Graduate Major in Chemical Science and Engineering

【Master's Degree Program】

1. Outline

Master's Degree Program in the Graduate Major in Chemical Science and Engineering aims at fostering human resources, who have basic academic skills and logical thinking ability in chemical science and engineering and related fields, and can contribute to developing environmentally-benign society by applying their science and engineering wisdom.

This Master's Degree Program aims at training international engineers and leading scientists, who can understand the relationship between "Science and Technology", "Industrials", and "Environment", acquire advanced expert knowledge in chemistry, well-rounded accomplishment, and international communication skills. In order to achieve this goal, the Master's Degree Program consists of "major course" and "research". The former contains advanced academic subjects in the fields of applied chemistry, polymer chemistry, and chemical engineering. For the latter, students acquire indispensable knowledge and education as advanced researchers.

The purpose of this Master's Degree Program contains training international leading chemistry researchers and engineers, who can understand fundamental properties and reactivities of materials in atomic/molecular level, acquire advanced knowledge of chemical engineering systems for transformation to useful materials involving polymers, and solve critical issues in any field by using expertise in chemical science and engineering.

2. Competencies Developed

In this Master's Degree Program, students will be able to acquire the following abilities:

- Systematical knowledge of science and technology focusing on materials, chemical transformation, and process system development
- Practical and problem-solving skills to promote academic research and technology development
- International communication and presentation skills to explain their research logically
- Ability to see the social trends, and find and solve current problems

3. Learning Goals

In this Master's degree program, students are expected to study the following contents to acquire the "Competencies Developed" mentioned above.

Ａ）Basic learning of specialized fields in chemical science and engineering

Learning including fundamental courses which provide wide scope of applied chemistry, macromolecular science, and chemical engineering, and introduction courses which provide basic knowledge for addressing social issues

Ｂ）Advanced learning of chemical science and engineering

Acquisition of deep specialized knowledge and applied skills through the lectures and exercises in the various optional courses including advanced fundamental learnings

C） Learning which cultivates the wide scope and initiative

Acquisition of ability to address the issues autonomously through research by using specialized knowledge and applied skills which acquired from above learnings

D） Learning to relive the social involvement

Learning of reliving studies and engineer ethics through systematic researches and development at the host agency such as institute and company, and the specialized courses made by lecturers from social communities

E） Learning to enforce communication skills

Cultivation of student’s presentation skill and sentence constitution ability to communicate importance of their research and significance of results to others logically and accurately

4. IGP Completion Requirements

The following requirements must be met to complete the Master's Degree Program of this major.

1. Attain a total of 30 credits or more from 400- and 500-level courses.
2. Fulfill requirements in Table M1 below.
3. Pass the master's thesis review and defense after presentation and assessment of the interim achievement.

Table M1 shows course categories and the number of credits required to complete the Master's Degree Program of this major. It also shows the required minimum credits in each course category and points to be noted when selecting the required courses and electives.

The learning goals to be obtained by students through courses are listed as “associated learning goals”. Prior to registering courses, students need to fully understand the course goals.

Table M1. Graduate Major in Chemical Science and Engineering Completion Requirements

Course category		<Required courses> Required credits	<Electives> Minimum credits required	Minimum credits required	Associated learning goals	Comments
Liberal arts and basic science courses	Humanities and social science courses		•2 credits from 400-level •1 credit from 500-level	5 credits	D	
	Career development courses		2 credits from 400- and 500-level		C,D,E	All Graduate Attributes (GA) should be acquired. (Refer to Section 7 for the definition of GA.)
	Other courses					
Core courses	Research seminars	Seminar in Chemical Science and Engineering S1 Seminar in Chemical Science and Engineering F1 Seminar in Chemical Science and Engineering S2 Seminar in Chemical Science and Engineering F2 A total of 8 credits, 2 credits each from the above courses.		22 credits	B,C,D,E	
	Research-related courses				B,C,D,E	
	Major courses		14 credits		A,B	
	Major courses and Research-related courses <u>outside</u> the Graduate Major in Chemical Science and Engineering standard curriculum					

Total required credits	**A minimum of 30 credits including those attained according to the above conditions**
Note	**・Japanese Language and Culture Courses offered to international students can be recognized as equivalent to the Humanities and Social Science Courses of the corresponding course level.** **・For details of the Liberal Arts and Basic Science Courses, please refer to the relevant sections.**

5. IGP Courses

Table M2 shows the Core Courses of the Master's Degree Program in this major. Graduate Majors listed in the Comments column offer core courses that are recognized as equivalent to the corresponding Major Courses or Research-related Courses in the standard curriculum of this major.

Table M2. Core Courses of the Graduate Major in Chemical Science and Engineering

Course category		Course number	Course title			Credits	Competencies	Learning goals	Comments
Research seminars	**400 level**	CAP.Y491.R	◎		Seminar in Chemical Science and Engineering S1	0-1-1	1,3,5	A,C,E	
		CAP.Y492.R	◎		Seminar in Chemical Science and Engineering F1	0-1-1	1,3,5	A,C,E	
	500 level	CAP.Y591.R	◎		Seminar in Chemical Science and Engineering S2	0-1-1	1,3,5	A,C,E	
		CAP.Y592.R	◎		Seminar in Chemical Science and Engineering F2	0-1-1	1,3,5	A,C,E	
Research-related courses	**400 level**	CAP.E411.L			Advanced Internship in Chemical Science and Engineering I	0-0-1	2,3,5	B,D	
		CAP.E412.L			Advanced Internship in Chemical Science and Engineering II	0-0-2	2,3,5	B,D	
Major courses	**400 level**	CAP.A423.L			Advanced Organic Synthesis I	1-0-0	1,5	B	
		CAP.A424.L			Advanced Organic Synthesis II	1-0-0	1,5	B	
		CAP.A425.L			Advanced Biofunctional Chemistry I	1-0-0	1,4,5	B	
		CAP.A426 L			Advanced Biofunctional Chemistry II	1-0-0	1,4,5	B	
		CAP.A441.L			Advanced Electrochemistry I	1-0-0	1	B	
		CAP.A442.L			Advanced Electrochemistry II	1-0-0	1	B	
		CAP.A443.L			Advanced Solid-state Physical Chemistry I	1-0-0	1	B	
		CAP.A444.L			Advanced Solid-state Physical Chemistry II	1-0-0	1	B	
		CAP.A461.L			Advanced Solid State Chemistry I	1-0-0	1	B	
		CAP.A462.L			Advanced Solid State Chemistry II	1-0-0	1	B	
		CAP.A463.L			Advanced Molecular Design of Metal	1-0-0	1,5	B	

					Complexes I				
		CAP.A464.L			Advanced Molecular Design of Metal Complexes II	1-0-0	1,5	B	
		CAP.A465.L			Advanced Bioinorganic Chemistry I	1-0-0	1	B	Not offered in AY 2023
		CAP.A466.L			Advanced Bioinorganic Chemistry II	1-0-0	1	B	Not offered in AY 2023
		CAP.A468.L			Advanced Electronic Structures in Solids II	1-0-0	1	B	
		CAP.C411.L			Chemical Engineering for Advanced Materials and Chemicals Processing I	1-0-0	1,5	A	Not offered in AY 2023
		CAP.C412.L			Process Systems Engineering	2-0-0	1,4,5	B	
		CAP.C421.L			Advanced Energy Transfer Operation	2-0-0	1,4,5	B	
		CAP.C423.L			Computational Fluid Dynamics	1-0-0	1,5	B	
		CAP.C424.L			Advanced Reaction Process Engineering	1-0-0	1,5	B	
		CAP.C425.L			Advanced Bioprocess Engineering	1-0-0	1,5	B	
		CAP.C431.L			Chemical Engineering for Advanced Materials and Chemicals Processing II	1-0-0	1	A	Not offered in AY 2023
		CAP.C432.L			Physico-Chemical Property Analysis in Chemical Engineering	1-0-0	1,4	B	
		CAP.C433.L			Phase Equilibrium Analysis in Chemical Engineering	1-0-0	1,4	B	
		CAP.C441.L			Transport Phenomena and Operation	2-0-0	1,2,4,5	B	
		CAP.C443.L			Advanced Chemical Reaction-Separation Process	1-0-0	1,5	B	
		CAP.C445L			Advanced Topics of Chemical Science and Engineering	1-0-0	1,2	B	Not offered in AY 2023
		CAP.I403.L			Advanced Coordination Chemistry	1-0-0	1	B	
		CAP.I405.L			Environmental Chemistry	2-0-0	1,5	B	
		CAP.I407.L			Introduction to Chemical Engineering (Basics)	1-0-0	1,5	A	
		CAP.I416.L			Catalysis for the Environmental Issues	1-0-0	1	B	
		CAP.I417.L			Introduction to Chemical Engineering (Unit Operation)	1-0-0	1,5	A	
		CAP.I419.L			Analytical Techniques for Environmental Chemistry	1-0-0	1,5	B	
		CAP.I420.L			Advanced Supramolecular Science	1-0-0	1	B	
		CAP.I423.L			Advanced Organic Materials Chemistry	1-0-0	1	B	
		CAP.I426.L			Introduction to Polymer Science	1-0-0	1,5	A	
		CAP.I427.L			Introduction to Polymer Chemistry	2-0-0	1,4,5	A	
		CAP.I435.L			Advanced Geochemistry	1-0-0	1,5	B	
		CAP.I437.L			Introduction to Polymer Physical Properties	1-0-0	1	A	
		CAP.I439.L			Advanced Organometallic Chemistry and	1-0-0	1	B	

					Catalysis				
		CAP.I446.L			Nano-Surface Chemistry and Advanced Devices	1-0-0	1,2,5	B	
		CAP.I438.L			Functionalized Nano-Materials Chemistry I	1-0-0	1	B	Not offered in AY 2023
		CAP.I445.L			Functionalized Nano-Materials Chemistry II	1-0-0	1	B	Not offered in AY 2023
		CAP.I411.L			Introduction to Photochemistry I	1-0-0	1,5	B	【Energy Science and Engineering】(ENR.H420)
		CAP.I412.L			Advanced Electrochemistry I	1-0-0	1	B	【Energy Science and Engineering】(ENR.H403)
		CAP.I414.L			Advanced Inorganic Materials Chemistry I	1-0-0	1,5	B	【Energy Science and Engineering】(ENR.H405)
		CAP.I418.L			Topics in Properties of Semiconductors	1-0-0	1,5	B	【Energy Science and Engineering】(ENR.H410)
		CAP.I421.L			Introduction to Photochemistry II	1-0-0	1,4,5	B	【Energy Science and Engineering】(ENR.H430) Not offered in AY 2023
		CAP.I422.L			Advanced Electrochemistry II	1-0-0	1,5	B	【Energy Science and Engineering】(ENR.H404)
		CAP.I424.L			Advanced Inorganic Materials Chemistry II	1-0-0	1,5	B	【Energy Science and Engineering】(ENR.H406)
		CAP.I425.L			Introduction to Organic Electrochemistry	1-0-0	1,5	B	【Energy Science and Engineering】(ENR.H415)
		CAP.I432.L			Topics in Applied Electrochemistry	1-0-0	1,5	B	【Energy Science and

									Engineering】(ENR.H411)
		CAP.P411.L			Advanced Polymer Synthesis	1-0-0	1	B	
		CAP.P413.L			Advanced Course of Step-growth Polymerization	1-0-0	1,4	B	
		CAP.P414.L			Advanced Polymer Assembly	1-0-0	1,4	B	
		CAP.P421.L			Special Lecture on Characterization of Polymer Structures and Properties	1-0-0	1	B	
		CAP.P422.L			Advanced Polymer Properties	1-0-0	1	B	
		CAP.P431.L			Elements of Polymer Science I	1-0-0	1,3,4,5	B	
		CAP.P432.L			Elements of Polymer Science II	1-0-0	1,5	B	
		CAP.P433.L			Introduction to Polymer Physical Chemistry	1-0-0	1	B	Not offered in AY 2023
		CAP.P471.L			Organic Optical Materials physics	1-0-0	1,5	B	【Materials Science and Engineering】(MAT.P401)
		CAP.P472.L		E	Soft Materials Physical Chemistry	1-0-0	1	B	【Materials Science and Engineering】(MAT.P402)
		CAP.P473.L			Soft Materials Physics	1-0-0	1,2	B	【Materials Science and Engineering】(MAT.P403)
		CAP.P474.L			Soft Materials Functional Physics	1-0-0	1,3	B	【Materials Science and Engineering】(MAT.P404)
		CAP.P477.L		E	Soft Materials Functional Chemistry	1-0-0	1,5	B	【Materials Science and Engineering】(MAT.P413)
		CAP.P478.L			Soft Materials Function	1-0-0	1,5	B	【Materials Science and Engineering】(MAT.P414)
		CAP.P480.L		E	Organic Materials Functional Design	1-0-0	1,5	B	【Materials Science and Engineering】(MAT.P421)
		CAP.P481.L		E	Organic Materials Design	1-0-0	1,5	B	【Materials

									Science and Engineering】(MAT.P422)
		CAP.P482.L			Advanced Course in Composite Materials	1-0-0	1	B	【Materials Science and Engineering】(MAT.P423)
		CAP.P485.L			Thermal Properties of Materials	1-0-0	1,5	B	【Materials Science and Engineering】(MAT.P426)
		CAP.P490.L			Soft Materials	2-0-0	1,2,3,5	B	【Materials Science and Engineering】(MAT.P483) Held in Tsinghua University
		CAP.P492.L			Soft Materials Design	1-0-0	1,5	B	【Energy Science and Engineering】(ENR.J407)
		CAP.P493.L			Advanced Course of Quantum Chemistry	2-0-0	1,5	B	【Materials Science and Engineering】(MAT.M421) Held in Tsinghua University
		CAP.P494.L			Advanced Nano Science	2-0-0	1,2,4,5	B	
		CAP.P495.L			Characterization of Nanomaterials	2-0-0	1	~~B~~A	【Materials Science and Engineering】(MAT.M402) Held in Tsinghua University
		CAP.P496.L			Advanced Solid State Physics	2-0-0	1,5	A	【Materials Science and Engineering】(MAT.M407) Held in Tsinghua University
		CAP.P497.L			Environmentally-Friendly Polymer Chemistry	1-0-0	1,5	B	【Energy Science and

									Engineering】(ENR.H450)
		CAP.T431.L			Advanced Organometallic Chemistry and Catalysis I	1-0-0	1,5	B	
		CAP.T432.L			Advanced Organometallic Chemistry and Catalysis II	1-0-0	1,5	B	
		CAP.T491.L			Materials simulation	2-0-0	1,5	A	【Tokyo Tech Academy for Convergence of Materials and Informatics】* (TCM.A402)
		CAP.T493.L			Materials Informatics	2-0-0	1,5	A	【Tokyo Tech Academy for Convergence of Materials and Informatics】* (TCM.A404)
	500 level	CAP.A521.L			Advanced Molecular Design for Organic Synthesis I	1-0-0	1,5	B	
		CAP.A522.L			Advanced Molecular Design for Organic Synthesis II	1-0-0	1,5	B	
		CAP.A561.L			Advanced Chemistry of Transition Metal Complexes I	1-0-0	1	B	
		CAP.A562.L			Advanced Chemistry of Transition Metal Complexes II	1-0-0	1	B	
		CAP.C512.L			Safety Engineering for Chemical Process	1-0-0	1,4	B	
		CAP.C521.L			Chemical Engineering in Global Business	1-0-0	1,2,3,5	B	
		CAP.C531.L			Advanced Chemical Equipment Design	2-0-0	1,5	B	
		CAP.C533.L			Plasma Chemistry and Plasma Processing	1-0-0	1,4	B	

		CAP.C534.L			Advanced Supercritical Fluid Process	1-0-0	1,4	B	
		CAP.C542.L			Fine Particle Engineering	1-0-0	1,2.4,5	B	
		CAP.C543.L			Tribology and Surface Engineering	1-0-0	1,2,5	B	
		CAP.I533.L			Advanced Strategic Organic Synthesis	1-0-0	1	B	
		CAP.I536.L			Advanced Material Cycle Analysis	1-0-0	1,5	B	
		CAP.I537.L			Systematic Material Design Methodology	1-0-0	4,5	B	
		CAP.I551.L			Environmental Microbiology	2-0-0	1,2,4,5	B,D	【Life Science and Technology】 (LST.A503)
		CAP.P511.L			Advanced Polymer Reactions	1-0-0	1,5	B	
		CAP.P521.L			Advanced Polymer Physics	1-0-0	1	B	
		CAP.P522.L			Advanced Polymer Structures	1-0-0	1,4,5	B	
		CAP.P541.L			Advanced Polymer Design for Energy Materials	1-0-0	1,4,5	B	【Energy Science and Engineering】 (ENR.H503)
		CAP.P584.L			Fundamentals of electrochemistry and the application to energy conversion materials	1-0-0	1,2,3,4,5	B	【Materials Science and Engineering】 (MAT.P506)
		CAP.P585.L			Analytical and analogical methods to solve the heat transfer equation and the application to infrared image processing	1-0-0	1,2,3,4,5	B	【Materials Science and Engineering】 (MAT.P507)
		CAP.P586.L			Nano-Materials Electronics	2-0-0	1,4	B	【Electrical and Electronic Engineering】 (EEE.D571)
		CAP.P587.L			Applied Vibrational Spectroscopy	1-0-0	1,2,4,5	B,C	【Materials Science and Engineering】 (MAT.P512)

		CAP.T532.L			Advanced Catalytic Reactions	1-0-0	1	B	

Note：

• ◎：Required course，○：Restricted elective，O：odd academic years，E：even academic years

• Competencies: 1 = Specialist skills, 2 = Liberal arts skills, 3 = Communication skills, 4 = Applied skills (inquisitive thinking and/or problem-finding skills), 5 = Applied skills (practical and/or problem-solving skills)

•【 】Course offered by another graduate major

• The character preceding the three digits in the course number denotes the course's subdiscipline (i.e., "D" represents the subdiscipline code in the course number ABC.D400.R): A (Applied chemistry), C (Chemical engineering), P (Polymer science), I (Interdisciplinary science and technology), E (Others), Z (Research seminars).

* The Tokyo Tech Academy for Convergence of Materials and Informatics (TAC-MI) courses are not exclusive to students enrolled in TAC-MI. However, as the courses involve the use of TSUBAME, capacity is limited. Registration by non-TAC-MI students may not always be accepted.

6. IGP Courses That Can Be Counted as Humanities and Social Science Courses

None

7. IGP Career Development Courses and IGP Courses That Can Be Counted as Career Development Courses

In order to fulfill the completion requirements for the master's degree program, students must attain at least 2 credits in Career Development Courses, and should satisfy all of the Graduate Attributes (GA) specified in Table MA-1 of the "Career Development Courses" listed as one of the "Liberal Arts and Basic Science Courses" in the Guide to Graduate Education and International Graduate Program, as well as shown below. Students will be evaluated in regards to GA achievements at the time of their degree completion. As to the courses with two GAs, both GAs stipulated for the courses are considered to be acquired if students receive the corresponding credits for those courses.

Career Development Courses and Major Courses that enable students to acquire GA and that are recognized as equivalent to Career Development Courses, offered by the Graduate Major, are listed in Table M3 below. Students can also acquire GA and credits by taking the Career Development Courses offered by Innovator and Inventor Development Platform (IIDP) listed as one of the "Liberal Arts and Basic Science Courses" in the Guide to Graduate Education and International Graduate Program.

However, it must be noted that credits attained from those courses that can be counted as Career Development Courses can be counted towards the completion requirements of master's degree program, either for the Major Courses or for the Career Development Courses (i.e., not for both). Nevertheless, even in the cases from those mentioned above where attained credits pertaining to these courses are not considered as Career Development Courses, their associated GAs may be considered by the Graduate Major to have been acquired.

For Graduate Attributes, refer to the Guide to the Career Development Courses.
The Graduate Attributes of the Master's Degree Program are listed in Table MA-1 as follows:

GA0M: You can clearly plan your own career and recognize the abilities necessary for realizing it while considering ethics and relevance to societal problems.

GA1M: You can acquire the knowledge, skills, and ethics necessary for realizing your planned career and contribute to societal problem-solving while collaborating with other experts

Table M3. Courses of the Graduate Major in Chemical Science and Engineering recognized as equivalent to Career Development Courses, and Career Development Courses

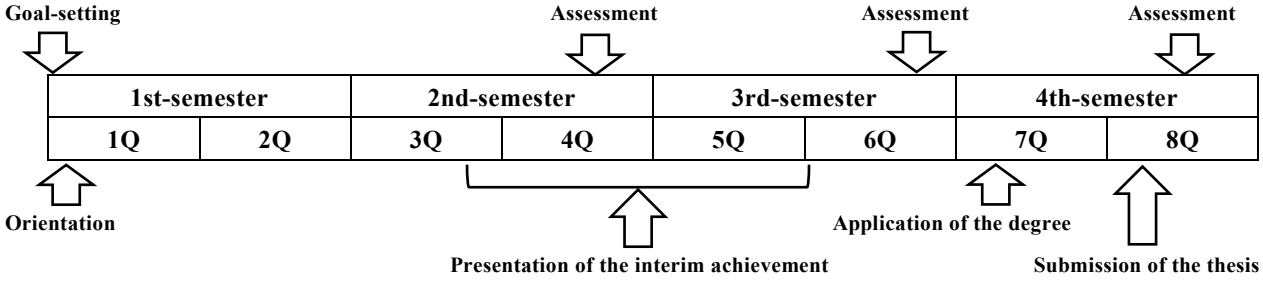
Course category	Course number	Course title	Credits	GA*	Learning goals	Comments
Courses that can be counted as Career Development Courses	CAP.E411.L	Advanced Internship in Chemical Science and Engineering I	0-0-1	GA1M	B,D	
	CAP.E412.L	Advanced Internship in Chemical Science and Engineering II	0-0-2	GA1M	B,D	
Career Development Courses	CAP.B501	Master's Recurrent Program 1-1 of Chemical Science and Engineering	0-0-1	GA0M GA1M	C,D,E	Career Development Course offered by the Graduate Major in Chemical Science and Engineering. You cannot count for the Major Course.
	CAP.B502	Master's Recurrent Program 1-2 of Chemical Science and Engineering	0-0-1	GA0M GA1M	C,D,E	Career Development Course offered by the Graduate Major in Chemical Science and Engineering. You cannot count for the Major Course.
	CAP.B503	Master's Recurrent Program 2 of Chemical Science and Engineering	0-0-2	GA0M GA1M	C,D,E	Career Development Course offered by the Graduate Major in Chemical Science and Engineering. You cannot count for the Major Course.

Credits in Career Development Courses must be attained from among the above-listed courses and those listed as such in the Liberal Arts and Basic Science Courses Guide.

＊GA: Graduate Attributes

8. Research Related to the Completion of Master Theses

The research related to the completion of a master thesis, aims at acquiring the basic abilities through an entire research process including goal-setting, problem resolution and basic communications. The following diagram represents a typical example before the final examination. The supervisor makes an assessment of the academic achievements, and reviews an individual course plan with respect to the research orientation and the progress.



・Presentation of the interim achievement

This presentation is for the deeper understanding of own research project with respect to the background, goal and significance.

・Criteria of the examination

Master thesis should contain new and original idea that could contribute to academic or industrial developments in applied chemistry.

・Process of the examination

The final examination is conducted as an oral presentation of the master thesis after a peer-review.

【Doctoral Degree Program】

1. Outline

The purpose of this Doctoral Degree Program is training international leading chemistry researchers and engineers who can understand fundamental properties and reactivities of materials in the atomic/molecular level, acquire highly advanced knowledge of chemical engineering systems for transformation to useful materials involving polymers, acquire an ability for advanced and creative academic research and technology development by using wide range of expertise in chemical science and engineering, possess a vision to establish a novel research field, and contribute to develop environmentally-benign society.

2. Competencies Developed

In this Doctoral Degree Program, students will be able to acquire the following abilities:

- Ability to develop creative academic research and novel technology by highly advanced knowledge in chemical science and engineering
- Ability to understand and elucidate essential fundamental properties, reactivities, and functions of materials in the atomic/molecular level by using highly advanced knowledge in chemical science and engineering
- Creativity to establish a novel research field by using the knowledge in human studies and social science
- Leadership to present guidelines for environmentally-friendly society

3. Learning Goals

In this Doctoral degree program, students are expected to study the following contents to acquire the “Competencies Developed” mentioned above.

Ａ）Acquisition of the advanced specialized knowledge of chemical science and engineering

Acquisition of the world-class specialized knowledge of applied chemistry, macromolecular science, and chemical engineering, and deepening and sharpening of the acquired knowledge through the research seminars

Ｂ）Acquisition of specialized knowledge in interdisciplinary field

Acquisition of ability to expand research into interdisciplinary field by utilizing and applying acquired specialized knowledge in student’s own specialized field

Ｃ）Learning of critical thinking skills and practical skills in chemical science and engineering

Acquisition of ability to build and practice leading-edge research theme in student’s own research field through academic writing of thesis

Ｄ）Learning to relive the social involvement

Learning of reliving studies and engineer ethics through systematic researches and development at the host agency such as institute and company, and the specialized courses made by lecturers from social communities

Ｅ）Learning to enforce logical thinking and communication skills

Training ability to present student’s own research domestically and internationally, and cultivation of the logical thinking and communication skills to develop an argument with researchers and engineers in various research fields

4. IGP Completion Requirements

The following requirements must be met to complete the Doctoral Degree Program of this major.

1. Attain a total of 24 credits or more from 600-level courses.
2. Fulfill requirements in Table D1 below.
3. Pass the doctoral thesis review and defense.

Table D1 shows course categories and the number of credits required to complete the Doctoral Degree Program of this major. It also shows the required minimum credits in each course category and points to be noted when selecting the required courses and electives.

The learning goals to be obtained by students through courses are listed as “associated learning goals”. Prior to registering courses, students need to fully understand the course goals.

Table D1. Graduate Major in Chemical Science and Engineering Completion Requirements

Course category		<Required courses> Required credits	<Electives> Minimum credits required	Minimum credits required	Associated learning goals	Comments
Liberal arts and basic science courses	Humanities and social science courses		2 credits	6 credits	B	
	Career development courses		4 credits		C,D,E	All Graduate Attributes (GA) should be acquired. (Refer to Section 7 for the definition of GA.)
	Other courses					
Core courses	Research seminars	Seminar in Chemical Science and Engineering S3 Seminar in Chemical Science and Engineering F3 Seminar in Chemical Science and Engineering S4 Seminar in Chemical Science and Engineering F4 Seminar in Chemical Science and Engineering S5 Seminar in Chemical Science and Engineering F5 A total of 12 credits, 2 credits each from the above courses.		16 credits	A,B,C,D,E	
	Research-related courses				C,D,E	
	Major courses				A,B,C,D	
	Major courses and Research-related Courses <u>outside</u> the Graduate Major in Chemical Science and Engineering standard curriculum					

Total required credits	**A minimum of 24 credits including those attained according to the above conditions**
Note	**・Japanese Language and Culture Courses offered to international students can be recognized as equivalent to the Humanities and Social Science Courses of the corresponding course level.** **・For details of the Liberal Arts and Basic Science Courses, please refer to the relevant sections.**

5. IGP Courses

Table D2 shows the Core Courses of the Doctoral Degree Program of this major. Graduate Majors listed in the Comments column offer core courses that are recognized as equivalent to the corresponding Major Courses or Research-related Courses in the standard curriculum of this major.

Table D2. Core Courses of the Graduate Major in Chemical Science and Engineering

Course category		Course number	Course title			Credits	Competencies	Learning goals	Comments
Research seminars	**600 level**	CAP.Z691.R	◎		Seminar in Chemical Science and Engineering S3	0-1-1	1,3,5	A,C,E	
		CAP.Z692.R	◎		Seminar in Chemical Science and Engineering F3	0-1-1	1,3,5	A,C,E	
		CAP.Z693.R	◎		Seminar in Chemical Science and Engineering S4	0-1-1	1,3,5	A,C,E	
		CAP.Z694.R	◎		Seminar in Chemical Science and Engineering F4	0-1-1	1,3,5	A,C,E	
		CAP.Z695.R	◎		Seminar in Chemical Science and Engineering S5	0-1-1	1,3,5	A,C,E	
		CAP.Z696.R	◎		Seminar in Chemical Science and Engineering F5	0-1-1	1,3,5	A,C,E	
Major courses	**600 level**	CAP.E611.L			Academic Writing Practice I	0-1-0	2,5	E	
		CAP.E612.L			Academic Writing Practice II	0-1-0	2,5	E	
		CAP.E621.L			Problem-Solving Program in Chemical Science and Engineering I	0-0-1	2,3,4	B,E	
		CAP.E622.L			Problem-Solving Program in Chemical Science and Engineering II	0-0-1	2,3,4	B,E	
		CAP.E623.L			Problem-Solving Program in Chemical Science and Engineering III	0-0-1	2,3,4	B,E	
		CAP.E624.L			Problem-Solving Program in Chemical Science and Engineering IV	0-0-1	2,3,4	B,E	
		CAP.E631.L			Chemical Science and Engineering Off-Campus Project I	0-0-1	2,3,5	B,D	

		CAP.E632.L			Chemical Science and Engineering Off-Campus Project II	0-0-2	2,3,5	B,D	
		CAP.E633.L			Chemical Science and Engineering Off-Campus Project III	0-0-4	2,3,5	B,D	
		CAP.E634.L			Chemical Science and Engineering Off-Campus Project IV	0-0-6	2,3,5	B,D	
		CAP.E635.L			Cooperative Education through Research Internships of Chemical Science and Engineering I	0-0-4	1,3,4,5	B,D	
		CAP.E636 L			Cooperative Education through Research Internships of Chemical Science and Engineering II	0-0-6	1,3,4,5	B,D	
		CAP.I686.L			International scientific presentation A	0-0-1	1,3	B,C,E	【Energy Science and Engineering】 (ENR.E604)
		CAP.I687.L			International scientific presentation B	0-0-1	1,3	B,C,E	【Energy Science and Engineering】 (ENR.E605)
		CAP.I688.L			International scientific presentation C	0-0-1	1,3	B,C,E	【Energy Science and Engineering】 (ENR.E606)
		CAP.I692.L			Academic Writing A	1-0-0	3,4	B,E	【Energy Science and Engineering】 (ENR.E610)
		CAP.I693.L			Academic Writing B	1-0-0	1,2,3,4	B,E	【Energy Science and Engineering】 (ENR.E611)
		CAP.I694.L			International energy project	0-0-2	2,3,4,5	C,E	【Energy Science and Engineering】 (ENR.E612)
		CAP.P601.L			Fundamentals of electrochemistry and the application to energy conversion materials (Advanced)	1-0-0	1,2,4,5	B	【Materials Science and Engineering】 (MAT.P602)
		CAP.P602.L			Applied Vibrational Spectroscopy (Advanced)	1-0-0	1,2,5	B	【Materials Science and Engineering】 (MAT.P603)

Note：

• ◎：Required course，○：Restricted elective，O：odd academic years，E：even academic years

• Competencies: 1 = Specialist skills, 2 = Liberal arts skills, 3 = Communication skills, 4 = Applied skills (inquisitive thinking and/or problem-finding skills), 5 = Applied skills (practical and/or problem-solving skills)

•【 】Course offered by another graduate major

• The character preceding the three digits in the course number denotes the course's subdiscipline (i.e., "D" represents the subdiscipline code in the course number ABC.D600.R): A (Applied chemistry), C (Chemical engineering), P (Polymer science), I (Interdisciplinary science and technology), E (Others), Z (Research seminars).

6. IGP Courses That Can Be Counted as Humanities and Social Science Courses

None

7. IGP Career Development Courses and IGP Courses That Can Be Counted as Career Development Courses

In order to fulfill the completion requirements for the doctoral degree program, students must attain at least 4 credits in Career Development Courses, and should satisfy all of the Graduate Attributes (GA) specified in Table A-1 of the “Career Development Courses” listed as one of the “Liberal Arts and Basic Science Courses” in the Guide to Graduate Education and International Graduate Program, as well as shown below. Students will be evaluated in regards to GA achievements at the time of their degree completion. As to the courses with two GAs, both GAs stipulated for the courses are considered to be acquired if students receive the corresponding credits for those courses.

Career Development Courses and Major Courses that enable students to acquire GA and that are recognized as equivalent to Career Development Courses, offered by the Graduate Major, are listed in Tables D3 below. Students can also acquire GA and credits by taking the Career Development Courses offered by Innovator and Inventor Development Platform (IIDP) listed as one of the “Liberal Arts and Basic Science Courses” in the Guide to Graduate Education and International Graduate Program.

However, it must be noted that credits attained from those courses that can be counted as Career Development Courses can be counted towards the completion requirements of doctoral degree program, either for the Major Courses or for the Career Development Courses (i.e., not for both). Nevertheless, even in the cases from those mentioned above where attained credits pertaining to these courses are not considered as Career Development Courses, their associated GAs may be considered by the Graduate Major to have been acquired.

For Graduate Attributes, refer to the Guide to the Career Development Courses.

The Graduate Attributes of the Doctoral Degree Program are listed in Table A-1 as follows:

GA0D: You can clearly design your own career and contribute to realizing scientific, technological, or social innovation through a comprehensive understanding of the knowledge, skills, social responsibilities and ethics required to become an active member of academia and/or industry.

GA1D: You can lead in realizing scientific, technological, or social innovation by acquiring the advanced leadership skills, entrepreneurial skills, knowledge and expertise, and by developing social responsibility necessary for materializing your designed career.

Table D3-1. Courses of the Graduate Major in Chemical Science and Engineering recognized as equivalent to Career Development Courses, and Career Development Courses

Course category	Course number	Course title	Credits	GA*	Learning goals	Comments
Courses that can be counted as Career Development Courses	CAP.E631.L	Chemical Science and Engineering Off-Campus Project I	0-0-1	GA1D,	B,D	
	CAP.E632.L	Chemical Science and Engineering Off-Campus Project II	0-0-2	GA1D	B,D	
	CAP.E633.L	Chemical Science and Engineering Off-Campus Project III	0-0-4	GA1D	B,D	
	CAP.E634.L	Chemical Science and Engineering Off-Campus Project IV	0-0-6	GA1D,	B,D	
	CAP.E635.L	Cooperative Education through Research Internships of Chemical Science and Engineering I	0-0-4	GA1D,	B,D	
	CAP.E636.L	Cooperative Education through Research Internships of Chemical Science and Engineering II	0-0-6	GA1D,	B,D	
Career Development Courses	CAP.B601	Doctoral Recurrent Program 1 of Chemical Science and Engineering	0-0-1	GA0D GA1D	C,D,E	Career Development Course offered by the Graduate Major in Chemical Science and Engineering. You cannot count for the Major Course.
	CAP.B602	Doctoral Recurrent Program 2-1 of Chemical Science and Engineering	0-0-2	GA0D GA1D	C,D,E	Career Development Course offered by the Graduate Major in Chemical Science and Engineering. You cannot count for the Major Course.
	CAP.B603	Doctoral Recurrent Program 2-2 of Chemical Science and Engineering	0-0-2	GA0D GA1D	C,D,E	Career Development Course offered by the Graduate

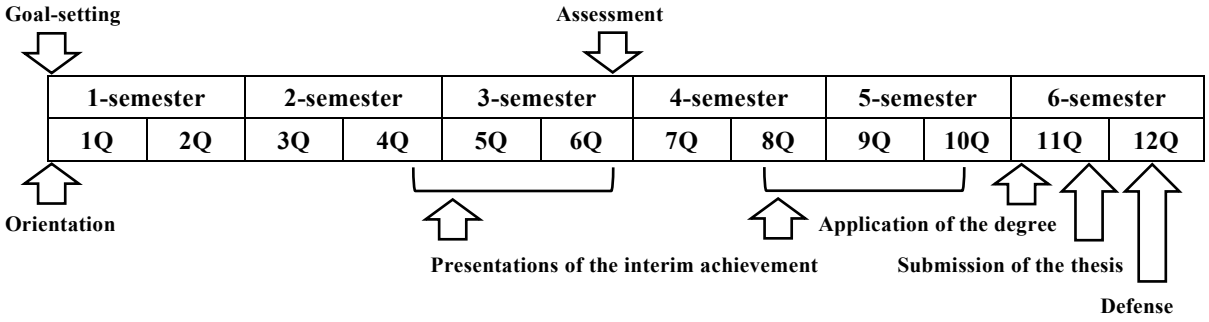
								Major in Chemical Science and Engineering. You cannot count for the Major Course.
	CAP.B604			Doctoral Recurrent Program 3 of Chemical Science and Engineering	0-0-3	GA0D GA1D	C,D,E	Career Development Course offered by the Graduate Major in Chemical Science and Engineering. You cannot count for the Major Course.
	CAP.B605			Doctoral Recurrent Program 4 of Chemical Science and Engineering	0-0-4	GA0D GA1D	C,D,E	Career Development Course offered by the Graduate Major in Chemical Science and Engineering. You cannot count for the Major Course.
Credits in Career Development Courses must be attained from among the above-listed courses and those listed as such in the Liberal Arts and Basic Science Courses Guide. **＊GA: Graduate Attributes**								

Students enrolled in the educational program for leading graduate schools, the Tokyo Tech Academy for Leadership (ToTAL) or WISE Programs may be offered courses recognized as equivalent to Career Development Courses besides those listed as such in the “Liberal Arts and Basic Science Courses” in the Guide to Graduate Education and International Graduate Program. For details about available courses or completion requirements, please refer to the Study Guide of the Academy that offers the relevant program.

8. Research Related to the Completion of Doctoral Theses

The research related to the completion of a doctoral thesis, aims at acquiring comprehensive ability including goal-setting, problem resolution and international communication at higher level. The following diagram represents a typical example

before the final examination.



・Criteria of the examination

Doctoral thesis should be genuinely the work of the candidate containing originality and significance that could contribute to academic or industrial developments in applied chemistry.

・Process of the examination

The doctoral thesis is reviewed by faculty members of the board who can judge the thesis from academic or technical viewpoints. The board can contain external experts from other universities or companies. After submission of the thesis and a public presentation by the candidate, the thesis will be peer-reviewed by the board. The final examination (defense) is conducted for an assessment of the thesis.