Graduate Major in Chemistry

【Master's Degree Program】

1. Outline

In the Graduate Major in Chemistry, the program provides education and research courses to understand matter-related chemical phenomena through analyses at atomic or molecular level, to create new materials based on the knowledge, and to contribute to development of society broadly. The curriculum consists of course work and laboratory-related work. The former includes foundational courses and in-depth courses in chemistry or chemistry-related fields. The latter includes courses to acquire knowledge and research skills required for successful scientists and engineers.

The Master's Degree Program is designed to cultivate individuals who possess a broad outlook based on both fundamental knowledge and advanced specialized academic ability on chemistry, and who can work independently on new problems.

2. Competencies Developed

We focus on the academic development of the following competencies:

- Fundamental academic ability to understand diverse findings related to chemistry
- Practical problem-solving skills based on advanced academic ability to material science
- Ability to tackle new problems independently and to explore depths of chemistry
- Ability to integral diverse ways of thinking to discover a new direction
- Communication skills applicable globally

3. Learning Goals

The goals of the active learning provided in the course to obtain the competencies described in the curriculum are as follows:

A) Basic learning of specialized fields in chemistry

Learning of basic understanding of chemical principles and concepts through fundamental courses (Basic Concepts of Inorganic Chemistry, Basic Concepts of Physical Chemistry, Basic Concepts of Organic Chemistry)

B) Advanced learning of chemistry

Leaning of advanced chemistry in various fields through Advanced Chemistry Courses

C) Learning to cultivate the wide perspective and initiative

Learning to acquire ability to contribute to their own research independently and basic skills for problem-solving

D) Learning of laboratory safety in chemistry

Learning to acquire ability to conduct chemical safely with preserving the environment

E) Learning to enforce communication skills

Learning to acquire skills for writing and presentation required for academic research

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. From the courses specified in the Graduate Major in Chemistry curriculum,
   - 4 credits acquired from Research Seminars in Chemistry
   - 4 credits acquired from Research-Related Courses in Chemistry
   - A minimum of 4 credits acquired from Basic Chemistry Courses (Basic Concepts series).
   - A minimum of 4 credits acquired from Advanced Chemistry Courses.
   - A minimum of 5 credits acquired from Liberal Arts and Basic Science Courses, including 2 credits or more from 400-level and one credit or more from 500-level Humanities and Social Science Courses, and 2 credits or more from Entrepreneurship Courses.
3. Pass the master's thesis review and defense.

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 Chemistry 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	C	
	Entrepreneurship Courses		2 credits		C	All Graduate Attributes (GA) should be acquired. (Refer to Section 7 for the definition of GA.)
	Other courses					
Core courses	**Research seminars**	Seminar in Chemistry S1 Seminar in Chemistry F1 Seminar in Chemistry S2 Seminar in Chemistry F2 A total of 4 credits, 1 credit each from the above courses.		18 credits	C, D, E	
	Research-related courses	Directed Laboratory Work in Chemistry I Directed Laboratory Work in Chemistry II Directed Laboratory Work in Chemistry III Directed Laboratory Work in Chemistry IV A total of 4 credits, 1 credit each from the above courses.			C, D, E	
	Major courses		• 4 credits or more from Basic Courses in Chemistry • 4 credits or more from Advanced Courses in Chemistry		A, B, C, D, E	
	Major courses and Research-related courses <u>outside</u> the Graduate Major in Chemistry 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 Course

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 Chemistry

Course category		Course number	Course title			Credits	Compe-tencies	Learning goals	Comments
Research seminars	400 level	CHM.Z491.R	◎	★	Seminar in Chemistry S1	0-1-0	1, 2, 3	C, D, E	
		CHM.Z492.R	◎	★	Seminar in Chemistry F1	0-1-0	1, 2, 3	C, D, E	
	500 level	CHM.Z591.R	◎	★	Seminar in Chemistry S2	0-1-0	1, 2, 3	C, D, E	
		CHM.Z592.R	◎	★	Seminar in Chemistry F2	0-1-0	1, 2, 3	C, D, E	
Research-related courses	400 level	CHM.L471.R	◎	★	Directed Laboratory Work in Chemistry I	0-0-1	1, 2, 3, 4, 5	C, D, E	
		CHM.L472.R	◎	★	Directed Laboratory Work in Chemistry II	0-0-1	1, 2, 3, 4, 5	C, D, E	
		CHM.A413.L			Environment Preservation and Chemical Safety	2-0-0	1,5	D	【Chemical Science and Engineering】 (CAP .E462)
	500 level	CHM.L571.R	◎	★	Directed Laboratory Work in Chemistry III	0-0-1	1, 2, 3, 4, 5	C, D, E	
		CHM.L572.R	◎	★	Directed Laboratory Work in Chemistry IV	0-0-1	1, 2, 3, 4, 5	C, D, E	
Major courses	400 level	CHM.A431.B	○		Laboratory Training of Synchrotron Radiation Science	0-0-1	1, 5	B, D	Advanced Chemistry Courses
		CHM.A435.L	○	★	Current Chemistry I	1-0-0	1, 2, 3	B	Advanced Chemistry Courses Only for even academic years
		CHM.A436.L	○	★	Current Chemistry II	1-0-0	1, 2, 3	B	Advanced Chemistry Courses Only for even academic years

		CHM.A437.L	○	★	Current Chemistry III	1-0-0	1, 2, 3	B	Advanced Chemistry Courses Only for odd academic years
		CHM.A438.L	○	★	Current Chemistry IV	1-0-0	1, 2, 3	B	Advanced Chemistry Courses Only for odd academic years
		CHM.A441.L	○		Recent Progress in Chemistry I	1-0-0	1	B	Advanced Chemistry Courses Only for even academic years
		CHM.A442.L	○		Recent Progress in Chemistry II	1-0-0	1	B	Advanced Chemistry Courses Only for even academic years
		CHM.A443.L	○		Recent Progress in Chemistry III	1-0-0	1	B	Advanced Chemistry Courses Only for even academic years
		CHM.A444.L	○		Recent Progress in Chemistry IV	1-0-0	1	B	Advanced Chemistry Courses Only for even academic years
		CHM.A445.L	○		Recent Progress in Chemistry V	1-0-0	1	B	Advanced Chemistry Courses Only for even academic years
		CHM.A446.L	○		Recent Progress in Chemistry VI	1-0-0	1	B	Advanced Chemistry Courses Only for even academic years
		CHM.A447.L	○		Recent Progress in Chemistry VII	1-0-0	1	B	Advanced Chemistry Courses Only for odd academic years
		CHM.A448.L	○		Recent Progress in Chemistry VIII	1-0-0	1	B	Advanced Chemistry Courses Only for odd academic years
		CHM.A449.L	○		Recent Progress in Chemistry IX	1-0-0	1	B	Advanced Chemistry Courses Only for odd academic years
		CHM.A450.L	○		Recent Progress in Chemistry X	1-0-0	1	B	Advanced Chemistry Courses Only for odd academic years
		CHM.A451.L	○		Recent Progress in Chemistry XI	1-0-0	1	B	Advanced Chemistry Courses Only for odd academic years
		CHM.A452.L	○		Recent Progress in Chemistry XII	1-0-0	1	B	Advanced Chemistry Courses Only for odd academic years
		CHM.A461.L		△ ☆	Presentation Exercises in Chemistry	0-1-0	1, 3, 5	C, E	

		CHM.A462.L		△ ☆ ★	Introductory Exercises in Chemistry	0-1-0	1, 2, 3, 4, 5	C, E	
		CHM.A471.B	○	△ ★	Materials Simulation	2-0-0	1, 5	B	【Tokyo Tech Academy for Convergence of Materials and Informatics】(TCM.A402)
		CHM.A472.B	○	△ ★	Materials Informatics	2-0-0	1, 5	B	【Tokyo Tech Academy for Convergence of Materials and Informatics】(TCM.A404)
		CHM.B401.A	○	★	Basic Concepts of Inorganic Chemistry I	1-0-0	1	A	Basic Chemistry Courses
		CHM.B402.A	○	★	Basic Concepts of Inorganic Chemistry II	1-0-0	1	A	Basic Chemistry Courses
		CHM.B431.B	○	★	Advanced Separation Science	2-0-0	1, 5	B	Advanced Chemistry Courses Only for odd academic years
		CHM.B433.B	○	★	Catalytic Chemistry on Solid Surface	2-0-0	1	B	Advanced Chemistry Courses Only for odd academic years
		CHM.B434.B	○	☆ ★	Advanced Course in Crystal Structure Science	2-0-0	1	B	Advanced Chemistry Courses
		CHM.B435.B	○		Global Environmental Chemistry	2-0-0	1	B	Advanced Chemistry Courses Only for even academic years
		CHM.B436.B	○	☆ ★	Photochemical Reactions I	1-0-0	1	B	Advanced Chemistry Courses Only for even academic years Only available for students who have taken this course during their bachelor's program
		CHM.B437.B	○	☆ ★	Photochemical Reactions II	1-0-0	1	B	Advanced Chemistry Courses Only for odd academic years Only available for students who have taken this course during their bachelor's program

		CHM.B438.B	○	☆ ★	Advanced Coordination Chemistry I	1-0-0	1	B	Advanced Chemistry Courses Only for even academic years
		CHM.B439.B	○	☆ ★	Advanced Coordination Chemistry II	1-0-0	1	B	Advanced Chemistry Courses Only for odd academic years
		CHM.C401.A	○	★	Basic Concepts of Physical Chemistry I	1-0-0	1	A	Basic Chemistry Courses
		CHM.C402.A	○	★	Basic Concepts of Physical Chemistry II	1-0-0	1	A	Basic Chemistry Courses
		CHM.C433.B	○	★	Advanced Physical Chemistry I	1-0-0	1	B	Advanced Chemistry Courses Only for odd academic years
		CHM.C434.B	○	★	Advanced Physical Chemistry II	1-0-0	1	B	Advanced Chemistry Courses Only for even academic years
		CHM.C435.B	○	★	Advanced Quantum Chemistry I	1-0-0	1	B	Advanced Chemistry Courses Only for odd academic years
		CHM.C436.B	○	★	Advanced Quantum Chemistry II	1-0-0	1	B	Advanced Chemistry Courses Only for even academic years
		CHM.C437.B	○	★	Advanced Material Chemistry I	1-0-0	1	B	Advanced Chemistry Courses Only for odd academic years
		CHM.C438.B	○	★	Advanced Material Chemistry II	1-0-0	1	B	Advanced Chemistry Courses Only for even academic years
		CHM.D401.A	○	★	Basic Concepts of Organic Chemistry I	1-0-0	1	A	Basic Chemistry Courses
		CHM.D402.A	○	★	Basic Concepts of Organic Chemistry II	1-0-0	1	A	Basic Chemistry Courses
		CHM.D431.B	○	★	Advanced Bioorganic Chemistry	2-0-0	1	B	Advanced Chemistry Courses Only for odd academic years
		CHM.D432.B	○	★	Advanced Organic Synthesis	2-0-0	1, 5	B	Advanced Chemistry Courses Only for odd academic years
		CHM.D433.B	○	★	Advanced Organometallic Chemistry	2-0-0	1	B	Advanced Chemistry Courses Only for even academic years
		CHM.D434.B	○	★	Advanced Structural Organic Chemistry	2-0-0	1	B	Advanced Chemistry Courses Only for even academic years

		CHM.E401.B	○	☆ ★	Interdisciplinary scientific principles of energy 1	1-0-0	1	A	【Energy Science and Informatics】(ESI.A401)
		CHM.E402.B	○	☆ ★	Interdisciplinary scientific principles of energy 2	1-0-0	1	A	【Energy Science and Informatics】(ESI.A402)
		CHM.E405.B	○	☆ ★	Interdisciplinary energy materials science 1	1-0-0	1, 5	B	【Energy Science and Informatics】(ESI.A405)
		CHM.E406.B	○	☆ ★	Interdisciplinary energy materials science 2	1-0-0	1, 5	B	【Energy Science and Informatics】(ESI.A406)
		CHM.E410.B	○	★	Optical properties of solids	2-0-0	1, 4	B	【Energy Science and Informatics】(ESI.I410)
		CHM.E420.B	○	★	Advanced Lecture on Crystal Structure and Correlation with Properties of Solids	1-0-0	1, 5	B	【Energy Science and Informatics】(ESI.I420)

• ◎:Required course, ○:Restricted elective, ★:Classes in English △: Course recognized as equivalent to that of the Tokyo Tech Academy for Convergence of Materials and Informatics (TAC-MI). Materials Simulation (CHM.A471.B) and Materials Informatics (CHM.A472.B) can only be taken by students registered in Tokyo Tech Academy for Convergence of Materials and Informatics. ☆: Course recognized as equivalent to that of the Tokyo Tech Academy of Energy and Informatics Program.

• 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: Basic Chemistry, B: Inorganic/Analytical Chemistry, C: Physical Chemistry, D: Organic Chemistry, E: Energy Science and Informatics Chemistry, L: Research Related Courses, P: Entrepreneurship Courses, Z: Research Seminars

6. IGP Courses that can be counted as Humanities and Social Science Courses

None

7. IGP Entrepreneurship Courses and IGP Courses That Can Be Counted as Entrepreneurship Courses

In order to fulfill the completion requirements for the master's degree program, students must attain at least two credits in Entrepreneurship Courses, and should satisfy all of the Graduate Attributes (GAs) specified in Table M-1 of the "Entrepreneurship Courses" listed as "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. For courses with two GAs, both GAs stipulated for the courses are considered to be acquired if students attain the corresponding credits for those courses.

Entrepreneurship Courses and Major Courses that enable students to acquire GAs and are recognized as equivalent to Entrepreneurship Courses, offered by the Graduate Major, are listed in Table M3 below. Students can also acquire GAs and credits by taking the Entrepreneurship Courses offered by the Center for Entrepreneurship Education (CEE) listed as “Liberal Arts and Basic Science Courses” in the Guide to Graduate Education and International Graduate Program.

As there are some Entrepreneurship Courses without GAs, please check carefully before registering for them.

However, it must be noted that credits attained from courses that are recognized as equivalent to Entrepreneurship Courses can be counted towards the completion requirements of the master’s degree program, either for Major Courses or for Entrepreneurship Courses (not for both). Nevertheless, even in cases where credits pertaining to courses that are not considered as Entrepreneurship Courses are attained, the associated GAs may be considered by the Graduate Major to have been acquired.

For Graduate Attributes, refer to the Guide to Entrepreneurship Courses.
The Graduate Attributes of the Master's Degree Program are listed in Table M-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, ethics and entrepreneurship 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 Chemistry recognized as equivalent to Entrepreneurship Courses, and Entrepreneurship Courses

Course category	Course number	Course title			Credits	GA*	Learning goals	Comments
Courses that can be counted as Entrepreneurship Courses	XIP.A401		★	Special International Practice in Science	1-0-0	GA1M		Common Course of School of Science Outside the Graduate Major in Chemistry standard curriculum
	CHM.A461.L			Presentation Exercises in Chemistry	0-1-0	GA0M	C, E	
	CHM.A462.L		★	Introductory Exercises in Chemistry	0-1-0	GA1M	C, E	
Entrepreneurship Courses	CHM.P581			Master's Recurrent Program 1-1 of Chemistry	0-0-1	GA0M GA1M	C, E	Entrepreneurship Course offered by the Graduate Major in Chemistry. (Cannot be counted for Major Courses)
	CHM.P582			Master's Recurrent Program 1-2 of Chemistry	0-0-1	GA0M GA1M	C, E	Entrepreneurship Course offered by the Graduate Major in Chemistry. (Cannot be counted for Major Courses)

	CHM.P583			Master's Recurrent Program 2 of Chemistry	0-0-2	GA0M GA1M	C, E	Entrepreneurship Course offered by the Graduate Major in Chemistry. (Cannot be counted for Major Courses)

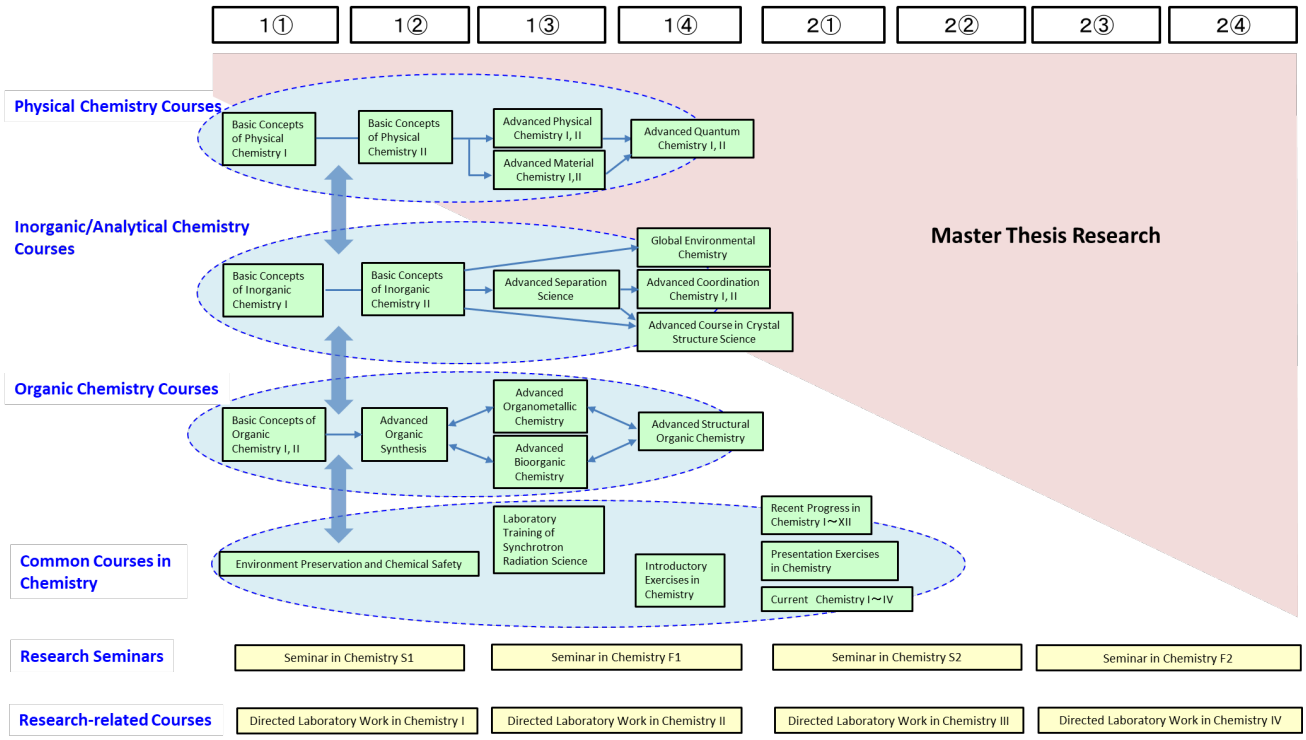
★: Classes in English

Credits in Entrepreneurship 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**

The Tokyo Tech Academy for Leadership (ToTAL), WISE Programs, or Center of Data Science and Artificial Intelligence may offer courses that are recognized as equivalent to Entrepreneurship Courses in addition to those listed as such under "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 or center that offers the relevant program.

8. Overview of Curriculum System



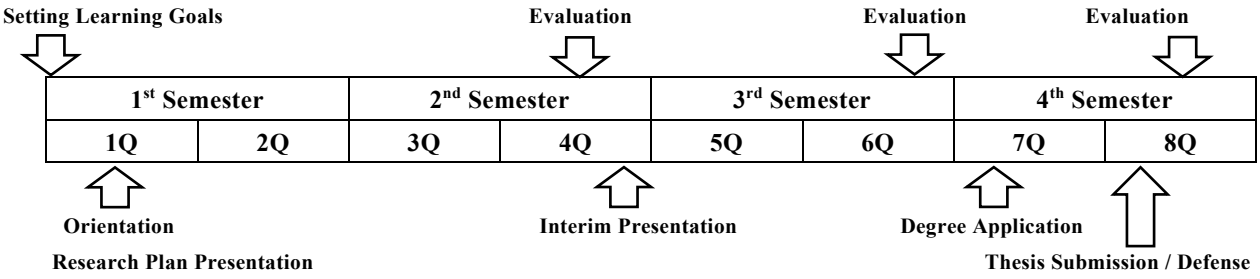
9. Example of a Standard Curriculum

	Inorganic/Analytical Chemistry Courses	Physical Chemistry Courses	Organic Chemistry Courses	Common Courses in Chemistry	Research Seminars Research-related Courses
400 level	• Basic Concepts of Inorganic Chemistry I,II • Advanced Separation Science • Advanced Course in Crystal Structure Science • Global Environmental Chemistry • Advanced Coordination Chemistry I,II	• Basic Concepts of Physical Chemistry I,II • Advanced Physical Chemistry I,II • Advanced Quantum Chemistry I,II • Advanced Material Chemistry I,II	• Basic Concepts of Organic Chemistry I,II • Advanced Bioorganic Chemistry • Advanced Organic Synthesis • Advanced Organometallic Chemistry • Advanced Structural Organic Chemistry	• Environment Preservation and Chemical Safety • Laboratory Training of Synchrotron Radiation Science • Current Chemistry I～IV • Recent Progress in Chemistry I～XII • Presentation Exercises in Chemistry • Introductory Exercises in Chemistry	• Seminar in Chemistry S1 • Seminar in Chemistry F1 • Directed Laboratory Work in Chemistry I • Directed Laboratory Work in Chemistry II
500 level					• Seminar in Chemistry S2 • Seminar in Chemistry F2 • Directed Laboratory Work in Chemistry III • Directed Laboratory Work in Chemistry IV

10. Research Related to the Completion of Master Theses

In the master thesis research, students will acquire and improve their problem setting and solving abilities, and communication and presentation skills. The important courses are related to the research on a thesis under the supervision of a faculty member, in which each student can develop their ability to apply their accumulated knowledge and skills to a research topic. They will learn how to organize and present their ideas in a logical way through preparation and presentation of the master thesis.

Study Plan



• Presentation of the research plan and the interim achievement

A research plan presentation on 1Q and an interim presentation on 4Q are examined to clarify the background and the objective of the research in terms of career development.

• The criteria for examination

Following requirements must be met.

1. The thesis must be a self-written paper, which includes novel knowledge and concept as well as original discussion.
2. The main part of the thesis must have been presented at an academic conference.

• The thesis review procedure

The review committee consists of at least three faculty members of the chemistry course. The final judgment is carried out after reviewing the thesis and the presentation by the candidate. The examination for the candidate who enters the PhD course is made by at least five faculty members.

【Doctoral Degree Program】

1. Outline

The purpose of the program is to train young talents to have a broad knowledge of both fundamental and specialized issues related to materials, to encourage them to become leaders of a specialized field related to Chemistry and to contribute natural science and applied fields.

2. Competencies Developed

We focus on the academic development of the following competencies:

- Have a broad and deep knowledge of Chemistry related topics, and can utilize this knowledge to approach new chemical problems
- Lead research at the frontiers of chemical sciences with a strong sense of responsibility and ethics
- Integrate the results of various fields related to materials research from a chemistry point of view, and actively use this knowledge
- Demonstrate international leadership in the field of study

3. Learning Goals

The curriculum will help to develop these competencies using the following approaches:

A) Study advanced challenges

Using the specialized skills from the master program, identifies new, important scientific problems and able to solve them

B) Able to integrate different fields of knowledge and organize them into new systems

C) Achieve international leadership in the study 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. From the courses specified in the Graduate Major in Chemistry curriculum,
   - 12 credits acquired from Research Seminars in Chemistry
   - 1 credit acquired from Advanced Exercises in Chemistry
   - A minimum of 18 credits acquired from Core Courses of the Graduate Major in Chemistry
   - A minimum of 6 credits acquired from Liberal Arts and Basic Science Courses
     (2 credits from Humanities and Social Science Courses, and 4 credits from Entrepreneurship Courses)
3. At least one paper published in a good peer-reviewed journal in the subject of the doctoral thesis. As a general rule, the student should be the first author. A paper accepted for publication is considered to be equivalent to published papers.
4. 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 Chemistry 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	
	Entrepreneurship Courses		4 credits		B, C	All Graduate Attributes (GA) should be acquired. (Refer to Section 7 for the definition of GA.)
	Other courses					
Core courses	**Research seminars**	Seminar in Chemistry S3 Seminar in Chemistry F3 Seminar in Chemistry S4 Seminar in Chemistry F4 Seminar in Chemistry S5 Seminar in Chemistry F5 A total of 12 credits, 2 credits each from the above courses.		18 credits	A, B	
	Research-related courses				A, B	
	Major courses	Advanced Exercise in Chemistry, 1 credit			A, B, C	
	Major courses and Research-related courses <u>outside</u> the Graduate Major in Chemistry 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 Chemistry

Course category		Course number	Course title			Credits	Compe-tencies	Learning goals	Comments
Research seminars	600 level	CHM.Z691.R	◎	★	Seminar in Chemistry S3	0-2-0	1, 2, 3, 4	A, B	
		CHM.Z692.R	◎	★	Seminar in Chemistry F3	0-2-0	1, 2, 3, 4	A, B	
		CHM.Z693.R	◎	★	Seminar in Chemistry S4	0-2-0	1, 2, 3, 4	A, B	
		CHM.Z694.R	◎	★	Seminar in Chemistry F4	0-2-0	1, 2, 3, 4	A, B	
		CHM.Z695.R	◎	★	Seminar in Chemistry S5	0-2-0	1, 2, 3, 4	A, B	
		CHM.Z696.R	◎	★	Seminar in Chemistry F5	0-2-0	1, 2, 3, 4	A, B	
Major courses	600 level	CHM.A641.L		★ E	Colloquium on Advanced Chemistry I	1-0-0	1, 2	A, B, C	Only for even academic years
		CHM.A642.L		★ E	Colloquium on Advanced Chemistry II	1-0-0	1, 2	A, B, C	Only for even academic years
		CHM.A643.L		★ O	Colloquium on Advanced Chemistry III	1-0-0	1, 2	A, B, C	Only for odd academic years
		CHM.A644.L		★ O	Colloquium on Advanced Chemistry IV	1-0-0	1, 2	A, B, C	Only for odd academic years
		CHM.A651.L		△	Laboratory Training of Advanced Chemistry I	0-0-1	1, 2, 3, 4, 5	C	
		CHM.A652.L		△	Laboratory Training of Advanced Chemistry II	0-0-1	1, 2, 3, 4, 5	C	
		CHM.A653.L		△	Laboratory Training of Advanced Chemistry III	0-0-1	1, 2, 3, 4, 5	C	
		CHM.A654.L		△	Laboratory Training of Advanced Chemistry IV	0-0-1	1, 2, 3, 4, 5	C	
		CHM.A661.L		★	Basic Exercises in Global Presentation	0-1-0	1, 2, 3	C	
		CHM.A662.L		★	Advanced Exercises in Global Presentation	0-1-0	1, 2, 3	C	

		CHM.L670.R	◎	★	Advanced Exercise in Chemistry	0-1-0	1, 2, 3, 4, 5	A, B, C	
		CHM.L671.L		★	Advanced Laboratory Work in Chemistry I	0-0-1	1, 2, 3, 4, 5	A, B	
		CHM.L672.L		★	Advanced Laboratory Work in Chemistry II	0-0-1	1, 2, 3, 4, 5	A, B	
		CHM.L673.L		★	Advanced Laboratory Work in Chemistry III	0-0-1	1, 2, 3, 4, 5	A, B	
		CHM.L674.L		★	Advanced Laboratory Work in Chemistry IV	0-0-1	1, 2, 3, 4, 5	A, B	
		CHM.L675.L		★	Advanced Laboratory Work in Chemistry V	0-0-1	1, 2, 3, 4, 5	A, B	
		CHM.L676.L		★	Advanced Laboratory Work in Chemistry VI	0-0-1	1, 2, 3, 4, 5	A, B	
		CHM.E601.L		☆ ★	InfoSyEnergy-outreach	0-0-1			【Tokyo Tech Academy of Energy and Informatics】(ENI.A601)
		CHM.E611.L		☆ ★	InfoSyEnergy-international forum 1	0-0-2			【Tokyo Tech Academy of Energy and Informatics】(ENI.B611)
		CHM.E612.L		☆ ★	InfoSyEnergy-international forum 2	0-0-2			【Tokyo Tech Academy of Energy and Informatics】(ENI.B612)
		CHM.E613.L		☆ ★	InfoSyEnergy-international forum 3	0-0-2			【Tokyo Tech Academy of Energy and Informatics】(ENI.B613)
		CHM.E614.L		☆	InfoSyEnergy-joint research project 1	0-0-2			【Tokyo Tech Academy of Energy and Informatics】(ENI.C611)
		CHM.E615.L		☆	InfoSyEnergy-joint research project 2	0-0-4			【Tokyo Tech Academy of Energy and Informatics】(ENI.C612)
		CHM.E616.L		☆ ★	InfoSyEnergy-international field work-short term	0-0-2			【Tokyo Tech Academy of Energy and Informatics】(ENI.C616)
		CHM.E617.L		☆ ★	InfoSyEnergy-international field work-long term	0-0-4			【Tokyo Tech Academy of Energy

									and Informatics】(ENI.C617)
		CHM.L681.L			Cooperative Education through Research Internships of Chemistry	0-0-4	1, 3, 4, 5	C	

Note:

• ◎:Required course, ○:Restricted elective, ★: Classes in English, O: odd academic years, E: even academic years, △: Course recognized as equivalent to that of the Tokyo Tech Academy for Convergence of Materials and Informatics (TAC-MI). Materials Simulation (CHM.A471.B) and Materials Informatics (CHM.A472.B) can only be taken by students registered in Tokyo Tech Academy for Convergence of Materials and Informatics. ☆: Course recognized as equivalent to that of the Tokyo Tech Academy of Energy and Informatics Program.

• 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)

• 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: Basic Chemistry, B: Inorganic/Analytical Chemistry, C: Physical Chemistry D: Organic Chemistry, E: Energy Science and Informatics Chemistry, L: Research Related Courses, P: Entrepreneurship Courses, Z: Research Seminars

6. IGP Courses that can be counted as Humanities and Social Science Courses

None

7. IGP Entrepreneurship Courses and IGP Courses That Can Be Counted as Entrepreneurship Courses

In order to fulfill the completion requirements for the doctoral degree program, students must attain at least four credits in Entrepreneurship Courses, and should satisfy all of the Graduate Attributes (GAs) specified in Table D-1 of the “Entrepreneurship Courses” listed as “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. For courses with two GAs, both GAs stipulated for the courses are considered to be acquired if students attain the corresponding credits for those courses.

Entrepreneurship Courses and Major Courses that enable students to acquire GAs and are recognized as equivalent to Entrepreneurship Courses, offered by the Graduate Major, are listed in Table D3 below. Students can also acquire GAs and credits by taking the Entrepreneurship Courses offered by the Center for Entrepreneurship Education (CEE) listed as “Liberal Arts and Basic Science Courses” in the Guide to Graduate Education and International Graduate Program.

As there are some Entrepreneurship Courses without GAs, please check carefully before registering for them.

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

For Graduate Attributes, refer to the Guide to Entrepreneurship Courses.
The Graduate Attributes of the Doctoral Degree Program are listed in Table D-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 advanced leadership skills, entrepreneurship, knowledge and expertise, and by developing social responsibility necessary for materializing your designed career.

Table D3. Courses of the Graduate Major in Chemistry recognized as equivalent to Entrepreneurship Courses, and Entrepreneurship Courses

Course category	Course number	Course title			Credits	GA*	Learning goals	Comments
Courses that can be counted as Entrepreneurship Courses	XIP.A601		★	Advanced International Practice in Science	1-0-0	GA1D		Common Course of School of Science Outside the Graduate Major in Chemistry standard curriculum
	CHM.A651.L			Laboratory Training of Advanced Chemistry I	0-0-1	GA1D	C	
	CHM.A652.L			Laboratory Training of Advanced Chemistry II	0-0-1	GA1D	C	
	CHM.A653.L			Laboratory Training of Advanced Chemistry III	0-0-1	GA1D	C	
	CHM.A654.L			Laboratory Training of Advanced Chemistry IV	0-0-1	GA1D	C	
	CHM.A661.L		★	Basic Exercises in Global Presentation	0-1-0	GA1D	C	
	CHM.A662.L		★	Advanced Exercises in Global Presentation	0-1-0	GA1D	C	
	CHM.L681.L			Cooperative Education through Research Internships of Chemistry	0-0-4	GA1D	C	
Entrepreneurship Courses	CHM.P682			Doctoral Recurrent Program 1 of Chemistry	0-0-1	GA0D GA1D	C, E	Entrepreneurship Course offered by the Graduate Major in Chemistry. (Cannot be counted for Major Courses)
	CHM.P683			Doctoral Recurrent Program 2-1 of Chemistry	0-0-2	GA0D GA1D	C, E	Entrepreneurship Course offered by the Graduate Major in Chemistry. (Cannot be counted for Major Courses)
	CHM.P684			Doctoral Recurrent Program 2-2 of Chemistry	0-0-2	GA0D GA1D	C, E	Entrepreneurship Course offered by the Graduate Major in Chemistry.

								(Cannot be counted for Major Courses)
	CHM.P685			Doctoral Recurrent Program 3 of Chemistry	0-0-3	GA0D GA1D	C, E	Entrepreneurship Course offered by the Graduate Major in Chemistry. (Cannot be counted for Major Courses)
	CHM.P686			Doctoral Recurrent Program 4 of Chemistry	0-0-4	GA0D GA1D	C, E	Entrepreneurship Course offered by the Graduate Major in Chemistry. (Cannot be counted for Major Courses)

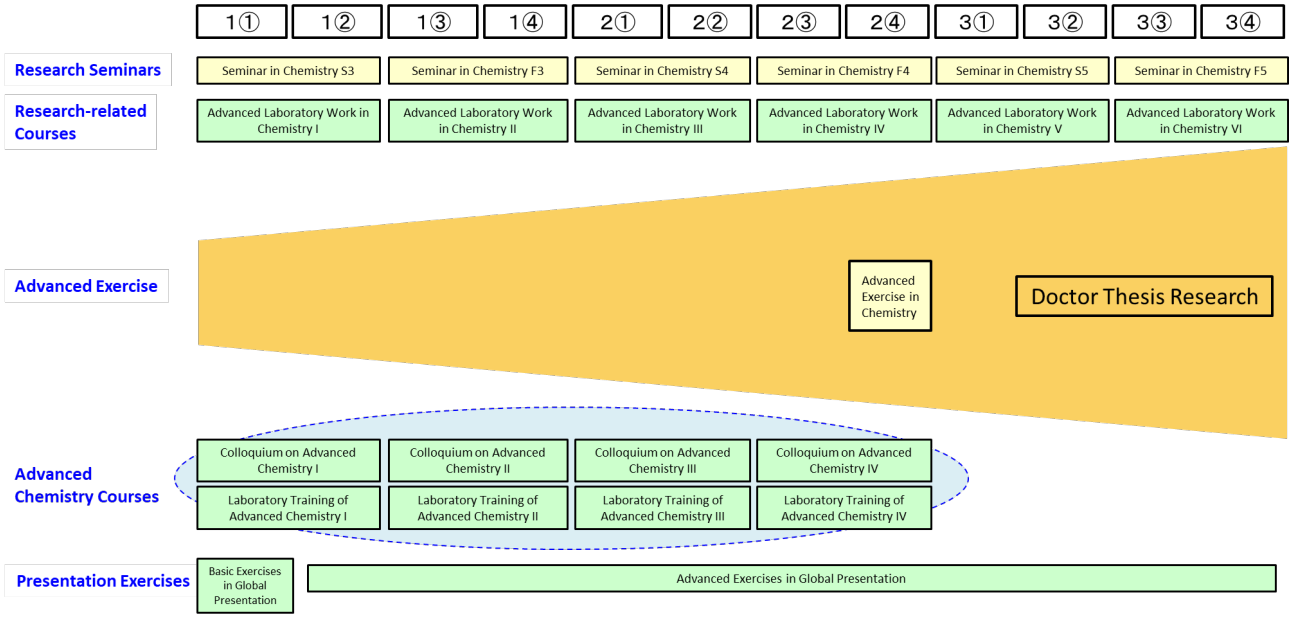
★: Classes in English

Credits in Entrepreneurship 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**

The Tokyo Tech Academy for Leadership (ToTAL), WISE Programs, or Center of Data Science and Artificial Intelligence may offer courses that are recognized as equivalent to Entrepreneurship Courses in addition to those listed as such under “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 or center that offers the relevant program.

8. Overview of Curriculum System

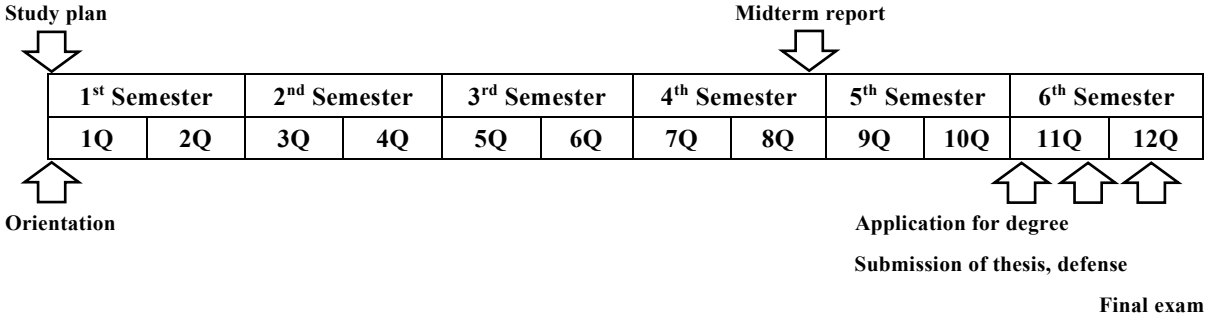


9. Example of a Standard Curriculum

	Research Seminars	Research-related Courses	Advanced Exercise	Advanced Chemistry Courses	Presentation Exercises
600 level	Seminar in Chemistry S3 Seminar in Chemistry F3 Seminar in Chemistry S4 Seminar in Chemistry F4 Seminar in Chemistry S5 Seminar in Chemistry F5	Advanced Laboratory Work in Chemistry I Advanced Laboratory Work in Chemistry II Advanced Laboratory Work in Chemistry III Advanced Laboratory Work in Chemistry IV Advanced Laboratory Work in Chemistry V Advanced Laboratory Work in Chemistry VI	Advanced Exercise in Chemistry	Laboratory Training of Advanced Chemistry I Laboratory Training of Advanced Chemistry II Laboratory Training of Advanced Chemistry III Laboratory Training of Advanced Chemistry IV Colloquium on Advanced Chemistry I Colloquium on Advanced Chemistry II Colloquium on Advanced Chemistry III Colloquium on Advanced Chemistry IV	Basic Exercises in Global Presentation Advanced Exercises in Global Presentation

10. Research Related to the Completion of Doctoral Theses

Through the doctoral thesis research, the candidate should discover new problem of significant importance in international scientific enterprise, and develop the abilities for pointing out the issues to be solved, analyzing the situations, and proposing the solution. At the same time, communication skills are also gained to publish the results nationally and internationally. The doctoral thesis, the thesis presentation and the final exam are based on the compilation of these achievements.



The criteria for examination

Following requirements must be met for the qualification:

1. The thesis should be original and is confirmed to be the world level of research which would contribute to the development of the academic field of chemistry.
2. The subject of the doctoral thesis should be published as at least one paper in a good peer-reviewed journal. As a general rule, the student should be the first author. A paper accepted for publication is considered to be equivalent to published papers.