Chemical Sciences Program

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Chemical Sciences Program

2014-2015 Academic Year

1. Aims and Scope

The KAUST Chemical Sciences Program (ChemS) was established in 2010 to provide a modern research-oriented education in Chemistry. Making use of the outstanding facilities at KAUST, the program distinguishes itself by a strong emphasis on research with a clear focus on current challenges related to catalysis and materials.

This interdisciplinary degree program is one of the programs offered by the Division of Physical Sciences & Engineering (PSE) at KAUST. It combines the expertise of three research centers: Catalysis, Advanced Membranes & Porous Materials, and Solar & Renewable Energy. Additional modules are offered in collaborations with other PSE programs and other divisions at KAUST.

KAUST ChemS research is centered on current challenges in catalysis and materials research toward energy security and environmental sustainability. Within these two interdisciplinary research thrusts, the following distinct research orientations are currently offered:

Catalysis	**Materials**
Hetero- and Homogeneous catalysis	Micro- and mesoporous materials
Organometallic and polymer chemistry	Metal-organic materials
Biocatalysis and green chemistry	Polymeric materials
Photo- and electrocatalysis	Supramolecular materials
Supramolecular and nanocatalysis	Inorganic solids
Theoretical chemistry	Smart materials for delivery and imaging

Targeting excellent graduate students worldwide, the KAUST ChemS program offers two options:

2. Master's Degree

The KAUST M.S. degree provides students with a sound foundation of skills and knowledge required for a successful career in chemical research. It prepares students for entering industrial research as well as for a Ph.D. degree at any world-leading research institute. This track targets students holding B.S. degree. In addition to extensive course studies, the thesis must be completed based on the research topic conducted by the student. Students will select a ChemS faculty thesis advisor within their first semester in the program.

3. Master's Thesis Option

Students are expected to choose their thesis committee by the end of their first semester. A thesis committee includes the M.S. thesis advisor and two other faculty members.

- First member/Chair: Supervisor (full-time KAUST faculty member)
- Second member: Full-time KAUST faculty member
- Third member: Faculty member (can be visiting faculty)

At least two of the above MUST come from within the student's degree program. If the student has a co-supervisor, this person can be considered one of the above three members required, provided they come under the categories listed (i.e. meet the requirements of position). A fourth member of the committee can be added with the supervisor's permission. It is recommended that there is one committee member (faculty) from outside the degree program, although this is not compulsory (as it is for PhDs). Post-doctoral fellows are not allowed to serve on thesis committees.

3.1 M.S. Thesis Degree Requirements

To earn an M.S. degree in Chemical Sciences, which requires a minimum of 36 credits, students are required to fulfill the following:
I- Credit Requirements

3.2 Core Curriculum (12 credits)

Select three from the core courses (9 credits): ChemS 320 - Advanced Organic Chemistry I; ChemS 340 - Advanced Organic Chemistry II; ChemS 330 - Advanced Inorganic Chemistry I; ChemS 350 - Advanced Inorganic Chemistry II; ChemS 360 - Advanced Physical Chemistry I; ChemS 370 - Advanced Physical Chemistry II.
Enroll in the Chemical Sciences program Lab Rotation ChemS 296 (3 credits): Students admitted to the Chemical Sciences M.S. thesis degree must participate in a rotation course their first semester in the program. The goal of this course is to introduce students to various research groups in the program in order to aid in the selection of a research advisor. Rotation assignments will be made by the mutual approval of designated faculty and the student. Students with a pre-approved advisor may spend the entire rotation period in a given lab with the approval of the advisor and program chair.
Enroll in Chemical Sciences Graduate Seminar ChemS 298 for 3 semesters. Students do not earn course credit for the graduate seminar, but will be awarded a satisfactory/unsatisfactory grade depending upon attendance.

- Elective Curriculum (9 credits)
- Enroll in three ChemS elective courses offered each semester by the program.
- Research/Capstone Experience (15 credits):
- Enroll in at least 15 credits of thesis research (ChemS 297). Students are permitted to register for more than 15 credits of M.S. thesis research as necessary and with the permission of their **thesis** advisor.

3.3 Master's Thesis Credits and Defense

The evaluation of M.S. thesis credits is through a Satisfactory/Unsatisfactory grade. The requirement of a public seminar based on the student's work is left to the discretion of the M.S. thesis advisor. For additional details on thesis requirements and committee formation (see General Degree Program Guidelines).

The student is responsible for scheduling the thesis defense date with his/her supervisor and committee members. The defense of the M.S. thesis should be scheduled by the end of the third semester. Candidates should give a copy of their thesis to the research committee at least 2 weeks before the final date of defense.

Candidates who are eligible to convert to Ph.D. from M.S. according to the discretion of the research advisor may do so after completion of all M.S. core and elective curriculum requirements, a Qualifying Presentation Exam (please contact direct supervisor for more details), and with the agreement of the Admissions Committee.

4. **Ph.D. Degree**

Ph.D. students will be involved in competitive and challenging research projects from the first day on campus. It is the distinct mission of the KAUST ChemS Ph.D. program that graduates will be able to undertake independent original research at the highest level. Prospective Ph.D. students select a ChemS faculty thesis advisor before admission. This track targets excellent students holding a B.S. degree to earn a Non-MS Ph.D. or students holding a M.S. degree to earn a Ph.D. in Chemistry. In addition to the course requirement, a "Ph.D. student" will take a proposal defense and obtain Ph.D. candidacy to become a "Ph.D. candidate". Ph.D. climaxes with writing a dissertation based on their own results followed by a dissertation defense to the committee organized by the faculty members.

4.1. Ph.D. Degree Requirements

To earn a Ph.D. degree in chemical science, students are required to fulfill the following:

1. Successful completion of Ph.D. coursework
2. Passing proposal defense to obtain candidacy status

3. Successful research data presentation
4. Preparing and submitting a doctoral dissertation and successfully defending it.

Students entering the Chemical Sciences PhD program with a MS degree in a different field are expected to complete 3 core courses and 3 elective courses from the Chemical Sciences MS curriculum requirements while earning their PhD.

5. Non-Masters Ph.D Option

This section describes the requirements for students who enter the Ph.D. program with a B.S. degree. Students are enrolled as a Pre-PhD status in the beginning of the study.

5.1. Credit Requirements

Core Curriculum (12 credits)

- Enroll in 3 ChemS core courses (9 credits): ChemS 320 - Advanced Organic Chemistry I; ChemS 340 - Advanced Organic Chemistry II; ChemS 330 - Advanced Inorganic Chemistry I; ChemS 350 - Advanced Inorganic Chemistry II; ChemS 360 - Advanced Physical Chemistry I; ChemS 370 - Advanced Physical Chemistry II.
- Enroll in the Chemical Sciences program Lab Rotation ChemS 296 (3 credits): Students admitted to the Chemical Sciences MS/PhD degree must participate in a rotation course their first semester in the program. The goal of this course is to introduce students to various research groups in the program.
- Enroll in Chemical Sciences Graduate Seminar ChemS 298 for 2 semesters and ChemS 398 for 4 semesters (total of 6 semesters of Graduate Seminar). Students do not earn course credit for the graduate seminar, but will be awarded a satisfactory/unsatisfactory grade depending upon attendance.

Elective Curriculum (9 credits)

- Enroll in 3 ChemS elective courses offered each semester by the program.

Research/Capstone Experience (78 credits)

Recommended Timeline towards Non-MS PhD: It is expected that a “Non-MS PhD” student should enroll in 15 credits for Fall and Spring semesters of their first year. The core courses, electives and 2 Graduate Seminar courses should be completed at this time.

- Enroll in 6 credits of Dissertation Research (ChemS 397) during the summer of first year.

- Complete a "Qualifying Presentation Exam" (contact direct supervisor for more details) to receive approval from supervisor that all requirements are met to move forward to PhD student status by Fall semester of year 2.
- After completing the Qualifying Presentation Exam and earning PhD student status, continue to enroll in Dissertation Research (ChemS 397) credits for the remainder of the degree (78 total credits of ChemS 397).
- Enroll in Chemical Sciences Graduate Seminar ChemS 398 for 4 semesters (compulsive). Students do not earn course credit for the graduate seminar, but will be awarded a satisfactory/unsatisfactory grade depending upon attendance.
- Follow PhD curriculum beginning with: II- Designation of a Research Advisor in the MS to PhD section below.

Students entering with a B.S. degree will not receive a M.S. degree along the way; however, students interested in earning a M.S. degree may do so by satisfying the MS degree requirements including a written thesis and a thesis defense.
Students entering with a B.S. from another institution may transfer in up to 9 credits of graduate level coursework towards the above requirements upon approval of the program.

6. Ph.D with an Master's

This section describes the requirements for students who enter Ph.D. program with a M.S. degree.

6.1. Credit Requirements

Core Curriculum (6 credits)

- Enroll in two ChemS Courses at the 300 level (6 credits)
- Enroll in Chemical Sciences Graduate Seminar ChemS 398 for 3 semesters. Students do not earn course credit for the graduate seminar, but will be awarded a satisfactory/unsatisfactory grade depending upon attendance.

Research/Capstone Experience (72 credits)

- Enroll in at least 72 credits of dissertation research (ChemS 397).

Students entering the program with an M.S. from KAUST or another institution may transfer coursework toward both the MS and PhD requirements listed above upon approval of the program and based on their program of study at KAUST.

6.2. Designation of a Research Advisor

To be successfully enrolled in the Chemical Sciences PhD program, prospective candidates should identify a faculty member to sponsor them prior to arrival at KAUST. Phone and personal interviews will be conducted to identify candidates for this program. In special cases where the advisor or student decide to change their agreement after the candidate has commenced his/her PhD work at KAUST, the student must find another sponsor to be allowed to continue in the program.

6.3. Ph.D. Dissertation Committee

A “Non-MS PhD” student should form his/her Dissertation Committee by the end of the fourth semester, not including summers.
A “PhD” student should form his/her Dissertation Committee by the end of second semester.
The Dissertation Committee is chaired by the supervisor and includes at least 2 other faculty members, one of whom must be external to the ChemS program. The committee may additionally include one or more members external to KAUST. Students are required to maintain active contacts with their committee members to discuss research progress. All committee members must be designated as dissertation readers.
The Dissertation Committee must include the following members:

- First member/Supervisor/Chair: Full-time KAUST faculty member (within the student's degree program)
- Second member: Full-time KAUST faculty member (within the student's degree program)
- Third member: Full-time KAUST faculty member (from another degree program)

If the student has a co-supervisor, this person can be act as one of the above required three members, provided they come under the categories listed (i.e. meet the requirements of position). If the co-supervisor does not come under one of the categories above, then they would need to be listed as a fourth member.
The Dissertation Committee for the Final Dissertation Defense is to include an External Examiner from outside of KAUST. A fifth member of the committee can be added with the supervisor's permission or if the degree program rules require it.

6.4. Research Proposal Exam and Candidacy

A “Non-MS PhD” student must complete the Research Proposal Exam by the end of the fifth semester.
A “PhD” student must complete the Research Proposal Exam by the end of the third semester.
The Research Proposal Exam consists of an oral presentation of an original proposal closely related to the candidate's area of research, but not the exact work done in the lab, as well as a current research summary with future research plans. The student

presentation will be followed by a question and answer session regarding both the proposal and general chemistry knowledge.
The student must submit a written research proposal to the Dissertation Committee at least two weeks prior to the oral defense. It must be attended by a minimum of three members of the Dissertation Committee. The committee will determine if the proposal is novel, includes a clear articulation of a successful research execution plan, and has the likely possibility of receiving funding from major funding agencies.
The committee's decision can take the form of pass, conditional pass, fail with retake, or fail. In the case of fail with retake, the committee will provide feedback to the student, who must prepare and pass a repeat examination within one semester. Upon successful completion of the Research Proposal Exam, a Ph.D. student will officially be converted to a Ph.D. Candidate. Students should turn in a completed copy of their proposal to the Graduate Program Coordinator. Students not granted a retake, or who fail the retake, will be dismissed from the University.

6.5. Guidelines for Research Proposal Exam preparation

Prior to dissertation defense, Ph.D. students will generate an original research proposal, closely related to their dissertation research, and defend it before the Dissertation Committee.
The closely related research proposal must be written and circulated (via hard copy) among the Dissertation committee at least two weeks before the oral presentation date. The student is responsible for organizing the committee members to meet for this oral exam and informing the Graduate Program Coordinator prior to the date agreed upon. This written proposal is a brief document, modeled after a standard funding agency (example: National Science Foundation, NSF) proposal. It should be no more than 15 pages in length including figures, with references in addition. It might be organized as suggested below:

Summary
A brief overview of the proposed work with emphasis on the intellectual merit and the broader impacts (1 page).
Background and Significance
This section should answer the question: Why is the proposed work important? Briefly sketch the background to the present proposal, critically evaluate existing knowledge, and identify gaps in our present understanding. This section may need to occupy as many as 3-4 pages.
Specific Aims
This section is intended to answer, in very specific terms, the question: What do you propose to do?
No background or other narrative material belongs in this section; it is not meant to stand alone, nor to provide details about the experimental system, but rather to provide a succinct and specific summary of the planned research. It is probably most helpful to write this section after writing the rest of the proposal. It should occupy no more than one page.

Experimental Design and Feasibility
This section should parallel the Specific Aims section and should answer the question: How will you do the proposed work?

Describe each experiment you propose to conduct and how you will analyze the data and interpret the results. Provide appropriate calculations or cite literature data to support the feasibility of the experiments you propose. Supporting evidence that comes from unpublished work must be clearly identified as such and specifically attributed. Discuss potential drawbacks of any proposed experiments that lack clear precedent, and propose alternative approaches to achieve the aims. This section may need to occupy as many as 3-4 pages.
References
The list of references must include complete citations, including all authors and the titles of research articles or book chapters.

6.6. Research Data Presentation (RDP)

A Research Data Presentation must be made to the Dissertation Committee no less than 6 months before the Final Dissertation Defense. The committee will then formally advise the candidate on research milestones that need to be met. A peer-reviewed publication based upon the RDP is required to obtain a Chemical Sciences Ph.D. degree. This requirement could be waived under extenuating circumstances and at the discretion of the student's dissertation committee.

6.7. Dissertation Defense

The student must schedule a dissertation defense after the doctoral research project and dissertation are completed. The dissertation defense will include a defense of the doctoral dissertation and a test of the candidate's knowledge in the specialized field of research. The format of the dissertation defense will be a public seminar presented by the candidate, with an open question period, followed by a private examination by the dissertation committee. The possible outcomes of the exam are pass, conditional pass, or fail. After a successful defense, the final written dissertation approved by the committee must be submitted within two months to the KAUST Library and must be signed by the supervisor and all dissertation committee members.

7. Chemical Sciences Program Course Descriptions

Chems 101 Basic Principles of General Chemistry (3-0-0)A course covering: basic concepts of Atomic numbers, masses, isotopes, stoichiometry, atomic orbitals. Bonding

in molecules: Lewis structures, resonance structures, Types of bonding interactions, Bond polarity and dipole moments, Hydrogen bonds, VB theory, hybridization, MO theory, isoelectronic molecules, aromaticity, VSEPR model. Acids, bases and solutions: Bronsted acids and bases, Lewis acid theory, Introduction to coordination complexes, stability of complexes. Reduction and oxidation: Standard reduction potentials E0, Concentration effects, complexation and precipitation vs. E0, Disproportionation. Basic spectroscopy techniques (UV/Vis, IR, NMR, X-Ray, MS).

ChemS 102 Basic Principles of Inorganic & Organic Chemistry (3-0-0)A course covering periodicity and molecular symmetry: Atomic/ ionic radii, Electron affinities and electronegativity, Symmetry operations and elements, Point groups and character tables, Chirality. General groups properties: Alkali metals: Group I, Earth alkali metals: Group 2, Earth metals: Group 13, d- block chemistry. Coordination and Organometallic Chemistry: Ligand field theory, Jahn-Teller effect, Common types of ligands, Carbonyl complexes, Isolobal principle. Functional groups and their transformations: Alcohols and alkyl halides, Aldehydes and ketones, Carboxylic acids and esters, Amines and amino acids, Lipids. Common Organic Reactions and their mechanism: Condensation reactions, Elimination reactions, Substitution reactions, Radical reactions.

ChemS 210. Material Chemistry I (3-0-3) (Same as CBE 210) *Prerequisite:* An understanding of the material covered in basic inorganic and organic chemistry. Presents students with a descriptive overview of Materials Chemistry with particular emphasis on the correlation between materials structure and their properties. This course will cover the following topics: molecular symmetry; basic crystallography; band theory; porous materials; nano-structured materials and some material characterization techniques including powder X-ray diffraction and physical adsorption.

ChemS 212. Spectroscopy Analysis (3-0-3) An introduction to the theory, application, and interpretation of four major types of spectroscopy: absorption, infrared, and nuclear magnetic resonance spectroscopy, and mass spectrometry. It will focus heavily on interpretation of spectra and application of these tools to address questions of structure and reactivity of organic, organometallic, and inorganic materials. A training session of two-dimensional nuclear magnetic resonance (COSY, NOESY, HSQC, HMBC, etc) will be offered.

ChemS 214. Nano-catalysis (3-0-3) An introduction to basic concepts of nanochemistry including various synthesis methods (nanofabrication by scanning probe instruments, lithography, sol-gel, hydrothermal, self-assembly, crystal growth etc), advance synthesis and modifications of nanomaterials (organic functionalization, metallic, bi-metallic, core-shell, shape and morphology controlled synthesis etc), tools to characterize nanomaterials (scanning probe microscopy like AFM, STM, MRM and electron microscopy like SEM, TEM). This course will also cover green nanochemistry, nanotech & environment and finally applications in various fields with special emphasis on nano-catalysis. This course will empower the students to understand the scientific importance and technological potential of nanotechnology and students will able perform three important activities related to Nanochemistry, i.e. synthesis, functionalization and application of nanomaterials.

ChemS 215. Polymers and Polymerization Processes (3-0-3) (Same as CBE 215) The preparation, reactions and properties of high-molecular-weight polymeric materials of both natural and synthetic origin. Physical and organic chemistry of polymers for persons with a basic training in chemistry, physics, or engineering. The course is a survey of preparative methods of polymers; step growth polymerization, radical polymerization, ionic polymerization, ring-opening polymerization, polymerization by transition metal catalysts; and methods of characterization (nuclear magnetic resonance, Raman, infrared, intrinsic viscosity, differential scanning, calorimetry, gel permeation chromatography) and scattering (light, x-rays).

ChemS 218. Photo and Electro Catalysis (3-0-3) Fundamentals of Photo and Electro catalysis presented with a novel approach for industrial applications.

ChemS 220. Organometallic Chemistry (3-0-3) The course aims to cover current aspects of research in the field of organometallic chemistry. It is assumed that students taking this course are already familiar with general organometallic chemistry at the undergraduate level. The course materials can be divided into two parts. We will cover topics relating to general organometallic chemistry to function as a refresher but with a practicing researcher's bent and some special topics with focuses on catalysis and its applications.

ChemS 240. Supramolecular Chemistry (3-0-3) Most of the crucial biological processes, such as antigen-antibody recognition and DNA replication, rely on non-covalent bonding and self-assembly. Taking lessons from Nature, chemists have crafted artificial systems capable of specific molecular recognition. Some of these fascinating molecules, such as crown ethers, cucurbiturils, and calixarenes, are pervasive in contemporary chemical literature. This course will examine the topics of non-covalent bonding, molecular recognition, and self-assembly.

ChemS 250. Material Chemistry II (3-0-3) Prerequisite: ChemS 210 or consent of instructor. An introduction to electron microscopy based techniques: Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Electron diffraction (ED), Scanning transmission electron microscopy (STEM), Energy-filtered TEM (EFTEM), Energy dispersive X-ray analysis (EDX), and Electron energy loss spectroscopy (EELS). On-site demonstration of the electron microscope will be given.

ChemS 296. Lab Rotation (3-0-3) MS students are expected to go through a lab rotation their first fall semester. The objective of this course is to help students in identifying their future research advisor by exposing them to different research areas. MS students are expected to complete 3 rotations their first semester (3 weeks per rotation). A student upon the approval of the advisor may choose to spend 3 rotations in one lab; this advisor will be the chosen research advisor. Students will choose at the end of their first semester the possible advisor(s) that they would like to work with. A faculty committee will then meet and place students according to mutual advisor/ student agreement. The nature of the rotation may vary from one lab to another depending on the advisor thus some rotations can be research focused others can involve more literature and background work.

ChemS 297. Thesis Research (variable credit) *Prerequisite:* Approval of Thesis Advisor. MS Thesis Master-level research leading to a formal written thesis and oral defense.

ChemS 298. Chemical Sciences Graduate Seminar Seminar focusing on special topics within the field.

ChemS 299. Directed Research (variable credit) *Prerequisite:* Approval of Advisor. Master-level research.

ChemS 301. Crystallography and Diffraction (3-0-3) The objective of this course is to present the basic concepts needed to understand the crystal structure of materials. Fundamental concepts including lattices, symmetries, point groups, and space groups will be discussed and the relationship between crystal symmetries and physical properties will be addressed. The theory of X-ray diffraction by crystalline matter along with the experimental X-ray methods used to determine the crystal structure of materials will be covered. Application of X-ray diffraction to proteins, electron diffraction and neutron diffraction will be briefly discussed.

ChemS 319. Bioinorganic Chemistry (3-0-3) (Same as CBE 319.) Interdisciplinary research on the inorganic chemistry of life has developed into a major source of innovation for catalyst development, material chemistry and medicine. The course "Biological Inorganic Chemistry" details the numerous functions of inorganic materials and ions in biology. It provides a general overview of the fundamental tasks performed by inorganic elements in living organisms as well as the related methods and theories with particular emphasis on enzymatic conversions, inorganic biomaterials and medical applications. Nature's strategies are elucidated based on model systems and basic concepts are illustrated by examples relevant to technological or medical applications. The course is designed for PhD students in chemistry, biochemistry and biotechnology, yet interested students on the M.Sc. level are welcome.

ChemS 320. Advanced Organic Chemistry I (3-0-3) A focus on a deeper understanding of the structure and reactivity of organic molecules with an emphasis on reaction mechanisms. It is a review of aspects of physical organic chemistry, covering structure and bonding, stereochemistry, and kinetics and thermodynamics, as well as molecular orbital theory with an introduction to the use of computational tools, such as Gaussian 09.

ChemS 326. Biocatalysis (3-0-3) (Same as CBE 326) Biocatalysis has become an integral part of modern industry technology enabling rapid developments in pharmacology, medicine, nutrition, analytics, environmental technology, fine chemical synthesis bio-fuel production and related areas. Starting out from basic food-processing fermentations e.g. related to bread baking or cheese making, today the results emerging from this discipline influence all areas of our daily life.Enzymes as nature's catalysts set the benchmarks for artificial systems in terms of activity and selectivity. Correspondingly, biocatalysis is regarded a key-competence in biotechnology and chemical industry. The course "Biocatalysis" provides students with a detailed understanding of fundamental aspects of the area, while it focuses on current applications of biocatalytic systems. It is designed for PhD students in chemistry, biochemistry and biotechnology, yet interested students on the M.Sc. level are welcome.

ChemS 330. Advanced Inorganic Chemistry I (3-0-3) *Prerequisite:* Adequate Knowledge in general chemistry rules and concepts. Generalizations of the periodic table and their relationship to classical and modern concepts of atomic and molecular structure. Inorganic stereochemistry including concepts of crystal chemistry, silicate chemistry,

coordination theory, ligand field theory, catalysis, acid-base theory, reaction mechanisms, organometallic chemistry and a detailed consideration of selected groups of the periodic table.

ChemS 340. Advanced Organic Chemistry II (3-0-3) *Prerequisite:* Adequate Knowledge in general chemistry rules and concepts. Reactivity and reactions of organic moieties including enolates, carbenes, radicals, carbonyl compounds, and transition metal organometallics; mechanisms of named reactions; multistep total synthesis techniques and reactions; advanced NMR and mass spectrometric techniques as applied to research efforts in organic chemistry and related fields, such as pharmaceuticals, materials science, supramolecular synthesis, and crystal engineering.

ChemS 350. Advanced Inorganic Chemistry II (3-0-3) *Prerequisite:* ChemS 330 or consent of instructor. Emphasis on concepts and applications of homogenous and heterogeneous catalysis and the impact of such processes on the advancement of different industries.

ChemS 360. Advanced Physical Chemistry I: Thermodynamics and Kinetics (3-0-3) Review fundamental concepts and laws of thermodynamics and kinetics. Learn and describe concepts of chemical potential, internal energy and chemical equilibrium of the system. Essence of kinetics to describe changes of chemical system with time, i.e., rates of chemical reactions, dealing with molecules in motion, collisions and diffusion of gases, and how to establish rate expression.

ChemS 370. Advanced Physical Chemistry II: Theoretical Chemistry (3-0-3) *Prerequisite:* Adequate knowledge in general chemistry rules and concepts. Review of quantum mechanics from a postulational viewpoint; variational and matrix methods; time independent and time-dependent perturbation theory; applications to molecular systems including potential energy surfaces and reaction pathways.

ChemS 397. PhD Dissertation research (variable credits) *Prerequisite:* Approval of Thesis Advisor. PhD Dissertation-level research leading to a formal written dissertation and oral defense.

ChemS 398. Chemical Sciences Graduate Seminar Seminar focusing on special topics within the field.

ChemS 399. Directed Research (variable credits) Prerequisite: Approval of Advisor. Doctoral-level supervised research.

Office of the Registrar

KAUST PROGRAM Guide

Fall 2014

8. Program and Degrees

King Abdullah University of Science and Technology (KAUST) advances science and technology through bold and collaborative research. It educates scientific and technological leaders, catalyzes the diversification of the Saudi economy and addresses challenges of regional and global significance, thereby serving the Kingdom, the region and the world.

Research and education, as well as their transformative potential, are central to KAUST's mission. KAUST has a three-part mission:

Research at KAUST – both basic and goal-oriented – is dedicated to advancing science and technology of regional and global impact. Research excellence inspires teaching and the **training o**f future leaders in science and technology.
Research and education at KAUST energize innovation and enterprise to support knowledge-based economic diversification.

Through the synergy of science and technology, and innovation and enterprise, KAUST is a catalyst for transforming people's lives.

In support of this mission, King Abdullah University of Science and Technology offers eleven graduate programs leading to M.S. and Ph.D. degrees.

9. KAUST offers the following two Degrees

- The M.S. degree typically takes three semesters and a summer to complete (18 months). The degree allows flexibility for internships, research, and academics. Learn more about M.S. degree requirements.
- The **Ph.D.** degree is typically a three- to four-year post-master's degree. The Ph.D., involves original research, culminating in a research dissertation. Learn more about Ph.D. degree requirements.

Three academic divisions, these are:

Biological and Environmental Sciences and Engineering (BESE)

- Bioscience (B)
- Environmental Science and Engineering (EnSE)
- Marine Science (MarS)
- Plant Science

Computer, Electrical and Mathematical Sciences and Engineering (CEMSE)

- Applied Mathematics and Computational Science (AMCS)
- Computer Science (CS)
- Electrical Engineering (EE)

Physical Sciences and Engineering Division (PSE)

- Chemical and Biological Engineering (CBE)
- Chemical Sciences (ChemS)
- Earth Science and Engineering (ErSE)
- Materials Science and Engineering (MSE)
- Mechanical Engineering (ME)

Each program is administered by a Graduate Committee and a Graduate Chair. Courses for each program will be listed at the 100 (non-credit), 200, 300 or 400 level.

Program Requirements

10. MASTERS PROGRAM

Admissions

Admission to the M.S. program requires the satisfactory completion of an undergraduate B.S. degree in a relevant or related area, such as Engineering, Mathematics or the Physical, Chemical and Biological Sciences.

11. Master's Degree requirements

The MS degree requires successful completion of 36 credits. Students are expected to complete the MS degree in three semesters plus one summer session. Degree requirements are divided into three sections: Core Curriculum; Elective Curriculum; and Research/Capstone Experience.

- Core Curriculum (9-15 credits): This portion of the degree program is designed to provide a student with the background needed to establish a solid foundation in the program area over and above that obtained through undergraduate studies.
- Elective Curriculum (9-15 credits): This portion of the degree program is designed to allow each student to tailor his/her educational experience to meet individual research and educational objectives. Depending upon the program and the

objectives, this may be met by added coursework or by additional research experience.

- Research/Capstone Experience (12 credits): The details of this portion of the degree program are uniquely determined by the student and his/her advisor and will involve a combination of research and other capstone experiences that build on the knowledge gained in coursework.

- Satisfactory participation in KAUST's Summer Session and Winter Enrichment Period (WEP) is mandatory. Summer Session courses are credit bearing and apply toward the degree. WEP courses do not earn credit towards the degree.

At least thirty-six (36) degree credits must be completed in graduate-level courses and research projects. These courses should be 200-level or above and must be approved by the student's advisor. Additional non-credit bearing activities, such as graduate seminars, may be required by the Program. Details on the specific program expectations, as well as the difference between the thesis and non-thesis degree options can be found through the link in the Program Guide (http://www.kaust.edu.sa/academics/programs/degrees.html). For a list of eligible faculty advisors, see: http://www.kaust.edu.sa/faculty-advisors.html

12. Thesis Requirements

Students wishing to pursue a thesis as part of their MS degree, must identify a research advisor and must file for Thesis status.

1. The application for the thesis option is due to the Registrar's Office by the ninth week of the student's second semester at KAUST.

2. Criteria for Acceptance into the Master's Degree with Thesis program.
    a. Students should have a well-constructed thesis proposal that includes a time-line for completion.
    b. The thesis proposal must be approved by the research advisor and the Dean of the Division.
    c. In the case of an optional thesis program, the student should have a minimum GPA of 3.2 and at least 12 credit hours completed at the conclusion of the first semester and be registered in at least 12 credit hours during the second semester.
    d. The research advisor must indicate that he/she endorses the thesis topic and scope of work and that it could reasonably be completed by the end of the third semester. Alternatively, the faculty member agrees to a longer

time frame, not to exceed the end the fourth semester, and to cover the student and experimental costs that accrue during this period.

The student's program of study should be structured such that the student may change to the MS without Thesis option and finish the degree by the end of the student's third semester.

Committee Structure and Thesis Defense

Evaluation of satisfactory completion of MS thesis work is performed by a committee comprising the M.S. thesis advisor and two other faculty members. The chair of the committee must be a faculty member within the program. One external faculty member or one Research Scientist may be allowed. The evaluation of MS thesis credits comprises of a satisfactory or unsatisfactory grade. The requirement of a public seminar based on the student's work is left to the discretion of the MS thesis advisor.

The student is responsible for scheduling the thesis defense date with his/her supervisor and committee members. It is advisable that the student submits a written copy of the thesis to the thesis committee members at least two weeks prior the defense date.

13. NON-THESIS OPTION

Students wishing to pursue the Non Thesis options must complete a minimum of 6 credits of directed research credits (299) is required. Summer internship credits may be used to fulfill the research requirement provided that the summer internship is research-based. Summer internships are subject to approval by the student's academic advisor.

Students must complete the remaining credits through one or a combination of the options listed below:

- Broadening Experience Courses: Courses that broaden a student's M.S. experience.
- Ph.D.-Level Courses: Courses numbered 300 or greater. Any course in the PhD core requirements that is passed with a minimum grade of B– may be used towards meeting the core PhD requirements of the program if the student chooses to continue for a PhD degree in at KAUST.
- Internship: Research-based summer internship (295). Students are only allowed to take one internship.

It should be noted that a student may also combine courses to satisfy the six-credit requirement. For example, a student could take one Ph.D.-level course and one graduate-level course in another program. A student may not enrol in two summer internships.

Thesis format requirements are described in the KAUST Thesis and Dissertation Guidelines (http://libguides.kaust.edu.sa/theses).

For a list of eligible faculty advisors, see:
http://www.kaust.edu.sa/faculty-advisors.html

Students may select a KAUST faculty member from another program to act as a research advisor (for either thesis or directed research), but must provide a one-page description of the research and an explanation of how such research would be relevant to the degree program. Upon approval by the program and the Dean, the faculty member would be allowed to act as an affiliated faculty member and advisor for the student.

Please Note: Degree Programs may have additional requirement to those listed above.

14. PhD Program

Admissions

Ph.D. students apply for and enter a specific degree program. A faculty advisor is either immediately designated (in the case of a student being recruited by a specific faculty member) or temporarily assigned; in the latter case, the student is expected to identify a research advisor by (at the latest) the end of the first year.

There are three phases and associated milestones for Ph.D. students:

- Passing a qualifying exam;
- Passing an oral defence of the dissertation proposal
- Dissertation phase with a final defense milestone.

PhD Degree Requirements

Ph.D. program requires the successful completion of at least 96 credit hours, (inclusive of previous Masters Degree coursework). Qualification and advancement to candidacy are contingent upon: (i) successfully passing Ph.D. coursework, (ii) designating a research advisor, (iii) successfully passing a qualifying exam, and (iii) writing and orally defending a research proposal. Possible outcomes include pass, failure with complete retake, failures with partial retake, and failure with no retake. Students not permitted to retake the exam, or who fail the retake, will be dismissed from the University. The maximum allotted time for advancement to candidacy for a student entering with a M.S. degree is two years; three years for students entering with a B.S.

Satisfactory participation in KAUST's Summer Session and Winter Enrichment Period (WEP) is mandatory. Summer Session courses are credit bearing and apply toward the degree. WEP courses do not earn credit towards the degree.

The required coursework is outlined below:

M.S. Degree

- Core courses
- Elective courses

Ph.D. Degree

- Two or more courses at the 300 level
- Graduate seminar if required by the program.

Students entering the program with a relevant M.S. from another institution may transfer coursework toward the requirements of the M.S. degree listed above upon approval of the program.

Students entering the program with a M.S. from KAUST may transfer coursework toward both the M.S. and Ph.D. requirements listed above upon approval of the program and based on their program of study at KAUST.

Students entering with a B.S. from another institution may transfer in up to 9 credits of graduate level coursework towards the above requirements upon approval of the program. In addition, students entering with a B.S. may also qualify to earn a M.S. degree by satisfying the MS degree requirements as part of the Ph.D. program.

Some degree programs may require a diagnostic entrance exam as a basis for admission, and students may be required to complete additional coursework depending on their degree-granting institution. If the M.S. degree is from a subject other than the Ph.D. degree program, there may be additional courses required and specified by the advisor.

Candidacy

Achieving Ph.D. candidacy is contingent upon successfully passing a qualifying examination, acceptance by the research advisor of a written research proposal and successfully passing an oral examination. Details should be confirmed in the individual degree program material. For a list of eligible faculty advisors for any degree program see: http://www.kaust.edu.sa/faculty-advisors.html

Passing the qualification phase is achieved by acceptance of all committee members of the written proposal and a positive vote of all but, at most, one member of the oral exam committee. If more than one member casts a negative vote, one retake of the oral defense is permitted if the entire committee agrees. A conditional pass involves conditions (e.g., another course in a perceived area of weakness) imposed by the committee, with the conditional status removed when those conditions have been met. Once constituted, the composition of the qualification phase committee can only be changed upon approval by both the faculty research advisor and the division dean.

Dissertation Research Credits

Besides coursework (6 or more credit hours), dissertation research (course number 397) must be earned during the first (proposal preparation and defense) and second phases of the Ph.D. program. A full-time workload for Ph.D. students is considered to be 12 credit hours per semester (courses and 397) and 6 credit hours in summer (397 only). There is a minimum residency requirement (enrolment period at KAUST) of 2.5 years for students entering with an M.S. degree, 3.5 years for students entering with a B.S. degree. The maximum enrolment period is 5.0 years, extendable upon approval of both the faculty research advisor and the division dean.

Dissertation and Dissertation Defense

The Dissertation Defense is the final exam of the PhD degree. It involves a public presentation of the results of the dissertation research followed by a question and answer session. The Dissertation and Defense committee consists of 4 members of which at least 3 must be KAUST faculty members. The committee Chair plus one other member must be an affiliated faculty member. The committee must also include one external examiner who must write a report on the thesis and attend the thesis defense. Qualified Visiting Professors may be involved as on-campus committee members. It is the responsibility of the student to inform the dissertation committee of his/her progress and meet deadlines for submitting defense date and graduation forms. It is expected that students will submit their dissertations to their committee six weeks prior to the defense date in order to receive feedback from the committee members in a timely manner. However, the advisor may approve exceptions to this expected timeline. The dissertation format requirements are described in the KAUST Thesis and Dissertation Guidelines. (http://libguides.kaust.edu.sa/theses).

The result of the defense will be made based on the recommendation of the committee. There are four possible results: (1) Pass: the student passes the exam and the dissertation is accepted as submitted; (2) Pass with revisions: the student passes the

exam and the student is advised of the revisions that must be made to the text of the dissertation; (3) Failure with retake: normally this means the student must do more research to complete the dissertation. The student must revise the dissertation and give another oral examination within six months from the date of the first defense; and (4) Failure: the student does not pass the exam, the dissertation is not accepted, the degree is not awarded, and the student is dismissed from the University.

Program Descriptions

The Master's and Doctoral degree program requirements listed above represent general university-level expectations. The specific details of each degree requirements are outlined in the descriptions of the individual degree programs.

15. University Guidelines

Grading

The KAUST grading system is a 4.0 scale utilizing letter grades, and these are the only grades that will be assigned.

A	=	4.00	C	=	2.00	I	= INCOMPLETE
A-	=	3.67	C-	=	1.67	IP	= IN PROGRESS
B+	=	3.33	D+	=	1.33	W	= WITHDREW
B	=	3.00	D	=	1.00	S	= SATISFACTORY
B-	=	2.67	D-	=	0.67	U	= UNSATISFACTORY
C+	=	2.33	F	=	0.00	WF	= WITHDREW FAILED

Incomplete Grades

Students who complete the majority of the requirements for a course but are unable to finish the course may receive an incomplete (I) grade. A grade of Incomplete will be assigned only with the consent of the instructor of the course after the instructor and the student have agreed on the academic work that needs to be completed and the date it is due (but no later than the end of the second week of the following semester or session). When the requirements for the course are completed, the instructor will submit a grade that will replace the incomplete grade on the student's academic record. Incompletes not completed by the end of the second week of the following semester or session will be changed to F (failing) grades.

Grades for students that are due to graduate

Note that any incomplete grades (as well as fail grades) will mean a student will not graduate or receive a diploma during the Commencement ceremony.

Incomplete grades are granted to individual students on a case-by-case basis. Incomplete grades should not be used as a mechanism to extend the course past the end of the semester.

Students are allowed only one incomplete grade while in a degree program at KAUST.

In Progress grade (IP)

Thesis Research (297) or Dissertation Research (397) should be graded as **IP** (In Progress), **S** (satisfactory) or **U** (unsatisfactory) for each semester.
(These IP grades will be converted by the Registrar's Office to "S" grades for all semesters, once the Office has been notified that the thesis or dissertation has been submitted to the Library)

Research or Seminar courses

Use the following grades for these research or seminar courses:

297	Thesis Research	Either IP or U
397	Dissertation Research	Either IP or U
295/395	Internship(summer)	Either S or U
298/398	Seminar	Either S or U
299/399	Directed Research	Either S or U

Summer Session and Winter Enrichment Program

Satisfactory participation in KAUST's Summer Session and Winter Enrichment Period (WEP) is mandatory. Summer Session courses are credit bearing and apply toward the degree. WEP courses do not earn credit towards the degree.

Cumulative Grade Point Average

A minimum GPA of 3.0 must be achieved in all coursework. Individual courses require a minimum of a B- for course credit.

A student's academic standing is based on his/her cumulative performance assessment and a semester performance based on the number of credits earned and GPA during the most recently completed semester.

Academic standing classifications are divided into four categories of decreasing levels of academic performance: (1) Good Standing; (2) Academic Notice; (3) Academic Probation; and (4) Academic Dismissal.

Cumulative Assessment

GPA	ACADEMIC STANDING
3.00 – 4.00	Good Standing
2.67 – 2.99	Academic Notice
2.33 – 2.66	Academic Probation
Below 2.33	Academic Dismissal
S/U PERFORMANCE	ACADEMIC STANDING
0 – 2 credits	GPA Standing
3 – 5 credits	GPA Standing less one category
6 – 8 credits	GPA Standing less two categories
9+ credits	Academic Dismissal

Semester Assessment

CREDITS EARNED	ACADEMIC STANDING
12 +credits	GPA Standing
9 – 11 credits	GPA Standing less one category
6 – 8 credits	GPA Standing less two category
0 – 5 credits	Academic Dismissal

Summer Session Assessment

CREDITS EARNED	ACADEMIC STANDING
6 credits	GPA Standing
3 – 5 credits	GPA Standing less one category
0 – 2 credits	GPA Standing less two categories

Definitions

Good Standing:

Student is making satisfactory academic progress toward the degree.

Academic Notice:

Student is not making satisfactory progress toward the degree. A student placed on Academic Notice will be monitored in subsequent semesters to ensure satisfactory progress toward the degree (see Good Standing). If the student's performance does not improve in the following semester, the student will be placed on academic probation.

Academic Probation:

Student is not making satisfactory progress toward the degree. A student placed on Academic Probation will be monitored in subsequent semesters to ensure satisfactory progress toward the degree (see Good Standing). If the student's performance does not improve in the following semester, the student will be academically dismissed.

Academic Dismissal:

Student is not making satisfactory progress toward the degree and is unlikely to meet degree requirements. Dismissed students will be required to leave the University. If deemed eligible, dismissed students will have one (1) week from receiving notice of dismissal to file an appeal.

Appeal Process for Students Academically Dismissed:

If the student is eligible to appeal, he/she must submit a written explanation why the dismissal should be rescinded along with any supporting documentation. The Committee on Academic Performance will hear the appeal and make a decision to grant or deny the appeal based on the appeal and documentation, the student's past performance, and the likelihood that the student is capable of successfully completing his/her academic program. If the appeal is denied, the student will be required to leave the University. The decision of the Committee is final; no additional appeals are permitted.

S/U Protection:

Due to the significant impact of U grades, a faculty member giving a U grade for a course involving 6 or more credits must obtain concurrence of the Dean prior to submitting the grade. If the grade is given for only a single class (including research credit) the number of credits will be capped at 6 when using the academic standing table displayed above.

Returning to Good Standing:

A student not in good standing due to a GPA deficiency may return to Good Standing by improving his/her cumulative GPA such that it meets or exceeds 3.00. A student not in good standing due to U grades may return to Good Standing by completing at least 12 credits during the subsequent semester with no U grades and a semester GPA of at least 3.00 in traditionally graded courses.

16. Transferring Credits

A student may petition to transfer graduate credits from another university, upon approval of the Program Chair and the Registrar. Each student's application will be reviewed on a case-by-case basis. The following rules apply:

- Up to three graduate-level courses not to exceed nine credits may be transferred for credit. Courses transferred for credit cannot have been counted as credits for another granted degree.
- The course grade for any course to be transferred must be a B or above.
- Courses transferred for degree credit must have been taken within three years prior to admission to KAUST.
- The student must submit a completed KAUST Transfer of Credit form and include the Course syllabus and course description.

The student is responsible for supplying an official transcript:

- The transcript may be no more than three months old.
- The transcript must be in English or accompanied by a certified English translation.
- The grading key must be included with the transcript.
- The transcript must include the course name, level, grade and credit value.
- The credit value of the course must be equivalent to a minimum of three KAUST credit hours.

Course Transfer and Equivalency

Graduate credit hours taken from any KAUST program may be applied to other KAUST graduate programs under the guidelines of the degree program to which the student is admitted. Graduate courses taken from another university or KAUST program that are equivalent in level and content to the designated courses in a major track may be counted toward meeting the major track requirement if their equivalence is confirmed by the program chair.

Students transferring from other PhD programs may receive some dissertation research and coursework credit units, on a case-by-case basis, for related work performed at their original institution. However, such students must satisfy the written and oral requirements for a research proposal (if the proposal had been submitted and approved at the original institution, the proposal may be the same, if approved by the research advisor). The minimum residency requirement for enrollment of such students at KAUST is two years.

Policy for Adding and Dropping Courses

A course may be added during the first week of the semester. Students may add courses after the first week with the permission of the instructor. Instructors have the right to refuse admission to a student if the instructor feels that the student will not have the time to sufficiently master the material due to adding the course late. A course may be dropped without penalty at any time during the first two weeks of the semester. Between the second and eighth week, students can drop a course but the course will appear on the student's transcript with the grade of "W" (withdraw). After the eighth week of a full semester, courses may be dropped only under exceptional circumstances and with the approval of the Course Instructor, the Program Chair and the Registrar.

Program Planning

It is the sole responsibility of the student to plan her/his graduate program in consultation with her/his advisor. Students are required to meet all deadlines. Students should be aware that most core courses are offered only once per year.