LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

Module Handbook / Program Catalog

Master's Degree: Chemistry

(Master of Science, M.Sc.)

(120 ECTS points)

Based on the Examination Regulations from 18. March 2016

88/032/---/H1/H/2015

Version: 01/02/2025

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Abbreviations and Explanations

ECTS	European Credit Transfer and Accumulation System
h	hours
SWS	contact hours per week per semester
SoSe	summer semester
WiSe	winter semester
WP	optional module (a choice of compulsory modules - Wahlpflichtmodul)
P	compulsory module (Pflichtmodul)

1. In the course catalogue assigned ECTS points are designated as follows: ECTS points that are not listed in parentheses are awarded upon successful completion of the respective graded exam. ECTS points listed in parentheses are for calculation purposes only

2. The semester for choosing the course can be either binding or can be considered as a recommendation, according to the stipulations stated in Appendix 2 in the examination regulations, and are indicated in the catalogue either by "designated semester" or "recommended semester", respectively.

3. The course catalogue is intended to serve as an orientation for the master's program, both in structure and content. For detailed regulations, please see the official examination regulations under www.lmu.de/studienangebot

4. Detailed information concerning the study program and everything around is available under https://www.cup.lmu.de/en/study/study-programs/ and https://www.cup.lmu.de/en/study/for-students/

Contacts

Application: https://www.cup.lmu.de/en/study/study-programs/master-chemistry/ - Application

Examinations Office:

Butenandtstr. 5-13, 81377 Munich, Germany
Bldg F, Room F 5.020
Office hours: Mo - Tue 9:30 - 12:00 a.m. and by appointment

Further Contact Points:

https://www.cup.lmu.de/en/study/service-points/

Introductory Event:

An introduction to the Master in Chemistry takes place every semester in the 1st week of lectures (usually on the 1st day of lectures, Monday afternoon). You can find exact information on time and place in the electronic course catalog LSF.

Description and goals of the master's program in chemistry

The **master's program in chemistry** is designed to follow the bachelor's program in chemistry and biochemistry and to afford a future-oriented education in chemistry, or a related subject, with stress upon the fundamentals of natural science and a more profound academic training. The goal of the program is to deepen and expand the knowledge and skills acquired in previous work. Combined with a broad choice of subjects in chemistry and interdisciplinary areas, the program's concept guarantees a flexible combination of subjects which answer to students' individual interests.

Courses are modular where students earn, by passing exams in lecture and lab courses, a total of 120 credits according to the European Credit Transfer system (ECTS). The final grade of the master's program is calculated as the average of all module grades. The module's continual assessment grades are calculated as their average together with a single weighted valuation (see Appendix A23, PSto § 21 and §10 clauses 3 and 4). Courses will be offered in either English or German.

The master's degree facilitates the transition to working life and is preparation for doctoral studies.

The program's description

The LMU's master's program, with its prescribed period of study of four semesters, can be entered in the fall or spring semester. Access is regulated by a so-called aptitude test. The study program is research oriented and allows for great freedom in the choice of subjects.

The program's basic concept offers students two options (see Fig. 1):

a) The choice of three major subjects (required electives, WB) in chemistry with 30 ECTS credits each (WB-A, WB-B, WB-C).

In **option a),** students specialize and focus on three core areas and complete a master's thesis exclusively on the basic areas of chemistry: inorganic, organic, physical and theoretical chemistry. The required electives (major) in chemistry comprise two required electives, with 15 ECTS credits each, a lab module (WP 1, WP 3, WP 6 or WP 7) with a specialized research lab course with seminar and a theoretical module (WP 2, WP 4, WP 41 or WP 42), which encompasses a compulsory colloquium and a large number of lecture courses (between four and ten) from which three must be chosen.

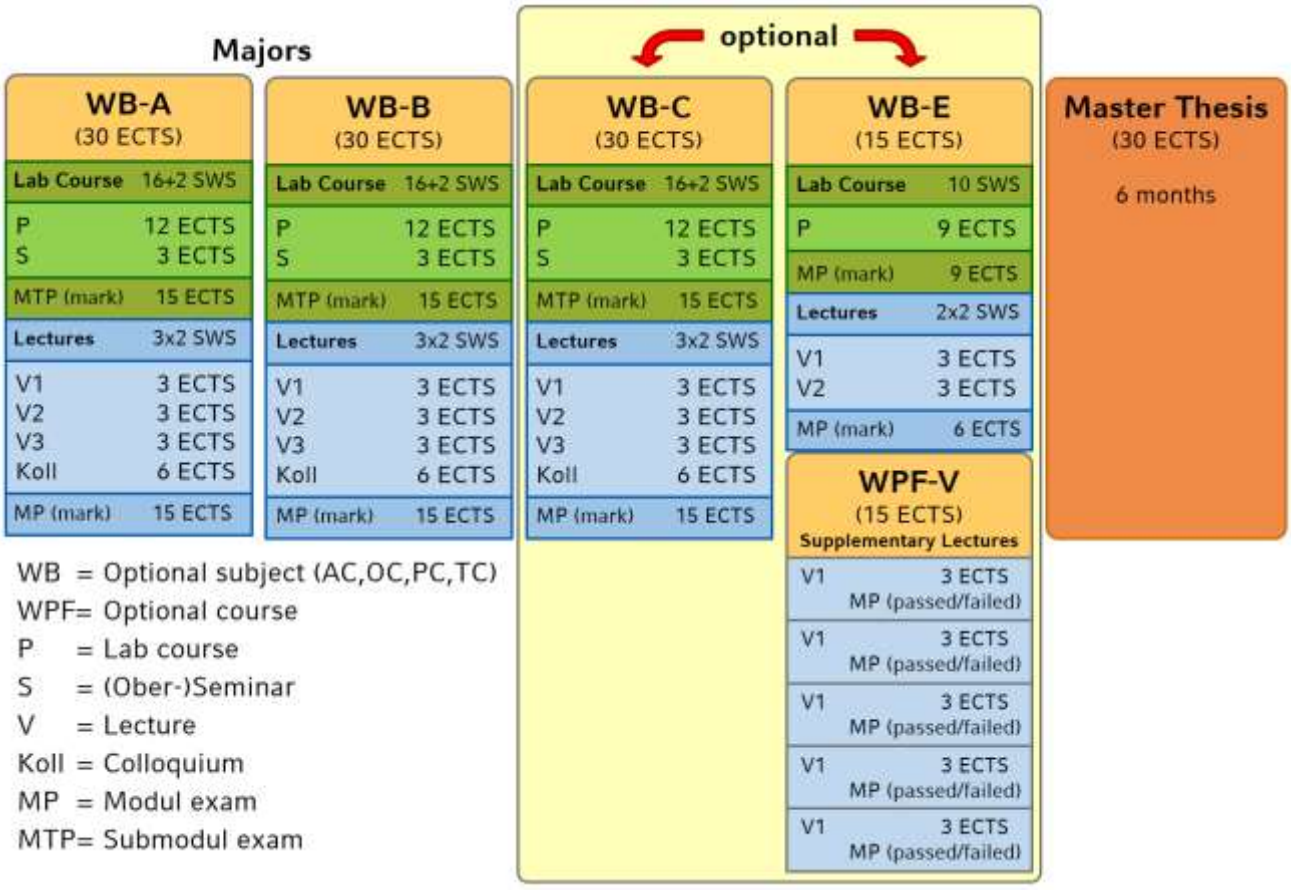


Fig. 1: An overview of the concept and the two master's program options.

b) Students choose two major subjects in chemistry with 30 ECTS credits each (WB-A, WB-B) plus a minor subject (WB-E) and supplementary lectures (WPF-V) with 15 ECTS credits each which must be in chemistry or chemistry-related subjects.

In **option b)**, students may choose two major subjects from the basic areas of chemistry, with a total of 30 ECTS credits each (see option a). A minor subject and further "supplementary" lecture courses must be taken.

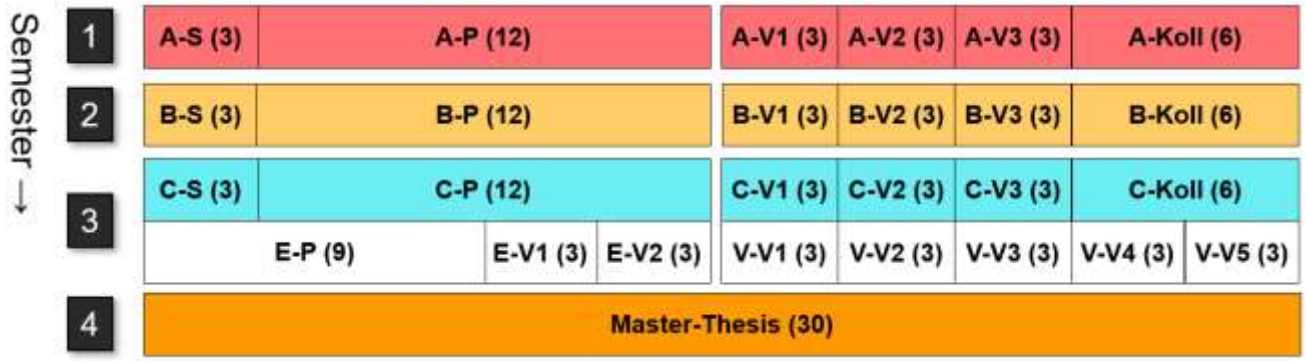
The minor subject (WB-E) consists of two compulsory-elective modules: a lab course module (WP 8 through WP 14 or WP 43) with 9 ECTS credits and a lecture course module (WP 5 or WP 44 through WP 50) with 6 ECTS credits. Two lecture courses must be chosen from the lecture course module. Subjects which had been chosen as a major may not be taken as minor courses. Additionally, minor courses in both physics (WP 17, WP 52 through WP55) and informatics (WP 18 through WP 21 and WP 56 through WP 57) with a total of 15 ECTS credits may be chosen along with courses such as patent law, pharmacology, toxicology (WP 15 and WP 51) and chemistry-related courses taken abroad.

The required five specialized supplementary lecture courses, with 3 ECTS each, may be selected from among the major and minor courses but may not be counted twice if the courses were taken earlier.

The program will have been completed after the submission of a master's thesis for which six months are earmarked. During the six months, a current topic of modern research is worked on in a research group of choice. In most cases the master's thesis is experimental in nature. Upon successful completion of the program the LMU bestows the academic title "Master of Science" (M.Sc.) and issues a certificate with grades. A master's degree is equivalent to that of a "Diploma" degree.

Two examples of a curriculum in the master's program in chemistry:

1)



2)

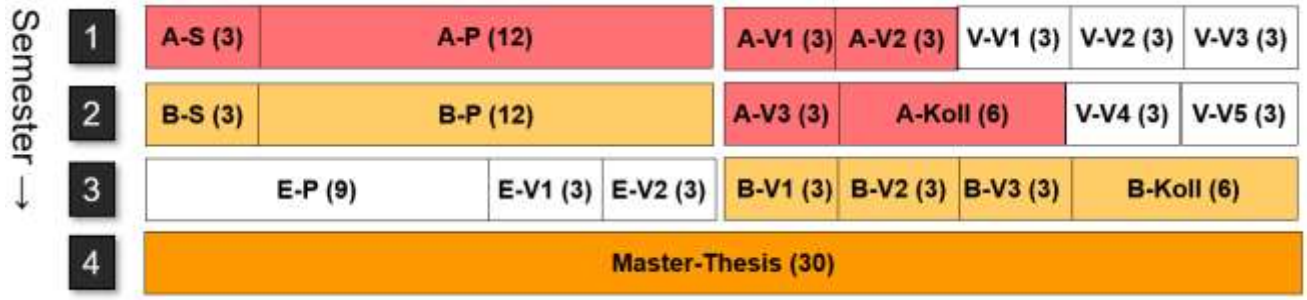


Fig. 2: Possible curricula: (1) above: in the third semester both options a) and b) are listed in parallel; A, B, C = major subject courses; E = minor subject courses; V = supplementary courses; S = seminar; P = research lab course; V = lecture course; K = colloquium; ECTS credits in parentheses;
(2) below: possible curricula with option b); lectures in major, minor as well as in supplementary course modules e.g. may hang over two semesters.

Module WP 1: Major Inorganic Chemistry (Lab Course)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lab Course	WP 1.1 Advanced Research Lab Course in Inorganic Chemistry (T1IA)	WiSe/ SoSe	240h (16 SWS)	120 h	(12)
Seminar	WP 1.2 Seminar in Inorganic Chemistry (T1IC)	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)

This module is comprised of 15 ECTS-points. Attendance time is 18 contact hours per week. Total time, including self-directed studies, is about 450 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with module WP 2 (lectures) if selected as a major subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Students are involved in current research projects in inorganic chemistry working groups. Under the guidance of a scientifically qualified supervisor, the students supplement, deepen and apply the methodological and theoretical knowledge from the Bachelor's degree course, as well as new techniques. They are also encouraged to carry out independent scientific work. This includes the planning and development of experiments, their safe and ecological execution, as well as the precise scientific analysis and evaluation of the experiment. In the accompanying seminar, students expand their specialist knowledge of the research topic, present and discuss their own and other current research results from the field of inorganic chemistry.
Qualification goals	Students acquire skills for chemical and physical research. These include • independently conduct scientific literature searches in a targeted manner, and present, identify, and cite

	appropriate papers. • understanding, using, modifying, and applying suitable Instructions and protocols. • to learn and deepen the planning and handling of complex experimental setups (including Schlenk technology, high pressure, distillation, crystallization and chromatography techniques). • recognize and assess safety issues when handling hazardous substances • make decisions and critically interpret and evaluate experimental data. • assess, present and discuss research results.
Module assessments	Lab report or lab assessment
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Klapötke, PD Dr. Jörg Stierstorfer
Language	German/English
Additional information	

Module WP 2: Major Inorganic Chemistry (Lectures)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (optional courses)	Rotation	Contact Hours	Self-directed Studies	ECTS
Colloquium	WP 2.1 Expert colloquium in Inorganic Chemistry (T1ZI)	WiSe/ SoSe	45h (3 SWS)	135 h	(6)
Lecture	WP 2.2.1 (= WP 21) Modern Inorganic Main-group Chemistry (T1ID)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 2.2.2 (= WP 22) Solid State Chemistry II (T1IE)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 2.2.3 (= WP 23) Coordination Chemistry II (T1IF)	WiSe/	30 h (2 SWS)	60 h	(3)
Lecture	WP 2.2.4 (= WP 24) Spectroscopic Methods (T1IG)	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 2.2.5 (= WP 25) Special Lectures in Inorganic Chemistry (T1IZ)	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 2.2.6 (= WP 79) Modern NMR-Spectroscopy in Liquids (T1IG-2)	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 2.2.8 (= WP 87) Chemistry of High-Energy Materials (T1IZ-6)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 2.2.9 (= WP 88) Intermetallic Phases (T1IZ-7)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 2.2.10 (= WP 89) Principles of Nanochemistry and Functional Materials (T1IZ-8)	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 2.2.11 (= WP 103) Daily Chemistry (T1IZ-14)	WiSe/	30 h (2 SWS)	60 h	(3)

This module is comprised of 15 ECTS-points. Attendance time is 9 contact hours per week. Total time, including self-directed studies, is about 450 h.

Type of the Module	Optional module with optional and compulsory courses.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with module WP 1 (lab course) if selected as a major subject. In this module three of the courses WP 2.2.1 to

	WP 2.2.11 must be elected.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 or 2 semesters.
Content	This module deepens expertise in the field of inorganic chemistry through the selection of three specialization courses. In the compulsory colloquium, expert talks are given by visiting professors or young scientists on common or current topics in inorganic chemistry.
Qualification goals	In the lectures, students are introduced to modern topics of current inorganic chemistry. In doing so, they expand their previously acquired knowledge with current and specialized technical information. The information is to be integrated into existing knowledge in order to formulate and discuss scientific questions. The acquired theoretical knowledge should be applied in the practical part of the course.
Module assessment	Exam or oral examination
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Klapötke
Language	German/English
Additional information	The oral module examination on three selected lectures takes place 4 times a year. Registration takes place at the examination office and is obligatory.

WP 2.1: Expert colloquium in Inorganic Chemistry (T1ZI)

Type of the submodule	Compulsory course.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	None
Entry requirements	None
Study pathway level	Between semester 1 and 3
Duration	This part of the module spans 1 semester.
Content	In the inorganic chemistry colloquium, internal and external experts present current research results from inorganic chemistry. In the follow-up to these scientific lectures, the students deal with the current specialist literature. The students have to post-process the scientific talks including literature search.
Qualification goals	After successful participation, students should be able to: • Learning different scientific presentation styles and possibilities. • Placing the content of a scientific presentation in the wider context of the subject of inorganic chemistry. • Consolidation of previously learned content through concrete research and application examples. • Qualified reproduction of the essential contents of a presentation to colleagues.
Module assessment	s. WP 2
Grading	-
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Klapötke
Language	German/English
Additional information	When registering for the module examination, 5 colloquia in the IC must be attended and indicated.

Module WP 3: Major Organic Chemistry (Lab Course)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lab Course	WP 3.1 Advanced Research Lab Course in Organic Chemistry (T1OA)	WiSe/ SoSe	240h (16 SWS)	120 h	(12)
Seminar	WP 3.2 Seminar in Organic Chemistry (T1OC)	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)

This module is comprised of 15 ECTS-points. Attendance time is 18 contact hours per week. Total time, including self-directed studies, is about 450 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with module WP 4 (lectures) if selected as a major subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Students are involved in current research projects in an organic chemistry working group. Under the guidance of a scientifically qualified supervisor, students supplement and deepen their methodological and theoretical knowledge from the Bachelor's degree course during the **internship** and are also encouraged to work independently in a scientific manner. In the **accompanying seminar**, students expand their specialist knowledge of the research topic and present and discuss their own research results.
Qualification goals	Students acquire skills for work in research, e.g.: • independent, target-oriented literature search • transfer of theoretical knowledge to practical applications • planning and execution of complex experimental set-ups • recognition and assess safety issues when handling

	hazardous substances • decision making and critical interpretation and evaluation of experimental data • assess, present and discuss research results.
Module assessments	Lab report or lab assessment
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Hendrik Zipse
Language	German/English
Additional information	

Module WP 4: Major Organic Chemistry (Lectures)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (optional courses)	Rotation	Contact Hours	Self-directed Studies	ECTS
Colloquium	WP 4.1 Expert colloquium in Organic Chemistry(T1ZO)	WiSe/ SoSe	45h (3 SWS)	135 h	(6)
Lecture	WP 4.2.1 (=WP 26) Physical-Organic Chemistry (T1OD)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 4.2.2 (=WP 27) The Chemistry of Heterocycles (T1OE)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 4.2.3 (=WP28) Modern Synthetic Methods (T1OF)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 4.2.4 (=WP 29) Synthesis Planning (T1OG)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 4.2.5 (=WP 30) Glycochemistry (T1OH)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 4.2.6 (=WP 31) Radicals in Chemistry and Biology (T1OI)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 4.2.7 (=WP 32) Lecture in Chemical Biology (T1OJ)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 4.2.8 (=WP 33) Advanced Topics in Chemical Biology (T1OK)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 4.2.9 (=WP 34) Special Lecture in Organic Chemistry (T1OZ)	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 4.2.10 (=WP 92) Supramolecular Chemistry (T1OS)	WiSe/	30 h (2 SWS)	60 h	(3)
Lecture	WP 4.2.11 (=WP 95) Organic and Bio-inspired Molecular Systems (T1OM)	WiSe/	30 h (2 SWS)	60 h	(3)
Lecture	WP 4.2.12 (=WP 108) Multi-Dimensional NMR Spectroscopy for Structure Elucidation of Big Molecules (T1OL)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 4.2.13 (=WP 110) Concepts and Tools in Chemical Biology (T1OR)	SoSe/	30 h (2 SWS)	60 h	(3)

This module is comprised of 15 ECTS-points. Attendance time is 9 contact hours per week. Total time, including self-directed studies, is about 450 h.

Type of the Module	Optional module with optional and compulsory

	courses.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with module WP 3 (lab course) if selected as a major subject. In this module three of the courses WP 4.2.1 to WP 4.2.13 must be elected.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 or 2 semesters.
Content	This module deepens special technical knowledge in the field of organic chemistry through the selection of three specialization courses. In the compulsory organic chemistry colloquium, internal and external experts present current research results from organic chemistry. In the follow-up to these scientific lectures, students deal with the current specialist literature.
Qualification goals	In the lectures, students are introduced to modern topics in current organic chemistry. In doing so, they expand their previously acquired knowledge with current and specialized technical information. The information is to be integrated into existing knowledge in order to formulate and discuss scientific questions. The acquired theoretical knowledge should be applied in the practical part of the course.
Module assessment	Exam or oral examination
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Hendrik Zipse
Language	German/English
Additional information	The oral module examination on three selected lectures takes place 4 times a year. Registration takes place at the examination office and is obligatory.

WP 4.1: Expert colloquium in Organic Chemistry (T1ZO)

Type of the submodule	Compulsory course.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	None
Entry requirements	None
Study pathway level	Between semester 1 and 3
Duration	This part of the module spans 1 semester.
Content	In the organic chemistry colloquium, internal and external experts present current research results from organic chemistry. In the follow-up to these scientific lectures, students deal with the current specialist literature.
Qualification goals	After successful participation, students should be able to: • Classify content from a scientific lecture in the wider context of the subject of organic chemistry. • Reproduce the essential contents of a scientific lecture in a qualified manner.
Module assessment	s. WP 4
Grading	-
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Hendrik Zipse
Language	German/English
Additional information	When registering for the module examination, 5 colloquia in the OC must be attended and indicated.

Module WP 5: Minor Lectures in Structural Biology (T1S1)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (optional courses)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 5.1 Lecture in Structural Biology (T1S1)	WiSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with the modules WP 16 and WP 43, if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	This lecture covers the basic principles of macromolecular crystallography (MX), small-angle X-ray scattering (SAXS) and cryo electron microscopy (cryo-EM) for their application in structural biology. The MX-part covers fundamental principles of macromolecular crystallization, X-ray diffraction, data collection and processing, including phase determination and model building/refinement. The SAXS method is further introduced as a complementary method for the analysis of molecules in solution, especially useful for flexible assemblies. The following parts of the lecture cover the fundamental knowledge and necessary steps to perform single-particle cryo electron microscopy, followed by its extension to cryo electron tomography.
Qualification goals	Students will acquire knowledge of key concepts in structural biology. They should be able to describe and explain the principal steps of solving high-resolution macromolecular structures with MX and cryo-EM, and understand the concepts and information content of solution scattering. Based on the methodologies acquired in the course the students will be able to understand the necessary steps of structural methods and critically compare the advantages of the individual methods to be able to transfer this knowledge to their applicability to

	new questions.
Module assessment	Exam or oral examination
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Beckmann, Prof. Hopfner
Language	English
Additional information	

Module WP 6: Major Physical Chemistry (Lab Course)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lab Course	WP 6.1 Advanced Research Lab Course in Physical Chemistry (T1PA)	WiSe/ SoSe	240h (16 SWS)	120 h	(12)
Seminar	WP 6.2 Seminar in Physical Chemistry (T1PC)	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)

This module is comprised of 15 ECTS-points. Attendance time is 18 contact hours per week. Total time, including self-directed studies, is about 450 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with module WP 41 (lectures) if selected as a major subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Introduction to current topics in physical chemistry by working on a selected scientific project while being integrated into a research group. Development of the required subject and methodological expertise on the level of a scientifically-oriented Master's program. Finding solutions to open scientific questions.
Qualification goals	Independent application of the subject and methodological expertise established within the study program of physical chemistry by addressing scientific problems. Supervised analysis and evaluation of the obtained results with respect to the current literature and state of knowledge. Providing a written report including results and discussion of the findings, considering the current state of knowledge. Qualified presentation of the results.
Module assessments	Lab report or lab assessment
Grading	The module is graded.

Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Frédéric Laquai
Language	German/English
Additional information	

Module WP 7: Major Theoretical Chemistry (Lab Course)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lab Course	WP 7.1 Advanced Research Lab Course in Theoretical Chemistry (T1TA)	WiSe/ SoSe	240h (16 SWS)	120 h	(12)
Seminar	WP 7.2 Seminar in Theoretical Chemistry (T1TC)	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)

This module is comprised of 15 ECTS-points. Attendance time is 18 contact hours per week. Total time, including self-directed studies, is about 450 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with module WP 42 (lectures) if selected as a major subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Students are introduced to current topics in theoretical chemistry by working on a selected scientific project integrated into a research group. Development of the required knowledge on the level of a scientifically oriented master's program, problem solving and testing of solutions to open scientific questions.
Qualification goals	Independent application of the expertise established within the study program of theoretical chemistry by working on scientific problems. Supervised discussion and evaluation of the achieved results with respect to the scientific literature. Writing a report on the results and their discussion considering current knowledge. Qualified presentation of the results.
Module assessments	Lab report or lab assessment
Grading	The module is graded.
Requirements for granting ECTS-	ECTS-points are awarded for passing the exam, which is

Points	allocated to the module.
Responsible person	Prof. Dr. Ochsenfeld, Prof. Dr. Fingerhut
Language	German/English
Additional information	

Module WP 8: Minor Inorganic Chemistry (Lab Course)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lab Course	WP 8.1 Research Lab Course in Inorganic Chemistry (T1IB)	WiSe/ SoSe	150h (10 SWS)	120 h	9

This module is comprised of 9 ECTS-points. Attendance time is 10 contact hours per week. Total time, including self-directed studies, is about 270 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with module WP 44 (lectures) if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Students are involved in current research projects in inorganic chemistry working groups. Under the guidance of a scientifically qualified supervisor, the students supplement, deepen and apply the methodological and theoretical knowledge from the Bachelor's degree course, as well as new techniques. They are also encouraged to carry out independent scientific work. This includes the planning and development of experiments, their safe and ecological execution, as well as the precise scientific analysis and evaluation of the experiment.
Qualification goals	Students acquire skills for chemical and physical research. These include • independently conduct scientific literature searches in a targeted manner, and present, identify, and cite appropriate papers. • understanding, using, modifying, and applying suitable Instructions and protocols. • to learn and deepen the planning and handling of complex experimental setups (including Schlenk technology, high pressure, distillation, crystallization

	and chromatography techniques). • recognize and assess safety issues when handling hazardous substances • make decisions and critically interpret and evaluate experimental data. • assess, present and discuss research results.
Module assessment	Lab report or lab assessment
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Klapötke
Language	German/English
Additional information	

Module WP 9: Minor Organic Chemistry (Lab Course)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lab Course	WP 9.1 Research Lab Course in Organic Chemistry (T1OB)	WiSe/ SoSe	150h (10 SWS)	120 h	9

This module is comprised of 9 ECTS-points. Attendance time is 10 contact hours per week. Total time, including self-directed studies, is about 270 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with module WP 45 (lectures) if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Students are involved in current research projects in an organic chemistry working group. Under the guidance of a scientifically qualified supervisor, students supplement and deepen their methodological and theoretical knowledge from the Bachelor's degree course during the **internship** and are also encouraged to work independently in a scientific manner.
Qualification goals	Students acquire skills for work in research, e.g.: • independent, target-oriented literature search • transfer of theoretical knowledge to practical applications • planning and execution of complex experimental set-ups • recognition and assess safety issues when handling hazardous substances • decision making and critical interpretation and evaluation of experimental data • assess, present and discuss research results.

Module assessment	Lab report or lab assessment
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Hendrik Zipse
Language	German/English

Additional information

Module WP 10 Minor Physical Chemistry (Lab Course)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lab Course	WP 10.1 Research Lab Course in Physical Chemistry (T1PB)	WiSe/ SoSe	150h (10 SWS)	120 h	9

This module is comprised of 9 ECTS-points. Attendance time is 10 contact hours per week. Total time, including self-directed studies, is about 270 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with module WP 46 (lectures) if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Introduction to current topics in physical chemistry by working on a selected scientific project while being integrated into a research group. Development of the required subject and methodological expertise on the level of a scientifically-oriented Master's program. Finding solutions to open scientific questions.
Qualification goals	Independent application of the subject and methodological expertise established within the study program of physical chemistry by addressing scientific problems. Supervised analysis and evaluation of the obtained results with respect to the current literature and state of knowledge. Providing a written report including results and discussion of the findings, considering the current state of knowledge. Qualified presentation of the results.
Module assessment	Lab report or lab assessment
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.

Responsible person	Prof. Dr. Frédéric Laquai
Language	German/English
Additional information	

Module WP 11: Minor Theoretical Chemistry (Lab Course)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lab Course	WP 11.1 Research Lab Course in Theoretical Chemistry (T1TB)	WiSe/ SoSe	150h (10 SWS)	120 h	9

This module is comprised of 9 ECTS-points. Attendance time is 10 contact hours per week. Total time, including self-directed studies, is about 270.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with module WP 47 (lectures) if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Students are introduced to current topics in theoretical chemistry by working on a selected scientific project integrated into a research group. Development of the required knowledge on the level of a scientifically oriented master's program, problem solving and testing of solutions to open scientific questions.
Qualification goals	Independent application of the expertise established within the study program of theoretical chemistry by working on scientific problems. Supervised discussion and evaluation of the achieved results with respect to the scientific literature. Writing a report on the results and their discussion considering current knowledge. Qualified presentation of the results.
Module assessment	Lab report or lab assessment
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Ochsenfeld, Prof. Dr. Fingerhut

Language	German/English

Additional information

Module WP 12: Minor Chemical Biology (Lab Course)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lab Course	WP 12.1 Research Lab Course in Chemical Biology (T1OX)	WiSe	150h (10 SWS)	120 h	9

This module is comprised of 9 ECTS-points. Attendance time is 10 contact hours per week. Total time, including self-directed studies, is about 270 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with module WP 48 (lectures) if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Students are integrated into current research projects in a working group in biological chemistry. Under the guidance of a scientifically qualified supervisor, students supplement and deepen the methodological and theoretical knowledge gained in their bachelor's degree in the **practical training**, and are also encouraged to work independently on scientific projects.
Qualification goals	Students acquire competences for research work. These would be • Independently carry out scientific literature research in a targeted manner • Learn how to plan and handle complex experimental set-ups • Recognise and assess safety issues when handling hazardous biological and chemical substances • Make decisions and critically interpret and evaluate experimental data • assess, present and discuss research results.

Module assessment	Lab report or lab assessment
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Thomas Carell
Language	German/English

Additional information

Module WP 13: Minor Biochemistry (Lab Course)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lab Course	WP 13.1 Research Lab Course in Biochemistry (T1YB)	WiSe/ SoSe	150h (10 SWS)	120 h	9

This module is comprised of 9 ECTS-points. Attendance time is 10 contact hours per week. Total time, including self-directed studies, is about 270 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with module WP 49 (lectures) if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Students work in a research group from the field of Biochemistry. Directly supervised by a professional scientist student get involved in an ongoing research project. During this **practical part** they learn and apply modern biochemical techniques, which comprise state of the art biochemical methods used in the day-to-day research of the lab. Thereby the students complement and deepen their methodical skills and theoretical knowledge. Students plan and execute scientific experiments independently.
Qualification goals	Students acquire competence to work in an actual research lab on an ongoing project. They acquire the expertise to do independent, target-oriented literature search followed by transfer of theoretical knowledge to practical applications. Students will be competent in planning and execution of complex biochemical experimental set-ups and can recognize and estimate related security questions when handling hazardous material. They gain the expertise of independent decision making and critical interpretation/evaluation of experimental data. Students acquire experience competence in presentation and discussion of their

	research data with other scientists.
Module assessment	Written report on or assessment of the practical laboratory course or written report on and assessment of the practical laboratory course
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Responsible person	Prof. Roland Beckmann
Language	English
Additional information	

Module WP 14: Minor Molecular and Cellular Genetics (Lab Course)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lab Course	WP 14.1 Research Lab Course in Molecular and Cellular Genetics (T1GB)	WiSe/ SoSe	150h (10 SWS)	120 h	9

This module is comprised of 9 ECTS-points. Attendance time is 10 contact hours per week. Total time, including self-directed studies, is about 270 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with module WP 50 (lectures) if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	The students carry out state-of-the-art biochemical and cell biological techniques such as RNAi in tissue culture cells, GFP-tagging of proteins by homologous recombination in eukaryotic cells, determination of their sub-cellular localization using fluorescence microscopy. They reconstitute macromolecular complexes in vitro and apply the CRISPR-Cas technology in cultured eukaryotic cells.
Qualification goals	Students acquire practical expertise in the independent application and interpretation of modern biochemical and cell biological methods. They gain competence in the application of genetic methods, such as CRISPR-Cas gene editing, and are competent in performing, evaluating and interpreting experiments with quantitative read-out such as in vitro reconstitution of protein complexes and fluorescence microscopy.
Module assessment	Written report on or assessment of the practical laboratory course or written report on and assessment of the practical laboratory course
Grading	The module is graded.

Requirements for granting ECTS-Points	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Responsible person	Prof. Beckmann
Language	English
Additional information	

Module WP 15: Specific Supplement to Chemistry (Lab Course)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lab Course	WP 15.1 Lab Course in Specific Supplement to Chemistry	WiSe/ SoSe	150h (10 SWS)	120 h	9

This module is comprised of 9 ECTS-points. Attendance time is 10 contact hours per week. Total time, including self-directed studies, is about 270 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with module WP 51 (lectures) if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	This module introduces students to current research issues in areas close to and distant from chemistry, such as materials science, patent law, or pharmacology and toxicology, by working on selected scientific projects and integrating students into a research or working group. Preparation of the necessary basics at the level of a scientifically oriented Master's degree course, development of possible solutions to open scientific questions.
Qualification goals	Independent implementation of the professional competence acquired during the course of study in the processing of scientific questions, classification of own scientific results under guidance in the current literature and structured written presentation of the results with reference to the scientific environment. Qualified presentation of the results.
Module assessment	Lab report or lab assessment
Grading	The module is graded.
Requirements for granting ECTS-	ECTS-points are awarded for passing the exam, which is

Points	allocated to the module.
Responsible person	Dean of Studies
Language	German/English
Additional information	The offered courses are subject to change. The current selection can be found in the LSF.

Module WP 15a: Pharmacology and Toxicology for Natural Scientists (Lab Course)

Degree programme	Master's degree: Chemistry

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lab Course	WP 15.1a Research laboratory internship: "Principles of Human Disease and Treatment"	WiSe	150h (10 SWS)	120 h	9

This module is comprised of 9 ECTS-points. Attendance time is 10 contact hours per week. Total time, including self-directed studies, is about 270 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	This module is associated with module WP 51a (lectures) if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	The students should learn the basics of pharmacology and toxicology. • Basics of pharmacokinetics (and pharmacodynamics • Presentation of the pharmacology of the most important organ systems and individual drug groups • Basics of toxicology, introduction of important toxic substances, poisonings and their treatment.
Qualification goals	The aim of the course is to master the basics of pharmacology and toxicology and to be able to transfer knowledge to current problems.
Module assessment	Lab report or lab assessment
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Ingrid Boekhoff, Dr. Andreas Breit und weitere Mitarbeiter/Innen des Walther-Straub-Institutes für

	Pharmakologie und Toxikologie
Language	German/English
Additional information	The individual research laboratory internships are arranged by teaching staff members of different groups of the Walther-Straub-Institute according to current research topics. Students are required to work independently under close supervision of an instructor and will learn specialized techniques used in the corresponding research field. **Moodle course:** https://moodle.lmu.de/course/view.php?id=11319#section-6

Module WP 16: Minor Lectures in Structural Biology (T1S2)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Seminar	WP 16.1 Advances Topics in Structural Biology (T1S2)	SoSe	30 h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with modules WP 5 and WP 43, if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	This lecture extends concepts used in structural biology and their application. The course covers advanced principles of scattering and diffraction and in addition, knowledge of protein building blocks, protein folds and ribonucleic acid-protein complexes will be provided. Based on selected topics, the students will learn about the role and application of structural biology methods in more detail, e.g. in understanding biological processes on molecular basis or in the process of pharmaceutical drug discovery. The students will prepare own presentations based on selected publications in the field of structural biology. Each student is expected to give a broad introduction to the scientific focus of the respective publication, followed by a presentation of the findings with emphasis on a critical discussion of the methods, results, quality, and the discussion.
Qualification goals	Students will acquire knowledge about advanced topics of three-dimensional macromolecular structure determination of proteins and nucleic acids, especially with respect to combinatorial/orthogonal methods and their individual advantages and disadvantages. The students will be able to present and critically discuss

	publications in the field of structural biology. Based on this knowledge and training, the students will be able to recognize the relevance of publications, which is important in their careers as structural biologists. In addition, the detailed in-depth analysis of structural biology publications will enable them to develop own approaches in future projects.
Module assessment	Written exam or oral examination
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Responsible person	Prof. Beckmann, Prof Hopfner
Language	English
Additional information	

Module WP 17: Minor Physics: Atomic and Molecular Physics

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 17.1 Lecture in Atomic and Molecular Physics (E4.1)	SoSe	60h (4 SWS)	120 h	(6)
Tutorial	WP 17.2 Tutorial in Atomic and Molecular Physics (E4.2)	SoSe	30 h (2 SWS)	60 h	(3)

This module is comprised of 9 ECTS-points. Attendance time is 6 contact hours per week. Total time, including self-directed studies, is about 270 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	Bachelor's programme Physics
Elective guidelines	This module is associated with modules WP 52 and WP 53, if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Concepts and experimental methods of atomic and molecular physics: Planckian radiation, Bohr-Sommerfeld quantum mechanics, H-atom, multi-electron atoms, atoms in external fields, spectroscopy, X-rays, molecular physics.
Qualification goals	The main learning objectives are knowledge and understanding of the above learning content, the ability to apply it and link it together. In addition, familiarity with methods of experimental physics and the ability to interpret, verify or falsify experimental results are general learning objectives. Students should become aware of the connection to phenomena in nature and to current research.
Module assessment	Two exams
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.

Responsible person	Dean of Studies in Physics
Language	German
Additional information	

Module WP 18: Minor Computer Sciences: Computer Science: Systems and Applications

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 18.1 Lecture Computer Science: Systems and Applications	SoSe	30h (3 SWS)	45 h	(3)
Tutorial	WP 18.2 Tutorial Computer Science: Systems and Applications	SoSe	45 h (2 SWS)	60 h	(3)

This module is comprised of 6 ECTS-points. Attendance time is 5 contact hours per week. Total time, including self-directed studies, is about 180 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	Minor subject in Computer Science to the extent of 60 ECTS credits for Bachelor's degree programs
Elective guidelines	This module is associated with module WP 56, if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Together with the lecture "Introduction to Computer Science: Programming and Software Development", this course is the basis in Computer Science as a minor subject. It therefore provides a broad introduction to the most important topics in computer science from a system-oriented and application-oriented perspective in order to create the basis for understanding more advanced topics from these subject areas: • Basics of computer hardware (von Neumann model, multi-core processors, working and permanent memory, etc.) • Basics of operating systems (process model, synchronization of concurrent processes, memory management, etc.) • Basics of computer networks (ISO/OSI model, in particular media access, routing, etc. and TCP/IP) • Basics of database systems (relational model, relational

	algebra, SQL, database design, etc.) • Basics of data mining (classification, cluster analysis, outlier handling, association rules, etc.) The module consists of a lecture and exercises in small groups. The content discussed in the lecture is practiced in the practical part using practical applications.
Qualification goals	Knowledge of the most important fundamentals of computer science from a system-oriented and application-oriented perspective. The aim of the course is to convey a basic understanding of the most important processes in the computer system from the hardware perspective as well as from the perspective of the operating system and the system software (including communication via computer networks) at a suitable scientific abstraction level. Important basic knowledge from the application areas of database systems and data mining should also be taught at a university level.
Module assessment	Exam or oral examination
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Thomas Seidl
Language	German
Additional information	

Module WP 19: Minor Computer Sciences: Computer Architecture

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 19.1 Lecture in Computer Architecture	SoSe	45h (3 SWS)	45 h	(3)
Tutorial	WP 19.2 Tutorial in Computer Architecture	SoSe	30 h (2 SWS)	60 h	(3)

This module is comprised of 6 ECTS-points. Attendance time is 5 contact hours per week. Total time, including self-directed studies, is about 180 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	Minor subject in Computer Science to the extent of 60 ECTS credits for Bachelor's degree programs
Elective guidelines	This module is associated with module WP 56, if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	This module provides an overview of the binary representation of information on computers, as well as the architecture and operation of modern computers according to von Neumann. The classical components of a computer are introduced. Their interaction is first dealt with theoretically and then practically using a machine language and an assembly language. It is shown how simple circuits and also more complex components of a processor and memory can be systematically designed and optimized with the help of Boolean algebra. The following are covered in detail: • Methods for binary representation of information in the computer, • Realization of memory using switching mechanisms as well as optical and magnetic media, • Boolean algebra for the design of circuits, • Design and optimization of simple logic circuits in processors,

	• Components of the von Neumann architecture and their optimization, • machine-oriented assembler programming, • the interaction of the lower levels of a computer, as well as • parallelization and multiprocessor systems.
Qualification goals	The aim of the module is to provide students with a detailed understanding of von Neumann's computer architecture, binary information representation and memory realization. They should learn to design and optimize logical circuits independently using Boolean algebra. The use of machine and assembly languages should deepen the aforementioned concepts. Students should thus learn to understand how the lower levels of a computer work and the effects of machine architecture on the execution of programs in higher languages.
Module assessment	Exam or oral examination
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Claudia Linnhoff-Popien
Language	German
Additional information	

Module WP 20: Minor Computer Sciences: Programming and Modeling

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 4.1 Lecture in Programming and Modeling	SoSe	45h (3 SWS)	45 h	(3)
Tutorial	WP 4.2 Tutorial in Programming and Modeling	SoSe	30 h (2 SWS)	60 h	(3)

This module is comprised of 6 ECTS-points. Attendance time is 5 contact hours per week. Total time, including self-directed studies, is about 180.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	Minor subject in Computer Science to the extent of 60 ECTS credits for Bachelor's degree programs
Elective guidelines	This module is associated with module WP 56, if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	This module introduces the basic principles of functional programming and data modeling. Emphasis is placed on conceptual clarity and a precise theoretical foundation using formal methods. The topics include, for example • The concept of function and basic types, • Recursion and termination, • User-defined data types, • polymorphism, type classes, modules, • higher order functions and currying, • Types, type checking, type inference, • pattern matching, • Delayed evaluation, strictness • Inputs and outputs and other side effects.
Qualification goals	The module aims to teach the following:

	• Mastery of basic concepts of (general as well as declarative) programming. • Ability to program small algorithms functionally and to evaluate them in comparison with imperative solutions. • Preparation for the future development of programming languages.
Module assessment	Exam or oral examination
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Sven Stickroth
Language	German
Additional information	Prior study of the module “Introduction to Programming” is recommended.

Module WP 21: Specialisation in Inorganic Chemistry - Modern Inorganic Main-group Chemistry (T1ID)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 21 Modern Inorganic Main-group Chemistry (T1ID)	SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	The lecture is divided into a) a systematics of reaction mechanisms in inorganic molecular chemistry and b) the halogen, chalcogen and pnictogen molecular compounds of the main group elements. a) Isomerizations, rearrangements, pseudorotations, nucleophilic and electrophilic substitution reactions, radical substitution reactions, energy-generating reactions, energetic considerations, orbital symmetry, concerted and multistep reactions, Substitution reactions on triple- and quadruple-coordinated boron compounds, substitution reactions on silicon, nitrogen and phosphorus centers, chloramines, substitution reactions on oxygen and sulfur centers, substitution reactions on chloric acids, naming reactions in inorganic chemistry. b) Noble gas compounds (xenon fluorides, oxides, oxo-fluorides), chemistry of sulphur nitrides, halogen oxides, sulphur oxides and suboxides, phosphorus halides, chalcogenides and binary P,N compounds, molecular carbon and silicon halides, chalcogenides

	and pnictides, aromaticity in inorganic chemistry, halogen, chalcogen and pnictogen compounds of boron and aluminium. In all cases, systematic correlations are shown and the synthesis, structure, binding ratios and reaction behavior are discussed using individual compounds as examples.
Qualification goals	After attending the module courses, students will be able to provide a systematic overview of the reaction mechanisms operating in inorganic chemistry and present a coherent overall picture of halogen, chalcogen and pnictogen molecular compounds of the main group elements. Students will be equipped with the necessary tools to work independently on mechanistic, conceptual and synthetic problems in the field of inorganic molecular chemistry.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Konstantin Karaghiosoff
Language	German/English
Additional information	Weblink: http://www.cup.lmu.de/ac/karaghiosoff/

Module WP 22: Specialisation in Inorganic Chemistry - Solid State Chemistry (T1IE)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 22.1 Solid State Chemistry II (T1IE)	SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Chemical bonding in solids, orbitals and energy bands, band structure methods and tools, Peierls-distortion with examples, electron-gas theories, the metallic state, intrinsic and doped semiconductors, Mott-insulators, cooperative magnetism, Pauli-paramagnetism, magnetoresistance, ferromagnetic half-metals, superconducting materials, basics of the BCS theory, metal-rich compounds, suboxides, metal clusters.
Qualification goals	After attending the lecture, students will be able to identify solid materials as metals, semiconductors, insulators or magnetic materials based on their electronic structures. They will be able to analyze band structures of simple solids and classify magnetic phenomena. They have an overview of superconducting materials and understand the basics of BCS theory. They are able to recognize and evaluate special chemical bonding situations in solids.
Module assessment	Exam or oral examination
Grading	Passed/ not passed

Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. D. Johrendt
Language	German/English
Additional information	Moodle-Webpage of the lecture: https://moodle.lmu.de/course/view.php?id=11141

Module WP 23: Specialisation in Inorganic Chemistry – Coordination Chemistry II: (Bio)Inorganic Reaction Mechanisms (T1IF)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 23.1 (Bio)Inorganic Reaction Mechanisms (T1IF)	WiSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	• Rate Laws. • Activation Parameters, Pressure-dependent reaction kinetics and activation volume, volume profile analysis. • Experimental Techniques dependent on reaction rate (e.g., stopped-flow, relaxation methods). • Solvent Exchange, Ligand Substitution. • Control of Steric and Electronic complex properties through ligand design and their effects on kinetic lability and substitution mechanism. • Substitution Behavior of square-planar and octahedral complexes (e.g., behavior of Pt(II) anti-tumor complexes, substitution behavior of cobalamin (vitamin B12)). • Activation of Small molecules (e.g., oxygen, superoxide, nitric oxide, carbon dioxide) by metalloenzymes and model complexes.

	• electron transfer reactions: basic principles of inner-sphere, outer-sphere, and proton-coupled electron transfer.
Qualification goals	The students are able to: • formulate rate laws from experimental data and graphically represent the concentration dependence of the rate. • derive kinetic parameters from experimental data and assign reaction mechanisms. • construct the volume profile of a reaction based on the pressure-dependent rate for both forward and reverse reactions. • classify reaction mechanisms and explain them with examples. • explain the kinetic lability or inertness of certain metal centers and/or their complexes based on their electronic and steric properties. • propose suitable technique to determine kinetic parameters in dependence on the rate of the reaction under investigation. • describe stepwise mechanisms of small molecule activation. • apply the principles of inner-sphere electron transfer and/or proton-coupled-electron transfer to the activation of small molecules and catalytic redox transformations.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Ivana Ivanović-Burmazović
Language	German/English
Additional information	Webpage of the lecture: https://moodle.lmu.de/course/view.php?id=18918

Module WP 24: Specialisation in Inorganic Chemistry - Spectroscopic Methods (T1IG)

(This module has been canceled/split)

Module WP 25: Specialisation in Inorganic Chemistry – Special Lectures in Inorganic Chemistry (T1IZ)

(This module has been canceled/split)

Module WP 78: Specialisation in Inorganic Chemistry - Modern NMR-Spectroscopy in the Solid-State (T1IG-1)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (optional courses)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 78.1a Solid-state NMR of nuclei with spin $I = ½$ (T1IG-1a)	WiSe	15h (1 SWS)	30 h	(1,5)
Lecture	WP 78.1b Solid-state NMR of quadrupolar nuclei ($I > ½$) (T1IG-1b)	SoSe	15h (1 SWS)	30 h	(1,5)

This module is comprised of 3 ECTS-points. Attendance time is 1 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 2 semesters
Content	Nuclear Magnetic Resonance (NMR) spectroscopy is one of the most important analytical methods in modern chemistry. Many questions can be answered by using solution NMR (also known as "high-resolution" NMR). However, there is also scientific interest in the investigation of solid materials using NMR spectroscopy, for example for poorly soluble compounds or for materials that lose their characteristic properties in solution (e.g. glasses, ceramics, zeolites or polymers). Based on the principles of solution NMR, the lecture introduces basic concepts and methods of solid-state NMR (FK-NMR) and illustrates them with various applications. Topics include: Basic principles of NMR spectroscopy (Bloch equations, effect of RF pulses, relaxation); anisotropic interactions in FK-NMR (chemical shift, dipolar coupling, quadrupole interaction); standard

	techniques for the determination of anisotropies (sample rotation, spin decoupling); Methods for improving sensitivity (signal averaging, cross-polarization); structure elucidation in solids using NMR (assignment of coordination environments via the chemical shift, distance measurements using REDOR, assessment of electronic symmetry via the quadrupole interaction).
Qualification goals	The students should acquire basic knowledge in theory and practice of solid-state NMR spectroscopy of quadrupolar nuclei. The students should be enabled to analyse solid-state NMR spectra of quadrupolar nuclei of medium complexity, to identify possible applications of quadrupolar NMR in research, and to critically evaluate solid-state NMR studies involving quadrupolar nuclei which have been published in the literature.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Dr. Thomas Bräuniger
Language	German/English
Additional information	Webpage of the lecture: http://www.cup.lmu.de/ac/braeuniger/

Module WP 79: Specialisation in Inorganic Chemistry - Modern NMR-Spectroscopy in Liquids (T1IG-2)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (optional courses)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 79.1a Modern NMR-Spectroscopy in Liquids, part 1 (T1IG-2a)	WiSe	15h (1 SWS)	30 h	(1,5)
Lecture	WP 79.1b Modern NMR-Spectroscopy in Liquids, part 2 (T1IG-2b)	SoSe	15h (1 SWS)	30 h	(1,5)

This module is comprised of 3 ECTS-points. Attendance time is 1 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 2 semesters
Content	Main topics are a) a short introduction into the principles of 1D NMR spectroscopy and the description and mode of operation of pulse sequences, b) important principles and 1D pulse sequences for the observation of ^{1}H, ^{13}C and in particular of hetero nuclei, c) basics of 2D NMR spectroscopy and d) important strategies and 2D pulse sequences used for structure elucidation of molecules. • Properties of the nuclei, nuclei in a magneti8c field, energy levels, populations, selection rules, single and multiple quantum transitions, magnetization, vector description, excitation, relaxation, relaxation times and mechanisms, magnetic interaction, coupling, first order and high order spin systems, strongly and weakly coupled systems, subspectral analysis, simulation of NMR spectra. • Basic pulse sequences, description of pulse sequences,

	FID-management, zero-filling, line-broadening, line-narrowing, measurement of relaxation times, double resonance experiments, selective and broadband decoupling, spin-tickling, NOE-effect, measurement of the NOE, gated decoupling, inverse gated decoupling, Hahn echo, SPT experiments, INEPT, DEPT, NMR spectroscopy of main group elements, NMR spectroscopy of metals, 1D-INADEQUATE experiments, suppression of solvent signals. • Structure of a 2D NMR experiment, encoding of the information in the second dimension, fields of application. • Heteronuclear and homonuclear J-resolved NMR spectroscopy, separation of heteronuclear and homonuclear scalar coupling, shift correlated 2D NMR spectroscopy, HETCOR, COSY, different types of COSY experiments (LR-COSY, DQF-COSY), TOCSY, inverse hetero-correlated 2D NMR spectroscopy, HMQC, HMBC, HSQC, 2D exchange spectroscopy, NOESY, EXSY, special experiments (2D-INADEQUATE, DOSY), field gradient methods.
Qualification goals	The lecture should give an overview on modern 1D and 2D pulse sequences and experiments and show the possible fields of application as well as the advantages of the different methods with respect to their application for structure determination in solution. With the help of the knowledge acquired in this lecture the students should be able to effectively apply 1D and 2D NMR spectroscopy in their own scientific research as well as later in their professional career. In particular students should be able, depending on the specific problem, to choose the adequate NMR experiment, to estimate reasonable parameters for the measurement, to adequately handle the obtained experimental data according to the specific problem and to extract from the data the relevant information.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Konstantin Karaghiosoff
Language	German/English
Additional information	The lecture is spread over 2 semesters (1 SWS each). Webpage of the lecture: http://www.cup.uni-muenchen.de/ac/karaghiosoff/homepage/nmr.html

Module WP 82: Specialisation in Inorganic Chemistry – Modern Inorganic Main-group Chemistry (T1IZ-1)

(This module is no longer available.)

Module WP 87: Specialisation in Inorganic Chemistry – Chemistry of High-Energy Materials (T1IZ-6)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (optional courses)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 87.1 Chemistry of High-Energy Materials I (T1IZ-6)	WiSe	30 h (2 SWS)	60 h	(3)

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester
Content	The module provides an introduction and overview of the chemistry of energetic materials: • historical overview • classification: explosives (primary, secondary), propellant (charges, rocket), pyrotechnics • primary explosives (thermodynamics, properties, synthesis, environmental issues, performance, uses) • secondary explosives (thermodynamics, properties, synthesis, environmental issues, performance, uses) • pyrotechnics (smoke generators, flares) • sensitivity (friction, impact, electrostatic, heat) • theory of energetic performance parameters (detonation velocity, detonation pressure, heat of explosion etc.) • computational methods for prediction of energetic performance (Gaussian, EXPLO5, CHEETAH)

	• safety (handling, storage, testing) • current trends in energetic material research (molecular design, 3-D printing, nano-EMs, EMOFs, thermobaric)
Qualification goals	After participating in this module, students will be able to describe key milestones in the development of various explosives and evaluate their contributions to the advancement of the field of energetic materials. They will be able to identify and classify explosives. Furthermore, they will be able to describe and explain the synthetic preparation of important examples of energetic materials (EMs) both in the laboratory and on an industrial scale. Students will be capable of defining, reproducing and deriving the most important energetic performance parameters, such as detonation velocity, or heat of explosion, and describe in detail how such values can be determined experimentally. They will be proficient in using programs like EXPLO5, Gaussian, and CHEETAH 2.0 to predict the aforementioned energetic performance parameters and interpret the resulting values. Students will be able to identify, explain, and evaluate relevant environmental aspects related to the production, application, and post-processing of EMs. They will be able to describe methods for testing the sensitivity of EMs and evaluate and interpret the results, particularly in relation to a specific EM. They will be capable of outlining and explaining key aspects of the safe handling of EMs and applying this knowledge in planning the handling of explosives. Students will recognize current trends in EM research and will be able to evaluate, critically analyze, and describe these trends.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Thomas M. Klapötke
Language	English
Additional information	Link to the Webpage of the lecture: http://www.hedm.cup.uni-muenchen.de/index.html

Module WP 88: Specialisation in Inorganic Chemistry – Intermetallic Phases (T1IZ-7)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (optional courses)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 88.1 Intermetallic Phases (T1IZ-7)	SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	This lecture provides a broad basic knowledge on the chemistry of intermetallic phases. Besides the different intermetallic systems which are defined by the dominating interatomic interactions, structural features and theoretical concepts will be presented which are important in order to develop an understanding for the electronic and geometric parameters conducting the phase formation and the diversity of intermetallic chemistry. Understanding for the basic concepts will be exercised on appropriately chosen examples. Also synthesis and preparation of intermetallic phases will be addressed, and the thermodynamical principles of phase formation will be presented on the basis of binary phase diagrams and the analytical techniques connected therewith. Intrinsically intermetallic features, such as e.g. quasicrystallinity, entropy-stabilised phase formation, will be addressed, as well as the importance of intermetallics in terms of materials science. The point of contact with other chemical fields such as covalent molecular or ionic chemistry are made clear and presented on numerous examples. Exercises will be provided in order to deepen the new knowledge and as a preparation for the

	final exam.
Qualification goals	On the basis of the Bachelor lectures on inorganic chemistry, the students remember basic principles such as dense sphere packings, simple electron counting rules, crystal structure description, symmetry, thermodynamics and electronic structures in solids. This enables a new understanding of the principles of phase formation of Zintl, Hume-Rothery and Frank-Kasper phases as basic and most important principal intermetallic phase systems. The students evaluate their individual features and gain acquaintance with new concepts. For the understanding of practical aspects of synthesis and preparation of intermetallic compounds and alloy systems, which in part in based on experiments the students have performed in the AC2 lab course, the principles of binary phase diagrams (melting diagrams) are presented. Their practical benefit for metallurgy will be evaluated on the basis of theoretical concepts and on the hand of many practical examples. Aspects of materials science of intermetallic systems will be presented, which enables the students to evaluate the application range of intermetallics and alloys in comparison to other materials. Modern aspects of intermetallic structural chemistry such as quasicrystalline systems or materials stabilised by high entropic effects are presented on a basic theoretical level as well as on the hand of numerous examples from application, so that the students learn to evaluate their unique selling points.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	PD Dr. C. Hoch
Language	German/English
Additional information	As a possible alternative, this lecture will be presented in teamwork together with Prof. Dr.-Ing. Caroline Röhr (University of Freiburg) and Dr. Stefanie Gärtner (University of Regensburg) in the form of a hybrid lecture with online parts. All teaching material will be provided to the participants in electronic form.

Module WP 89: Specialisation in Inorganic Chemistry – Principles of Nanochemistry and Functional Materials (T1IZ-8)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (optional courses)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 89.1a Functional Materials (T1IZ-8a)	SoSe	15h (1 SWS)	30 h	(1,5)
Lecture	WP 89.1b Principles of Nanochemistry (T1IZ-8b)	WiSe	15h (1 SWS)	30 h	(1,5)

This module is comprised of 3 ECTS-points. Attendance time is 1 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 2 semesters
Content	The course „Functional Materials" conceptually draws on the courses solid-state chemistry I and II on the bachelor and master level, respectively, and is designed to give an overview of selected topics in modern materials and solid-state chemistry. The course aims at providing a systematic physico-chemical basis of important classes of materials, and at highlighting their application potential based on selected examples. Emphasis is placed on modern inorganic, organic and hybrid materials systems at the intersection between basic and applied research, and on analyzing their structure-property-function relationships. Content: The lecture is divided into three main topics (carbon-based materials, porous materials, photonic materials), each discussing different representatives (e.g. fullerenes, carbon nanotubes, graphene; metal-organic and covalent organic frameworks, mesoporous materials; 1D, 2D and 3D photonic crystals). Physical properties and analytical methods (e.g. concepts of structure and bonding, porosity and surface determination, optical properties of photonic

	crystals) as well as fields of application (e.g. energy conversion, gas storage, medicine, electronics, optics) are discussed based on selected examples. The course „Principles of Nanochemistry“ gives an introduction into the concepts and current trends in the emerging field of chemical nanoscience. Although the term „nano“ is ubiquitous, the definition of „nanoscience“ and, in particular, „nanochemistry“, often remains vague. This course therefore aims at providing insights into the concepts, content and current topics of nanochemistry, as well as carving out differences and commonalities with classical chemistry. Emphasis will be placed on distinguishing the current ”nano-hype“ from actual physical phenomena specifically emerging in the nanoworld (e.g. quantum size confinement effects, top-down vs bottom-up nanostructuring methods), and the potential of nanochemistry as a rapidly evolving multidisciplinary field will be critically evaluated. Content: The course is divided into ”concepts of nanochemistry“ (size confinement effects, quantum dots, surface plasmons, surface, shape and reactivity of nanomaterials, self-assembly), ”synthesis of nanostructures“ (nucleation and growth, synthesis of spherical, anisotropic and multi-component nanoparticles), and ”chemical patterning“ (”soft lithography“ and other chemical and physical lithographies, dip-pen nanolithography).
Qualification goals	Functional materials: Students should be able to identify and analyze important trends and properties within the discussed material classes (e.g. structure-property relationships, reactivity), and develop concepts of synthesis planning, characterization and functionality from what they have learned and transfer them to related systems. They should be able to understand, analyze and critically evaluate relevant scientific literature on the discussed material classes. Principles of nanochemistry: Students should be able to understand the concepts and physical principles of nanochemistry (e.g. size quantum effects, nucleation and growth of nanostructures, etc.), explain them using examples and evaluate them in the context of “classical” material chemistry. The students should be familiar with basic experiments for the synthesis and analysis of nanostructures and they should be able to apply, assess and transfer them to other material systems. Students should be able to analyze and critically evaluate relevant literature and use it for their own synthesis and analysis planning.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-	ECTS-points are awarded for passing the exam, which is

Points	allocated to the module.
Responsible person	Prof. Dr. B. Lotsch
Language	German/English
Additional information	Link to the Webpage of the lecture: http://www.cup.uni-muenchen.de/ac/lotsch/teaching.html

Module WP 103: Specialisation in Inorganic Chemistry – Daily Chemistry (T1IZ-14)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (optional courses)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 93 Daily Chemistry (T1IZ-14)	WiSe	30h (2 SWS)	60 h	(3)

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester
Content	Everyday objects, phenomena, cosmetics, nutrition, stimulants, supplements and drugs are discussed in relation to their chemical background. Content from all areas of chemistry (inorganic, organic, physical, biochemical and pharmacological chemistry) is taught and conveyed.
Qualification goals	Students deepen their basic knowledge of chemistry and learn how theoretical knowledge is later applied in industry. Students are encouraged to examine and critically test various areas of chemical applications and products. The benefits for consumers, dangers and also economic and sustainable aspects are taught and discussed. In addition to imparting knowledge, the module primarily serves to revitalize and increase passion and motivation for the field of chemistry.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-	ECTS-points are awarded for passing the exam, which is

Points	allocated to the module.
Responsible person	Dr. Jörg Stierstorfer
Language	German
Additional information	The daily chemistry lecture also includes experimental demonstrations and tests as well as a variety of chemicals for sensory perception.

Module WP 26: Specialisation in Organic Chemistry – Physical-Organic Chemistry (T1OD)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 26.1 Physical-Organic Chemistry (T1OD)	WiSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	• Introducing to a view on organic molecules and their reactions that is based on energetic terms. • By introducing Benson increments, radical stabilization energies and acidity functions for the characterization of very strong acids and bases the fundamental knowledge is acquired, which allows the students to derive relative free energies of reactants, products and intermediates of organic reactions. • The Hammett equation is introduced as a prominent example of a linear free energy relationship, and it is demonstrated how kinetic and thermodynamic dimensions can be linked. • Theories and models of (organic) chemical reactivity, such as More O'Ferrall-Jencks diagrams, the Hammond-Leffler analysis, the reactivity selectivity principle, the Klopman-Salem concept of charge and frontier orbital control, the Curtin-Hammett principle and the Marcus equation are presented and their scope is discussed.

Qualification goals	• Students recognize the interrelation of chemical thermodynamics and kinetics, basics that are typically acquired in lectures of Physical Chemistry, with the properties and reactions of organic molecules that are objects of teaching activities in Organic Chemistry. • Students make use of physicochemical data that is available from scientific tables or internet sources in order to predict reactivities and selectivities of organic transformations and to use the data as a strategic tool for planning syntheses. • By learning about the basics of linear free energy relationships the students will be enabled to evaluate concepts of organic chemistry, derive mechanisms of reactions and use effects of substituents for a targeted development of catalysts.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	PD Dr. Armin Ofial
Language	German/English
Additional information	

Module WP 27: Specialisation in Organic Chemistry - The Chemistry of Heterocycles (T1OE)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 27.1 The Chemistry of Heterocycles (T1OE)	SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Students will be given a systematic overview of the structure, the properties and the reactivity of heterocycles as a function of their respective ring sizes, the number and type of heteroatoms, and their degree of saturation. Typical examples will be selected for an in-depth discussion of synthetic strategies and their occurrence in biologically relevant systems. In addition, the role of heterocycles in general concepts and theories in organic reactivity will be discussed.
Qualification goals	Students know the structure, the properties and the reaction types of standard heterocycles. Using this foundation students are able to predict the structure and the properties of novel heterocycles. This also includes an understanding of the role of heterocyclic systems in biologically important processes. The students are able to plan the synthesis of new heterocycles and are able to plan the synthesis of other organic compounds utilizing the particular reactivity of heterocyclic systems.
Module assessment	Exam or oral examination

Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Ivan Huc
Language	English
Additional information	

Module WP 28: Specialisation in Organic Chemistry - Modern Synthetic Methods (T1OF)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 28.1 Modern Synthetic Methods (T1OF)	WiSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Key organic reactions are explored with a focus on stereoselectivity. Emphasis is placed on additions to carbonyl groups, enolate alkylation, aldol reactions, and the oxidation and reduction of olefins. Stereoselectivity in each reaction is analyzed using relevant transition state models.
Qualification goals	Students should be able to interpret organic transformations in terms of stereoselectivity. Additionally, the students should be able to design stereoselective syntheses for target organic molecules using suitable starting materials, reagents, and catalyst systems.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Oliver Trapp, Dr. Fumito Saito

Language	German/English

Additional information

Module WP 29: Specialisation in Organic Chemistry – Synthesis Planning (T1OG)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 29.1 Synthesis Planning (T1OG)	WiSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	The lecture deals with the retrosynthetic analysis and deconstruction of organic compounds. The following topics are explained in the course of the lecture: a) Characteristic properties of the most efficient organic synthesis and the resulting demands on retrosynthesis; b) Bond-breaking approaches based on functional groups; c) Bond-breaking approaches based on the carbon skeleton; d) Decomposition and assembly of cyclic structures; e) Efficient use of protecting groups in retrosynthetic deconstruction and subsequent synthesis planning; f) Practice of retrosynthetic analysis and synthesis planning using suitable, contemporary natural products. In addition to these main topics, further (retro)synthesis-relevant terms and topics, e.g. symmetry, previously untaught name reactions, effects of regio-, chemo- and stereoselectivity and compounds from the "chiral pool",

	are explained to the students.
Qualification goals	Upon successful completion of this course, students should be able to design total syntheses of simple target molecules. Furthermore, they should be able to analyze published syntheses with respect to their strategic elegance and synthetic efficiency.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Dr. Dino Berthold, Prof. Dr. Oliver Trapp
Language	German/English
Additional information	

Module WP 30: Specialisation in Organic Chemistry – Glycochemistry (T1OH)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 30.1 Glycochemistry (T1OH)	SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Carbohydrates represent an important class of natural products, that carry important functions not only as energy storage and structural materials, but also in intracellular communication. Against the background of the biological role of carbohydrates and glycoconjugates important current developments in glycobiology will be presented. This includes an initial recapitulation of occurence, function, and reactivity of carbohydrates (and their mimetics), complemented by modern methods for the regio- and stereoselective synthesis of oligosaccharides and glycoconjugates. This latter part includes standard protecting group strategies as well as enzymatic glycoside syntheses and biosynthetic routes for N-/O-glycoproteins. The important biological roles of sialic acids and of selected glycolipids will be discussed.
Qualification goals	Students are competent in terms of discussing the structure, the diversity and the properties of carbohydrates. They are able to recognize the connection between structure, conformation, stereochemistry and properties of carbohydrates, and are well-versed in defining and applying synthetic strategies for glycosides

	and oligosaccharides. The students are also familar with the central role of carbohydrates in the context of inter- and intracellular communication. Building on this expertise the students can answer questions on the biological and potential medicinal role of carbohydrates, for example in the area of vaccine development or antitumor therapies.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Anja Hoffmann-Röder
Language	German/English
Additional information	**Literature:** • T. Lindhorst, Essentials of Carbohydrate Chemistry and Biochemistry • M. E. Taylor, K. Duckhammer, Glycobiology, Oxford Univ. Press 2003 • A. Varki, R. D. Cummings, J. D. Esko, et al. (Eds.) Essentials of Glycobiology, Cold Spring Harbor Laboratory Press 2009.

Module WP 31: Specialisation in Organic Chemistry - Radicals in Chemistry and Biology (T1OI)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 31.1 Radicals in Chemistry and Biology (T1OI)	WiSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	The course offers a comprehensive and detailed discussion of all aspects of radicals and radical ions, many of which have been mentioned briefly in the chemistry bachelor program. This includes an introductory comparison of thermochemical and kinetic data of open shell systems that are essential in areas such as organic synthesis, polymer chemistry, or biological chemistry. This is followed by the discussion of synthetically important radical reactions with particular emphasis on reduction and C-C bond forming reactions. Photoredox catalysis is of particular importance here. After addressing shortly the specifics in reactions of radical ions and biradicals, both of which play important roles in medicinally important reactions, the lecture moves on to biologically important radical reactions. This latter chapter is subdivided into the unwanted and destructive radical chemistry behind the autoxidation of lipids and important biopolymers, and the well-controlled radical chemistry of enzymes. This last chapter includes examples from P450 oxidation chemistry, enzymes dependent on B_{12} and SAM cofactors, and ribonucleotide

	reductases (RNRs).
Qualification goals	After successful participation, students should be able to: • Critically evaluate published results on the role of radicals in organic synthesis, polymer chemistry and biological chemistry. • Use kinetic and thermodynamic data to validate reaction mechanisms and optimize synthetic processes. • Recognize the function of catalysts and additives in photoredox catalysis and transfer them to new systems. Explain the course of substrate reactions of radical enzymes and transfer them to new substrates.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Hendrik Zipse
Language	Englisch
Additional information	Link to the Webpage of the lecture: http://www.cup.uni-muenchen.de/oc/zipse/radicalsinchemistryandbiology.html

Module WP 32: Specialisation in Organic Chemistry - Basics of Cloning, Genomics and Proteomics (T1OJ)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 32.1 Basics of Cloning, Genomics and Proteomics (T1OJ)	WiSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 2 semesters
Content	The course covers the regulations of genetic engineering. Cloning strategies and the purification of proteins are explained. The methods of modern protein analysis and proteomic analysis are explained and it is shown how chemical tools can be used to solve biological questions. Possibilities for the modification of proteins are discussed. Modern methods of genome sequencing and editing are explained and relationships between chemistry and biology are highlighted.
Qualification goals	The students • can transfer the basic principles of how biomolecules are chemically modified to substance classes not explicitly covered in the practical part of the course. • will learn to study and to characterize the purity of biomolecules with the help of modern techniques such as mass spectrometry and sequencing. • will learn the basic safety regulations important for handling and working with genetically modified

	organism.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Thomas Carell
Language	German/English
Additional information	

Module WP 33: Specialisation in Organic Chemistry - Coenzymes and Biosynthesis (TIOK)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 33.1 Coenzymes and Biosynthesis (TIOK)	SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	The basic biosynthetic pathways of amino acids, sugars and nucleic acids are presented and their significance for pharmaceutical interventions is demonstrated. The reaction mechanisms of cofactors are explained and these are linked to the mechanisms of organic reactions. The basics of enzyme catalysis are taught and links to organic synthesis are shown. Disease relevant cellular cellular pathways are discussed together with the basis principles of medicinal chemistry.
Qualification goals	Students learn the basic principles of biosynthetic pathways and are able to establish cross-relationships between chemistry, biochemistry and medicine.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.

Responsible person	Prof. Dr. Thomas Carell
Language	Englisch
Additional information	

Module WP 34: Specialisation in Organic Chemistry – Special Lecture in Organic Chemistry (T1OZ)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 34.1 Special Lecture in Organic Chemistry (T1OZ)	WiSe/ SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	The lecture offers students in-depth knowledge of the subject with a range of topics that changes from semester to semester. The course format can be used for special lectures on common or current topics in organic chemistry.
Qualification goals	Students are introduced to special topics in organic chemistry in the lectures. In doing so, they deepen their previously acquired knowledge with special specialist information. This should be integrated into existing knowledge in order to formulate and discuss scientific questions. The acquired theoretical knowledge should be applied in the practical part of the course.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-	ECTS-points are awarded for passing the exam, which is

Points	allocated to the module.
Responsible person	Prof. Dr. Hendrik Zipse
Language	German/English
Additional information	

Module WP 92: Specialisation in Organic Chemistry – Supramolecular Chemistry (T1OS)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 92.1 Supramolecular Chemistry (T1OS)	WiSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	The concepts and perspectives of supramolecular chemistry are presented and their importance in the area of chemical and biological systems is discussed. The underlying fundamental principles of molecular recognition, the design of receptors, supramolecular systems in catalysis, transport processes in membranes as well as the construction of supramolecular aggregates and machines are explained and put into the context of organic synthesis and molecular chemistry.
Qualification goals	The aim is to learn about the basic principles of supramolecular chemistry and develop the ability to develop supramolecular systems.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.

Responsible person	Prof. Dr. Oliver Trapp
Language	German/English
Additional information	

Module WP 95: Specialisation in Organic Chemistry – Organic and Bio-inspired Molecular Systems: Molecular recognition and drug design (T1OM)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 95.1 Organic and Bio-inspired Molecular Systems (T1OM)	WiSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Students will be given a systematic overview of molecular recognition phenomena, including their thermodynamic and kinetic aspects, the driving forces involved, and the experimental techniques allowing for their assessment. A special focus will be given to the recognition of proteins and nucleic acids. The control and design of molecular shape via rigidification, macrocyclization and folding will be presented. Students will also be given a systematic overview of strategies to identify ligands for a given target molecule, including computational-based approaches, biomimicry, combinatorial chemistry and hightroughput screening, dynamic combinatorial chemistry, target assisted screening, and display selection technologies.
Qualification goals	After their participation to the Module, students are able to evaluate the importance and mechanism of molecular recognition phenomena including for the purpose of drug design. They can analyze the context of a particular research project and propose methods or relevant

	strategies to investigate molecular recognition or to identify ligands for a given target.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Ivan Huc
Language	English
Additional information	

Module WP 100: Specialisation in Organic Chemistry – Chemical and molecular mechanisms in medicine (T1OV)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 100.1 Chemical and molecular mechanisms in medicine (T1OV)	SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Content of the module are the fundamental principles of chemical, biochemical and molecular biological processes that lead to diseases, as well therapeutic interventions and mode of action of drugs: pathogens (infectious diseases, vaccines); genetic diseases; structure and function of the immune system; tumor development; structure and function of drug molecules (antibiotics, antivirals, gene therapy, chemotherapy, nucleic-acid therapeutics and their delivery, PROTACs).
Qualification goals	After the successful participation, students will remember and understand the chemical and biochemical processes behind the development and treatment of certain diseases. Moreover, they will not only understand, but also be able to explain and discuss in detail current state of research developments in the area of chemical mechanisms in medicine (i.e. drug design, molecular process of gene therapy and epigenetic changes, delivery of drug molecules). The students will be able to apply their learned theoretical knowledge to current problem sets in the area of chemical mechanisms in medicine, as

	well as qualitatively assess actual research data. Taken together, following the successful participation in this module, the students will have obtained an overview over different causes of diseases, starting points for therapeutic intervention and classes of drug molecules.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Dr. Sabine Schneider
Language	English
Additional information	

Module WP 108: Specialisation in Organic Chemistry – Multi-Dimensional NMR Spectroscopy (T1OL)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 108.1 Multi-Dimensional NMR Spectroscopy for Structure Elucidation of Big Molecules (T1OL)	WiSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	• Theory of nuclear spin resonance: Bloch equation, density operator, spin operators and product operator formalism, interactions of nuclear spins and Hamiltonian operators, strong and weak J-coupling • Classical NMR experiments and their pulse sequences (INEPT, EXSY, COSY, NOESY, HMQC/HMBC, HSQC), decoupling, chemical exchange and Bloch-McConnell equations • Data acquisition and processing: Fourier transformation, digitization, Nyquist, quadrature detection, phase correction, apodization, 2D acquisition according to States • Methods for isotope labeling: recombinant protein expression, cell-free protein synthesis, in vitro transcription • Protein NMR: structure of p-proteins, sequential assignment, multidimensional NMR and classical triple resonance experiments (HNCO, HNCA, HNCACB) structure determination, ligand binding • Nucleic acid NMR: classical RNA spectra, J-couplings

	via hydrogen bonds, sequential assignment • Relaxation: Spin lattice and spin-spin relaxation, measurement of T1 and T2 time constants, relaxation mechanisms, correlation function and spectral power density, size dependence of relaxation, core-Overhauser effect, TROSY • Dynamics: time scales of protein dynamics, relaxation dispersion, CEST • Optional solid-state NMR: magic angle rotation, recoupling, applications
Qualification goals	Students can understand NMR experiments as the movement of magnetization vectors in the magnetic field. Students acquire the ability to understand simple NMR experiments with product operator formalism. They can predict the result of an experiment applied to a given spin system. Students are able to independently identify optimal NMR experiments and isotope labeling for scientific questions with a focus on biomolecular NMR. The students know the fundamental limitations of NMR spectroscopy due to relaxation and they know ways to circumvent these limitations.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Anne Schütz
Language	Englisch
Additional information	

Module WP 110: Specialisation in Organic Chemistry – Concepts and Tools in Chemical Biology (T1OR)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 110.1 Concepts and Tools in Chemical Biology (T1OR)	SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	This chemical biology course for chemistry/biochemistry students at the master's level covers basic and advanced concepts and tools at the intersection between chemistry and biology. This includes aspects of molecular biology, biochemistry, chemical reactions, chemical genetics, and directed evolution. The class covers advanced experimental techniques used in chemical biology research, such as protein engineering, bioorthogonal chemistry, select labeling and imaging techniques, and touches on computational approaches. Students will learn how these techniques are applied to study biological systems and adress relevant research questions.
Qualification goals	Overall, the goal of this chemical biology class is to equip students with the knowledge, skills, and competence to pursue further research at the interface of chemistry and biology, whether in academia or industry.

	Specific goals are: • In-depth Understanding: The class seeks to deepen the understanding of the principles, theories, and experimental techniques at the interface of chemistry and biology. • Integration of Concepts: The class aims to integrate concepts from chemistry and biology to explore complex biological processes at the molecular level. This involves understanding how chemical principles govern biological functions and how biological systems can be manipulated using chemical tools. • Knowledge of advanced techniques in modern chemical biology • Interdisciplinary Research: The class aims to endow students with the competence to think critically and creatively about interdisciplinary research problems. By bridging the gap between chemistry and biology, students shall be motivated to tackle complex scientific challenges that require expertise from both disciplines.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Andrea Rentmeister
Language	English
Additional information	-

Module WP 35: Specialisation in Physical Chemistry – Energyconversion (T1PD)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 35.1 Energy Conversion (T1PD)	SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	In this course we will discuss the global energy landscape and traditional technologies as a starting point for the treatment of selected sustainable energy conversion strategies. The focus will be on the physicochemical foundations and recent materials developments addressing these challenges. Emphasis will be placed on solar energy conversion with photovoltaic devices including classical semiconductor, excitonic and third generation solar cells, and the generation of solar fuels through photoelectrochemical and artificial photosynthesis concepts. Moreover, we will address the mechanisms and materials for electrochemical energy storage using batteries and capacitors, as well as different types of fuel cells.
Qualification goals	The students should gain an understanding of the global energy landscape and traditional energy technologies. Moreover, they should understand the physicochemical foundations and recent materials developments regarding solar energy conversion with photovoltaic devices including classical semiconductor, excitonic and third generation solar cells, and the generation of solar fuels

	through photoelectrochemical and artificial photosynthesis concepts. Moreover, they should gain an understanding of the mechanisms and materials for electrochemical energy storage using batteries and capacitors, as well as different types of fuel cells.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Thomas Bein
Language	English
Additional information	-

Module WP 36: Specialisation in Physical Chemistry – Electrochemistry (T1PE)

(This module is no longer available.)

Module WP 37: Specialisation in Physical Chemistry - Introduction to Electron Microscopy (T1PF)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 37.1 Introduction to Electron Microscoy (T1PF)	SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	This lecture introduces the theoretical foundations of imaging theory for conventional and Raster TEM. Concepts of geometrical optics are briefly recapitulated, followed by imaging employing wave optics. Established imaging modes such as bright, dark field and Z-contrast are derived in detail assuming single-scattering as an intuitive and mathematically traceable framework. Multislice and Bloch-wave models are introduced as solutions of the Helmholtz equation so as to include multiple scattering in realistic simulations. Four-dimensional TEM is presented as a setup providing real and diffraction space information simultaneously. Methodologies to measure atomic electric fields and charge densities are derived theoretically. First moment and ptychographic imaging are introduced and demonstrated using examples from 2D materials, organic chemistry and biology, providing the foundations for solving the inverse electron scattering problem in experiment and theory.
Qualification goals	The successful participation enables students

	• to understand the diffraction- and aberration-limited resolution of microscopes in a wave-optical framework, • to formulate image formation in conventional and raster-TEM mathematically considering the aberration function and apertures using Fourier optics, and to calculate images in weak phase approximation, • to interpret image contrasts in atomically resolved phase-contrast TEM and Z-contrast STEM, and to derive optimised imaging conditions independently, • to map and calculate the distribution of electric fields using 4D STEM data employing first moments or direct electron ptychography, • to explain kinematical diffraction at crystals by means of Ewald's construction and the reciprocal lattice, • to understand the theoretical foundations of relativistic electron scattering in transmission, and to apply the multislice and Bloch-wave algorithms, • to analyse the impact of thermal atomic motion on diffraction patterns within the Debye-Waller and Frozen Phonon models.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Müller-Caspary
Language	German/English
Additional information	

Module WP 38: Specialisation in Physical Chemistry - Microscopy for Nanotechnology (T1PG)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 38.1 Microscopy for Nanotechnology (T1PG)	WiSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	The first topics of this lecture are the physical basics of optical microscopy, the propagation of electromagnetic fields and of the optical near- and far-field. In the area of optical microscopy, confocal microscopy and different super-resolution techniques are discussed as examples. The lecture then introduces the fundamentals of scanning electron and transmission electron microscopy and discusses the different interactions between electrons and matter. Then the image formation process is sketched for both methods. The last part of the lecture introduces the fundamentals of scanning probe microscopy using the examples scanning tunnelling, scanning force and scanning near-field optical microscopy.
Qualification goals	The first aim of the lecture is to develop a general understanding of wave propagation and of the resulting diffraction limit of conventional microscopes. Using the examples of confocal light and scanning electron microscopy, the fundamental differences resulting from light and material waves are illustrated. The second aim is to develop a general understanding of the fundamental concepts and principles of scanning probe microscopy.

	Using scanning tunnelling und scanning force microscopy as examples, common features and essential differences are to be recognized. Overall the lecture aims at introducing different modern high-resolution microscopy techniques and highlights common aspects and differences together with the specific areas of application of the different techniques.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Achim Hartschuh
Language	German/English
Additional information	

Module WP 39: Specialisation in Physical Chemistry – Solid-State Spectroscopy (T1PH)

(This module is no longer available.)

Module WP 40: Specialisation in Physical Chemistry - Fluorescence Microscopy and Spectroscopy (T1PI)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 40.1 Fluorescence Microscopy and Spectroscopy (T1PI)	WiSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	During this course, we will discuss the basics of Fluorescence Spectroscopy and Microscopy including: a classical and semi-classical description of the interaction of light with matter leading to absorption, stimulated emission and fluorescence; the Strickler-Berg Relationship; the structure of fluorescent molecules; the Jablonski diagram; excitation and emission Spectra; fluorescence lifetime measurements in the time domain and frequency domain; quenching and the Stern-Volmer equation; Förster Resonance Energy Transfer; Anisotropy; Fluorescence Correlation Spectroscopy; photophysical processes such as excited state dynamics; super resolution microscopy. An introduction will be given to fluorescence instrumentation and principles of photon detection and single-photon counting.
Qualification goals	Upon completion of this course, the student should have a solid understanding of the fundamental processes that occur during fluorescence, detailed knowledge of some of the most popular applications of fluorescence spectroscopy and a theoretical understanding of how

	instruments used in fluorescence spectroscopy and microscopy function.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Don C. Lamb, PhD
Language	English
Additional information	**Literature:** • Parson, W. W. *Modern Optical Spectroscopy*; Springer: Berlin Heidelberg New York, 2007. • Lakowicz, J. R. *Principles of Fluorescence* Spectroscopy*, 3rd ed*; Springer Science+Business Media: New York, 2006.

Module WP 41: Major Physical Chemistry (Lectures)

Degree programme Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (optional courses)	Rotation	Contact Hours	Self-directed Studies	ECTS
Colloquium	WP 41.1 Expert colloquium in Physical Chemistry (T1ZP)	WiSe/ SoSe	45 h (3 SWS)	135 h	(6)
Lecture	WP 41.2.1 (=WP 35) Energy Conversion (T1PD)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 41.2.3 (=WP 37) Introduction to Electron Microscopy (T1PF)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 41.2.4 (=WP 38) Microscopy for Nanotechnology (T1PG)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 41.2.6 (=WP 40) Fluorescence Microscopy and Spectroscopy (T1PI)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 41.4.7 (=WP 58) Laserspectroscopy (T1PJ)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 41.4.8 (=WP 59) Heterogeneous Catalysis (T1PK)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 41.2.9 (=WP 60) Surface Physics (T1PL)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 41.2.11 (=WP 62) Special Lecture in Physical Chemistry (T1PZ)	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 41.2.12 (=WP 94) Single Molecule Experiments (T1PN)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 41.2.13 (=WP 98) DNA-Nanotechnology (T1PP)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 41.2.14 (=WP 105) Physical characterization of solid-state nanostructures (T1PR)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 41.2.15 (=WP 109) Biomolecular Self-Assembly (T1PT)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 41.2.16 (=WP 112) Protein Design and Structural Prediction (T1PU)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 41.2.17 (=WP 113) Electronic Processes in Semiconductors (T1PW)	WiSe	30 h (2 SWS)	60 h	(3)

This module is comprised of 15 ECTS-points. Attendance time is 9 contact hours per week. Total

time, including self-directed studies, is about 450 h.

Type of the Module	Optional module with optional and compulsory courses.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with module WP 6 (lab course) if selected as a major subject. In this module three of the courses WP 41.2.1 to WP 41.2.17 must be elected.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 or 2 semesters.
Content	This module deepens special technical knowledge in the field of physical chemistry through the selection of three specialization courses. In the compulsory physical chemistry colloquium, internal and external experts present current research results from physical chemistry. In the follow-up to these scientific lectures, students deal with the current specialist literature.
Qualification goals	In the lectures, students are introduced to modern topics in current physical chemistry. In doing so, they expand their previously acquired knowledge with current and specialized technical information. The information is to be integrated into existing knowledge in order to formulate and discuss scientific questions. The acquired theoretical knowledge should be applied in the practical part of the course.
Module assessment	Exam or oral examination
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Wintterlin
Language	German/English
Additional information	The oral module examination on three selected lectures takes place 4 times a year. Registration takes place at the examination office and is obligatory.

WP 41.1: Expert colloquium in Physical Chemistry (T1ZP)

Type of the submodule	Compulsory course.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	None
Entry requirements	None
Study pathway level	Between semester 1 and 3
Duration	This part of the module spans 1 semester.
Content	Experts (internal and external) present current results of their research in the physical chemistry Colloquium. In the follow-up to these scientific lectures, the students deal with the current specialist literature. The students have to post-process the scientific talks including literature search.
Qualification goals	Placing the content of a scientific presentation in the wider context of the subject of physical chemistry. Qualified reproduction of the essential contents of a presentation to colleagues. Knowledge of current experimental and theoretical science, which flows into own research work.
Module assessment	s. WP 41
Grading	-
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	All professors of Physical Chemistry and Theoretical Chemistry
Language	German/English
Additional information	When registering for the module examination, 5 colloquia in the PC must be attended and indicated.

Module WP 42: Major Theoretical Chemistry (Lectures)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (optional courses)	Rotation	Contact Hours	Self-directed Studies	ECTS
Colloquium	WP 42.1 Expert colloquium in Theoretical Chemistry (T1ZT)	WiSe/ SoSe	45h (3 SWS)	135 h	(6)
Lecture	WP 42.2.1 (=WP 63) Theory of chemical dynamics: Molecular dynamics (T1TD)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 42.2.2 (=WP 64) Theory of chemical dynamics: Quantum dynamics (T1TE)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 42.2.3 (WP 65) Density Functional Theory (T1TF)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 42.2.5 (WP 67) Linear Scaling Quantum Methods for large Molecules (T1TH)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 42.2.6 (=WP 68) Special Lecture in Theoretical Chemistry (T1TZ)	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 42.2.7 (=WP 107) Theory of energy and electron transfer in photoactive systems (T1TI)	SoSe	30 h (2 SWS)	60 h	(3)

This module is comprised of 15 ECTS-points. Attendance time is 9 contact hours per week. Total time, including self-directed studies, is about 450 h.

Type of the Module	Optional module with optional and compulsory courses.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with module WP 7 (lab course) if selected as a major subject. In this module three of the courses WP 42.2.1 to WP 42.2.7 must be elected.
Entry requirements	none

Study pathway level	Between semester 1 and 3
Duration	The module spans 1 or 2 semesters.
Content	This module deepens special technical knowledge in the field of theoretical chemistry through the selection of three specialization courses. In the compulsory theoretical chemistry colloquium, internal and external experts present current research results from physical chemistry. In the follow-up to these scientific lectures, students deal with the current specialist literature.
Qualification goals	In the lectures, students are introduced to modern topics in current theoretical chemistry. In doing so, they expand their previously acquired knowledge with current and specialized technical information. The information is to be integrated into existing knowledge in order to formulate and discuss scientific questions. The acquired theoretical knowledge should be applied in the practical part of the course.
Module assessment	Exam or oral examination
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Ochsenfeld
Language	German/English
Additional information	The oral module examination on three selected lectures takes place 4 times a year. Registration takes place at the examination office and is obligatory.

WP 42.1: Expert colloquium in Theoretical Chemistry (T1ZT)

Type of the submodule	Compulsory course.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	none
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Experts (internal and external) present current results of their research in the Theoretical Chemistry Colloquium. In the follow-up to these scientific lectures, the students deal with the current specialist literature. The students have to post-process the scientific talks including literature search.
Qualification goals	Placing the content of a scientific presentation in the wider context of the subject of theoretical chemistry. Qualified reproduction of the essential contents of a presentation to colleagues. Knowledge of current experimental and theoretical science, which flows into own research work.
Module assessment	s. WP 42
Grading	-
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Fingerhut, Prof. Dr. Ochsenfeld
Language	German/English
Additional information	When registering for the module examination, 5 colloquia in the TC must be attended and indicated.

Module WP 43: Minor Structural Biology (Lab Course) (T1SB)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lab Course	WP 43.1 Research Lab Course in Structural Biology (T1SB)	WiSe/ SoSe	150h (10 SWS)	120 h	9

This module is comprised of 9 ECTS-points. Attendance time is 10 contact hours per week. Total time, including self-directed studies, is about 270 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with the modules WP 5 and WP 43, if selected as a minor subject.
Entry requirements	Successful Participation at WP 5
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	This practical course covers the steps to be able to perform structural analysis of macromolecules using X-ray crystallography (MX) and single-particle cryo electron microscopy (cryo-EM). First, the students perform bioinformatic analysis to find the relationship of the protein's amino acid sequence to sequences of other organisms, and to predict functional domains. In addition, they will use *in silico* modeling (e.g. Alphafold) to generate structural models from their query sequences. In the MX-part the students learn and receive hands-on training in structure solution using X-ray diffraction data. The student will independently analyze exemplary diffraction data and perform all steps from data processing to phase determination, density modification and model/ligand building and refinement. During the cryo-EM part, the students will receive training in sample and grid-preparation followed by exemplary data collection at the cryo-electron microscope. The students will then process and evaluate single-particle datasets covering all steps from particle picking, 2D/3D classification etc. to then yield and interpret density maps which can be used to fit and refine a molecular model. Finally, the quality of the model is

	validated.
Qualification goals	Students will acquire knowledge about the basic steps to solve macromolecular structures of proteins and nucleic acids by MX and cryo-EM. They will be able to describe and explain the principal steps of data processing, and structure determination and can use and transfer this knowledge to new problems. The students will be able to compare the two techniques to critically asses their usability on different potential targets. With the hands-on training in model building and model interpretation, the students will be able to interpret three-dimensional structural data of macromolecules in order to understand and explain central concepts of e.g. enzymatic processes or protein-ligand interactions. After the course, students will be able to independently apply structural biology methods and/or be able to critically address structural biology related results in literature.
Module assessment	Written report on or assessment of the practical laboratory course or written report on and assessment of the practical laboratory course
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Responsible person	Prof. Hopfner
Language	English
Additional information	

Module WP 44: Minor Inorganic Chemistry (Lectures)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (optional courses)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 44.0.1 (= WP 21) Modern Inorganic Main-group Chemistry (T1ID)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 44.0.2 (= WP 22) Solid State Chemistry II (T1IE)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 44.0.3 (= WP 23) Coordination Chemistry II (T1IF)	WiSe/	30 h (2 SWS)	60 h	(3)
Lecture	WP 44.0.4 (= WP 24) Spectroscopic Methods (T1IG)	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 44.0.5 (= WP 25) Special Lectures in Inorganic Chemistry (T1IZ)	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 44.0.6 (= WP 79) Modern NMR-Spectroscopy in Liquids (T1IG-2)	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 44.0.8 (= WP 87) Chemistry of High-Energy Materials (T1IZ-6)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 44.0.9 (= WP 88) Intermetallic Phases (T1IZ-7)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 44.0.10 (= WP 89) Principles of Nanochemistry and Functional Materials (T1IZ-8)	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 44.0.11 (= WP 103) Daily Chemistry (T1IZ-14)	WiSe/	30 h (2 SWS)	60 h	(3)

This module is comprised of 6 ECTS-points. Attendance time is 4 contact hours per week. Total time, including self-directed studies, is about 180 h.

Type of the Module	Optional module with optional courses.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with module WP 8 (lab course) if selected as a minor subject. In this module two of the courses WP 44.0.1 to WP 44.0.11 must be elected.

Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 or 2 semesters.
Content	This module deepens expertise in the field of inorganic chemistry through the selection of three specialization courses. In the compulsory colloquium, expert talks are given by visiting professors or young scientists on common or current topics in inorganic chemistry.
Qualification goals	In the lectures, students are introduced to modern topics of current inorganic chemistry. In doing so, they expand their previously acquired knowledge with current and specialized technical information. The information is to be integrated into existing knowledge in order to formulate and discuss scientific questions. The acquired theoretical knowledge should be applied in the practical part of the course.
Module assessment	Exam or oral examination
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Klapötke
Language	German/English
Additional information	The oral module examination on two selected lectures takes place 4 times a year. Registration takes place at the examination office and is obligatory.

Module WP 45: Minor Organic Chemistry (Lectures)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (optional courses)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 4.2.1 (=WP 26) Physical-Organic Chemistry (T1OD)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 4.2.2 (=WP 27) The Chemistry of Heterocycles (T1OE)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 4.2.3 (=WP28) Modern Synthetic Methods (T1OF)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 4.2.4 (=WP 29) Synthesis Planning (T1OG)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 4.2.5 (=WP 30) Glycochemistry (T1OH)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 4.2.6 (=WP 31) Radicals in Chemistry and Biology (T1OI)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 4.2.7 (=WP 32) Lecture in Chemical Biology (T1OJ)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 4.2.8 (=WP 33) Advanced Topics in Chemical Biology (T1OK)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 4.2.9 (=WP 34) Special Lecture in Organic Chemistry (T1OZ)	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 4.2.10 (=WP 92) Supramolecular Chemistry (T1OS)	WiSe/	30 h (2 SWS)	60 h	(3)
Lecture	WP 4.2.11 (=WP 95) Organic and Bio-inspired Molecular Systems (T1OM)	WiSe/	30 h (2 SWS)	60 h	(3)
Lecture	WP 4.2.12 (=WP 108) Multi-Dimensional NMR Spectroscopy for Structure Elucidation of Big Molecules (T1OL)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 4.2.13 (=WP 110) Concepts and Tools in Chemical Biology (T1OR)	SoSe/	30 h (2 SWS)	60 h	(3)

This module is comprised of 6 ECTS-points. Attendance time is 4 contact hours per week. Total time, including self-directed studies, is about 180 h.

Type of the Module	Optional module with optional courses.

Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with module WP 9 (lab course) if selected as a minor subject. In this module two of the courses WP 45.0.1 to WP 45.0.13 must be elected.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 or 2 semesters.
Content	This module deepens special technical knowledge in the field of organic chemistry through the selection of three specialization courses. In the compulsory organic chemistry colloquium, internal and external experts present current research results from organic chemistry. In the follow-up to these scientific lectures, students deal with the current specialist literature.
Qualification goals	In the lectures, students are introduced to modern topics in current organic chemistry. In doing so, they expand their previously acquired knowledge with current and specialized technical information. The information is to be integrated into existing knowledge in order to formulate and discuss scientific questions. The acquired theoretical knowledge should be applied in the practical part of the course.
Module assessment	Exam or oral examination
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Hendrik Zipse
Language	German/English
Additional information	The oral module examination on two selected lectures takes place 4 times a year. Registration takes place at the examination office and is obligatory.

Module WP 46: Minor Physical Chemistry (Lectures)

Degree programme Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (optional courses)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 46.0.1 (=WP 35) Energy Conversion (T1PD)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 46.0.3 (=WP 37) Introduction to Electron Microscopy (T1PF)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 46.0.4 (=WP 38) Microscopy for Nanotechnology (T1PG)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 46.0.6 (=WP 40) Fluorescence Microscopy and Spectroscopy (T1PI)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 46.0.7 (=WP 58) Laserspectroscopy (T1PJ)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 46.0.8 (=WP 59) Heterogeneous Catalysis (T1PK)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 46.0.9 (=WP 60) Surface Physics (T1PL)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 46.0.11 (=WP 62) Special Lecture in Physical Chemistry (T1PZ)	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 46.0.12 (=WP 94) Single Molecule Experiments (T1PN)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 46.0.13 (=WP 98) DNA-Nanotechnology (T1PP)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 46.0.14 (=WP 105) Physical characterization of solid-state nanostructures (T1PR)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 46.0.15 (=WP 109) Biomolecular Self-Assembly (T1PT)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 46.0.16 (=WP 112) Protein Design and Structural Prediction (T1PU)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 46.0.17 (=WP 113) Electronic Processes in Semiconductors (T1PW)	WiSe	30 h (2 SWS)	60 h	(3)

This module is comprised of 6 ECTS-points. Attendance time is 4 contact hours per week. Total time, including self-directed studies, is about 180 h.

Type of the Module	Optional module with optional courses.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with module WP 10 (lab course) if selected as a minor subject. In this module two of the courses WP 46.0.1 to WP 46.0.17 must be elected.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 or 2 semesters.
Content	This module deepens special technical knowledge in the field of physical chemistry through the selection of three specialization courses. In the compulsory physical chemistry colloquium, internal and external experts present current research results from physical chemistry. In the follow-up to these scientific lectures, students deal with the current specialist literature.
Qualification goals	In the lectures, students are introduced to modern topics in current physical chemistry. In doing so, they expand their previously acquired knowledge with current and specialized technical information. The information is to be integrated into existing knowledge in order to formulate and discuss scientific questions. The acquired theoretical knowledge should be applied in the practical part of the course.
Module assessment	Exam or oral examination
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Wintterlin
Language	German/English
Additional information	The oral module examination on two selected lectures takes place 4 times a year. Registration takes place at the examination office and is obligatory.

Module WP 47: Minor Theoretical Chemistry (Lectures)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (optional courses)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 47.0.1 (=WP 63) Theory of chemical dynamics: Molecular dynamics (T1TD)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 47.0.2 (=WP 64) Theory of chemical dynamics: Quantum dynamics (T1TE)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 47.0.3 (WP 65) Density Functional Theory (T1TF)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 47.0.5 (WP 67) Linear Scaling Quantum Methods for large Molecules (T1TH)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 47.0.6 (=WP 68) Special Lecture in Theoretical Chemistry (T1TZ)	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 47.0.7 (=WP 107) Theory of energy and electron transfer in photoactive systems (T1TI)	SoSe	30 h (2 SWS)	60 h	(3)

This module is comprised of 6 ECTS-points. Attendance time is 4 contact hours per week. Total time, including self-directed studies, is about 180 h.

Type of the Module	Optional module with optional courses.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with module WP 11 (lab course) if selected as a minor subject. In this module two of the courses WP 47.0.1 to WP 47.0.7 must be elected.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 or 2 semesters.

Content	This module deepens special technical knowledge in the field of theoretical chemistry through the selection of three specialization courses. In the compulsory theoretical chemistry colloquium, internal and external experts present current research results from physical chemistry. In the follow-up to these scientific lectures, students deal with the current specialist literature.
Qualification goals	In the lectures, students are introduced to modern topics in current theoretical chemistry. In doing so, they expand their previously acquired knowledge with current and specialized technical information. The information is to be integrated into existing knowledge in order to formulate and discuss scientific questions. The acquired theoretical knowledge should be applied in the practical part of the course.
Module assessment	Exam or oral examination
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Ochsenfeld
Language	German/English
Additional information	The oral module examination on two selected lectures takes place 4 times a year. Registration takes place at the examination office and is obligatory.

Module WP 48: Minor Chemical Biology (Lectures)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 48.1 (=WP 32) Basics of Cloning, Genomics and Proteomics (T1OJ)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 48.2 (WP 33) Coenzymes and Biosynthesis (T1OK)	SoSe	30 h (2 SWS)	60 h	(3)

This module is comprised of 6 ECTS-points. Attendance time is 4 contact hours per week. Total time, including self-directed studies, is about 180 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with module WP 12 (lab course) if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 2 semesters.
Content	The module broadens and deepens special professional knowledge from the field of Chemical Biology.
Qualification goals	In the lectures, students will work on modern topics in current biological chemistry. In doing so, they will expand their previously acquired knowledge with current and specialised information. New information will be integrated into existing knowledge in order to formulate and discuss scientific questions. An understanding of organic chemical reactions in the context of biosynthesis, especially of reactions involving cofactors, will be developed. The students gain a deeper understanding of biosynthetic pathways and their significance for our health and the occurrence of disease processes. An understanding of medicinal chemistry for the treatment of diseases is obtained. The basics of scientific work in chemical biology are acquired, as are the fundamentals of chemical reactivity. The acquired theoretical knowledge is to be applied in the

	practical part of the course.
Module assessment	Exam or oral examination
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Thomas Carell
Language	German/English

Additional information

Module WP 49: Minor Biochemistry (Lectures)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 49.1 Lecture in Biochemistry (T1Y1)	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 49.2 Advanced Topics in Biochemistry (T1Y2)	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)

This module is comprised of 6 ECTS-points. Attendance time is 4 contact hours per week. Total time, including self-directed studies, is about 180 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with module WP 13 (lab course) if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 or 2 semesters.
Content	The module broadens and deepens special professional knowledge from the field of Biochemistry. The lectures cover central aspects in the cellular biochemistry and life cycle of proteins, key processes in genome biology and the most important model organisms used in current modern research.
Qualification goals	The lectures are based on current research topics in Biochemistry with new research results continuously updated. The lecture will enable students to understand modern Biochemistry research towards primary literature and review article level and to broaden and deepen their already acquired knowledge. They will understand and learn to judge selected literature experiments to test research hypotheses with current topics in Biochemistry. The acquired theoretical knowledge will be implemented during the practical course.
Module assessment	Exam or oral examination

Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Hopfner
Language	English
Additional information	You can choose from the following lectures: • Life cycle of Proteins • Flow of genetic Information • Model Organisms

Module WP 50: Minor Molecular and Cellular Genetics (Lectures)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 50.1 Lecture in Molecular and Cellular Genetics (T1G1)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 50.2 Advanced Topics in Molecular and Cellular Genetics(T1G2)	SoSe	30 h (2 SWS)	60 h	(3)

This module is comprised of 6 ECTS-points. Attendance time is 4 contact hours per week. Total time, including self-directed studies, is about 180 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	Master's degree Biochemistry
Elective guidelines	This module is associated with module WP 14 (lab course) if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 2 semesters.
Content	The module introduces special knowledge from the field of Molecular and Cellular Genetics. The lectures cover genetic mechanisms underlying complex cellular processes and the multiple levels of regulation of gene expression before and after transcription comprising topics such as cancer, aging and cellular quality control.
Qualification goals	Students gain an expertise in up-to-date topics of current research in Molecular and Cellular Genetics. They acquire knowledge and competence to understand and evaluate special topics about regulation of gene expression and about genetic mechanisms controlling complex cellular processes such as cancer, aging and cellular quality control. New specialized information is integrated in existing knowledge to gain the capacity to formulate and discuss related scientific problems. The acquired theoretical knowledge is further implemented during

	the practical course.
Module assessment	Written exam or oral examination
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Responsible person	Prof. Beckmann
Language	English
Additional information	

Module WP 51: Specific Supplement to Chemistry (Lectures)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 51.1 Lecture in Specific Supplement to Chemistry (T1RY)	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 51.2 Advanced Topics in Specific Supplement to Chemistry (T1RZ)	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)

This module is comprised of 6 ECTS-points. Attendance time is 4 contact hours per week. Total time, including self-directed studies, is about 180 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	-
Elective guidelines	This module is associated with module WP 15 (lab course) if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 or 2 semesters.
Content	This module introduces students to current research issues in areas close to and distant from chemistry, such as materials science, patent law, or pharmacology and toxicology, by working on selected scientific projects and integrating students into a research or working group. Preparation of the necessary basics at the level of a scientifically oriented Master's degree course, development of possible solutions to open scientific questions.
Qualification goals	In the lectures, students are introduced to modern subject areas of their future professional life. In doing so, they expand their previously acquired knowledge with current and specialized information. The information is to be integrated into existing knowledge in order to formulate and discuss scientific questions. The acquired theoretical knowledge should be applied in the practical part of the course.

Module assessment	Exam or oral examination
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Dean of Studies
Language	German/English
Additional information	The offered courses are subject to change. The current selection can be found in the LSF.

Module WP 51a: Pharmacology and Toxicology for Natural Scientists

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 52.1a Principles of Human Disease and Treatment	WiSe	60 h (4 SWS)	30 h	(3)
Seminar	WP 52.2a Principles of Human Disease and Treatment	WiSe	30 h (2 SWS)	60 h	(3)

This module is comprised of 6 ECTS-points. Attendance time is 6 contact hours per week. Total time, including self-directed studies, is about 180 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	Bachelor's programme Physics
Elective guidelines	This module is only associated with modules WP 15a (lab course), if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	The module "Pharmacology and Toxicology for Natural Scientists – Basics of Human Diseases and Treatment" consists of a lecture, a seminar and a 6–8-week research internship. The students will learn the basics of pharmacology and toxicology, e.g.: • Principles of pharmacokinetics, pharmacodynamics and pharmacogenetics • Fundamentals of the pathophysiology of central and important diseases as well as the basics of diagnosis and pharmacological treatment including an introduction into the major drug groups commonly used in therapeutics as well as novel therapeutic approaches (Advanced Therapy Medicinal Products, ATMP). • Basics of toxicology, introduction of important toxic substances, poisonings and their treatment.

Qualification goals	The learning objective is to understand the basics of pharmacology and toxicology, to get the ability to transfer knowledge to current problems in the field of pharmacology, to get insights into everyday laboratory methods used in pharmacology and toxicology and to critically evaluate and present scientific publications.
Module assessment	Exam or oral examination
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	PD Dr. I. Boekhoff
Language	German/English
Additional information	Moodle course: https://moodle.lmu.de/course/view.php?id=11319#section-6

Module WP 52: Minor Physics: Nuclear and Particle Physics

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 52.1 Lecture in Particle Physics (E5.1)	WiSe	45 h (3 SWS)	75 h	(4)
Tutorial	WP 52.2Tutorial in Particle Physics (E5.2)	WiSe	15 h (1 SWS)	45 h	(2)

This module is comprised of 6 ECTS-points. Attendance time is 4 contact hours per week. Total time, including self-directed studies, is about 180 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	Bachelor's programme Physics
Elective guidelines	This module is associated with modules WP 17, WP 54 or WP 55, if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Concepts and experimental methods of nuclear and particle physics: structure of atomic nuclei, nuclear reactions and nuclear decays, instruments of nuclear and particle physics, reactions and decays of hadrons, elementary particles and elementary interactions.
Qualification goals	The main learning objectives are knowledge and understanding of the above learning content, the ability to apply it and link it to one another. In addition, familiarity with methods of experimental physics and the ability to interpret, verify or falsify experimental results are general learning objectives. Students should become aware of the connection to phenomena in nature and to current research.
Module assessment	exam
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.

Responsible person	Dean of Studies in Physics
Language	German
Additional information	

Module WP 53: Minor Physics: Solid-State Physics

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 53.1 Lecture in Solid-State Physics (E6.1)	WiSe	45 h (3 SWS)	75 h	(4)
Tutorial	WP 53.2 Tutorial in Solid-State Physics (E6.2)	WiSe	15 h (1 SWS)	45 h	(2)

This module is comprised of 6 ECTS-points. Attendance time is 4 contact hours per week. Total time, including self-directed studies, is about 180 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	Bachelor's programme Physics
Elective guidelines	This module is associated with modules WP 17, WP 54 or WP 55, if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Concepts and experimental methods of solid state physics: crystal structures, lattice vibrations, mechanical, thermal, dielectric, magnetic and optical properties of crystalline solids, insulators, semiconductors, metals, superconductivity.
Qualification goals	The main learning objectives are knowledge and understanding of the above learning content, the ability to apply it and link it together. In addition, familiarity with methods of experimental physics and the ability to interpret, verify or falsify experimental results are general learning objectives. Students should become aware of the connection to phenomena in nature and to current research.
Module assessment	exam
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.

Responsible person	Dean of Studies in Physics
Language	German
Additional information	

Module WP 54: Minor Physics: Quantum Mechanics

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 54.1 Lecture in Quantum Mechanics (T2.1)	WiSe	60 h (4 SWS)	120 h	(6)
Tutorial	WP 54.2 Tutorial in Quantum Mechanics (T2.2)	WiSe	30 h (2 SWS)	60 h	(3)

This module is comprised of 9 ECTS-points. Attendance time is 6 contact hours per week. Total time, including self-directed studies, is about 270 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	Bachelor's programme Physics
Elective guidelines	This module is associated with modules WP 52 or WP 53, if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Concepts and theoretical methods of quantum mechanics: Physical foundations of quantum mechanics, mathematical representations of quantum mechanics, Schrödinger, Heisenberg and interaction picture, orbital angular momentum and spin, applications to quantum systems (e.g. harmonic oscillator, hydrogen atom).
Qualification goals	The main learning objectives are knowledge and understanding of the above learning content and the mathematics required for this, as well as the ability to apply the learning content and link it to one another. In addition, familiarity with methods of theoretical physics and the ability to create models and deduce results from models are general learning objectives. Students should become aware of the connection to phenomena in nature and to current research.
Module assessment	Exam
Grading	The module is graded.

Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Dean of Studies in Physics
Language	German
Additional information	

Module WP 55: Minor Physics: Statistical Physics

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 55.1 Lecture in Statistical Physics (T4.1)	WiSe	60 h (4 SWS)	120 h	(6)
Tutorial	WP 55.2 Tutorial in Statistical Physics (T4.2)	WiSe	30 h (2 SWS)	60 h	(3)

This module is comprised of 9 ECTS-points. Attendance time is 6 contact hours per week. Total time, including self-directed studies, is about 270 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	Bachelor's programme Physics
Elective guidelines	This module is associated with modules or WP 53, if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Concepts and theoretical methods of statistical physics: fundamentals of statistical physics, statistical and phenomenological thermodynamics, applications (e.g. classical many-body systems, phase transitions, quantum gases).
Qualification goals	The main learning objectives are knowledge and understanding of the above learning content and the mathematics required for this, as well as the ability to apply the learning content and link it to each other. In addition, familiarity with methods of theoretical physics and the ability to create models and deduce results from models are general learning objectives. Students should become aware of the connection to phenomena in nature and to current research.
Module assessment	Exam
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam,

	which is allocated to the module.
Responsible person	Dean of Studies in Physics
Language	German
Additional information	

Module WP 56: Minor Computer Sciences: Introduction to Programming - Programming and Software Development

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	P 1.1 Introduction to Programming - Programming and Software Development	WiSe	60 h (4 SWS)	120 h	(6)
Tutorial	P 1.2 Tutorial in Introduction to Programming - Programming and Software Development	WiSe	30 h (2 SWS)	60 h	(3)

This module is comprised of 9 ECTS-points. Attendance time is 6 contact hours per week. Total time, including self-directed studies, is about 270 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	Minor subject in Computer Science to the extent of 60 ECTS credits for Bachelor's degree programs
Elective guidelines	This module is associated with modules WP 18 to WP 20 or WP 57, if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	This module provides an introduction into imperative, object-oriented and concurrent programming using a high-level programming language. In addition to knowledge of programming, general principles, concepts, methods and techniques for the representation, structuring and processing of data and the development of algorithms are covered. Emphasis is placed on conceptual clarity and differentiation of various concepts. Topics of the lecture include: • Basic concepts of algorithms and programs and their execution, • Syntax of programming languages and their description,

	• Basic data types (primitive data types and reference data types such as arrays) and imperative control structures, • Basics of the complexity and correctness of imperative programs, • Recursion, • Simple sorting methods, • Introduction to object-oriented program design and its graphical modeling (UML classes and object diagrams), • Classes, interfaces, packages and inheritance, • Exception handling, • Object-oriented realization of dynamic data structures (lists, trees), • Generic data types, • Use of existing APIs, • Basic concepts of concurrent programming: threads, synchronization and jamming. • Use of an integrated development environment
Qualification goals	Students are enabled to algorithmically implement solutions for smaller and manageable problems and to realize them as executable programs using a higher programming language. The use of an integrated development environment promotes professionalization. Furthermore, students develop an understanding of the general principles of computer science, programming and programming languages, which lays the foundation for students to be able to quickly and precisely familiarize themselves with new programming languages (after gaining further experience during the course of their studies).
Module assessment	Exam or oral examination
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Sven Stickroth
Language	German
Additional information	

Module WP 57: Minor Computer Sciences: Operating Systems

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 8.1 Lecture in Operating Systems	WiSe	45h (3 SWS)	45 h	(3)
Tutorial	WP 8.2 Tutorial in Operating Systems	WiSe	30 h (2 SWS)	60 h	(3)

This module is comprised of 6 ECTS-points. Attendance time is 6 contact hours per week. Total time, including self-directed studies, is about 180 h.

Type of the Module	Optional module with compulsory courses.
Applicability to other degree programmes	Minor subject in Computer Science to the extent of 60 ECTS credits for Bachelor's degree programs
Elective guidelines	This module is associated with module WP 56, if selected as a minor subject.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	This module provides an introduction into the relevant components of modern operating systems. Methods for process management and process control, in particular for concurrent processes, are discussed first. In particular, methods for recognizing and avoiding conflicts (deadlocks and race conditions) with multiple access to shared resources are covered. The following are taught in detail: • the development history of operating systems • strategies for process management in operating systems • the support of the operating system for the parallelization of programs • strategies for resource management and process coordination • techniques for memory management and for controlling input and output channels

	• local and distributed interprocess communication This module provides students with the necessary basic knowledge to make targeted use of the special structure and technical properties of modern operating systems. This provides an important basis for later familiarization with the development of optimized and scalable programs for modern operating systems.
Qualification goals	This module provides students with the necessary basic knowledge for the targeted use of the special structure and technical properties of modern operating systems. This provides an important basis for later familiarization with the development of optimized and scalable programs for modern operating systems.
Module assessment	Exam or oral examination
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Claudia Linnhoff-Popien
Language	German
Additional information	

Module WP 58: Specialisation in Physical Chemistry - Laserspectroscopy (T1PJ)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 58.1 Laserspectroscopy (T1PJ)	SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	The lecture treats the theoretical, experimental and conceptual basics of laser spectroscopy. This includes the properties of laser light, the general setup of lasers and their working principles, different laser types and the generation of short laser pulses. A series of different applications are introduced, including fluorescence-, ultrafast- and non-linear spectroscopy.
Qualification goals	The students develop the understanding of the laser process and the requirements for generating laser light. They get know different scientific questions that can be addressed by laser spectroscopy. They are able to evaluate different laser spectroscopic methods according to their usability towards given sample systems and problem sets.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-	ECTS-points are awarded for passing the exam, which is

Points	allocated to the module.
Responsible person	Prof. Dr. A. Hartschuh, Prof. D. Lamb
Language	German/English
Additional information	

Module WP 59: Specialisation in Physical Chemistry - Heterogeneous Catalysis (T1PK)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 59.1 Heterogeneous Catalysis (T1PK)	WiSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	The general topic is the physico-chemical basis of heterogeneous catalysis. The course starts with the treatment of industrial catalytic processes and identifies open questions related to these reactions. Then it treats the methods developed by "surface science" to address these problems. This includes the most important surface analytical tools, a theoretical treatment of the bonding of molecules to solid surfaces, and an analysis of chemical elementary processes of adsorbed molecules on surfaces. By means of microkinetic models and of current *in situ* experiments it finally creates a link back to industrial catalytic processes.
Qualification goals	The course aims at developing an understanding of the experimental and theoretical methods of surface chemistry. It enables students to understand how these methods can be applied to heterogeneous catalysis. It activates and makes use of basic knowledge of physical chemistry in the fields of kinetics, thermodynamics, and quantum mechanics. In this way it provides access to modern catalysis research.

Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Joost Wintterlin
Language	German/English

Additional information

Module WP 60: Specialisation in Physical Chemistry –Surface Physics (T1PL)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 60.1 Surface Physics (T1PL)	SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Physical properties of surfaces form the basis of all interactions of solids with their environments but are much more difficult to study than bulk properties. The course treats the current knowledge about the geometry and electronic structure of solid surfaces. It treats modern ultra-high vacuum technology and several surface analytical methods, such as scanning probe techniques, electron diffraction, and photoelectron spectroscopy.
Qualification goals	The course first develops basic knowledge of three-dimensional solid-state physics and then generates an understanding how to transfer its instruments, such as the reciprocal lattice, and models, such as the quasi-free electron and tight-binding theory, to two-dimenional systems. It also provides an understanding of the pertinent experimental methods, enabling access to the current literature on surface physics.
Module assessment	Exam or oral examination
Grading	Passed/ not passed

Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Joost Wintterlin
Language	German/English
Additional information	

Module WP 61: Specialisation in Physical Chemistry - Nanoscience (T1PM)

(This module is no longer available.)

Module WP 62: Specialisation in Physical Chemistry – Special Lecture in Physical Chemistry (T1PZ)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 62.1 Special Lecture in Physical Chemistry (T1PZ)	WiSe/ SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	The lecture offers students in-depth knowledge of the subject with a range of topics that changes from semester to semester. The course format can be used for special lectures on common or current topics in physical chemistry.
Qualification goals	Students are introduced to special topics in physical chemistry in the lectures. In doing so, they deepen their previously acquired knowledge with special specialist information. This should be integrated into existing knowledge in order to formulate and discuss scientific questions. The acquired theoretical knowledge should be applied in the practical part of the course.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-	ECTS-points are awarded for passing the exam, which is

Points	allocated to the module.
Responsible person	Dean of Studies
Language	German/English
Additional information	

Module WP 94: Specialisation in Physical Chemistry – Single Molecule Experiments (T1PN)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 94.1 Single Molecule Experiments (T1PN)	WiSe/	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	This lecture first introduces the fundamental approach and concepts of single-molecule experiments. Building on the advantages of direct access to the static and dynamic heterogeneity of molecular systems, the focus is on biophysically and chemically relevant methods and applications. The primary area of emphasis is optical single-molecule detection, including implementation methods, the relevance and spectroscopy of probes, and the labeling of biomolecules. Subsequently, key applications for super-resolution microscopy and sequencing methods are presented. In addition to optical methods and their use in the context of optical microscopy, electronic single-molecule detection is addressed, with a focus on sequencing methods and biosensing. Finally, force-based techniques such as scanning probe microscopy and optical tweezers are introduced, along with their role in studying biopolymers. The application section emphasizes natural and artificial molecular motors and machines, whose mechanisms are accessible exclusively through single-molecule methods, such as fluorescence resonance energy transfer (FRET).

Qualification goals	Students can describe the advantages and disadvantages of single-molecule methods. They can explain their areas of application and assess in which research questions single-molecule measurements are feasible and beneficial. They are able to describe the technical implementation of these methods and are aware of their limitations, such as concentration ranges and interaction strengths. Key applications, such as the principles of super-resolution and the advantages in sequencing methods, can be contrasted and comparatively analyzed. The physical and physico-chemical principles can be articulated, and the significance of single-molecule methods for gaining insights can be identified.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Philip Tinnefeld
Language	German/English
Additional information	

Module WP 96: Specialisation in Physical Chemistry – Electron Microscopy and Analytical Techniques (T1PO)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 96:1 Electron Microscopy and Analytical Techniques (T1PO)	WiSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Electron microscopy can provide a comprehensive characterization of solid samples, including morphology, structure, composition and defects, including even electronic properties, with a resolution down to the sub-atomic level. This overview lecture covers the major techniques of electron microscopy as well as associated spectroscopy methods. In addition, ion microscopy for imaging and material manipulation is introduced. Based on electron-sample interactions, basic optics and instrumental aspects, various imaging and spectroscopy methods are discussed with respect to properties such as resolution, sensitivity and limits.
Qualification goals	Understand the principles of all major methods in electron microscopy and associated spectroscopic techniques. Understand the advantages and limitations of the methods on the physical basis of these principles. Ability to choose and adapt an appropriate method to their materials science problem to extract the maximum information content. Optimize data acquisition and correctly extract maximum

	information content.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Dr. Markus Döblinger
Language	German/English
Additional information	

Module WP 98: Specialisation in Physical Chemistry – DNA-Nanotechnology (T1PP)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 98.1 DNA-Nanotechnology (T1PP)	SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	In this lecture, DNA is presented as a programmable material, with less emphasis on molecular biology. The focus ranges from foundational concepts to topics in current research. The physico-chemical principles of nucleic acids are introduced and discussed within the framework of basic polymer theories, such as the "wormlike chain model." Subsequently, methods for creating DNA nanostructures, including DNA origami and molecular machines, are explored. How can these structures be purified and characterized? What methods can be used to visualize their properties? Additionally, various applications of DNA nanotechnology are presented, spanning nanoscale imaging, drug delivery, and molecular robotics. Other key topics include molecular logic, molecular computing, and hybrid materials. Finally, recent developments in molecular nanotechnology, particularly including AI-assisted protein design, are incorporated.
Qualification goals	With the help of this lecture, students can differentiate the principles of molecular nanotechnology from conventional nanotechnology, which is dominated by lithographic

	methods, and understand the unique features of nucleic acid-based nanotechnology. They can discuss and evaluate the distinctive properties of polymers on the one hand and programmable, orthogonal interactions on the other. Manufacturing methods can be classified and assessed in terms of their complexity, purification processes, and characterization techniques. Current applications can be presented, with a particular focus on the significance of increasingly AI-based design methods.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Philip Tinnefeld
Language	German/English
Additional information	

Module WP 105: Specialisation in Physical Chemistry – Physical characterization of solid-state nanostructures (T1PR)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 105.1 Physical characterization of solid-state nanostructures (T1PR)	SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	The course presents selected cases from the field of crystalline solid-state physics in mathematical and physical detail, in particular: • Introduction of atomic scattering amplitudes for X-rays and electrons, structure factors, kinematical Fresnel and Fraunhofer diffraction at bulk crystals and low-dimensional nanostructures, correspondence to X-ray and electron scattering experiments. • Derivation of the Bloch theorem and emergence of the band structure assuming quasi-free electrons, eigenvalue problem, band gap, concept of effective mass, correspondence to light-optical absorption spectra. • Discussion of the phase problem as a characteristic of the recording process, problem of X-ray optics (Fresnel lenses), introduction to computational imaging and superresolution of nanostructures; • Presentation of iterative phase reconstruction methods,

	in particular the ePIE formalism and gradient-based approaches. The curriculum consists of both, derivation from fundamental physics in lecture format and demonstration employing the computer in CIP pools. The students prepare computer programs autonomously under the lecturer's supervision so as to visualise scattering phenomena, band structures, phase reconstructions and super-resolved microscopic images.
Qualification goals	Successful participation enables students • to employ advanced mathematical approaches such as Fourier transforms and series, Dirac's δ-function, convolution integrals and theorems for the description of physical properties of crystalline solids, • to determine crystal symmetries and crystallite sizes from diffraction data, • to interpret band structures using the extended and reduced zone representation, • to exemplarily calculate band structures within the framework of Bloch's concept in terms of the solution to an eigenvalue problem employing the computer (e.g. python, Matlab, Octave), and to investigate the influence of crystal parameters (lattice parameters and structure factors), • to understand the inverse scattering problem and to follow its solution via dedicated redundancies in experimental recordings, • to simulate four-dimensional data of scanning diffraction (X-rays & electrons) and to obtain super-resolved phase reconstructions via independently implemented algorithms (ePIE, gradient schemes) on the computer.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Knut Müller-Caspary
Language	German/English
Additional information	

Module WP 106: Specialisation in Physical Chemistry – Diffraction for Materials Science (T1PS)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 106.1 Diffraction for Materials Science (T1PS)	WiSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Diffraction methods are among the most abundant tools for structural characterization in materials science. In most cases, these methods are rather aiming at the properties of powders, thin films and surfaces rather than the crystal structure determination from single crystals by classical X-ray crystallography. This lecture explores these diffraction methods and geometries along with their underlying principles and the different types of radiations used. Outline: 1. Overview: Diffraction experiments in materials science 2. Scattering, diffraction and the reciprocal lattice Diffraction and Fourier Transform, Generation of X-rays, Form factor for X-rays, neutrons and electrons, Laue conditions, Pair distribution function, Structure factor 3. Bascis in Crystallography 4. Powder diffraction Indexing, Phase analysis, Powder X-ray diffractometers, Intensity and profile contributions,

	Particle size, Texture and strain, Profile and Rietveld refinement 5. Diffraction of films Rocking curve, Pole figures, Grazing incidence geometry, X-ray penetration, X-ray reflectivity, (Grazing-incidence) Small angle X-ray scattering, 6. Electron Diffraction Transmission Electron Microscope, Ewald construction, Selected area electron diffraction, Dynamical diffraction, Excitation error, Electron backscatter diffraction 7. Neutron Diffraction Neutron sources and diffractometer components, Neutron scattering lengths, Neutron diffraction patterns
Qualification goals	Choose and adapt the appropriate diffraction method to their materials science problem to extract the maximum information content. Evaluate the diffraction data correctly to quantify and refine crystallographic, physical and morphological information on their samples. Become familiar with more specialized diffraction methods in order to kick-start the learning curve with these methods.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Dr. Markus Döblinger
Language	German/English
Additional information	

Module WP 109: Specialisation in Physical Chemistry – Biomolecular Self-Assembly (T1PT)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 109.1 Biomolecular Self-Assembly (T1PT)	SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Exploration of the concepts of self-assembly across biomolecular classes and physical phases. Students integrate these concepts from lecture to lecture and post-process in a paper presentation.
Qualification goals	Understanding of the ubiquitous nature of biomolecular self-assembly processes and the underlying physico-chemical principles. Previously obtained knowledge is broadened in terms of its biological relevance. Discussion and formulation of scientific problems related to self-assembly.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Alena Khmelinskaia

Language	English

Additional information

Module WP 112: Specialisation in Physical Chemistry – Protein Design and Structural Prediction (T1PU)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 112.1 Protein Design and Structural Prediction (T1PU)	WiSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Introduction to computational methods in structural prediction and protein design, spanning both physics-based and neural network-based methods. Students are exposed both to the concepts underlying the methods as well as to hands-on exercises.
Qualification goals	Understanding of the conformational sampling problem of protein folding. Conceptualization of protein design as the inverse problem of protein structural prediction. Learned concepts are explored in hands-on exercises during the class and combined in an individual mini-project on an assigned design problem.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Alena Khmelinskaia

Language	English

Additional information

Module WP 113: Specialisation in Physical Chemistry – Electronic Processes in Semiconductors (T1PW)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 113.1 Electronic Processes in Semiconductors (T1PW)	WiSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	This course offers an introduction to electronic processes in organic semiconductors nowadays used in many optoelectronic devices such as organic light-emitting diodes and organic solar cells. First, the theoretical basics of electronic transitions and excited states (excitons) are discussed, followed by an overview of basic measurement (spectroscopy) techniques. Next, emission spectra of single molecules, ensembles of molecules, and aggregates are reviewed, and basic concepts of excitation energy transfer and (photo)excitations in conjugated polymers are introduced. Finally, the course discusses technological applications of organic semiconductors and introduces advanced (time-resolved) spectroscopy and data analysis techniques.
Qualification goals	At the end of the course the attendees will be: i.) familiar with the description of electronic transitions in organic and hybrid materials, ii.) familiar with the description of charge transfer, transport, and recombination, iii.) familiar with common steady-state and time-resolved optical spectroscopy techniques, iv.) familiar with

	advanced spectroscopy techniques and data analysis tools, v.) able to analyze and understand spectroscopic data from common steady-state and time-resolved spectroscopic techniques.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Frédéric Laquai
Language	English
Additional information	**Textbooks:** • Bernard Valeur and Mário Nuno Berberan-Santos: Molecular Fluorescence –Principles and Applications, Wiley VCH, 2012 • Anna Köhler, Heinz Bässler: Electronic Processes in Organic Semiconductors –An Introduction, Wiley VCH, April 2015 • Mark Fox: Optical Properties of Solids, Oxford University Press, Incorporated • Hans Kuzmany: Solid-State Spectroscopy, Springer

Module WP 63: Specialisation in Theoretical Chemistry - Theory of Chemical Dynamics: Molecular Dynamics (T1TD)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 63.1 Theory of Chemical Dynamics: Molecular Dynamics (T1TD)	SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Principles of molecular dynamics and applications in current topics of chemistry: Classical molecular dynamics (MD) – relation of Schrödinger equation and the classical approximation to nuclear dynamics; Solution of Newtons equations of motion for the nuclei and introduction to various integration algorithms (propagators) to describe the temporal evolution (trajectories) of the particles; Periodic boundary conditions for condensed phase systems; Interaction potentials – efficient algorithms for the computation of short and long range interactions; MD simulations in the various ensembles (micro-canonical, canonical, constant pressure), relation to statistical mechanics and introduction of concepts of thermostat and barostat. Modern water and biomolecular force fields; Computer experiments and statistical analysis of trajectories; Improvement of the theoretical description via on-the-fly ab-intio molecular dynamics; QM/MM and surface hopping methods for excited states; Nuclear quantum effects; Rare event sampling methods and freee energy

	simulations; Modern applications from theoretical and biophysical chemistry. A complementary MATLAB code is provided and discussed, demonstrating the general implementation of a molecular dynamics algorithm. Implementation of an MD algorithm for a Lennard-Jones Fluid as MATLAB code.
Qualification goals	The students will gain a fundamental understanding of molecular dynamical problems and how molecular dynamics simulations function as key driver of atomistic insight. They will develop an understanding how the mathematical theory is transferred into numerical algorithms and how the scaling behavior of the algorithms can be improved to address more complex chemical and biological systems. The first contact with numerical MATLAB codes deepens the knowledge of molecular dynamics algorithms and provides a basis for computer experiments by the students. The principles of phase space and ensemble averages provide a rigorous relation of simulation results to experimental observables. Modern simulation techniques allow the students to gain first insight into contemporary research questions.
Module assessment	Oral examination.
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. B. Fingerhut
Language	German/English
Additional information	**Literature:** • D. Frenkel, B. Smit, Understanding Molecular Simulation - From Algorithms to Applications, Academic Press (2023), ISBN 978-0-323-90292-2. • M. Griebel, S. Knapek, G. Zumbusch, Numerical Simulation in Molecular Dynamics (Numerics, Algorithms, Parallelization, Applications), Springer Berlin Heidelberg (2007), ISBN 978-3-540-68094-9. • M. P. Allen, D. J. Tildesley, Computer Simulation of Liquids, 2. Ed., Oxfort University Press (2017), ISBN 978-0-19-880319-5.

Module WP 64: Specialisation in Theoretical Chemistry - Theory of Chemical Dynamics: Quantum Dynamics (T1TE)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 64.1 Theory of Chemical Dynamics: Quantum Dynamics (T1TE)	WiSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Principles of quantum dynamics and applications to current topics in femtochemistry: solution of the time dependent Schrödinger equation (TDSE) for the nuclear dynamics in molecular systems by means of different methods. General definition and characterization of wavepackets, solution of the TDSE in the eigenstate basis for analytic solvable systems, Fourier Transformation theorems connected to the fast solution of the TDSE, propagators for the time evolution in ab initio potentials of arbitrary molecular systems, light-matter interaction. Applications: Ultrafast dynamics, theoretical description of pump-probe spectroscopy, control of chemical reactions by femtosecond pulses, implementation of propagation algorithms in MATLAB codes as well as simulation of selected examples.
Qualification goals	Understanding of quantum dynamical problems and transfer of the theory to mathematical algorithms by developing and using own MATLAB codes as well as the visualization of the results

Module assessment	Presentation (20+10 Min) plus Programming
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. B. Fingerhut
Language	German/English
Additional information	**Literature:** David Tannor „Introduction to Quantum Mechanics: A Time-dependent Perspective" University Science Books (2007), ISBN 1-891389-23-8

Module WP 65: Specialisation in Theoretical Chemistry - Density Functional Theory (T1TF)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 65.1 Density Functional Theory (T1TF)	SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	• Historical overview of density functional theory • Conceptual and mathematical foundations of density functional theory • Overview of the most important exchange-correlation functionals, considering their respective strengths and weaknesses • Strategies for deriving exchange-correlation functionals • Persisting challenges in density functional theory • Implementation aspects of density functionals in modern quantum chemistry programs • Introduction to time-dependent density functional theory for the description of electronically excited states • Introduction to the related field of Green's functions
Qualification goals	After attending the course, students will be able to: • Explain, discuss, and apply the conceptual and mathematical foundations of density functional theory • Name modern density functionals and describe their

	advantages and disadvantages • Compare the advantages and disadvantages of modern density functionals and determine which functional is suitable or unsuitable for a given problem • Present different strategies for deriving density functionals • Name and explain the persisting challenges in density functional theory • Explain the fundamentals of time-dependent density functional theory as well as the theory of Green's functions
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Dr. D. Graf / Prof. Dr. C. Ochsenfeld
Language	German/English
Additional information	**Literature:** • R. G. Parr, W. Yang: Density-Functional Theory of Atoms and Molecules, Oxford University Press 1989 • H. Eschrig: The Fundamentals of Density Functional Theory, Teubner 1996 • W. Koch, M. Holthausen: A Chemist's Guide to Density Functional Theory, Wiley 2001 • E. Engel, R. M. Dreizler: Density Functional Theory – An Advanced Course, Springer 2011 • M. A. L. Marques, N. T. Maitra, F. M. S. Nogueira, E. K. U. Gross, A. Rubio, Fundamentals of Time-Dependent Density Functional Theory, Springer 2012 • A. L. Fetter, J. D. Walecka: Quantum Theory of Many-Particle Systems, Dover Publications 2003

Module WP 66: Specialisation in Theoretical Chemistry – Theoretical Solid-State Chemistry (T1TG)

(This module is no longer available.)

Module WP 67: Specialisation in Theoretical Chemistry - Linear Scaling Quantum Methods for large Molecules (T1TH)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 67.1 Linear Scaling Quantum Methods for large Molecules (T1TH)	SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	The lecture provides insights into modern developments in quantum chemistry for calculating large molecular systems: density matrix, density operator, projector properties; the metric; linear-scaling methods for calculating the Fock matrix; avoiding the diagonalization in SCF theory; linear-scaling energy gradients; Laplace-based methods; calculation of molecular properties for large molecules; linear-scaling MP2 energies and MP2 energy gradients
Qualification goals	Advanced understanding of modern quantum-chemical methods for calculating complex molecular systems
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.

Responsible person	Prof. Dr. C. Ochsenfeld
Language	German/English
Additional information	**Literature:** Reviews in Computational Chemistry, Volume 23, Wiley-VCH

Module WP 68: Specialisation in Theoretical Chemistry – Special Lecture in Theoretical Chemistry (T1TZ)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 68.1 Special Lecture in Theoretical Chemistry (T1TZ)	WiSe/ SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	The lecture offers students in-depth knowledge of the subject with a range of topics that changes from semester to semester. The course format can be used for special lectures on common or current topics in organic chemistry.
Qualification goals	Students are introduced to special topics in organic chemistry in the lectures. In doing so, they deepen their previously acquired knowledge with special specialist information. This should be integrated into existing knowledge in order to formulate and discuss scientific questions. The acquired theoretical knowledge should be applied in the practical part of the course.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-	ECTS-points are awarded for passing the exam, which is

Points	allocated to the module.
Responsible person	Prof. Dr. C. Ochsenfeld
Language	German/English
Additional information	

Module WP 107: Specialisation in Theoretical Chemistry – Theory of energy and electron transfer in photoactive systems (T1TI)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 107.1 Theory of energy and electron transfer in photoactive systems (T1TI)	SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	Building on the courses of theoretical chemistry in the Bachelor's program, the lecture deals with modern aspects of energy and electron transfer reactions in photoactive materials, such as light-harvesting complexes, reaction centers and polymers for organic photovoltaics. The theoretical foundations for their time-dependent quantum mechanical description are developed, the lecture covers the following main topics: • Born-Oppenheimer approximation, adiabatic and diabatic representation of potential surfaces • Formalism of time-dependent quantum mechanics with a focus on time-dependent perturbation theory • Fermi's golden rule • Interaction picture and correlation functions • Quantum mechanical description of kinetic processes

	and chemical reaction rates • Theory of electron transfer reactions • Density matrix description of the dynamics in condensed phase • Exciton dynamics and energy transfer • Outlook on modern, non-perturbation-theoretical numerical methods Links to current research examples are provided for the individual main topics.
Qualification goals	The lecture develops an in-depth understanding of dynamic processes that are of central importance in materials science and physical and theoretical chemistry. Students gain insight into time-dependent perturbation theory methods and learn the limits of their applicability. Conceptual analogies and differences between energy and electron transfer reactions are worked out. Furthermore, the outlook to modern numerical methods offers students an insight into current research topics.
Module assessment	Oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Benjamin Fingerhut
Language	German/English
Additional information	**Literature:** • G. C. Schatz, M. A. Ratner, Quantum Mechanics in Chemistry, Dover Publications (2002), ISBN 978-0-486-42003-5. • V. May, O. Kühn, Charge and Energy Transfer Dynamics in Molecular Systems, Wiley-VCH (2004), ISBN 3-527-40396-5. • A. Nitzan, Chemical Dynamics in Condensed Phase, Oxford University Press (2006), ISBN 978-0-19-968668-1.

Module WP 35: Specialisation in Physical Chemistry – Energyconversion (T1PD)

Degree programme	Master's degree: Chemistry

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 35. Energyconversion (T1PD)	SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40, WP 58 to WP 76, WP 78, WP 79, WP 81 to WP 89, WP 91 to WP 93 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	In this course we will discuss the global energy landscape and traditional technologies as a starting point for the treatment of selected sustainable energy conversion strategies. The focus will be on the physicochemical foundations and recent materials developments addressing these challenges. Emphasis will be placed on solar energy conversion with photovoltaic devices including classical semiconductor, excitonic and third generation solar cells, and the generation of solar fuels through photoelectrochemical and artificial photosynthesis concepts. Moreover, we will address the mechanisms and materials for electrochemical energy storage using batteries and capacitors, as well as different types of fuel cells.
Qualification goals	The students should gain an understanding of the global energy landscape and traditional energy technologies. Moreover, they should understand the physicochemical foundations and recent materials developments regarding solar energy conversion with photovoltaic devices including classical semiconductor, excitonic and third generation solar cells, and the generation of solar fuels

	through photoelectrochemical and artificial photosynthesis concepts. Moreover, they should gain an understanding of the mechanisms and materials for electrochemical energy storage using batteries and capacitors, as well as different types of fuel cells.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Dr. Thomas Bein
Language	German/English
Additional information	

Module WP 70: Specialisation in Biochemistry (T1Y1)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 70.1 Lecture in Biochemistry (T1Y1)	WiSe/ SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	The module broadens and deepens special professional knowledge from the field of Biochemistry. The lectures cover central aspects in the cellular biochemistry and life cycle of proteins, key processes in genome biology and the most important model organisms used in current modern research.
Qualification goals	The lectures are based on current research topics in Biochemistry with new research results continuously updated. The lecture will enable students to understand modern Biochemistry research towards primary literature and review article level and to broaden and deepen their already acquired knowledge. They will understand and learn to judge selected literature experiments to test research hypotheses with current topics in Biochemistry. The acquired theoretical knowledge will be implemented during the practical course.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-	ECTS-points are awarded for passing the exam, which is

Points	allocated to the module.
Responsible person	Prof. Hopfner
Language	German/English
Additional information	You can choose from the following lectures: • Life cycle of Proteins • Flow of genetic Information • Model Organisms

Module WP 71: Advanced Specialisation in Biochemistry (T1Y2)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 71.1 Advanced Studies in Biochemistry (T1Y2)	WiSe/ SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	The module broadens and deepens special professional knowledge from the field of Biochemistry. The lectures cover central aspects in the cellular biochemistry and life cycle of proteins, key processes in genome biology and the most important model organisms used in current modern research.
Qualification goals	The lectures are based on current research topics in Biochemistry with new research results continuously updated. The lecture will enable students to understand modern Biochemistry research towards primary literature and review article level and to broaden and deepen their already acquired knowledge. They will understand and learn to judge selected literature experiments to test research hypotheses with current topics in Biochemistry. The acquired theoretical knowledge will be implemented during the practical course.
Module assessment	Exam or oral examination
Grading	Passed/ not passed

Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Hopfner
Language	German/English
Additional information	You can choose from the following lectures: • Life cycle of Proteins • Flow of genetic Information • Model Organisms

Module WP 72: Specialisation in Structural Biology

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 72.1 Lecture in Structural Biology	WiSe/ SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	This lecture extends concepts used in structural biology and their application. The course covers advanced principles of scattering and diffraction and in addition, knowledge of protein building blocks, protein folds and ribonucleic acid-protein complexes will be provided. Based on selected topics, the students will learn about the role and application of structural biology methods in more detail, e.g. in understanding biological processes on molecular basis or in the process of pharmaceutical drug discovery. The students will prepare own presentations based on selected publications in the field of structural biology. Each student is expected to give a broad introduction to the scientific focus of the respective publication, followed by a presentation of the findings with emphasis on a critical discussion of the methods, results, quality, and the discussion.
Qualification goals	Students will acquire knowledge about advanced topics of three-dimensional macromolecular structure determination of proteins and nucleic acids, especially with respect to combinatorial/orthogonal methods and

	their individual advantages and disadvantages. The students will be able to present and critically discuss publications in the field of structural biology. Based on this knowledge and training, the students will be able to recognize the relevance of publications, which is important in their careers as structural biologists. In addition, the detailed in-depth analysis of structural biology publications will enable them to develop own approaches in future projects.
Module assessment	Exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Responsible person	Prof. Beckmann, Prof Hopfner
Language	English
Additional information	

Module WP 73: Specialisation in Molecular and Cellular Genetics (T1G1)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 73.1 Lecture Molecular and Cellular Genetics (T1G1)	WiSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	The module introduces special knowledge from the field of Molecular and Cellular Genetics. The lectures cover genetic mechanisms underlying complex cellular processes and the multiple levels of regulation of gene expression before and after transcription comprising topics such as cancer, aging and cellular quality control.
Qualification goals	Students gain an expertise in up-to-date topics of current research in Molecular and Cellular Genetics. They acquire knowledge and competence to understand and evaluate special topics about regulation of gene expression and about genetic mechanisms controlling complex cellular processes such as cancer, aging and cellular quality control. New specialized information is integrated in existing knowledge to gain the capacity to formulate and discuss related scientific problems. The acquired theoretical knowledge is further implemented during the practical course.
Module assessment	Exam or oral examination

Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Responsible person	Prof. Beckmann
Language	English
Additional information	

Module WP 74: Advanced Specialisation in Molecular and Cellular Genetics (T1G2)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 74.1 Advanced In-depth Studies Molecular and Cellular Genetics (T1G2)	SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	The module introduces special knowledge from the field of Molecular and Cellular Genetics. The lectures cover genetic mechanisms underlying complex cellular processes and the multiple levels of regulation of gene expression before and after transcription comprising topics such as cancer, aging and cellular quality control.
Qualification goals	Students gain an expertise in up-to-date topics of current research in Molecular and Cellular Genetics. They acquire knowledge and competence to understand and evaluate special topics about regulation of gene expression and about genetic mechanisms controlling complex cellular processes such as cancer, aging and cellular quality control. New specialized information is integrated in existing knowledge to gain the capacity to formulate and discuss related scientific problems. The acquired theoretical knowledge is further implemented during the practical course.
Module assessment	Exam or oral examination

Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS credits will be granted when the module examination (or the examination of pertinent mandatory and potential elective compulsory module parts) has/have been completed successfully.
Responsible person	Prof. Beckmann
Language	English
Additional information	

Module WP 75: Discipline Specific Studies in Chemistry (T1RV)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 75.1 Topics in Discipline Specific Studies in Chemistry (T1RV)	WiSe/ SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	This module supplements knowledge in the field of chemistry, which may also beyond the field of chemistry.
Qualification goals	In the lecture, students are introduced to modern topics of later professional life. In doing so, they expand their previously acquired knowledge with current and specialized information. The information is to be integrated into existing knowledge in order to formulate and discuss scientific questions.
Module assessment	Oral presentation or exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Dean of Studies

Language	German/English

Additional information

Module WP 76: Advanced Discipline Specific Studies in Chemistry (T1RW)

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Lecture	WP 76.1 Advanced Topics in Discipline Specific Studies in Chemistry (T1RW)	WiSe/ SoSe	30h (2 SWS)	60 h	3

This module is comprised of 3 ECTS-points. Attendance time is 2 contact hours per week. Total time, including self-directed studies, is about 90 h.

Type of the Module	Optional module with compulsory course.
Applicability to other degree programmes	-
Elective guidelines	If a minor subject is selected, specialisation courses from modules WP 21 to WP 40 and WP 58 to WP 113 have to be selected with 15 ECTS in total.
Entry requirements	none
Study pathway level	Between semester 1 and 3
Duration	The module spans 1 semester.
Content	This module supplements knowledge in the field of chemistry, which may also beyond the field of chemistry.
Qualification goals	In the lecture, students are introduced to modern topics of later professional life. In doing so, they expand their previously acquired knowledge with current and specialized information. The information is to be integrated into existing knowledge in order to formulate and discuss scientific questions.
Module assessment	Oral presentation or exam or oral examination
Grading	Passed/ not passed
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Dean of Studies

Language	German/English

Additional information

Module P 1: Master's Degree Module

Degree programme	Master's degree: Chemistry (M.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact Hours	Self-directed Studies	ECTS
Master's thesis	P1.1 Master's thesis	WiSe/ SoSe		900 h	30

This module is comprised of 30 ECTS-points. Total time, including self-directed studies, is about 900 h.

Type of the Module	Compulsory module with compulsory course
Applicability to other degree programmes	none
Elective guidelines	none
Entry requirements	Successful participation in two compulsory modules of WP 1, WP 3, WP 6 und WP 7
Study pathway level	Semester 4
Duration	The module spans 1 semester.
Content	The content of the Master's thesis is the independent study of a specific problem in the field of chemistry, including the preparation of a written scientific research report.
Qualification goals	After participating the final module, students are able to comprehensively develop and present a defined subject area within six months; project and teamwork skills. Through the Master's thesis, students gain a theoretical and practical understanding of specific issues in chemistry, also building on the knowledge gained in their previous studies. They can carry out scientific experiments correctly and present and discuss their results correctly in a research report in terms of form and content.
Module assessment	Master's thesis
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.

Responsible person	Dean of Studies
Language	German/English
Additional information	

Sitemap of the Campus Großhadern/Martinsried

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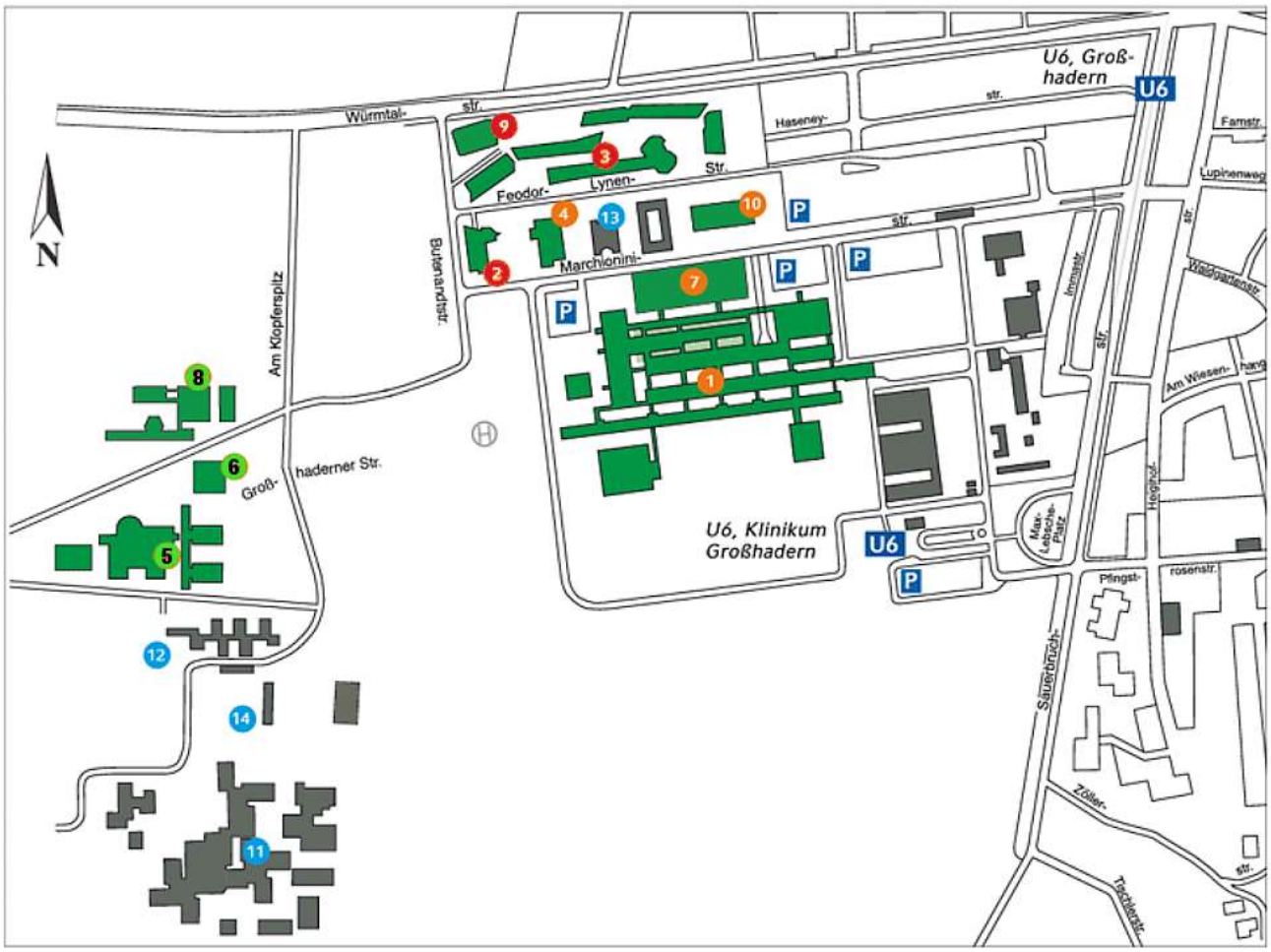

1 Klinikum der Universität München, Standort Großhadern 2 Genzentrum 3 Fakultät für Chemie und Pharmazie 4 Zentrum für Neuropathologie und Prionenforschung 5 Fakultät für Biologie/Biozentrum 6 Campuszentrum 7 Operationszentrum 8 Biomedizinisches Centrum 9 Forschungszentrum für Molekulare Biosysteme (BioSysM) 10 Zentrum zur Erforschung von Schlaganfall, Demenz und neurodegenerativen Erkrankungen 11 Max-Planck-Institute für Biochemie und Neurobiologie 12 Innovations- und Gründerzentrum Biotechnologie (IZB) 13 Helmholtz Zentrum München – Hämatologikum 14 BioM GmbH