

CHEMISTRY

THE WIESS SCHOOL OF NATURAL SCIENCES

CHAIR

Kenton H. Whitmire

PROFESSORS

Andrew R. Barron

W. Edward Billups

Philip R. Brooks

Vicki L. Colvin

Robert F. Curl, Jr.

Paul S. Engel

Graham P. Glass

Naomi Halas

John S. Hutchinson

James L. Kinsey

Seiichi P.T. Matsuda

Ronald J. Parry

Ronald L. Sass

Gustavo E. Scuseria

Richard E. Smalley

James M. Tour

R. Bruce Weisman

Kenton H. Whitmire

Lon J. Wilson

ASSOCIATE PROFESSORS

E. Pernilla L. Wittung Stafshede

Boris I. Yakobson

ASSISTANT PROFESSORS

Victor Behar

Cecilia Clementi

Jason H. Hafner

Jeffrey D. Hartgerink

Anatoly Kolomeisky

Michael S. Wong

ADJUNCT PROFESSORS

Marco Ciufolini

Tohru Fukuyama

Peter Harland

Michael Metzker

M. Robert Willcott

LECTURERS

Lawrence B. Alemany

Mary E. R. McHale

DISTINGUISHED FACULTY FELLOW

Robert H. Hauge

Bruce R. Johnson

FACULTY FELLOW

Valery Khabashesku

Kristen Kulinowski

VISITING PROFESSOR

Raphael Levine

DEGREES OFFERED: BA, BS, MA, PHD

Recognizing the wide range of studies encompassed by chemistry, the department encourages undergraduates to explore offerings in other departments such as mathematics, computational and applied mathematics, biochemistry, and physics as well as upper-level courses in chemistry. An interdepartmental major is offered in chemical physics. Taking advantage of the department's extensive facilities, each BS degree candidate carries out a program of individual research under the supervision of a faculty member.

Graduate studies emphasize individual research, together with a fundamental understanding of chemistry beyond the students' specific interests. Faculty research interests include the synthesis and biosynthesis of organic natural products; the synthesis of small cycloalkanes, molecular recognition, and biological catalysis; bioinorganic and organometallic chemistry; main group element and transition metal chemistry; the chemistry of group 13 elements; high-pressure and high-temperature chemistry; fluorine chemistry; chemical vapor deposition; the design of nanophase solids; molecular photochemistry and photophysics; infrared kinetic spectroscopy, laser and NMR spectroscopy; studies of electron transfer in crossed beams; theoretical and computational chemistry; and the study of fullerene molecules, carbon nanotubes, and their derivatives; polymer synthesis and characterization; molecular electronics; and molecular machines.

DEGREE REQUIREMENTS FOR BA IN CHEMISTRY

For general university requirements, see Graduation Requirements (pages 14–15). Students choosing to receive a BA in chemistry must have a total of at least 120 semester hours at graduation, including the following courses required of all majors.

Core Courses

Chemistry

CHEM 121/122 *General Chemistry* with laboratory or CHEM 151/152 *Honors Chemistry* with laboratory

CHEM 211/212 *Organic Chemistry*

CHEM 215 *Organic Chemistry Lab*

CHEM 311/312 *Physical Chemistry*

CHEM 351 *Introductory Module in Experimental Chemistry I*

CHEM 352 *Introductory Module in Experimental Chemistry II*

CHEM 353 *Introductory Module in Analytical Methods*

CHEM 360 *Inorganic Chemistry*

Mathematics*

MATH 101/102 *Single Variable Calculus I and II* or MATH 121/122

MATH 211 *Ordinary Differential Equations and Linear Algebra*

MATH 212 *Multivariable Calculus* or MATH 221/222 *Honors Calculus III and IV*

Physics

PHYS 101 or 111 *Mechanics*

PHYS 102 or 112 *Electricity and Magnetism*

Other

NSCI 230 *Computation in the Natural Sciences* or CAAM 210 *Introduction to Engineering Computation* (or equivalent)

* The Department of Mathematics may, after consultation with a student concerning his/her previous math preparation, recommend that a student be placed into a higher level math course than for which the student has official credit. The Department of Chemistry will accept this waiver of the math classes upon a written confirmation of the waiver from the Department of Mathematics and upon the student's successful completion of the higher

level math course.

Advanced Courses

Additional Lecture Courses

At least 1 course from the following:

CHEM 401 *Advanced Organic Chemistry*

CHEM 430 *Quantum Chemistry*

CHEM 495 *Transition Metal Chemistry*

Additional Laboratory Courses

At least 3 advanced laboratory module credit hours from the following list:

CHEM 373 *Advanced Module in Fullerene Chemistry*

CHEM 374 *Advanced Module in Synthetic Chemistry*

CHEM 375 *Advanced Module in Nanochemistry*

CHEM 376 *Advanced Module in Materials Chemistry*

CHEM 377 *Advanced Module in Catalysis*

CHEM 381 *Advanced Module in Physical Chemistry, A*

CHEM 382 *Advanced Module in Physical Chemistry, B*

CHEM 383 *Advanced Module in Instrumental Analysis, A*

CHEM 385 *Advanced Module in Polymer Chemistry*

CHEM 391 *Advanced Module in Catalysis*

CHEM 395 *Advanced Module in Green Chemistry*

CHEM 435 *Methods of Computational Quantum Chemistry*

To ensure that students receive suitable breadth in their laboratory experience, advanced module selections must be approved by the student's major committee.

Other advanced laboratory courses from chemically related disciplines (biochemistry, materials science, environmental engineering, etc.) may be substituted for these advanced modules, with approval of the committee. Chemistry majors may also substitute 2 advanced organic laboratory module credit hours for CHEM 215, with approval of the committee. Three hours of CHEM 491 (taken for one entire semester) may be substituted for 1 advanced laboratory module if no other CHEM 491 credit is taken in the same semester.

Students in the chemistry BA major must satisfy the university distribution requirements and complete no fewer than 64 semester hours in addition to the departmental requirements for the chemistry major, giving a minimum total of 120 hours for graduation.

DEGREE REQUIREMENTS FOR BS IN CHEMISTRY

The core chemistry, math, physics, and NSCI 230 requirements for the BS degree are the same as those for the BA degree. PHYS 201 *Waves and Optics* and PHYS 202 *Modern Physics* are recommended but not required.

In addition to the core requirements, the BS degree requires the following course and laboratory work:

- 2 courses total from the **Additional Lecture Courses** list
- 3 advanced modules from the **Additional Laboratory Courses** list. As with the BA degree, 2 advanced laboratory modules may be substituted for CHEM 215 with departmental approval.
- At least 3 semester hours in undergraduate research (CHEM 491) in no less than 2-hour segments. With departmental approval, students may satisfy this requirement with HONS 470/471, which requires participation in CHEM 491 meetings. Students may also satisfy 3 of the 6 required hours in upper-level courses with additional research.
- 6 hours credit in upper-level courses (300 level or higher) in chemistry, mathematics, computational and applied mathematics, physics, biochemistry, or other subjects with adviser approval.

Students in the chemistry BS major must satisfy the distribution requirements (see pages 15–16) and complete no fewer than 60 semester hours in addition to the departmental requirements for the chemistry major, giving a minimum total of 128 hours for graduation.

American Chemical Society Certification—The Rice Department of Chemistry is on the approved list of the Committee on Professional Training of the American Chemical Society and so can certify that graduates have met the appropriate standards. The BA degree is not certifiable. For certification, students must complete:

- All degree requirements for the BS degree listed above
- CHEM 495 *Transition Metal Chemistry* as one of the additional lecture courses
- A department-approved course in biochemistry
- 9 hours total in upper-level courses from chemistry, physics, mathematics, computational and applied mathematics, biochemistry, or other courses in science or engineering with the approval of the department. The required course in biochemistry listed above counts toward this total.

A foreign language, preferably German, is recommended.

Chemical Physics Major—The chemical physics major leading to a BS degree is offered in conjunction with the Department of Physics and Astronomy. Students take upper-level courses in both chemistry and physics, focusing on the applications of physics to chemical systems. Students majoring in chemical physics must complete the following courses:

Core Courses

Chemistry

CHEM 121/122 *General Chemistry with Laboratory* or CHEM 151/152 *Honors Chemistry with Laboratory*

CHEM 211 *Organic Chemistry*

CHEM 311/312 *Physical Chemistry*

Physics

PHYS 101 or 111 *Mechanics*

PHYS 102 or 112 *Electricity and Magnetism*

PHYS 201 *Waves and Optics*

PHYS 202 *Modern Physics*

PHYS 231 *Elementary Physics Lab II*

PHYS 301 *Intermediate Mechanics*

PHYS 302 *Intermediate Electrodynamics*

Mathematics

MATH 101/102 *Single Variable Calculus I and II*
or MATH 121/122

MATH 211 *Ordinary Differential Equations and Linear Algebra*

MATH 212 *Multivariable Calculus* or MATH 221/222 *Honors Calculus III and IV*

Additional Courses

1 course from CHEM 212 or CHEM 360

2 courses from PHYS 311, PHYS 312, CHEM 430, or CHEM 415

6 hours from CHEM 215, CHEM 351, CHEM 352, CHEM 373–391, CHEM 435, PHYS 331, or PHYS 332. Up to 2 hours of independent research (CHEM 491 or PHYS 491/492 may be counted toward this requirement.)

2 courses from NSCI 230, CAAM 210, or mathematics or computational and applied mathematics at the 300 level or above

ADMISSION REQUIREMENTS FOR ACCELERATED BS/PHD PROGRAM IN CHEMISTRY

The high level of training provided in the Rice BS program enables certain specially qualified undergraduates to enter an accelerated program that allows them to complete a PhD degree within two or three years after receiving their BS degree. Students electing this option must begin their research during the summer following their junior year and continue the research by taking CHEM 491 during their senior year.

** Students wishing to be considered for the accelerated BS/PhD program should apply to the Department by January 15 of the second semester of their sophomore or junior years at Rice. The student should submit with the application a letter describing why they would like to enroll in this program and outline briefly their intended plan of study, stating their area of interest and with whom they would like to undertake graduate research. After an interview, the Department's graduate admissions committee will consider the application and inform the candidate of their decision by no later than April 15 of that semester. Students admitted to the program will be assigned a committee to work out details of required courses for the accelerated program.

DEGREE REQUIREMENTS FOR MA AND PHD IN CHEMISTRY

For general university requirements, see Graduate Degrees (pages 57–58). Students who have completed course work equivalent to that required for a BA or BS in chemistry may apply for admission to the PhD program. For more information, see Admission to Graduate Study (pages 56–57).

MA Program—Students are NOT normally admitted to study for an MA degree. However, this degree is sometimes awarded to students who do not wish to complete the entire PhD program. Candidates for the MA degree must:

- Complete 6 one-semester courses
- Produce a thesis that presents the results of a program of research approved by the department
- Pass a final oral examination

Students who are admitted to PhD candidacy may apply for an automatic master's degree.

REQUIREMENTS FOR THE PHD IN CHEMISTRY AT RICE UNIVERSITY

The PhD in Chemistry is awarded for original research in Chemistry. Candidates receive a PhD after successfully completing at least 90 semester hours of advanced study in Chemistry and related fields and culminating in a thesis that describes an original and significant investigation in Chemistry. The thesis must be satisfactorily defended in a public oral examination. The student must pass the thesis defense before the end of the 16th semester of residency.

RESEARCH

During the first semester of residence students will select a research advisor from among the members of the faculty; the department chair must approve this choice. In some cases, students may choose research advisors outside of the department; however, such arrangements must be approved by the chemistry faculty. The research advisor will guide the student in the choice of an appropriate research topic and in the detailed training required to complete that project. Students must enroll in CHEM 800 (Graduate Research) and must participate in one of the graduate seminar classes offered by the department (currently CHEM 600) each semester that the student is in residence.

COURSE WORK

The student must complete 6 three-semester-hour graduate-level lecture courses at Rice University. In order to satisfy this requirement, each of these courses must satisfy the following criteria:

- They must be approved by the department's graduate advising committee.
- If a Chemistry course, it must be at the 400 level or higher. Certain 300 level courses in other departments may be acceptable with prior approval by the department's graduate advising committee. Courses must be in technical subjects in Science or Engineering. Courses in teaching, presentation or management will not be counted towards the 6-class requirement.
- Each course must be passed with a grade of B or higher. It is possible to repeat or replace a course, upon approval of the department's graduate advising committee. A maximum of two courses can be repeated/replaced.

Students transferring from other graduate institutions or students with a master degree can apply to have a maximum of 2 courses waived. A course waiver request must be accompanied by proof that a course pertinent to the student's field of research has been successfully completed at a different institution. Waiver requests must be submitted for approval to the department's graduate advising committee.

TEACHING

Each student is required to participate in CHEM 700 (Teaching Practicum), for four semesters with no grade less than B-.

QUALIFYING EXAMINATION

An examination committee, consisting of three faculty members excluding the research advisor, will be assigned to each student, typically in the second semester. The student must defend an original research proposal before this committee, involving both a written and oral presentation of the original research proposal. The written proposal must conform to the format and guidelines established by the

Chemistry Department, which are available in the Department office. The written proposal must be submitted to the committee at least one week before the date of the oral examination. The examination (including any follow up work deemed necessary by the committee) must be passed by the last day of class at the end of the student's fourth semester in residency.

ADVANCEMENT TO CANDIDACY FOR THE PHD

The course and examination requirements listed above must be completed within two years of admittance to the graduate program. After completing these requirements, a student must petition to be advanced to candidacy for the PhD degree. Upon advancement to candidacy a student chooses a thesis committee of at least three faculty members with the guidance and approval of the research advisor and department Chair. The thesis committee must include one faculty member holding his/her primary appointment outside of the Chemistry Department.

SATISFACTORY PERFORMANCE

Students are expected to perform satisfactorily in research as judged by their research director and their thesis committee. Students may also be requested to fulfill certain service functions for the Department. The student must be enrolled full time in a research group each semester that the student is in residence (except the first semester). Every year the student must submit an annual three-page research progress report to the thesis committee by August 1st.

The thesis committee will assess the progress being made in research and may invite the student to present a discussion of their work. If progress is unsatisfactory, the committee may recommend a semester of probation, which may result in dismissal from the program if progress remains unsatisfactory in the subsequent semester. The student, advisor, or committee may request a meeting between student and committee at other times to evaluate progress or to determine a course of action.

In order to remain in good standing, a student must receive grades above B- in CHEM 800, CHEM 700, and the various seminar courses. In the completed lecture courses, a student must maintain an average GPA of 3.00 (B) or higher. Failure to maintain satisfactory progress in research and/or grades will result in probation and possible dismissal.

APPEAL

Students may petition the Chemistry Department Graduate Advising Committee for variances on these academic regulations.