REQUIREMENTS FOR THE PH.D. DEGREE IN CHEMISTRY

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The Ph.D. degree in Chemistry is a professional degree that stands for a general mastery of the subject of Chemistry, a specialized knowledge of a field within Chemistry, and the ability to successfully undertake and defend independent research. Ultimately, **a Ph.D. degree in Chemistry is earned for scientific discovery**, this includes performing and defending independent research. As a result, **satisfactory research progress throughout a student's career is of primary importance**. General requirements for the Ph.D. are described in the Washington University in St. Louis, Graduate School of Arts & Sciences, "GRAD GUIDE". In addition, there are specific requirements for the Ph.D. degree in Chemistry that are described here. Because of the diversity of sub-disciplines within Chemistry and of individual backgrounds and interests, there will be variations between individual Chemistry divisions.

I. Residence.

There is no minimum residence requirement for the Ph.D. degree at Washington University in St. Louis, but a typical Ph.D. in Chemistry takes between five and six years of graduate study, with most of this time ordinarily spent doing research at Washington University in St. Louis. While the official program length is six years, students are expected to graduate within five years of study; a student must obtain permission from the Chemistry Graduate Work Committee (GWC) to continue beyond five years. If time beyond six years in residence is necessary, both the full Chemistry faculty and the Graduate School must approve the request. The absolute maximum time to degree is set by the Graduate School, which is currently seven years, and beyond that date a student will not receive a stipend, nor receive benefits. Each semester the student's performance will be reviewed by the Chemistry GWC and satisfactory progress toward the degree must be demonstrated. A Chemistry Ph.D. candidate would be in good standing within the Chemistry Ph.D. program if the student fulfills the following:

1) Coursework requirements: maintaining a GPA of at least 3.0 and passing at least four courses in the candidate's research area and two courses out of that area by the end of four semesters in residence;
2) Teaching: satisfactory fulfill the teaching requirements of the Chemistry Department and the Graduate School;
3) Pre-thesis Research Proposal: write a proposal describing the thesis research to be undertaken, including relevant background and referencing, and satisfactorily present and defend this research in front of the student's Ph.D. advisory committee prior to the end of the student's third semester in residence;
4) Research: actively pursuing research in a group approved by the Department of Chemistry, and successful progressing towards a Ph.D. as evaluated by the student's thesis advisor and the student's Ph.D. advisory committee;
5) Safety: take and pass the Chemical Laboratory Safety course (Chem 599), maintain a safe research and working environment, and practice safe protocols.

If any requirements are not met, the Department will prescribe, on the basis of the recommendation of the GWC or the student's Thesis Advisory Committee (TAC) or the department as a whole if the advisory committee has not been appointed either 1) a probationary period during which the student will be expected to satisfy the requirements, or 2) immediate dismissal for egregious violations.

A student in "good standing" in the Chemistry Ph.D. program may receive a regular graduate-student stipend from the Department for a period of at least five years (the "Five-Year Rule"). A graduate student considering a request for an extension into his/her sixth year must have an Advisory Committee meeting and obtain the committee's approval for an extension of a specified period not to exceed two semesters. Then a formal request to extend the Five-Year Rule for up to one year must be made by written petition to the GWC. The petition must be counter-signed by the student's research advisor and must clearly state and **describe in detail** the unanticipated circumstances leading to the request and the expected time to completion.

In only rare circumstances can a student be granted a second extension that would extend the total duration of study beyond the program length, which is six years. Prior to requesting such an extension, a student must first have an Advisory Committee meeting and obtain the committee's approval for an extension of a specified period. If approval is deemed appropriate by the Committee, a formal request for an extension beyond the sixth year must be made by written petition to the GWC. Again, the petition must be counter signed by the student's research advisor and must clearly state and **describe in detail** the unanticipated circumstances leading to the request and the expected time to completion. If approved by the GWC, the research advisor of the student requesting the extension beyond the sixth year must then present the case to the entire Chemistry Faculty for their consideration at a Faculty meeting. If the Chemistry Faculty approves the request for an extension, the GWC will forward the request to the office of the Dean of the Gradual School. The Dean must approve the request in order for the student to remain as a full-time Ph.D. student at Washington University, to continue receiving a stipend from either federal grant support or through Chemistry Department resources, and to receive health insurance and wellness fee subsidies of 90%.

II. Course Work.

Students take proficiency examinations in Biological, Inorganic, General, Organic, and Physical Chemistry when first entering the Ph.D. program. The results of these proficiency examinations, coupled with the student's disciplinary interests and goals and undergraduate preparation, are to be used by the student and advisor, either the temporary advisor or thesis advisor, as a guide to fill in gaps in the student's background and to ensure the student has a sufficient knowledgebase for conducting independent research in chemistry. Based on the results of these examinations, it may be beneficial for a student to take specific undergraduate or graduate coursework in appropriate fields. Adjustments in the program of study may occur upon selection of a permanent advisor or with the recommendation of the advisory committee (see below).

All Chemistry Ph.D. students should take at least six graduate courses (400 level or higher) at Washington University prior to qualifying for dissertation status, ≥ 72 credits. At least four of these graduate courses must be in the area of the student's thesis research, and at least two of these graduate courses should be outside of a student's research area. Any of these courses can be taken outside of the Chemistry Department, such as in the Biology or Physics Departments or in the Schools of Engineering or Medicine. The student's thesis advisor and the student's Ph.D. advisory committee must approve the courses as in- or out-of area, and a coursework form indicating completion of the course work requirement must be submitted to the graduate coordinator prior to the end of a student's second year in residence. Typical programs of study for specific sub-disciplines

are given in the appendices to this document. Graduate courses are normally graded A, B, C, D, or NCR with possible +/– sub-partitions. Units of instruction with grades of NCR are not creditable towards the fulfillment of degree requirements. Grades of A and B are considered satisfactory grades. *A grade of C is considered an unsatisfactory grade and each grade of C must be balanced by a grade of A in a course with at least the same number of credits.* Students are also required to have an overall B average (3.0 GPA) in all course work (research and journal club credits are not to be included in determining the average). If a student's GPA falls below a 3.0, the student will be placed on academic probation, and given one semester to raise his/her GPA above the minimum 3.0 level.

Chemistry Ph.D. students should enroll in at least 9.0 credits for the fall and spring semesters until a total of at least 72.0 credits has been earned. (At least 18 of these credits should be from coursework.) Chemistry Ph.D. students should enroll in Independent Research, Chem 590 in the section associated with his/her thesis advisor in order to fulfill the 9.0 credits per semester. As a result, most of the 72.0 credits will be associated with Chem 590. Again, a grade of B or higher is considered satisfactory. **If a student earns a grade below a B in Chem 590, the student will be placed on probation.** The student must hold a **thesis advisory committee** (**TAC**) meeting within the following semester or summer term. Section III. Describes the composition of the TAC. If the student on probation has not yet held his/her first TAC meeting, the format of the meeting should follow the **Dissertation Research Proposal** format, described in Section IV. If the student on probation has already held his/her first TAC meeting, the format of the meeting should follow the **Annual Progress Committee Meetings** format, described in Section IV. This meeting will serve to aid in evaluating the student's progress and to offer recommendations on how to improve his/her research progress. The TAC will provide feedback and recommendations to the GWC, the Chemistry Department, and the student on a course of action. The recommendation of the GWC on the status of the student (dismissal from the program or return to good standing) will be given to the student within two weeks after receiving the TAC Summary Evaluation. If the recommendation is for dismissal from the Chemistry Ph.D. program, this decision will be forward to the Dean of the Graduate School, and the final decision on the student status will be made by the Dean.

III. Thesis Research / Thesis Advisory Committee.

First-year graduate students are required to attend all of the Thursday evening research presentations given by the faculty during the Fall semester, and are required to meet with at least four different faculty members to discuss research directions and opportunities within their first semester in the program. Students are required to fill out advisor selection forms no later than December 15th for students beginning in the fall semester and by June 1st for students beginning in the spring semester. On the advisor selection forms, students must indicate their top three or four choices for advisors in order of priority. The Department Chairman then approves the first choice or makes necessary adjustments. While every attempt is made to grant students their first selection, other considerations, such as numbers of students, funding, and research advisor preferences, are considered when matching students with research groups. If a student is not able to find a research group, the student is no longer considered in good standing in the Chemistry Ph.D. program, and the student will be placed on academic probation.

The student in consultation with his/her advisor will propose a **thesis advisory committee** (**TAC**), made up of the research advisor and two additional faculty members. The chair of the TAC must be a tenured or tenure track faculty member from the Chemistry Department, but the chair cannot be the student's thesis advisor. At least two of the committee members must be tenured or tenure-track faculty from the Chemistry

Department. Additional members to the committee are permitted, especially when these members may provide valuable feedback and insights that will aid the progress of the student. Additional members are permitted on the annual thesis committee, but additional members must have a doctoral degree and an active research program, whether at Washington University, at another university, in government, or in industry. The GWC will approve all TACs, and some effort will be made to minimize the overburden of committee assignments for the faculty members. *It is important to emphasize that the thesis advisor should try to limit his/her contributions during a student's annual progress committee meetings as it is the student's presentation, and committee is trying to evaluate the student's progress and understanding of the material.*

A student's first TAC meeting must be held before the beginning of the student's fourth semester of residence in the Chemistry Ph.D. program. The first TAC meeting will be comprised of a written thesis research proposal, an oral presentation of the proposal, and questioning about the proposal and related material by the committee, as described in the following section. The TAC will meet with the student at least once per year starting in the student's six semester of residence to discuss progress, further course work, and research. It is the student's responsibility to schedule this yearly TAC meeting. Students are encouraged to schedule their TAC meetings well in advance as travel plans, teaching duties, committee assignments, and grant obligations are heavy during the academic year.

IV. Pre-thesis Research Proposal and Annual Progress Committee Meetings.

Dissertation Research Proposal. A student's first meeting with his/her TAC must be within the student's first three semesters in residence. The goal of this meeting is for the student to develop a written dissertation research proposal and then present and defend the proposal in front of the TAC. The student will prepare a written dissertation proposal (approximately 10 pages following ACS style formatting and referencing) on his/her research project, including background information (typically 5-7 pages) and the student's proposed research (3-5 pages). This proposal most likely will include preliminary data, but it is not required. The first page of the proposal should include a "statement of the scientific problem", the student's "hypothesis", and "specific aims" of the research being proposed. The student is urged to discuss the dissertation proposal with his/her advisor and seek the advisor's help in designing the proposed work. The proposal should be provided to the thesis advisory committee no later than two weeks before the schedule date of his/her oral presentation of the research proposal.

The student should give a 20-25 minute presentation to his/her TAC. It is recommended that these presentations should be in public forum, possibly part of an existing journal or mechanistic club rotation, but a student can request these be in private with only the student and TAC present. It is expected that the TAC will limit questions and comments during the student's presentation. If the presentation is given in a public forum, the audience will be invited to ask questions, and once those are complete, the audience will leave and not be present for the question and answer period. The questions should focus both on the proposal, on background relevant to the proposal, and on coursework related to the proposed research directions.

Each TAC member will individually access the student's proposal and presentation using a "Dissertation Research Proposal - Committee Member Evaluation" form. Each TAC member will grade the student (0-20 points) in five different categories 1) Quality of Written Proposal, including appropriate background and referencing; 2) Quality of Oral Presentation; 3) Knowledge of background material / fundamentals / coursework related to the proposal; 4) Ability to understand and answer questions; and 5) Overall evaluation of the student's ability to complete a thesis within five years. A passing grade is considered to be a sum of the

five scores to be ≥ 60 points, and it is expected that a good student would score between 70 and 80 points. Only a truly exceptional student would likely score above 80 points.

Following the completion of the question and answer period, the student will leave the room, and the TAC will discuss their evaluation of the student. At the completion of the discussion, the chair of the TAC will collect the evaluation sheets form the committee members and average the scores for the five categories and enter these as the committee scores on a "Dissertation Research Proposal - Committee Summary Evaluation" form. The chair should also write summaries, including strengths, weaknesses, and areas of concern, within each category to not only provide justifications for the scores but to also offer recommendations for the student to consider. The chair of the TAC should discuss the evaluation of the committee and give the committee summary evaluation form to the student. It is the student's responsibility to turn the committee summary evaluation form to the graduate coordinator.

A passing score for the dissertation research proposal is a sum of ≥ 60 points. If a student scores below 60 points, the student is placed on probation, and the student must write a revised research proposal and present and defend it in front of the committee before the student's fourth semester in residence. The process for the initial Dissertation Research Proposal will be repeated, including the writing of an original research proposal and a 20-25 minute presentation to his/her advisory committee with one exception, one additional tenured or tenure-track Chemistry faculty member must be included on the thesis advisory committee. Thus, there will typically be four members on the committee for a second Dissertation Research Proposal. If the student scores below 60 points on this second attempt, the department will recommend to the Dean of the Graduate School that the student be dismissed from the program at the end of his/her fourth semester in residence.

Annual Progress Committee Meetings. A student must hold annual progress committee meetings every twelve months beginning in the student's sixth semester of residence. At each meeting, the student will make an approximately 30 minute presentation of his/her thesis work to the student's TAC. The presentation should begin with a brief (1-2 slides) description of the relevant background. A thesis outline that includes progress and accomplishments as well as highlights of tasks that still need to be completed should be included in the presentation. For annual progress committee meetings held in the eighth semester or beyond, the student should include a detailed timeline representing when those tasks that still need to be completed will be undertaken and completed.

Each TAC member will individually access the student's proposal and presentation using an "Annual Progress Committee Meeting - Committee Member Evaluation" form. Each committee member will grade the student (0-20 points) in five different categories 1) Quality of Oral Presentation; 2) Knowledge of background material / fundamentals / coursework related to the proposal; 3) Ability to understand and answer questions; 4) Quality and quantity of data collected; and 5) Overall evaluation of the student's ability to complete a thesis within five years. A passing grade is considered to be a sum of the five scores to be ≥ 60 points, and it is expected that a good student would score between 70 and 80 points. Only a truly exceptional student would likely score above 80 points.

Following the completion of the presentation and question and answer period, the student will leave the room, and the TAC will discuss their evaluation of the student. At the completion of the discussion, the chair of the TAC will collect the evaluation forms and average the scores for the five categories and enter these as the committee scores on an "Annual Progress Committee Meeting - Committee Summary Evaluation" form. The chair should also write summaries, including strengths, weaknesses, and areas of concern, within each

category to not only provide justifications for the scores but to also offer recommendations for the student to consider. The chair of the TAC should discuss the evaluation of the committee and give the committee summary evaluation form to the student. It is the student's responsibility to turn the committee summary evaluation form to the graduate coordinator.

A passing score for the dissertation research proposal is a sum of ≥ 60 points. If a student scores below 60 points, the student is placed on probation, and the student must hold another progress committee meeting within one academic semester. If the student scores below 60 points on this committee meeting, the department will recommend to the Dean of the Graduate School that the student be dismissed from the program at the end of that academic semester.

If a student would like to request an extension beyond his/her fifth or sixth year, this written request, which should include details of what must be completed before his/her thesis defense can be scheduled and a detailed, realistic timeline for the completion of these tasks, must be given to the TAC. The recommendation of the TAC regarding the request should be documented on the "Annual Progress Committee Meeting - Committee Summary Evaluation" form for review by the GWC.

V. Teaching.

Science and teaching are intimately connected in chemistry since a research result or finding is only useful if it can be communicated and coherently explained to both knowledgeable and general audiences. Furthermore, it is imperative that future teachers know how to adapt their teaching styles to include new findings into the curriculum and to utilize new teaching methods and techniques into the classroom. PhD chemists in industry must know how to effectively communicate findings and proposals to superiors as a key component in securing funding for their group's efforts. As a result, the Chemistry Department continuously places a focus on teaching and communication at all levels of its PhD program, starting with mentored teaching experiences (MTEs) and research group meetings, progressing towards formal presentations and peer mentoring, and culminating with developing and defending original ideas and research results.

It is an academic requirement that all Chemistry PhD students must participate in an MTE for four semesters, usually within the first two years of residence in the program. In all MTE assignments, a student's performance is required to be of sufficiently high quality to be deemed acceptable by the faculty. **Poor teaching performance will result in dismissal from the Chemistry Ph.D. program.**

VI. Laboratory Safety.

Each student must fully comply with the safety requirements established by Washington University and the Department of Chemistry in order to undertake research or to participate in an MTE in the Department. Each student must:

A. Take the Environmental, Health, and Safety (EH&S) Seminar Course given during orientation and pass the associated examination. Students must take and pass the EH&S on-line safety course each year thereafter.

B. Take and pass (with a 'B' or better) the Chem 599 Chemical Laboratory Safety Course during their first fall semester in residence.

C. Participate in the yearly "Laboratory Specific Safety Training" that is provided by each research group.

D. Maintain safe-research practices while undertaking thesis research. This includes careful planning of each experiment, generating and following approved standard operating procedures (SOPs), performing a

hazard assessment prior to beginning an experiment, and following best practices and policies established by EH&S for collecting and disposing of unwanted materials.

Each students should keep copies of the documentation for completing each of the above requirements, and the original documentation should be included in the EH&S Bluebook that is located in the research laboratory of the student. **Non-compliance with safety requirements will result in dismissal from the Chemistry Ph.D. program.**

VII. Doctoral Dissertation.

A student must demonstrate the ability to carry out independent research through the preparation and defense of an acceptable dissertation.

VIII. Doctoral Oral Examinations Committee.

Committees normally contain at least five (5) members. It is expected that the student's TAC will serve on the Doctoral Oral Examination Committee (DOEC), and the chair of the DOEC is usually the chair of the student's TAC, not the student's research advisor. Four (4) of the five members of the DOEC must be *tenured or tenure-track* faculty members in residence at Washington University; one of these four may be a member of the Emeritus faculty. The fifth member of the DOEC must have a doctoral degree and an active research program, whether at Washington University, at another university, in government, or in industry. At least three (3) of the five members of the DOEC must come from the Chemistry Department, and at least one (1) member must not be from the Chemistry Department. An optional sixth committee member, who holds a doctoral degree and has illustrated qualifications in the thesis area, may be added. It is the obligation of the student to secure the appropriate DOEC members with approval of the committee chair. The Director of Graduate Studies for the Chemistry Department then approves the DOEC, and forwards the completed "*Dissertation Defense Committee*" form to the Dean of the Graduate School. Ordinarily the Dean follows the Department's recommendations for Committee membership. The Graduate School will send to all members of the DOEC an official appointment notice including information about the candidate and his/her dissertation. The Chairperson of the DOEC will also be sent an Examination Approval Form. It is strongly recommended that the dissertation be made available to DOEC members at least one-month before the examination, but not less than two weeks before the examination date.

Additional Graduate School information and requirements can be found in the "*Doctoral Dissertation Guide*", (http://graduateschool.wustl.edu/files/graduate/Doctoral_Dissertation_Guide.pdf).

IX. Recommended Coursework.

The following sections describe coursework that are recommended for students with interests in different research fields. This list is not inclusive, and some courses may not be offered every year. Due to scheduling conflicts some courses may be moved from Fall to Spring semesters, and *vice versa*. Students should refer to the Washington University course listings web site for a complete list of courses being taught in current and past semesters: (https://acadinfo.wustl.edu/CourseListings/Semester/Listing.aspx) ** **Students must consult with their advisor(s), either their temporary or thesis advisor, when registering for coursework.**

BIOCHEMISTRY

The Biochemistry Faculty expects that graduate students who are planning to specialize in biological chemistry will, in addition to fulfilling Departmental requirements, undertake the following:

1. Biochemistry students are expected to take Biochemistry I (Chem 481) and Biochemistry II (Chem 482).
2. Biochemistry students are expected to participate in Biological Chemistry Journal Club (Chem 515) in the first four semesters. In the fall semester of the second year in residence, students will present a formal seminar on their Ph.D. dissertation proposal in the Journal Club.
3. Recommended elective coursework within Biochemistry is listed below, which spans interests in bioorganic, bioinorganic, biophysical, bioanalytical, and chemical biology. Other electives are also possible.

Fall

Chem 481	Biochemistry I
Chem 515	Biological Chemistry Seminar

Electives

Biol 5068	Fundamentals of Molecular Cell Biology
Chem 451	Organic Chemistry III
BME 530A	Molecular Cell Biology for Engineers
Chem 5511	Mechanistic Organic Chemistry
Chem 453	Bioorganic Chemistry
Chem 462	Synthetic Polymer Chemistry
Chem 461	Inorganic
Chem 401	Physical Chemistry I
Bio 5357	Chemistry & Physics of Biomolecules
Bio 5146	Principles and Applications of Biological Imaging
ESE 455	Quantitative Methods for Systems Biology
BME 538	Cell Signal Transduction
EECE 551	Metabolic Engineering and Synthetic Biology

Spring

Chem 482	Biochemistry II
Chem 515	Biological Chemistry Seminar

Electives

Chem 475	Chemical Biology
Chem 558	Spectral Methods in Organic Chemistry
Chem 485	Nucleic Acids Chemistry
Chem 464	Inorganic Biochemistry
Chem 430	Simulation in Chemistry and Biochemistry
Chem 479	Computation Chemistry and Molecular Modeling
Chem 556	Kinetics and Mechanism
Chem 402	Physical Chemistry II
Chem 578	Nuclear Magnetic Resonance Spectroscopy
Chem 584	Molecular Spectroscopy
Chem 5312	Macromolecular Interactions
Chem 550	Mass Spectrometry
Chem 555	Nanomedicine
BME 5913	Molecular Systems Biology
Math 460	Multivariate Statistical Analysis
Math 494	Mathematical Statistics

INORGANIC CHEMISTRY

The Inorganic Faculty expects that graduate students who are planning to specialize in inorganic or organometallic chemistry will, in addition to fulfilling Departmental requirements, undertake the following:

1. Enroll in Inorganic Chemistry (Chem 461) or pass *with an exceptional score* the Inorganic Placement Exam, given in the fall prior to the start of classes.

2. Complete the inorganic core curriculum by taking *at least* three of the following six "specialty" inorganic chemistry courses:

Organometallic Chemistry	Chem 459
Inorganic Biochemistry	Chem 464
Solid State and Materials Chemistry	Chem 465
Inorganic Chemistry Laboratory	Chem 470
Advanced Inorganic Chemistry	Chem 541
Special Topics in Inorganic Chemistry - topics vary	Chem 542
Physical Properties of Quantum Nanostructures	Chem 543

3. Participate in the "Inorganic/Organometallic Chemistry Seminar" (Chem 540). This one-credit student-led informal seminar meets one hour per week. Student participants in the seminar present topics from the current literature or their own research. Normally, first-year students audit the seminar in their first semester and take it for credit in their following four semesters in residence.

NUCLEAR CHEMISTRY

The Nuclear Faculty expects that graduate students in this discipline to take the nuclear lecture (Chem. 436) and radiochemistry (Chem. 435) classes. Students following the physical nuclear track should also complete graduate level courses in both quantum mechanics and statistical mechanics. Students following the radiochemistry track should complete Inorganic Chemistry (Chem 461), Organometallic Chemistry (Chem 459) and advanced special topics synthetic courses as appropriate. Regular participation in the nuclear science group meetings is expected. This participation includes one presentation per year.

ORGANIC CHEMISTRY

The Organic Faculty expects that graduate students who are planning to specialize in organic, bioorganic, or organic materials chemistry will, in addition to fulfilling Departmental requirements, undertake the following:

1. **Courses**. Enroll in the two courses that are regarded by the Organic Faculty as the core curriculum for Ph.D. work in organic/bioorganic/materials chemistry, Organic Chemistry III and Spectral Methods in Organic Chemistry during the first year of graduate study. Additional elective courses will be chosen by students in consultation with their advisors and can consist of courses offered by other departments such as the Biomedical Science Division, Engineering and Physics.

   Fall Courses:*

Organic Chemistry III	Chem 451

   Electives:

Synthetic Polymer Chemistry	Chem 452
Mechanistic Organic Chemistry (Physical Organic I)	Chem 5511
General Biochemistry I	Chem 481
Bioorganic Chemistry	Chem 453
Inorganic Chemistry	Chem 461
Organometallic Chemistry	Chem 459

   Spring Courses:

Spectral Methods in Organic Chemistry	Chem 558

   Electives:

Advanced Organic Synthesis	Chem 557
Kinetics and Mechanism (Physical Organic II)	Chem 556
Nucleic Acids Chemistry	Chem 485
Inorganic Biochemistry	Chem 464
Simulation in Chemistry and Biochemistry	Chem 430
Computation Chemistry and Molecular Modeling	Chem 479
Nanomedicine	Chem 555

   Other Electives:

Special Topics in Mass Spectrometry	Chem 550
Special Topics in Organic Chemistry	Chem 555
Nuclear Magnetic Resonance Spectroscopy	Chem 578
Environmental Organic Chemistry	EECE 531

2. **Journal Club**. Participate in the Chemical Reaction Mechanisms Journal Club, each semester for at least the first two years. This informal seminar meets one hour each week. Student participants in the seminar present topics from the current literature and discuss proposed thesis projects.

3. **Graduate Student Seminar**. Attend (audit) the Organic Chemistry Seminar course, Chem 559, during the first academic year, and enroll in the course during the second year of graduate work. At present, Chem 559 meets in the spring semester. In the second year, organic and bioorganic graduate students present a seminar on a topic that is not directly related to their chosen research subject. Attend also the Department of Chemistry Seminars.

PHYSICAL CHEMISTRY

Physical Chemistry students are encouraged to take a curriculum that is aimed at supporting their research endeavors while also spanning the major areas within Physical Chemistry. A typical Physical Chemistry student will take the following coursework:

First Year:

Fall:

Physical Chemistry I	Chem 401

Spring:

Physical Chemistry II	Chem 402
Chemical Kinetics	Chem 403
Quantum Chemistry and Spectra	Chem 571
NMR Spectroscopy	Chem 578
Molecular Spectroscopy	Chem 584

Second Year:

Advanced Quantum Mechanics	Chem 581
Statistical Thermodynamics	Chem 562

Electives include, but are not limited to:

Spectroscopic Analysis	Chem 405
Simulation in Chemistry and Biochemistry	Chem 430
Radioactivity and Its Applications	Chem 436
Instrumental Methods: Physical Chemistry	Chem 445
Physical Properties of Quantum Nanostructures	Chem 543
Electron Spin Resonance	Chem 5762
Special Topics in Physical Chemistry	Chem 580
Molecular Reaction Dynamics	Chem 585

Students are also encouraged to take electives in interdisciplinary courses that are offered by other sub-disciplines in the Chemistry Department or by other departments or schools at Washington Univ. The approval of the student's advisor is required to take these electives. Such courses include, but are not limited to:

Inorganic Chemistry	Chem 461
Solid State & Materials Chemistry	Chem 465
Advanced Inorganic Chemistry	Chem 541
Mass Spectrometry	Chem 550
Mechanics	Phys 411
Electricity and Magnetism I	Phys 421
Solid State Physics	Phys 472
Classical Electrodynamics I	Phys 505
Nuclear Magnetic Resonance	Phys 536
Solid State Physics I	Phys 549
Mechanical Properties of Materials	MEMS 5601
Materials Characterization Techniques I	MEMS 5603
Materials Characterization Techniques II	MEMS 5604
Quantitative Materials Science & Engineering	MEMS 5610
Computational Chem. of Molecular & Nanoscale Systems	EECE 536
Introduction to Nano-photonic Devices	ESE 532
Thermodynamics and Phase Equilibria	EPSc 569

MATERIALS CHEMISTRY

Graduate students with an interest in Materials Chemistry are encouraged to take a curriculum in one of the major chemistry disciplines (Biochemistry, Inorganic, Organic, Physical) that is supplemented with electives that are aimed at supporting their research endeavors while also spanning the major areas within Materials Chemistry. The coursework may vary as students research projects can be diverse with possible emphases on synthesis, physical characterization, or computational. Each student should consult their advisor in setting up an appropriate curriculum.

Materials courses offered by the Chemistry Department are:

Fall Courses:

Solid State & Materials Chemistry	Chem 465
Synthetic Polymer Chemistry	Chem 452

Spring:

Physical Properties of Quantum Nanostructures	Chem 543

Students are encouraged to take electives in interdisciplinary courses that are offered by other sub-disciplines in the Chemistry Department or by other departments or schools at Washington Univ. The approval of the student's advisor is required to take these electives. Such courses include, but are not limited to:

Materials Science	EECE 305
Computational Chemistry of Molecular and Nanoscale Systems	EECE 536
Mechanical Properties of Materials	MEMS 5601
Materials Characterization Techniques I	MEMS 5603
Materials Characterization Techniques II	MEMS 5604
Introduction to Polymer Blends and Composites	MEMS 5607
Introduction to Polymer Science & Engineering	MEMS 5608
Electronics Materials Processing	MEMS 5609
Quantitative Materials Science & Engineering	MEMS 5610
Principles and Methods of Micro and Nanofabrication	MEMS 5611
Computational Chem. of Molecular & Nanoscale Systems	EECE 536
Introduction to Nano-photonic Devices	ESE 532
Thermodynamics and Phase Equilibria	EPSc 569
Principle and Methods of Micro- and Nanofabrication	CSE 506M
Environmental Nanochemistry	EECE 534