoring in allied health and other applied sciences. The laboratory sequence will support the above topics including both qualitative and quantitative experiments, and analysis of data.*

**Prerequisite:** *Algebra 1 (High school course.)*

**CAN Number:** CHEM7

**Title:** *General Chemistry for Allied Health Majors, 1<sup>st</sup> Quarter, with Laboratory*

**Description:** *An Introduction to the principles of chemistry including physical and chemical changes, energetics, atomic structure, bonding, nomenclature, chemical calculations, chemical reactions (including solubility, neutralization, and oxidation-reduction) gas laws, solutions, acids and bases, pH, equilibrium, and nuclear chemistry. Appropriate for students majoring in allied health and other applied sciences. The laboratory sequence will support the above topics including both qualitative and quantitative experiments, and analysis of data.*

**Prerequisite:** *Algebra 1 (High school course.)*

**CAN Number:** CHEM8

**Title:** ~~Chemistry~~ *Organic and Biochemistry* for Allied Health Majors, 2nd semester, with Laboratory

**Description:** ~~An introduction to organic and biological chemistry for students who do not plan advanced study in science.~~ *An introduction to the principles of organic and biological chemistry including nomenclature, functional groups, and properties of organic and biological compounds. Applications of organic and biochemistry to living systems. Appropriate for students majoring in allied health and other applied sciences. The laboratory sequence will support the above topics including both qualitative and quantitative experiments, and analysis of data.*

**Prerequisite:** *General Chemistry for Allied Health Majors, with Laboratory; CAN CHEM 6 or 7.*

**CAN Number:** CHEM9

**Title:** ~~Chemistry~~ *Organic Chemistry* for Allied Health Majors, 2nd quarter, with Laboratory

**Description:** *An introduction to the principles of organic chemistry including nomenclature, functional groups, and properties of organic compounds. The course will include an introduction to biologically important molecules. Appropriate for students majoring in allied health and other applied sciences. The laboratory sequence will support the above topics including both qualitative and quantitative experiments, and analysis of data.*

**Prerequisite:** *General Chemistry for Allied Health Majors, 1<sup>st</sup> Quarter, with Laboratory; CAN CHEM 7.*

**CAN Number:** CHEM11

**Title:** ~~Chemistry~~ *Biochemistry* for Allied Health Majors, 3rd quarter, with Laboratory

**Description:** *An introduction to the principles of biochemistry including nomenclature, structures, properties, and reactions of biological compounds as applied to living systems. Appropriate for students majoring in allied health and other applied sciences. The laboratory sequence will support the above topics including both qualitative and quantitative experiments, and analysis of data.*

**Prerequisite:** *Organic Chemistry for Allied Health Majors, 2<sup>nd</sup> Quarter, with Laboratory, CAN CHEM 9*

**CAN Number:** CHEM12

**Title:** Quantitative Analysis, with Laboratory

**Description:** ~~The practice and theory of wet chemical methods and an introduction to instrumental methods of analysis with a focus on precision and accuracy of experimental data.~~ *The practice and theory of chemical laboratory methods including techniques of gravimetric, volumetric, spectrophotometric analysis and separation, and introductory instrumental analysis with a focus on precision and accuracy of experimental data. The laboratory sequence will support the above topics and emphasize quantitative measurements, analysis of data and error propagation.*

**Prerequisite:** *General Chemistry for Science Majors, 1 Year, with Laboratory, CAN CHEM SEQ A, CAN CHEM 1+3 +5 or CAN CHEM 2+4*

**CAN Number:** CHEM SEQ A

**Title:** *General Chemistry for Science Majors, 1 Year, with Laboratory* (Sum of the Content of CAN CHEM 1+3+5 or CAN CHEM 2+4)

**Description:** The complete sequence will present fundamental principles and concepts of chemistry including, but not limited to atomic structure, *quantum theory*, periodic properties, *chemical reactions*, stoichiometry, gas laws *and theories*, molecular structure and bonding, states of matter, *solutions*, acids and bases, chemical equilibrium, thermodynamics, *oxidation-reduction*, electro-chemistry and chemical kinetics, *nuclear chemistry*, *organic chemistry*, *descriptive chemistry*, and *coordination chemistry*. The laboratory sequence will support the above topics including both qualitative and quantitative experiments, *analysis of data and error propagation*. *The American Chemical Society (ACS) General Chemistry Guide and the General Chemistry examinations provide information on topics and indicate an appropriate level of this sequence.*

**Prerequisite:** *Algebra I and II (Two years of high school algebra. High school chemistry and physics recommended.)*

**CAN Number:** CHEM SEQ B

**Title:** *General, Organic and Biochemistry for Allied Health Majors, 1 Year, with Laboratory* (Sum of the Content of CAN CHEM 7+9+11 or CAN CHEM ~~2+4~~6+8)

**Description:** ~~Sum of the content of CAN CHEM 7+9+11 or CAN CHEM 6+8~~ The complete sequence will present the basic principles of chemistry including physical and chemical changes, energetics, atomic structure, bonding, nomenclature, chemical calculations, chemical reactions (including solubility, neutralization, and oxidation-reduction,) gas laws, solutions, acids and bases, pH, equilibrium, nuclear chemistry. The sequence will also include an introduction to the principles of organic and biological chemistry including nomenclature, functional groups, and properties of organic and biological compounds and applications of organic and biochemistry to living systems. Appropriate for students majoring in allied health and other applied sciences. The laboratory sequence will support the above topics including both qualitative and quantitative experiments, and analysis of data. *. The American Chemical Society (ACS) General-Organic-Biochemistry examinations provide information on topics and indicate an appropriate level of this sequence.*

**Prerequisite:** *Algebra I (high school course.)*

**CAN Number:** CAN CHEM SEQ C

**Title:** *Organic Chemistry for Science Majors, 1 Year, with Laboratory*

*(Sum of the Content of CAN CHEM 21 + 23 + 25 or CAN CHEM 22 + 24)*

**Description:** *The complete sequence will include aspects of structure, physical properties and reactivity of the groups of organic chemistry, including alkanes, alkenes, alkynes, halocarbons, alcohols, ethers, aromatic compounds, aldehydes, ketones, amines, carboxylic acids and their derivatives, carbohydrates, amino acids, and nucleic acids. The sequence will also include nomenclature, aspects of stereochemistry, reaction mechanisms, and determination of structure using spectroscopy. The laboratory will support the above topics, as well as introduce current techniques in preparation, purification, identification, and isolation of organic molecules. The American Chemical Society (ACS) Organic Chemistry Guide and the Organic Chemistry examinations provide information on topics and indicate an appropriate level of this sequence.*

**Prerequisite:** *General Chemistry for Science Majors. CAN CHEM SEQ A.*

**CAN Number:** *CHEM 21*

**Title:** *Organic Chemistry for Science Majors, 1<sup>st</sup> quarter, with Laboratory*

**Description:** *The course will consist of a portion of the topics listed under CAN CHEM SEQ C. The laboratory sequence will support the above topics. It is strongly recommended that CAN CHEM 21, 23, and 25 (CAN CHEM SEQ C) be completed at a single institution before transfer.*

**Prerequisite:** *General Chemistry for Science Majors.*

*CAN CHEM SEQ A.*

**CAN Number:** *CHEM 23*

**Title:** *Organic Chemistry for Science Major, 2<sup>nd</sup> quarter, with Laboratory*

**Description:** The course will consist of a portion of the topics listed under CAN CHEM SEQ C. The laboratory sequence will support the above topics. It is strongly recommended that CAN CHEM 21, 23, and 25 (CAN CHEM SEQ C) be completed at a single institution before transfer.

**Prerequisite:** *Organic Chemistry for Science Major, 1<sup>st</sup> quarter, with Laboratory, CAN CHEM 21*

**CAN Number:** *CAN CHEM 25*

**Title:** *Organic Chemistry for Science Major, 3<sup>rd</sup> quarter, with Laboratory*

**Description:** The course will consist of a portion of the topics listed under CAN CHEM SEQ C. The laboratory sequence will support the above topics. It is strongly recommended that CAN CHEM 21, 23, and 25 (CAN CHEM SEQ C) be completed at a single institution before transfer.

**Prerequisite:** *Organic Chemistry for Science Major, 2<sup>nd</sup> quarter, with Laboratory, CAN CHEM 23*

**CAN Number:** *CHEM 2422*

**Title:** *Organic Chemistry for Science Majors, 1<sup>st</sup> semester, with Laboratory*

**Description:** This course will consist of a portion of the topics listed under CAN CHEM SEQ C. The laboratory sequence will support the above topics. It is strongly recommended that CAN CHEM 22 and 24 (CAN CHEM SEQ C) be completed at a single institution before transfer.

**Prerequisite:** *General Chemistry for Science Majors. CAN CHEM SEQ A.*

**CAN Number:** *CHEM 24*

**Title:** *Organic Chemistry for Science Majors, 2<sup>nd</sup> semester, with Laboratory*

**Description:** This course will consist of a portion of the topics listed under CAN CHEM SEQ C. The laboratory sequence will support the above topics. It is strongly recommended that CAN CHEM 22 and 24 (CAN CHEM SEQ C) be completed at a single institution before transfer.

**Prerequisite:** *Organic Chemistry for Science Majors, 1<sup>st</sup> semester, with Laboratory; CAN CHEM 24*