



LUDWIG-
MAXIMILIANS-
UNIVERSITÄT
MÜNCHEN



Module Handbook / Program Catalogue
Bachelor's Degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

(180 ECTS points)

Based on the Examination Regulations from March 22, 2010

83/447/---/H1/H/2010

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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 catalog 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 catalog either by "designated semester" or "recommended semester", respectively.
3. The course catalog is intended to serve as an orientation for the bachelor'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

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/>

Introduction Session:

A comprehensive introduction will take place on the first day of the lecture period. Detailed information on time and place can be found in the [online course catalog LSF](#).

Description and goals of the bachelor's program in Chemistry and Biochemistry

Through the high proportion of required lab courses, students of the LMU's **bachelor's program in "Chemistry and Biochemistry"** will be prepared for the challenges of experimental science. The program will acquaint students with experimental methods by strongly linking theory and practice while conveying expert knowledge, honing powers of observation and teaching technical skills, especially in handling hazardous substances – all of which are indispensable for independent scientific work. The bachelor's program forms the basis for subsequent specialization.

Courses are organized into modules where students, by taking exams after lecture and lab courses, must reach 180 credits, according to the European Credit Transfer System (ECTS). The final bachelor's grade is calculated as the mean average of all module grades. The module grades are calculated from continual assessments averaged with the ECTS credits of more weighted exams (see: Appendix A14, PStO §20 and §10 clause 3).

A bachelor's degree allows for an early transition to working life or serves as preparation, for example, for more in-depth study in the master's programs in chemistry or biochemistry.

Program structure

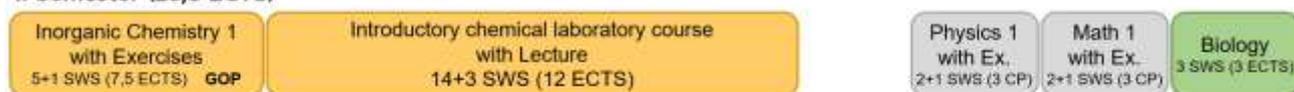
The bachelor's program in chemistry and biochemistry, with a prescribed period of study of six semesters, always begins in the winter semester. The program's concept – the "Y Model" – has all students attending the same basic courses for the first four semesters. The **required lecture and lab courses** of the "**Basic Program**" (120 ECTS) teach basic knowledge and skills in inorganic, organic, physical and theoretical chemistry and biochemistry as well as in biology, mathematics and physics. Lab courses teach basic experimental practices and methods and familiarize students with the most important material classes as well as basic data processing and the use of relevant program systems.

The fifth and sixth semesters comprise the "**Orientation Program**" (60 ECTS) where students choose their "majors" and prepare their bachelor's thesis. Here, training in inorganic, organic, physical, and theoretical chemistry and biochemistry, or, biology (with microbiology and cell biology) will be deepened. The lectures and seminars of this part of the program expand upon the knowledge gained in the "Basic Program" and offer a survey of current themes and modern developments in chemistry and biochemistry. During this phase of the final two semesters of the program allows students to choose their "majors" in chemistry or biochemistry through required elective courses (WP1 – WP5), each with 15 ECTS, and two lecture courses plus one lab course within the module. Individual aptitudes can be developed, individual job profiles can be created for the future, or the requirements for the master's program in chemistry and biochemistry can be acquired.

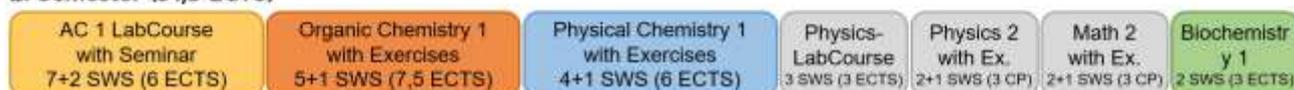
Advanced lecture and lab courses surrounding the major subject convey the most current experimental techniques and analytical methods. The program concludes with the submission of a bachelor thesis on a subject from one of the five core subjects in chemistry. In addition to the elective modules (major) with 15 ECTS each, students may choose from lecture courses found in the module "Supplementary Courses" (WP 12 with 15 ECTS) in astronomy, bioinformatics, solid state physics, computer science, crystallography, pharmaceutical chemistry, pharmaceutical biology, pharmacology and toxicology and theoretical physics. During the fifth semester the compulsory module "Toxicology and the Law" (3 ECTS) must be passed. The sixth semester comprises, among others, the "Bachelor Diploma Module" (12 ECTS).

Upon completion of the program the LMU bestows upon students the academic title "Bachelor of Science" (B.Sc.) and issues a certificate with grades.

1. Semester (28,5 ECTS)



2. Semester (31,5 ECTS)



3. Semester (28 ECTS)



4. Semester (32 ECTS)



5.-6. Semester (60 ECTS)

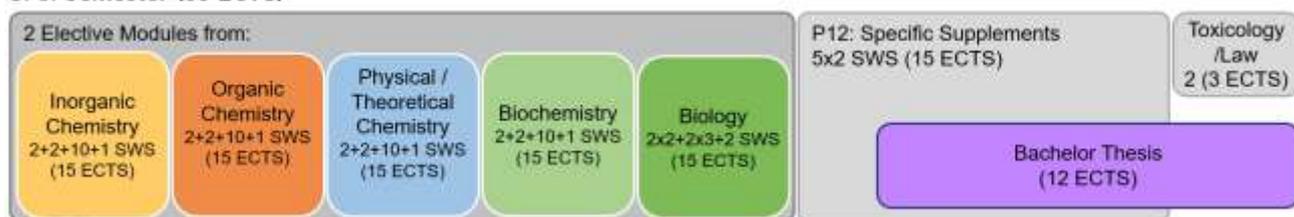


Fig. 1: The ideal course of study/curriculum for the six-semester bachelor's program in chemistry and biochemistry (AC, OC, PC, TC, BC = inorganic, organic, physical, theoretical and biochemistry; the numbers indicate the number of hours/week; ECTS are in parentheses).

Module P 1: Basic Chemistry

Degree programme

Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact hours	Self-directed studies	ECTS
Lecture	P 1.1: General and Inorganic Chemistry 1 (Experimental Chemistry)	WiSe	75 h (5 SWS)	120 h	(6,5)
Exercise	P 1.2: Exercise to the lecture General and Inorganic Chemistry 1 (Experimental Chemistry)	WiSe	15 h (1 SWS)	15 h	(1)
Lecture	P 1.3: Organic Chemistry 1	SoSe	75 h (5 SWS)	120 h	(6,5)
Exercise	P 1.4: Exercise to the lecture Organic Chemistry 1	SoSe	15 h (1 SWS)	15 h	(1)
Lecture	P 1.5: Physical Chemistry 1	SoSe	60 h (4 SWS)	90 h	(5)
Exercise	P 1.6: Exercise to the lecture Physical Chemistry 1	SoSe	15 h (1 SWS)	15 h	(1)

This module is comprised of 21 ECTS-points. Class attendance is 17 contact hours per week. Total time, including self-directed studies, is about 630 hrs.

Type of the module	Compulsory module with required courses.
Applicability to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 1 and 2
Duration	The modul spans 2 semesters.
Content	The module covers the basic concepts of general, inorganic, organic and physical chemistry; important substance classes and functional groups, an overview of technical processes and an introduction to important reaction mechanisms in chemistry. Details in P 1.1-1.6
Qualification goals	After attending the module courses, students are able to summarize the main concepts of the lectures and transfer the knowledge to current problems.

In the exercises, they can apply these concepts to typical examples and analyze the results.

Details in P 1.1-1.6

Module assessment

Written or oral 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

Prof. Dr. Dr. h.c. Thomas M. Klapötke, Prof. Dr. Oliver Trapp, Prof. Dr. Joost Winterlin

Language

German

Additional information

P 1.1: General and Inorganic Chemistry 1 (Experimental Chemistry) T1AA

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	<ul style="list-style-type: none"> • Bachelor's degree program in Biology, • Bachelor's degree program in Pharmaceutical Sciences, • State examination program in Pharmacy, • Education degree program
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 1
Duration	The course spans 1 semester.
Content	Substances and substance separation, chemical reactions and energy transfer, atoms and molecules, bonding theory (MO, VB), hydrogen, atomic shell, noble gases, oxygen, covalent bonding, ozone, metal bond, ionic bond and salts, water, halogens, halogenated hydrocarbons, reaction rates and chemical equilibrium, acids and bases, hydrogen peroxide, halogen-oxygen compounds, interhalogen compounds and noble gas compounds, electrochemistry and redox reactions, chalcogens, Group V elements, Group IV elements, Group III elements, Group II elements, Group I elements.
Qualification goals	<p>The students should be able to:</p> <ol style="list-style-type: none"> a) outline basic fundamental concepts of general and inorganic chemistry and apply these to atomic structure, chemical bonding, acid-base and redox reactions, as well as to the structure of crystalline solids. b) explain and apply the fundamentals of thermodynamics and kinetics to describe simple chemical reactions. c) describe the organizational principles of the periodic table of the elements and apply them to explain the properties of chemical elements. d) recall, discuss, and describe basic syntheses and transformations of simple inorganic compounds using the accepted scientific notation. e) translate concrete examples given in lectures to general principles. f) describe and explain important concepts of bonding theory (MO and VB). g) describe and illustrate experiments that demonstrate key aspects of the chemical properties of various fundamental inorganic compounds and elements.

Submodule assessment	Written or oral examination. The submodule assessment represents also the Basic Examination (Grundlagen- und Orientierungsprüfung (GOP))
Grading	The course 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. Dr. h.c. Thomas M. Klapötke
Language	German
Additional information	Recommended literature: <ul style="list-style-type: none">• C. Mortimer, <i>Das Basiswissen der Chemie</i>, Thieme, Stuttgart, 2003.• E. Riedel, <i>Inorganic Chemistry</i>, de Gruyter, Berlin, 2007.

P 1.2: Exercise to the Lecture General and Inorganic Chemistry 1 (Experimental Chemistry) T1AB

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	<ul style="list-style-type: none"> • Bachelor's degree program in Biology, • Bachelor's degree program in Pharmaceutical Sciences, • State examination program in Pharmacy, • Education degree programs
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 1
Duration	The course spans 1 semester.
Content	<p>The learning contents are fundamentals in inorganic and general chemistry consisting of three parts:</p> <p>Part A: Basics in chemistry – the science of substances, constitution and structure of matter, atoms, atomic bonds, gas reactions, polar molecules, salts, chemical equilibria, acid-base reactions, redox reactions, electrochemistry, solids.</p> <p>Part B: Chemistry of the main group elements</p> <p>Part C: Chemistry of the side group elements</p>
Qualification goals	The educational objective is the task mastery of the contents of the lecture and learning of the transfer of this knowledge to current issues. The contents of the lecture will be engrossed in the tutorials.
Submodule assessment	s. P 1.1
Grading	The course 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. Dr. h.c. Thomas M. Klapötke
Language	German
Additional information	<p>Recommended literature:</p> <ul style="list-style-type: none"> • C. Mortimer, <i>Das Basiswissen der Chemie</i>, Thieme, Stuttgart, 2003.

- E. Riedel, *Inorganic Chemistry*, de Gruyter, Berlin, 2007.

Organizational information:

Students register for the tutorial through the faculty website

P 1.3: Lecture Organic Chemistry 1 (T1BC)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	<ul style="list-style-type: none"> • Bachelor's degree program in Biology, • Bachelor's degree program in Pharmaceutical Sciences, • State examination program in Pharmacy, • Education degree programs
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 2
Duration	The course spans 1 semester
Content	Topics include fundamental aspects of organic chemistry such as the most relevant functional groups, important classes of natural substances and synthetic polymers, important technical processes, fundamental reaction mechanisms, the basics of stereochemistry and the bonding in organic molecules.
Qualification goals	<p>Students have the ability to:</p> <ol style="list-style-type: none"> a) draw structures of organic compounds and explain their 3D-structure; b) to recognize the most important functional groups and their associated properties and their reactivity; c) recognize basic reactions and reaction mechanisms and be able to apply them to examples; d) develop a systematic name for organic compounds following the IUPAC rules; e) develop a basic understanding of stereochemistry (3D structure).
Submodule assessment	Written or oral examination.
Grading	The course 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. Oliver Trapp
Language	German
Additional information	<ul style="list-style-type: none"> • K. P. Vollhardt, N. E. Schore, <i>Organische Chemie</i>, Wiley-VCH, Weinheim, 2012.

- B. König, H. Butenschön, *Organische Chemie*, Wiley-VCH, Weinheim, **2007**.
- Introductory textbook: W. H. Brown, T. Poon, *Einführung in die Organische Chemie*, Wiley-VCH, Weinheim, **2020**.
- Advanced textbook: F. A. Carey, R. J. Sundberg, *Organische Chemie*, Wiley-VCH, Weinheim, **1995**.

P 1.4: Exercise to the Lecture Organic Chemistry 1 (T1BD)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	<ul style="list-style-type: none"> • Bachelor's degree program in Biology, • Bachelor's degree program in Pharmaceutical Sciences, • State examination program in Pharmacy, • Education degree programs
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 2
Duration	The course spans 1 semester.
Content	The exercise sessions repeat the material presented in the lecture course using selected problems sets. The active participation of the students is required.
Qualification goals	The qualification goals of the exercise sessions are identical to those of the organic chemistry 1 lecture.
Submodule assessment	s. P 1.3
Grading	The course 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. Oliver Trapp
Language	German
Additional information	<p>Recommended literature:</p> <p>s. P 1.3</p> <p>Organizational information:</p> <p>Students register for the tutorial through the faculty website.</p>

P 1.5: Lecture Physical Chemistry 1 (T1BE)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 2
Duration	The course spans 1 semester
Content	Topics are classical thermodynamics, electrochemistry, and kinetics. The thermodynamics part treats equations of state of ideal and real gases and of solids and liquids, the laws of thermodynamics, work and heat, the state functions internal energy and enthalpy, calorimetry, heat engines, the state functions entropy, free energy and free enthalpy, the chemical potential, phase equilibria and phase diagrams, the chemical equilibrium and how it depends on pressure and temperature. The electrochemistry part treats the thermodynamic basis of electrochemistry, the electrochemical potential, the Galvani and Nernst potentials. The kinetics part treats elementary reactions and rate laws of simple chemical reactions.
Qualification goals	In the thermodynamics and electrochemistry part students obtain insight into the axiomatic structure of a scientific theory. They learn how to use the methods of the abstract thermodynamic theory to solve actual chemical problems. Using the obtained knowledge, they are enabled to quantitatively calculate physical-chemical quantities that are also required in their practical laboratory work. In the kinetics part they obtain insight into the time evolution of chemical reactions, and they learn how to deal with simple differential equations.
Submodule assessment	Written or oral examination.
Grading	The course 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. Joost Wintterlin
Language	German
Additional information	Recommended literature: P. W. Atkins, J. de Paula, J. Keeler, <i>Atkins' Physical Chemistry</i> , Oxford University Press, 2022.

P 1.6: Exercise to the Lecture Physical Chemistry 1 (T1BF)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 2
Duration	The course spans 1 semester.
Content	The contents are those listed in module P 1.5 (lecture Physical Chemistry 1). The exercises aim to enhance the knowledge of the contents of the lecture.
Qualification goals	By solving exercises, students learn how to apply the theoretical basis developed in the lecture to evaluate macroscopic physical-chemical quantities. This includes, e.g., calculating phase coexistence lines, equilibrium partial pressures in gas reactions, cell voltages of batteries, and activation energies of chemical reactions. By presenting their solutions of the exercises to their tutorial groups, the students practice their presentation skills. The general objective is to enhance the students' insight into classical thermodynamics, electrochemistry, and kinetics by practically applying these theories to actual chemical problems.
Submodule assessment	s. P 1.5
Grading	The course 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. Joost Wintterlin
Language	German
Additional information	<p>Recommended literature:</p> <ul style="list-style-type: none"> • P. W. Atkins, J. de Paula, J. Keeler, <i>Atkins' Physical Chemistry</i>, Oxford University Press, 2022. <p>Organizational information:</p> <p>Students register for the tutorials through the faculty website.</p>

Module P 2: Laboratory Course General and Inorganic Chemistry

Degree programme

Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact hours	Self-directed studies	ECTS
Lecture	P 2.1: Introduction to experimental chemistry	WiSe	45 h (3 SWS)	45 h	3
Lab course	P 2.2: Introductory chemical laboratory course	WiSe	210 h (14 SWS)	60 h	9

This module is comprised of 12 ECTS-points. Class attendance is 17 contact hours per week. Total time, including self-directed studies, is about 360 hrs.

Type of the module	Compulsory module with required courses.
Applicability to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 1
Duration	The modul spans 1 semester.
Content	The course covers the theoretical fundamentals of General and Inorganic Chemistry: chemical reaction and chemical equilibrium (stoichiometry and law of mass action), chemical calculations, acid-base chemistry, precipitation reactions, redox reactions and fundamentals of complex chemistry, as well as the application of these reaction types in quantitative analysis; importance of colours in analytical chemistry (absorption of light in dilute solutions, fluorescence), fundamentals of reaction kinetics, (reaction order, rate constants), electrochemistry (conductivity, electrolysis, galvanic cells).
Qualification goals	Students understand the theoretical fundamentals of general and inorganic chemistry, quantitative analysis and important principles of physical chemistry and can apply these in the experiments of the practical course. Learning how to carry out chemical experiments safely and accurately and how to carry out quantitative analyses to verify theoretical models. Comprehensible recording of the experiments including discussion of the results.
Module assessment	Written or oral examinations and lab course 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. Ivanović-Burmazović, Prof. Knut Müller-Caspary, Dr. Ina Kellner
Language	German
Additional information	s. P 2.1 and P 2.2

P 2.1: Introduction to Experimental Chemistry (T1AC)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 1
Duration	The course spans 1 semester.
Content	<p>The course covers the theoretical fundamentals of general and inorganic chemistry: chemical reactions and chemical equilibrium (stoichiometry and law of mass action), chemical calculations, acid-base chemistry, precipitation reactions, redox reactions and the fundamentals of complex chemistry. The focus here is on the application of these reaction types in quantitative analysis and the calculations required for this. Part in physical chemistry: importance of colours in analytical chemistry (light as wave and particle, absorption, fluorescence, spectrometer), fundamentals of reaction kinetics (0, 1st, 2nd order reactions, methods for experimental determination), fundamentals of electrochemistry (conductivity, electrolysis, galvanic cells).</p>
Qualification goals	<p>The learning objective of the course focuses on the acquisition of the most important theoretical principles of general and inorganic chemistry. The main focus is on learning practically relevant methods of quantitative inorganic analysis as well as important analytical methods in physical chemistry.</p> <p>After successfully completing the course, students will be able to correctly set up reaction equations, determine oxidation numbers, calculate substance quantities, molar masses, concentrations and pH values. They will understand the theory of titrimetric, gravimetric and potentiometric methods of quantitative analysis and the basics of chromatography. They understand the basic concepts of complex chemistry and can draw and name simple complexes and evaluate their stability.</p> <p>Students understand the basic physical principles of grating-type spectrometers, know the rate laws relevant to the practical course and know how to determine reaction orders and rate constants on the basis of experimental data. They can explain the temperature dependence based on collision theory and understand the influence of catalysts. Students acquire basic knowledge of the electrical conductivity of solutions, redox processes and</p>

electrolysis. Using the Nernst equation and standard potentials, electrochemical power supplies can be explained quantitatively. In particular, the lecture enables students to correctly interpret and quantitatively analyse the data obtained in the practical course against this theoretical background.

Submodule assessment	Written or oral examination.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Ivanović-Burmazović, Prof. Müller-Caspary, Dr. Ina Kellner
Language	German
Additional information	<p>The lecture accompanies the practical (2.2) such that the theoretical content is presented in advance at suitable timing.</p> <p>Recommended literature:</p> <p>Jander/Blasius, <i>Anorganische Chemie I + II</i>, Hirzel, Stuttgart, 2016.</p> <p>Script of the LiebigLab containing the description of the experiments, manuals and questions is provided on the central online platform (moodle).</p>

P 2.2: Introductory Chemical Laboratory Course (T1AD)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 1
Duration	The course spans 1 semester.
Content	<p>The content of the first few weeks is the basics of general and inorganic chemistry in practice: basics for laboratory work (handling burners, scales, glass processing), handling hazardous substances (operating instructions), chemical calculations, acid-base reactions, precipitation reactions, redox reactions, complex formation reactions, as well as the application of these reaction types in dimensional analysis.</p> <p>The basic knowledge is further deepened in three inorganic project parts such as the natural lime cycle, amino acids as polyfunctional molecules and oxidation reactions (bleaching, disinfection and oxidative stress). The background of the physical chemistry is also treated in three project parts: the origin of colors, kinetic of chemical reactions, and important basics in electrochemistry.</p> <p>In a subsequent research project, students work independently on a specific practical task in which they apply the knowledge they have learnt in the practical course and transfer it to new problems. The students present their results to a larger audience in the form of a poster presentation with a corresponding discussion.</p>
Qualification goals	<p>The learning objective of the course is focussed on the practical implementation and application of the most important fundamentals of general and inorganic chemistry as well as physical chemistry for each individual participant. Students will be able to work safely with hazardous substances, laboratory equipment and simple glassware. They acquire a clean and precise working method for carrying out analytical determinations and master the calculations and data processing required for analysing the results. You will be able to record and critically evaluate your own test results and transfer the knowledge gained to other problems.</p> <p>After completing their own research project, students are able to independently research suitable methods of analysis and experimental procedures and apply them in</p>

	practice. They can present their results graphically and explain them in free speech.
Submodule assessment	Scientific recording of experimental data and oral examination on the contents of experimental work. Moreover, numerous analyses (with valuation) have to be finished.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the submodule-
Responsible person	Prof. Ivanović-Burmazović, Prof. Müller-Caspary, Dr. Ina Kellner
Language	German
Additional information	<p>Recommended literature:</p> <p>Jander/Blasius, <i>Anorganische Chemie I + II</i>, Hirzel, Stuttgart, 2016.</p> <p>Script of the LiebigLab containing the description of the experiments, manuals and questions is provided on the central online platform (moodle).</p> <p>Organizational information:</p> <p>Registration for the lab course through the faculty website.</p> <p>The practical courses are opened daily (except Tuesday) from 13:00 to 17:00 in the student laboratories of the Department of Chemistry (Building D) at the Campus Großhadern.</p>

Module P 3: Propedeuticum

Degree programme

Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact hours	Self-directed studies	ECTS
Lecture	P 3.1: Mathematics for Chemists 1	WiSe	30 h (2 SWS)	30 h	(2)
Exercise	P 3.2: Exercises in Mathematics for Chemists 1	WiSe	15 h (1 SWS)	15 h	(1)
Lecture	P 3.3: Introductory physics for chemistry and biochemistry students 1	WiSe	30 h (2 SWS)	30 h	(2)
Exercise	P 3.4: Tutorial in physics for chemistry and biochemistry students 1	WiSe	15 h (1 SWS)	15 h	(1)
Lecture	P 3.5: Basics of biology	WiSe	45 h (3 SWS)	45 h	(3)
Lecture	P 3.6: Mathematics for Chemists 2	SoSe	30 h (2 SWS)	30 h	(2)
Exercise	P 3.7: Exercises in Mathematics for Chemists 2	SoSe	15 h (1 SWS)	15 h	(1)
Lecture	P 3.8: Introductory physics for chemistry and biochemistry students 2	SoSe	30 h (2 SWS)	30 h	(2)
Exercise	P 3.9: Tutorial in physics for chemistry and biochemistry students 2	SoSe	15 h (1 SWS)	15 h	(1)
Lab course	P 3.10: Physical laboratory course	SoSe	45 h (3 SWS)	45 h	(3)

This module is comprised of 18 ECTS-points. Class attendance is 18 contact hours per week. Total time, including self-directed studies, is about 540 hrs.

Type of the module	Compulsory module with required courses.
Applicability to other degree programs	
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 1
Duration	The modul spans 1 semester.

Content	The module covers fundamental concepts in natural sciences of mathematics, physics and biology, which are relevant for further studies in chemistry and biochemistry. Details in P 3.1-3.10
Qualification goals	After attending the module courses, students are able to summarize the main concepts of the lectures and transfer the knowledge to current problems. In the exercises, they can apply these concepts to typical examples and analyze the results. Details in P 3.1-3.10
Module assessment	Written or oral examinations.
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. Achim Hartschuh, Prof. Ralf Jungmann, Prof. Förstemann
Language	German
Additional information	

P 3.1: Mathematics for Chemists 1 (T1AE)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	Education degree programs
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 1
Duration	The course spans 1 semester.
Content	<p>Learning content includes set theory, types of numbers, sequences, series, functions of a variable: continuity and limit values, differentiation, integration, discussion of curves as well as vector operations and matrices.</p> <p>The understanding of the content of the lecture is deepened in the exercises and the abstraction from concrete examples to general principles is promoted.</p>
Qualification goals	<p>After successfully completing the module, the student should be familiar with whole, real and complex numbers and their properties and be able to calculate with them; Be able to differentiate and integrate functions of a variable and use the most important techniques of numerical analysis, such as interpolation, linear approximation and numerical integration; Understand the basics of vector and matrix calculations, such as scalar and cross products or matrix-vector and matrix-matrix-multiplications and be able to use them.</p>
Submodule assessment	Written or oral examination.
Grading	The course 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. Achim Hartschuh
Language	German
Additional information	<p>Recommended literature:</p> <p>N. Rösch, <i>Mathematik für Chemiker</i>, Springer-Verlag, Berlin, Heidelberg, NewYork, 2013.</p>

P 3.2: Exercises in Mathematics for Chemists 1 (T1AF)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	Education degree programs
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 1
Duration	The course spans 1 semester
Content	<p>Learning content includes set theory, types of numbers, sequences, series, functions of a variable: continuity and limit values, differentiation, integration, discussion of curves as well as vector operations and matrices.</p> <p>The understanding of the content of the lecture is deepened in the exercises and the abstraction from concrete examples to general principles is promoted.</p>
Qualification goals	<p>After successfully completing the module, the student should be familiar with whole, real and complex numbers and their properties and be able to calculate with them; Be able to differentiate and integrate functions of a variable and use the most important techniques of numerical analysis, such as interpolation, linear approximation and numerical integration; Understand the basics of vector and matrix calculations, such as scalar and cross products or matrix-vector and matrix-matrix-multiplications and be able to use them.</p>
Submodule assessment	Written or oral examination.
Grading	s. P 3.1
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
Additional information	<p>Recommended literature:</p> <p>N. Rösch, <i>Mathematik für Chemiker</i>, Springer-Verlag, Berlin, Heidelberg, NewYork, 2013.</p> <p>Organizational information:</p> <p>Students register for the tutorial through the faculty website</p>

P 3.3: Introductory Physics for Chemistry and Biochemistry Students 1

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	Education degree programs
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 1
Duration	The course spans 1 semester.
Content	Learning content includes: basic methodology of physics, error calculation, (SI) units of measurement, mechanics, hydrostatics, hydrodynamics, oscillations and wave theory, thermodynamics. Topics include: the art of measurement, motion, forces, gravitation, work and energy, momentum, rotary motion, fluids, vibrations, waves, special relativity, 1st and 2nd law of thermodynamics and statistical thermodynamics.
Qualification goals	<p>The students have command of the contents of the lecture course and are able to transfer the knowledge to current problems.</p> <p>The understanding of the contents of the lecture course is deepened and the generalization of knowledge is promoted.</p>
Submodule assessment	Written or oral examination.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Ralf Jungmann
Language	German
Additional information	<p>Recommended literature:</p> <p>P. Tipler, <i>Physik</i>, Spektrum Akademischer Verlag, Heidelberg, 2009.</p>

P 3.4: Tutorial in Physics for Chemistry and Biochemistry Students 1

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	Education degree programs
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 1
Duration	The course spans 1 semester.
Content	Learning content includes: basic methodology of physics, error calculation, (SI) units of measurement, mechanics, hydrostatics, hydrodynamics, oscillations and wave theory, thermodynamics. Topics include: the art of measurement, motion, forces, gravitation, work and energy, momentum, rotary motion, fluids, vibrations, waves, special relativity, 1st and 2nd law of thermodynamics and statistical thermodynamics.
Qualification goals	<p>The students have command of the contents of the lecture course and are able to transfer the knowledge to current problems.</p> <p>The understanding of the contents of the lecture course is deepened, by mathematically solving fundamental exercises exemplarily. The generalization of knowledge and methodology is promoted.</p>
Submodule assessment	s. P 3.3
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Ralf Jungman
Language	German
Additional information	<p>Recommended literature:</p> <p>P. Tipler, <i>Physik</i>, Spektrum Akademischer Verlag, Heidelberg, 2009.</p> <p>Organizational:</p> <p>Students register for the tutorial through the faculty website.</p>

P 3.5: Basics of Biology (T3C1)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	Education degree programs
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 1
Duration	The course spans 1 semester.
Content	The lecture covers the fundamental areas of biology: Biological macromolecules, cells, gene expression, genetics, evolution of species, phylogeny, cell cycle, basic aspects of physiology, immunobiology, neurobiology, and ecology are key aspects. The goal of the lecture is to develop a basic understanding of biological processes at all levels of organization. In a supplementary session, lecture material is discussed interactively, sometimes explored through computer simulations, and, where appropriate, connections to current societal issues are made.
Qualification goals	Students describe specific knowledge from the basics of biology. They are able to classify biological phenomena in a broad range of topics and can explain fundamental, subject-specific aspects. They discuss simple problems (e.g. from evolutionary biology or physiology) and also explain the connection between aspects from different lectures (e.g. evolution of sensory organs). They design simple strategies to experimentally observe fundamental processes in the field of biology. Furthermore, they can critically evaluate the deployment of modern developments from biology in the context of current societal needs and challenges.
Submodule assessment	Written exam.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Förstemann
Language	German
Additional information	Recommended Literature:

- Urry et al., *Biologie (Campbell)*, Pearson Studium, 11. Auflage (**2019**). ISBN: 978-3-86894-366-5N.
- Campbell, J. Reece, *Biologie*, Pearson Studium, **2009**.

P 3.6: Mathematics for Chemists 2 (T1BG)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	Education degree programs
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 2
Duration	The course spans 1 semester
Content	Contents are matrix operations, Eigenvalue equations, functions of several variables: differentiation, integration, and series.
Qualification goals	Having passed the module the student should be able to determine the partial derivatives of functions with several variables and to perform corresponding integrations; to discuss the local properties of functions with several variables on the basis of a Taylor expansion; know the most important types of coordinate systems (Cartesian, polar and spherical) and their advantages as well as the transformation between them; be able to invert matrices and to calculate determinants and to apply these when dealing with linear systems of equations; be able to deal with the simple algebraic eigen value problem.
Submodule assessment	Written or oral examination.
Grading	The course 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. Achim Hartschuh
Language	German
Additional information	Recommended literature: N. Rösch, <i>Mathematik für Chemiker</i> , Springer-Verlag, Berlin, Heidelberg, NewYork, 2013.

P 3.7: Exercises in Mathematics for Chemists 2 (T1BH)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	Education degree programs
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 2
Duration	The course spans 1 semester.
Content	Contents are matrix operations, Eigenvalue equations, functions of several variables: differentiation, integration, and series.
Qualification goals	Having passed the module the student should be able to determine the partial derivatives of functions with several variables and to use these when discussing their local properties on the basis of a Taylor expansion; to calculate path as well as multiple integrals for functions with several variables and to apply the concept of a complete differential; perform coordinate and basis transformations; to invert matrices applying various algorithms and to calculate their determinants; to solve homogeneous and inhomogeneous linear systems of equations; to apply the solution of the simple algebraic eigen value problem among others for calculations on the electronic structure of molecules on the basis of the LCAO-method.
Submodule assessment	s. P 3.6
Grading	The course 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. Achim Hartschuh
Language	German
Additional information	<p>Recommended literature:</p> <p>N. Rösch, <i>Mathematik für Chemiker</i>, Springer-Verlag, Berlin, Heidelberg, NewYork, 2013.</p> <p>Organizational:</p> <p>Students register for the tutorial through the faculty website.</p>

P 3.8: Introductory Physics for Chemistry and Biochemistry Students 2

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	Education degree programs
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 2
Duration	The course spans 1 semester
Content	Learning content includes electrodynamics and optics. Topics include electrostatics, electric current, dielectrics, magnetism, law of induction, alternating voltage and alternating current, Maxwell's equations, electromagnetic waves and propagation of electromagnetic waves, optical phenomena (refraction and dispersion, scattering, interference) and black body radiation
Qualification goals	<p>The learning goal is to master the lecture content, supported by live experimental demonstrations tailored to the lecture content.</p> <p>Participants acquire the ability to understand the physics (in words and through mathematical formulations) behind various phenomena and instruments in everyday life and become familiar with the fundamentals of electrodynamics and optics in order to be able to apply what they have learned to subject-specific questions.</p>
Submodule assessment	Written or an oral examination.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Mark Wenig
Language	German
Additional information	<p>Recommended literature:</p> <ul style="list-style-type: none"> • Halliday: Physik (Bachelor Edition), D. Halliday, R. Resnick, J. Walker, Wiley-VCH, Berlin, ISBN: 9783527407460 • P. Tipler, <i>Physik</i>, Spektrum Akademischer Verlag, Heidelberg, 2009.

P 3.9: Tutorial in Physics for Chemistry and Biochemistry Students 2

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	Education degree programs
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 2
Duration	The course spans 1 semester.
Content	Learning content includes electrodynamics and optics. Topics include electrostatics, electric current, dielectrics, magnetism, law of induction, alternating voltage and alternating current, Maxwell's equations, electromagnetic waves and propagation of electromagnetic waves, optical phenomena (refraction and dispersion, scattering, interference) and black body radiation. The students exercise the contents of the lecture course by solving assignments.
Qualification goals	The students deepen their understanding of the lecture content by solving given assignments and discussing with the tutors
Submodule assessment	s. P 3.8
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Mark Wenig
Language	German
Additional information	<p>Recommended literature:</p> <ul style="list-style-type: none"> • Halliday: Physik (Bachelor Edition), D. Halliday, R. Resnick, J. Walker, Wiley-VCH, Berlin, ISBN: 9783527407460 • P. Tipler, <i>Physik</i>, Spektrum Akademischer Verlag, Heidelberg, 2009. <p>Organizational:</p> <p>Students register for the tutorial through the faculty website.</p>

P 3.10: Physical Laboratory Course

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	Education degree programs
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 2
Duration	The course spans 1 semester.
Content	The students independently carry out experiments on mechanics, thermodynamics, oscillations and waves, optics, and electrodynamics and analyse the measurement data.
Qualification goals	<p>After taking part in the course, the students are able to verify physical laws using simple experiments independently and to set up and use experimental setups according to instructions.</p> <p>They know methods for conducting physical experiments and scientific documentation. They are able to record and evaluate measurement data and to question the results, obtained by quantitatively examining the experimental uncertainties, critically.</p> <p>They will also be able to safely operate basic physics devices and combine experimental observations and measurements with theoretical knowledge.</p> <p>They can competently present basic physics in oral form. They will develop communication skills by working cooperatively in small groups and gain experience in scientific discussions.</p>
Submodule assessment	A written exam, scientific protocol and presentation.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Dr. Jürgen Durst
Language	German
Additional information	Recommended literature:

H. Eichler, H. Kronfeldt, J. Sahm, *Das neue Physikalische Grundpraktikum*, Springer Spektrum, Berlin, **2016**.

Organizational information:

Registration for the lab course through the faculty website.

Information to the laboratory course of experimental physics:

https://www.praktikum.physik.uni-muenchen.de/bsc_ch/index.html

Module P 4: Inorganic Chemistry 1

Degree programme Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact hours	Self-directed studies	ECTS
Seminar	P 4.1: Seminar for Inorganic Chemistry laboratory course 1 (T1BA)	SoSe	30 h (2 SWS)	30 h	(2)
Lab course	P 4.2: Inorganic Chemistry laboratory course 1 (T1BB)	SoSe	105 h (7 SWS)	15 h	(4)

This module is comprised of 6 ECTS-points. Class attendance is 9 contact hours per week. Total time, including self-directed studies, is about 180 hrs.

Type of the module Compulsory module with required courses.

Applicability to other degree programs -

Elective guidelines none

Entry requirements Passed exams of the Module P 2 "Laboratory Course General and Inorganic Chemistry"

Study pathway level Recommended semester: 2

Duration The modul spans 1 semester.

Content The focus is on the wet-chemical and spectroscopic qualitative analysis of various elements from the periodic table and their ions. These include approx. 20 anions and multiple metals, mainly from the alkali and alkaline earth metals, the ammonium sulfide group and the H₂S group.

Students learn how to detect and separate inorganic chemistry (qualitative analysis) and gain in-depth knowledge of the periodic table. The occurrence of the elements and their compounds in industrial processes are covered.

After a learning and training phase in the laboratory, the students apply, deepen, and prove their knowledge of the periodic table in comprehensive examination analyses (15 individual analyses and 5 mixed analyses).

Qualification goals After successfully completing the AC1 practical module, students will have basic but also advanced inorganic chemistry knowledge in the field of qualitative analysis and the representation of elements. Basic working techniques of inorganic chemistry (e.g. precipitation reactions, digestion, filtration, centrifugation, hand spectroscopy) are learned and

internalized. Safe working with unknown hazardous substances is demonstrated and practiced. Students are then able to carry out independent analyses safely, professionally and precisely and evaluate their results. They can apply what they have learned to solve chemical problems and transfer their knowledge to new problems.

In the practical course and the accompanying seminar, students deepen their understanding of qualitative separation and detection methods and develop the ability to deduce general chemical principles from specific examples.

In addition, students develop the ability to plan experiments independently, document them clearly and analyze the results precisely.

Module assessment	Oral examination, scientific protocol and lab course assessment.
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam and the lab course, which are allocated to the module.
Responsible person	Prof. Dr. Klapötke / PD Dr. Jörg Stierstorfer
Language	German
Additional information	<p>Organizational information:</p> <p>Registration for the lab course through the faculty website.</p> <p>The practical courses are opened Tuesday - Friday from 12:00 - 17:00 in the student laboratories of the Department of Chemistry (Building D) at the Campus Großhadern.</p>

Module P 5: Basics of Biochemistry

Degree programme Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact hours	Self-directed studies	ECTS
Lecture	P 5.1: Biochemistry 1	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	P 5.2: Biochemistry 2	WiSe	30 h (2 SWS)	30 h	(2)
Exercise	P 5.3: Exercises to the lecture Biochemistry 2	WiSe	15 h (1 SWS)	15 h	(1)

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

Type of the module Compulsory module with required courses.

Applicability to other degree programs

- Bachelor's degree program in bioinformatics,
- Education degree program

Elective guidelines none

Entry requirements none

Study pathway level Recommended semester: 2

Duration The modul spans 1 semester.

Content The module introduces fundamental classes of substances in biochemistry (carbohydrates, nucleic acids, proteins, lipids, metabolites), processes that build up or transform these substances (DNA replication, chromatin structure, transcription, translation, metabolism), as well as the cell biology context (compartmentalization, substance transport across membranes, protein transport, cytoskeleton). Using specific examples, it also presents fundamental principles of enzymology (equilibria, thermodynamics of biochemical reactions, reaction mechanisms, enzyme kinetics, regulatory principles, and enzyme inhibition), metabolic communication between organs, and drug development.

Qualification goals Students describe the chemical foundations of living systems. They can establish qualitative and quantitative connections (e.g., between molecules and cellular structures or between alternative substrates), identify analogous situations using this knowledge, and determine the components involved. They explain coupled processes (e.g., metabolic pathways,

synthesis and maturation of membrane proteins) and assess energy and information flows in biochemical systems.

Module assessment	Written 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. Förstemann, Prof. Hopfner, Prof. Stingele
Language	German
Additional information	

P 5.1: Biochemistry 1 (T1BI)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	<ul style="list-style-type: none"> • Bachelor's degree program in bioinformatics, • Education degree program
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 2
Duration	The course spans 1 semester.
Content	<p>This lecture covers the chemical structure and fundamental functions of biological macromolecules (DNA, RNA, proteins), as well as the biologically most important lipids and sugars. Following this, the basic concepts of enzymes and catalysis are introduced, progressing to the quantitative treatment of enzyme properties (Michaelis-Menten kinetics, inhibition). Building on this foundation, the basic principles and concepts of the biosynthesis of DNA (DNA replication), RNA (transcription), and proteins (translation), as well as the structure of biological membrane structures, are presented. Finally, the function of biological macromolecules and biochemical concepts will be discussed using selected examples such as the cell cycle, cooperativity and regulation, the structure and function of chromatin, protein transport, and signal transduction.</p>
Qualification goals	<p>Students will acquire subject-specific knowledge about the fundamental concepts and structure of central biological molecules and macromolecules. They should be able to describe and explain the biosynthesis of DNA, RNA, and proteins as well as biochemical fundamentals and concepts of selected biochemical cellular processes. Using peptide bonds and proteolysis as examples, students should be able to transfer the fundamentals of chemical bonding to the central concept of the enzyme as a catalyst. Through the quantitative treatment of enzyme kinetics, central parameters such as catalysis and binding constants and principles of enzyme inhibition should be understood.</p>
Submodule assessment	Written or oral examination.
Grading	The course 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 German

Additional information **Recommended literature:**
Berg; Tymoczko; Gatto; Stryer; *Biochemistry*, W.H. Freeman, New York, **2019**.

P 5.2: Biochemistry 2 (T1CF)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	<ul style="list-style-type: none"> • Bachelor's degree program in bioinformatics, • Education degree program
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 3
Duration	The course spans 1 semester
Content	Basic energy metabolism serves as an example to illustrate the principles of energetics and enzymology in biochemical systems (equilibria, thermodynamics of biochemical reactions, reaction mechanisms, enzyme kinetics, regulatory principles, and enzyme inhibition). Pathological changes, metabolic communication between organs, and principles of drug development are introduced. Particular emphasis is placed on understanding the regulatory principles that adjust the activity of metabolic pathways to meet specific needs. Each lecture is also reviewed independently by students using textbooks and related online resources.
Qualification goals	Students identify the metabolites of energy metabolism, the coenzymes involved, and the differences between catabolic and anabolic processes. They explain the principle of rate-limiting reactions as well as feedback inhibition by the end product in a metabolic pathway. Students also recognize the coupling of different metabolic pathways through metabolites, energy, and reduction equivalents and transfer this understanding to analogous situations. They apply concepts of enzyme kinetics to describe sequences of reactions within metabolic pathways as a system.
Submodule assessment	A written or an oral exam or presentation or (oral exam and presentation) or (written exam and presentation).
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Förstemann
Language	German
Additional information	Recommended literature:

Berg, Tymoczko et al., *Biochemie (Stryer)*, Springer
Spektrum Verlag Berlin, 8. Auflage (2017). ISBN: 978-
3-662-54619-2

P 5.3: Exercises to the Lecture Biochemistry 2 (T1CG)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	<ul style="list-style-type: none"> • Bachelor's degree program in bioinformatics, • Education degree program
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 3
Duration	The course spans 1 semester.
Content	The exercises are coordinated with the Biochemistry 2 lecture and cover the topics addressed there.
Qualification goals	Students describe the concepts presented in the Biochemistry-2 lecture and apply them to analogous situations through assignments. They extrapolate their knowledge to pathological conditions and recognize the intersections between biochemistry, medicine, and plant physiology. In the practical sessions, they demonstrate active reflection, independently recognize the full extent of the questions asked, use discipline-specific vocabulary, and, where applicable, showcase their teamwork skills through discussions or group work.
Submodule assessment	s. P 5.2
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Förstemann
Language	German
Additional information	<p>Recommended literature:</p> <p>Berg, Tymoczko et al., <i>Biochemie (Stryer)</i>, Springer Spektrum Verlag Berlin, 8. Auflage (2017). ISBN: 978-3-662-54619-2</p> <p>Registration information:</p> <p>Students register for the tutorial through the faculty website.</p>

Module P 6: Organic Chemistry 1

Degree programme

Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact hours	Self-directed studies	ECTS
Lecture	P 6.1: Organic Chemistry 2	WiSe	75 h (5 SWS)	120 h	(6,5)
Exercise	P 6.2: Exercises to the lecture Organic Chemistry 2	WiSe	15 h (1 SWS)	15 h	(1)
Lab course	P 6.3: Organic Chemistry Laboratory Course 1	WiSe	225 h (15 SWS)	0 h	7,5

This module is comprised of 15 ECTS-points. Class attendance is 21 contact hours per week. Total time, including self-directed studies, is about 450 hrs.

Type of the module	Compulsory module with required courses.
Applicability to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 3
Duration	The modul spans 1 semester.

Content

Lecture topics are: nucleophilic substitutions on saturated carbon; elimination reactions; additions to C-C multiple bonds; nucleophilic addition and substitution on the carbonyl group; enolate chemistry; sulphur, silicon and phosphorus in organic chemistry; pericyclic reactions; rearrangements and fragmentations; reductions and oxidations; radical reactions; aromatic chemistry; organometallic chemistry and transition metal catalysis; protecting group chemistry; synthesis of complex compounds. These are supplemented by a practice-oriented introduction to analytical methods for molecular chemistry.

The organic chemistry practical course 1 begins with a two-week preliminary course where important preparative techniques (e.g. drying of solvents, extraction, crystallization, distillation, column chromatographic separation) and the application of analytical methods (e.g. refractive index, melting point, UV/VIS, IR, NMR, GC/TLC-MS, elemental analysis) are learned. Students will also have access to short videos and a working method video quiz on the moodle

learning platform. In the following eight-week main part, students will independently prepare selected compounds according to literature procedures and from current research projects of research groups and examine them using analytical/spectroscopic methods. By carrying out analyses, the structure of unknown organic compounds is to be identified on the basis of their physical and spectroscopic data.

Safe laboratory work, the handling of hazardous substances and the proper disposal of chemical waste are practiced in the practical course. The experimental protocols to be drawn up by the students serve as proof of the documentation of scientific results and their critical evaluation. Students will also learn how to use chemical drawing programs and programs for evaluating spectroscopic data.

Qualification goals	<p>After successfully completing the module students will be able to:</p> <ul style="list-style-type: none"> • Know synthetic methods for important classes of organic compounds as they are used on laboratory scale. • Formulate the mechanisms of important synthetic reactions in detail. • Routinely carry out basic synthetic operations, work-up and purification procedures in organic chemistry in compliance with occupational safety regulations. • Apply basic knowledge of spectroscopic analysis methods in organic chemistry to determine the structure of their synthesized products. • Prepare protocols for their experiments in accordance with current scientific standards and comply with the rules of good scientific practice. <p>Maintain an objective, open and cooperative relationship with the laboratory community, support each other and carry out joint tasks responsibly.</p>
Module assessment	Five written or five oral examinations, scientific protocol and lab course 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. Andrea Rentmeister, Prof. Anne Schütz, Prof. Dr. Hendrik Zipse, Dr. Bernhard Kempf.
Language	German
Additional information	<p>Literature references:</p> <p>1) K. Schwetlick, <i>Organikum</i>, 24. Aufl., Wiley-VCH, Weinheim, 2015.</p>

- 2) S. Hünig, P. Kreitmeier, G. Märkl, J. Sauer, *Arbeitsmethoden in der organischen Chemie*, 3. Aufl., Lehmanns Media, Berlin, 2019.
- 3) J. Clayden, N. Greeves, S. Warren, *Organische Chemie*, 2. Auflage, Springer, **2013**.
- 4) R. Brückner, *Reaktionsmechanismen*, 3. Aufl., Springer Spektrum, 2015.
- 5) M. Hesse, H. Meier, B. Zeeh, *Spektroskopische Methoden in der Organischen Chemie*, 8. Aufl., Thieme, Stuttgart, 2011.

Organizational information:

The OC2 lecture with exercise is split onto the 3rd and 4th semester and is examined each with a final exam.

P 6.1: Organic Chemistry 2 (T1CA)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 3
Duration	The course spans 2 semester.
Content	Lecture topics are: nucleophilic substitutions on saturated carbon; elimination reactions; additions to C-C multiple bonds; nucleophilic addition and substitution on the carbonyl group; enolate chemistry; sulphur, silicon and phosphorus in organic chemistry; pericyclic reactions; rearrangements and fragmentations; reductions and oxidations; radical reactions; aromatic chemistry; organometallic chemistry and transition metal catalysis; protecting group chemistry; synthesis of complex compounds. These topics are supplemented by a practice-oriented introduction to analytical methods for molecular chemistry.
Qualification goals	<p>After successful participation in the lecture, students should be able to:</p> <ol style="list-style-type: none"> Know synthetic methods of important organic compound classes as they are used on a laboratory scale. Implement synthesis instructions from the current technical literature on a laboratory scale. Know and implement safety regulations for syntheses on a laboratory scale. Formulate the mechanisms of synthetically important reactions in detail.
Submodule assessment	Five written or five oral examinations.
Grading	The course 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. Andrea Rentmeister, Prof. Anne Schütz, Prof. Dr. Hendrik Zipse.
Language	German

Additional information

Recommended literature:

- J. Clayden, N. Greeves, S. Warren, *Organische Chemie*, 2. Auflage, Springer, **2013**.
- R. Brückner, *Reaktionsmechanismen*, Spektrum Akademischer Verlag, Heidelberg, **2011**.

Organizational information:

The OC2 lecture is split onto the 3rd and 4th semester and is examined each with a final exam.

P 6.2: Exercises to the Lecture Organic Chemistry 2 (T1CB)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 3
Duration	The course spans 2 semester.
Content	In the exercises, lecture topics are explored in further detail using selected examples and with the active participation of the students.
Qualification goals	After successful participation, students should be able to: a) Know methods of synthesis of important classes of organic compounds as they are used on a laboratory scale. b) Formulate the mechanisms of synthetically important reactions in detail.
Submodule assessment	s. P 6.1
Grading	The course 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. Andrea Rentmeister, Prof. Anne Schütz, Prof. Dr. Hendrik Zipse.
Language	German
Additional information	<p>Recommended literature:</p> <ul style="list-style-type: none"> • J. Clayden, N. Greeves, S. Warren, <i>Organische Chemie</i>, 2. Auflage, Springer, 2013. • R. Brückner, <i>Reaktionsmechanismen</i>, Spektrum Akademischer Verlag, Heidelberg, 2011. <p>Organizational information:</p> <p>Students register for the tutorial through the faculty website.</p> <p>The OC2 exercises are divided between the 3rd and 4th semester to accompany the lecture.</p>

P 6.3: Organic Chemistry Laboratory Course 1 (T1CC)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	Passed exams in the lecture Organic Chemistry 1 (P 1.3) and accompanying exercises (P 1.4).
Study pathway level	Recommended semester: 3
Duration	The course spans 1 semester.
Content	<p>The organic chemistry practical course 1 begins with a two-week preliminary course where important preparative techniques (e.g. drying of solvents, extraction, crystallization, distillation, column chromatographic separation) and the application of analytical and spectroscopic examination methods (e.g. refractive index, melting point, UV/VIS, IR, NMR, GC/TLC-MS, elementary analysis) are learned. Students are also provided with short videos and a working method video quiz on the moodle learning platform. In the following eight-week main part, students will independently prepare selected compounds according to literature procedures, and from current research projects of research groups and examine them using analytical/spectroscopic methods. By working on analyses, the structure of unknown organic-chemical compounds is to be identified on the basis of their physical and spectroscopic data.</p> <p>Safe work in the laboratory, the handling of hazardous substances and the proper disposal of chemical waste are practiced in the practical course. The experimental protocols to be prepared by the students serve as proof of the documentation of scientific results and their critical evaluation. Students will also learn how to use molecular characterization programs and programs for evaluating spectroscopic data.</p>
Qualification goals	<p>After successfully completing the organic chemistry practical course 1, students will be able to:</p> <ul style="list-style-type: none"> • Routinely carry out basic synthetic operations, work-up and purification procedures in organic chemistry in compliance with occupational safety regulations. • Apply basic knowledge of spectroscopic analysis methods in organic chemistry to determine the structure of their synthesized products.

- Prepare protocols for their experiments in accordance with current scientific standards and comply with the rules of good scientific practice.

Maintain an objective, open and cooperative relationship with the laboratory community, support each other and carry out joint tasks responsibly.

Submodule assessment	Scientific protocol and lab course assessment.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the lab course.
Responsible person	Prof. Dr. Andrea Rentmeister, Prof. Anne Schütz, Prof. Dr. Hendrik Zipse, Dr. Bernhard Kempf.
Language	German
Additional information	<p>Recommended literature:</p> <ol style="list-style-type: none"> 1) K. Schwetlick, <i>Organikum</i>, 24. Aufl., Wiley-VCH, Weinheim, 2015. 2) S. Hünig, P. Kreitmeier, G. Märkl, J. Sauer, <i>Arbeitsmethoden in der organischen Chemie</i>, 3. Aufl., Lehmanns Media, Berlin, 2019. 3) J. Clayden, N. Greeves, S. Warren, <i>Organische Chemie</i>, 2. Auflage, Springer, 2013. 4) R. Brückner, <i>Reaktionsmechanismen</i>, 3. Aufl., Springer Spektrum, 2015. 5) M. Hesse, H. Meier, B. Zeeh, <i>Spektroskopische Methoden in der Organischen Chemie</i>, 8. Aufl., Thieme, Stuttgart, 2011. <p>Organizational information:</p> <p>Registration for the lab course through the faculty website.</p> <p>The practical courses are opened Monday- Wednesday from 12:00 - 17:00 and Friday 12:30 - 17:30 in the student laboratories of the Department of Chemistry (Building F) at the Campus Großhadern.</p>

Module P 7: Physical Chemistry 1

Degree programme

Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact hours	Self-directed studies	ECTS
Lecture	P 7.1: Physical Chemistry 2	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	P 7.2: Exercises to the lecture Physical Chemistry 2	WiSe	30 h (2 SWS)	30 h	(2)
Seminar	P 7.3: Seminar for Physical Chemistry Laboratory Course 1	SoSe	15 h (1 SWS)	45 h	(2)
Lab Course	P 7.4: Physical Chemistry Laboratory Course 1	SoSe	105 h (7 SWS)	15 h	(4)

This module is comprised of 12 ECTS-points. Class attendance is 13 contact hours per week. Total time, including self-directed studies, is about 360 hrs.

Type of the module

Compulsory module with required courses.

Applicability to other degree programs

-

Elective guidelines

none

Entry requirements

none

Study pathway level

Recommended semester: 3 and 4

Duration

The modul spans 2 semester.

Content

Contents are the basics of quantum mechanics and the chemical bond, introduction to the concepts of quantum mechanics, simple exactly solvable quantum systems, many-electron atoms and atomic structure, chemical bonds and molecular structure, polyatomic molecules.

The students exercise the contents of the lecture course with problem sets.

Contents are thermodynamics, electrochemistry, kinetics, spectroscopy.

Contents are introduction to the theoretical background of advanced laboratory techniques and methods in the areas of thermodynamics, electrochemistry, kinetics, and spectroscopy.

Qualification goals

The students have command of the contents of the lecture course and are able to transfer the knowledge to current problems in basic quantum mechanics. They know how to calculate physical properties of atoms and molecules, how to describe the electronic structure of atoms and molecules and how to relate this to chemical reactivity. Especially, they are familiar with operator mathematics and are able to solve problems related to small model quantum systems. They are able to apply quantum mechanical models to interpret atomic and molecular spectra. They are familiar with approximative methods to solve the Schrödinger equation for complex systems. The students have command of the experimental techniques related to basic thermodynamical and kinetic experiments, are able to work in a team and to document and present their experimental results.

Module assessment

Two written or oral examinations, scientific protocol, lab course assessment and presentation.

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. Ochsenfeld, Prof. Hartschuh

Language

German

Additional information

s. P 7.1-7.3

Organizational information:

The PC2 lecture with exercise is split onto the 3rd and 4th semester and is examined each with a final exam.

P 7.1: Physical Chemistry 2 / Theoretical Chemistry 1 (T1CDa)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 3
Duration	The course spans 2 semester.
Content	<p>Contents are the basics of quantum mechanics and the chemical bond, introduction to the concepts of quantum mechanics, simple exactly solvable quantum systems, the Hydrogen atom, many-electron atoms and atomic structure, chemical bonds and molecular structure, polyatomic molecules.</p> <p>The students exercise the contents of the lecture course with problem sets.</p>
Qualification goals	The students have command of the contents of the lecture course and are able to transfer the knowledge to current problems in basic quantum mechanics. They know how to calculate physical properties of atoms and molecules, how to describe the electronic structure of atoms and molecules and to relate this to chemical reactivity. They are familiar with the fundamental approximative methods to solve the Schrödinger equation for complex systems.
Submodule assessment	Two written or oral examinations.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Fingerhut, Prof. Ochsenfeld
Language	German
Additional information	<p>Recommended literature:</p> <ul style="list-style-type: none"> • P. Atkins, <i>Physikalische Chemie</i>, Wiley-VCH Verlag, Weinheim, 2006. • G. Wedler, <i>Lehrbuch der Physikalischen Chemie</i>, Wiley-VCH Verlag, Weinheim, 2004.

- Peter W. Atkins and Ronald S. Friedman, Molecular Quantum Mechanics, Fifth Edition, Oxford Press 2010

Organizational information:

The PC2 lecture is split onto the 3rd and 4th semester and is examined each with a final exam.

P 7.2: Exercises to the Lecture Physical Chemistry 2 / Theoretical Chemistry 1 (T1CE)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 3
Duration	The course spans 2 semester.
Content	<p>Contents are the basics of quantum mechanics and the chemical bond, introduction to the concepts of quantum mechanics, simple exactly solvable quantum systems, the Hydrogen atom, many-electron atoms and atomic structure, chemical bonds and molecular structure, polyatomic molecules.</p> <p>The students exercise the contents of the lecture course with problem sets.</p>
Qualification goals	<p>The students have command of the contents of the lecture course and are able to transfer the knowledge to current problems. Especially, they are familiar with operator mathematics and can solve problems related to small model quantum systems. They are able to apply quantum mechanical models to interpret atomic and molecular spectra. They can solve example problems by variational and perturbational methods. The understanding of the contents of the lecture course is deepened, the generalization of knowledge is promoted.</p>
Submodule assessment	s. P 7.1
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Fingerhut, Prof. Ochsenfeld
Language	German
Additional information	<p>Recommended literature:</p> <ul style="list-style-type: none"> • P. Atkins, <i>Physikalische Chemie</i>, Wiley-VCH Verlag, Weinheim, 2006.

- G. Wedler, *Lehrbuch der Physikalischen Chemie*, Wiley-VCH Verlag, Weinheim, **2004**.
- Peter W. Atkins and Ronald S. Friedman, *Molecular Quantum Mechanics*, Fifth Edition, Oxford Press 2010

Organizational information:

Students register for the tutorial through the faculty website.

The PC2 exercises are divided between the 3rd and 4th semester to accompany the lecture.

P 7.3: Seminar for Physical Chemistry Laboratory Course 1 (T1DE)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 4
Duration	The course spans 1 semester.
Content	Oral presentations given by the students on topics from thermodynamics, electrochemistry, kinetics, solid-state chemistry/light and quantum theory.
Qualification goals	<p>The students learn to:</p> <ul style="list-style-type: none"> • Independently introduce themselves into current research topics in Physical Chemistry and to develop an understanding of the underlying concepts and methods. • Present advanced topics and methods of Physical Chemistry. <p>Competences: Presentation of scientific topics, understanding and knowledge of concepts and methods in Physical Chemistry.</p>
Submodule assessment	s. P 7.4
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the the lab course, which is allocated to the submodule.
Responsible person	Prof. Hartschuh
Language	German
Additional information	<p>Recommended literature:</p> <p>P. Atkins, Physical Chemistry, Wiley-VCH Verlag, Weinheim, 2006.</p>

P 7.4: Physical Chemistry Laboratory Course 1 (T1DF)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	<p>Successful participation at</p> <ul style="list-style-type: none"> • lecture courses Physical Chemistry 1 and 2 with exercises (P 1.5, P 1.6, P 7.1, P 7.2), and • lecture courses Mathematics for natural scientists 1 and 2 with exercises (P 3.1, P 3.2, P 3.6, P 3.7).
Study pathway level	Recommended semester: 4
Duration	The course spans 1 semester.
Content	<p>The module begins with an introductory session covering topics such as laboratory safety, the structure of the lab course, and the preparation of lab reports. Subsequently, students conduct 15 experiments focused on advanced methods in physical chemistry. The experiments cover the following topics:</p> <p>Thermodynamics (vapor pressure curve, boiling point elevation, freezing point depression, Joule-Thomson effect, thermodynamics of an equilibrium, combustion enthalpy using a bomb calorimeter, mixing enthalpy of binary mixtures, heat capacities of gases, temperature-dependent electromotive force)</p> <p>Kinetics (activation energy of a first-order reaction, acid-catalyzed sucrose inversion, enzyme kinetics)</p> <p>Electrochemistry (electrochemical cell, fuel cell, determination of the Faraday constant, coulometric titration)</p> <p>Quantum theory (quantum chemical calculation of the inversion barrier and harmonic vibrational frequencies of ammonia, Zeeman effect)</p> <p>Solid-state chemistry/light (hydrogen spectrum, electron diffraction, photoelectric effect)</p>
Qualification goals	<p>After completing this course, the students can:</p> <ul style="list-style-type: none"> • Perform laboratory experiments on the thermodynamical properties of substances and substances and phases at equilibrium • Analyze and discuss the measurement data in the context of theoretical model descriptions.

- Study electrochemical processes regarding their thermodynamical parameters, analyze the experimental results in the context of theoretical models.
- Perform laboratory experiments on the fundamental phenomena of quantum theory and analyze the experimental results in the context of theoretical models.
- Study and analyze elementary chemical reactions and understand reaction mechanisms on a molecular level.

Competences: Independent experimental work, writing of scientific protocols, analytical capabilities, hands on expertise on fundamental methods of Physical Chemistry, Good scientific practice

Submodule assessment	Scientific protocol, oral exam, presentation and lab course assessment.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the lab course.
Responsible person	Prof. Hartschuh
Language	German
Additional information	<p>Recommended literature:</p> <p>P. Atkins, Physical Chemistry, Wiley-VCH Verlag, Weinheim, 2006.</p> <p>Organizational information:</p> <p>Registration for the lab course through the faculty website.</p> <p>All necessary information regarding the organization of the lab course, including experiment instructions and safety data sheets, will be published on Moodle approximately one week before the start of the course.</p> <p>The lab course is synchronized with the Biochemistry 1 P8.3 and Inorganic Chemistry 2 P10.4 laboratory courses P7.4 running in parallel. The practical courses are opened Monday- Friday from 12:00 - 17:00 in the student laboratories of the Department of Chemistry (Building E) at the Campus Großhadern.</p>

Module P 8: Biochemistry 1

Degree programme

Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact hours	Self-directed studies	ECTS
Exercise	P 8.1: Methods of Biochemistry 1	WiSe	15 h (1 SWS)	30 h	(1,5)
Lecture	P 8.2: Biochemistry 3	SoSe	30 h (2 SWS)	60 h	(3)
Lab Course	P 8.3: Biochemistry laboratory course 1	SoSe	75 h (5 SWS)	60 h	(4,5)

This module is comprised of 9 ECTS-points. Class attendance is 8 contact hours per week. Total time, including self-directed studies, is about 270 hrs.

Type of the module

Compulsory module with required courses.

Applicability to other degree programs

-

Elective guidelines

none

Entry requirements

none

Study pathway level

Recommended semester: 3

Duration

The modul spans 2 semester.

Content

We discuss fundamental aspects of working with biomolecules *in vitro*. In particular, methods for the isolation, detection, and analysis of nucleic acids, *in vitro* work with DNA (restriction digestion, cloning, PCR), recombinant protein expression, cell lysis, and simple forms of protein chromatography are presented. Furthermore, procedures for measuring and analyzing enzyme kinetics data are presented, and the planning of simple molecular biology experiments (PCR, cloning) is practiced using computer programs.

Qualification goals

Students describe the phenomena that lead to the structure of proteins and nucleic acids and explain the relationship between structure and activity. They can apply these principles from the discussed examples to analogous situations. They know essential biochemical parameters and work techniques and independently apply them in the laboratory. They independently evaluate the experimental data and summarize the execution, evaluation, and discussion of the results in protocols according to scientific standards. In doing so, they also acquire time management skills.

Module assessment	Written or oral examinations and scientific protocol.
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. Jae, Prof. Förstemann
Language	German
Additional information	

P 8.1: Methods of Biochemistry 1 (T1CH)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 3
Duration	The course spans 1 semester.
Content	This lecture covers basic biochemical laboratory techniques to isolate, analyze and detect nucleic acids as well as proteins. We also discuss aspects of molecular biology (restriction enzyme digests, polymerase chain reaction etc.).
Qualification goals	The students describe basic biochemical procedures and recognize critical parameters such as pH value, salt concentration, detergents, and temperature. They create sensibly composed solutions ('buffers') from this and apply this knowledge to specific situations in the laboratory. They evaluate enzyme kinetic data using modern computer methods. They are aware of the requirements for a scientific experimental protocol.
Submodule assessment	Written or oral examination.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Klaus Förstemann
Language	German
Additional information	

P 8.2: Biochemistry 3 (T1DG)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 4
Duration	The course spans 1 semester.
Content	The lecture deepens the understanding of the diversity in structure and function of biological macromolecules. Nucleic acids, proteins, and particularly their assembly into molecular machines are the focal points. Furthermore, the biochemical functions and molecular mechanisms of key molecular machines, such as RNA polymerase, the ribosome, the proteasome, the exosome, ATPases, and receptors, will be presented in greater detail. Finally, current research topics from the Department of Biochemistry will be introduced to provide insight into modern biochemical fields.
Qualification goals	Students will gain the ability to learn and evaluate molecular mechanisms of key molecular machines and to independently recognize common principles of their operation. Additionally, they will develop the skill to identify the structural foundations that enable the activity and regulation of essential molecular machines in the cell. Finally, students will acquire the competence to understand modern biochemical research fields and to contextualize the methods used.
Submodule assessment	Written or an oral examination.
Grading	The course 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
Language	German
Additional information	<p>Recommended literature:</p> <ul style="list-style-type: none"> • Alasdair Steven, Wolfgang Baumeister, Louise N. Johnson, Richard N. Perham, <i>Molecular Biology of Assemblies and Machines</i>, 2016 • B. Alberts, <i>Molecular Biology of the Cell</i>, Taylor & Francis, New York, 2022.

P 8.3: Biochemistry Laboratory Course 1 (T1DH)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 4
Duration	The course spans 1 semester.
Content	The three internship weeks are thematically divided into enzyme kinetics, DNA analytics, and protein analytics. The tasks are related to the content of the lecture "Methods of Biochemistry 1 (T1CH)." Students independently plan, carry out, and interpret experiments and analyses in small groups (typically 2–3 students per group). They independently evaluate the results and summarize the experimental procedures, outcomes, and insights gained in reports. The preparation of the reports is based on the knowledge and practiced understanding of the requirements for a scientific lab report.
Qualification goals	Students apply subject-specific knowledge of biochemical working techniques and methodological competencies in scientific work within the framework of the internship. In this context, not only must familiar protocols be carried out independently, but certain aspects of the experiments must also be developed and/or calculated. Meaningful combinations of different techniques can be developed. Working in small groups fosters social skills. The independent preparation of protocols requires the application of specialized knowledge for experiment evaluation and hones written presentation skills. Fixed submission deadlines promote the development of time-management skills.
Submodule assessment	A written exam or scientific protocol or (written exam and scientific protocol).
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the the lab course.
Responsible person	Prof. Lucas Jae
Language	German

Additional information

Module P 9: Spectroscopy

Degree programme

Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact hours	Self-directed studies	ECTS
Lecture	P 9.1: Spectroscopy 1	WiSe	30 h (2 SWS)	75 h	(3,5)
Exercise	P 9.2: Exercises for Spectroscopy 1	WiSe	15 h (1 SWS)	15 h	(1)
Lecture	P 9.3: Spectroscopy 2	SoSe	30 h (2 SWS)	75 h	(3,5)
Exercise	P 9.4: Exercises for Spectroscopy 2	SoSe	15 h (1 SWS)	15 h	(1)

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

Type of the module	Compulsory module with required courses.
Applicability to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 3 and 4
Duration	The modul spans 2 semester.
Content	The module covers the basic concepts of spectroscopy and spectroscopic techniques, important mathematical and physical methods of spectroscopy, and the evaluation of spectra. Details in P 9.1-9.4
Qualification goals	After attending the module courses, students are able to summarize the main concepts of the lectures and transfer the knowledge to current problems. In the exercises, they can apply these concepts to typical examples and analyze the results. Details in P 9.1-9.4
Module assessment	Written or oral examinations.
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, Prof. Dr. Anne Schütz

Language

German

Additional information

P 9.1: Spectroscopy 1 (T1CI)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 3
Duration	The course spans 1 semester.
Content	Introduction to Symmetry Considerations of Organic Molecules and to IR and UV-VIS Spectroscopy. The first part of the lecture discusses group theory and explains the use of character tables while providing the necessary foundational knowledge. Applications are discussed in the context of spectroscopy. The second part of the lecture introduces the vibrational and electronic spectroscopy of molecules. In addition to the basics for interpreting spectra, the most important instrumental aspects are presented.
Qualification goals	After successfully completing the module, students will be familiar with the fundamentals of group theory and understand the methods to characterize molecules and qualitatively predict their properties. They will have mastered the key instrumental and theoretical principles of IR and UV-VIS absorption spectroscopy as well as Raman spectroscopy. This includes both the phenomenological description and the quantum mechanical treatment of rotational and vibrational motion, as well as the electronic structure. Students will be able to explain the corresponding transition probabilities and are familiar with the applications of molecular spectroscopy in analytical contexts.
Submodule assessment	Written or oral examination.
Grading	The course 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
Additional information	Recommended literature:

- J. Hollas, *Moderne Methoden in der Spektroskopie*, Vieweg, Braunschweig, **1995**.
- David J. Willock, *Molecular Symmetry*, John Wiley & Sons Ltd., West Sussex, United Kingdom, **2009**.

P 9.2: Exercises for Spectroscopy 1 (T1CJ)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 3
Duration	The course spans 1 semester
Content	Exercises on Symmetry Considerations of Organic Molecules and IR and UV-VIS Spectroscopy. In the first part of the course, students independently perform exercises on group theory and the use of character tables, which are then reviewed and discussed. In the second part of the exercises, topics related to the vibrational and electronic spectroscopy of molecules are discussed.
Qualification goals	After successfully completing the module, students will be able to independently determine the point group of a molecule and use the corresponding character table to derive selection rules for vibrational and UV-VIS spectroscopy in absorption and Raman spectroscopy. Furthermore, they will be able to apply the theoretical foundations of spectroscopy when analyzing rotational, vibrational, and electronic excitation spectra to determine characteristic parameters, such as rotational or anharmonicity constants or absorption edges. They will also be able to relate these parameters to the structural and electronic properties of the studied molecules.
Submodule assessment	s. P 9.1
Grading	The course 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
Additional information	Organizational information: Students register for the tutorials through the departmental website.

Recommended literature:

- J. Hollas, *Moderne Methoden in der Spektroskopie*, Vieweg, Braunschweig, **1995**.
- David J. Willock, *Molecular Symmetry*, John Wiley & Sons Ltd., West Sussex, United Kingdom, **2009**.

P 9.3: Spectroscopy 2 (T1DI)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 4
Duration	The course spans 1 semester.
Content	<p>NMR Spectroscopy:</p> <p>Interactions of nuclear spins with the magnetic field and with each other, basics of NMR spectroscopy in solution, chemical shift, spin-spin couplings, chemical and magnetic equivalence, measurement methods and basic properties of the Fourier transform, two-dimensional NMR spectroscopy (EXSY, NOESY, COSY), heteronuclear NMR experiments (HSQC, HMQC, HMBC, HETCOR), relaxation, nuclear Overhauser effect (NOE).</p> <p>Mass Spectrometry:</p> <p>Components of mass spectrometers, various ionisation methods such as EI, CI, APCI, ESI, FAB, MALDI, various injection methods such as RI, DIP, DEP, GC, LC, special techniques like MS/MS.</p>
Qualification goals	Students acquire a basic understanding of how NMR spectroscopy and mass spectrometry work. They learn about the applications and the limitations of the respective methods and develop the ability to select the optimal experiments to address concrete scientific questions especially with regard to organic chemistry.
Submodule assessment	Written or oral exam.
Grading	The course 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. Anne Schütz, Dr. Werner Spahl
Language	German
Additional information	Organisatorisches:

Die Benotung der Veranstaltung: NMR-Spektroskopie
80 %, Massenspektrometrie 20 %.

Die Anmeldung zur Klausur erfolgt über das
Internetportal der Fakultät.

Literaturempfehlung:

M. Hesse, H. Meier, B. Zeeh, *Spektroskopische
Methoden in der organischen Chemie*, Thieme Verlag,
Stuttgart, **2005**.

P 9.4: Exercises for Spectroscopy 2 (T1DJ)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 4
Duration	The course spans 1 semester
Content	<p>NMR Spectroscopy:</p> <p>Interactions of nuclear spins with the magnetic field and with each other, basics of NMR spectroscopy in solution, chemical shift, spin-spin couplings, chemical and magnetic equivalence, measurement methods and basic properties of the Fourier transform, two-dimensional NMR spectroscopy (EXSY, NOESY, COSY), heteronuclear NMR experiments (HSQC, HMQC, HMBC, HETCOR), relaxation, nuclear Overhauser effect (NOE).</p> <p>Mass Spectrometry:</p> <p>Components of mass spectrometers, various ionisation methods such as EI, CI, APCI, ESI, FAB, MALDI, various injection methods such as RI, DIP, DEP, GC, LC, special techniques like MS/MS.</p>
Qualification goals	Students acquire a basic understanding of how NMR spectroscopy and mass spectrometry work. They learn about the applications and the limitations of the respective methods and develop the ability to select the optimal experiments to address concrete scientific questions especially with regard to organic chemistry.
Submodule assessment	s. P 9.3
Grading	The course 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. Anne Schütz, Dr. Werner Spahl
Language	German
Additional information	Organizational information:

Students register for the exam through the departmental website.

Grading: 80 % NMR-spectroscopy, 20 % mass spectrometry.

Recommended literature:

M. Hesse, H. Meier, B. Zeeh, *Spektroskopische Methoden in der organischen Chemie*, Thieme Verlag, Stuttgart, **2005**

Module P 10: Inorganic Chemistry 2

Degree programme

Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact hours	Self-directed studies	ECTS
Lecture	P 10.1: Inorganic Chemistry 2 (Concepts of Inorganic Chemistry)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	P 10.2: Inorganic Chemistry 3 (Coordination Chemistry)	SoSe	30 h (2 SWS)	60 h	(3)
Seminar	P 10.3: Seminar for Inorganic Chemistry laboratory course 2	SoSe	15 h (1 SWS)	45 h	(2)
Lab Course	P 10.4: Inorganic Chemistry Laboratory Course 2	SoSe	105 h (7 SWS)	15 h	(4)

This module is comprised of 12 ECTS-points. Class attendance is 12 contact hours per week. Total time, including self-directed studies, is about 360 hrs.

Type of the module	Compulsory module with required courses.
Applicability to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 4
Duration	The modul spans 2 semester.
Content	<p>Module content includes important concepts of inorganic chemistry; essential substance classes and functional groups, an overview of analytical methods and important reaction mechanisms.</p> <p>Details s. P 10.1-10.4</p>
Qualification goals	<p>Students are able to carry out inorganic syntheses according to given synthesis instructions and handle hazardous substances responsibly and safely in compliance with the applicable safety and environmental regulations. Students will have mastered the theoretical background of their experimental work and learn to record their experiments correctly. Students can use spectroscopic methods to characterize simple inorganic compounds.</p> <p>Details s. P 10.1-10.4</p>

Module assessment	Written or oral exams and scientific protocol.
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. Johrendt, Prof. Dr. Ivana Ivanovi-Burmazović
Language	German
Additional information	Recommended literature: Holleman-Wiberg, <i>Lehrbuch der Anorganischen Chemie</i> , De Gruyter, Berlin, 2007 .

P 10.1: Inorganic Chemistry 2 (Concepts of Inorganic Chemistry) T1DA

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 3
Duration	The course spans 1 semester
Content	Periodicity of atomic properties, sizes of atoms, electronegativity, relativistic effects, chemical bonding concepts, VB-theory, Molecular orbital schemes, ligand group orbitals, isolobal concept, Ionic crystals, lattice energy, multiple bonds, the metallic state, basics of magnetism, structure and bonding in cluster compounds.
Qualification goals	After attending the lecture, students will be able to understand, apply and evaluate various concepts of inorganic chemistry.
Submodule assessment	Written or oral examination.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Prof. Johrendt
Language	German
Additional information	Link to the Moodle-Webpage of this lecture: https://moodle.lmu.de/course/view.php?id=6666

P 10.2: Inorganic Chemistry 3 (Coordination Chemistry) T1DB

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 4
Duration	The course spans 1 semester.
Content	<ul style="list-style-type: none"> • Spatial structure of coordination compounds and types of isomerism. • Thermodynamics and Kinetics of complex formation reactions. • Types and properties of ligands. • Chemical bonding: MO scheme of octahedral complexes, crystal field model to describe frontier orbitals, Valence Bond theory. • Electronic spectrum and electron structure. • Spectroscopic selection rules. • Jahn-Teller distortion. • Paramagnetic and diamagnetic complexes. • spin-only formula, ferro-, ferri- and antiferromagnetic spin coupling. • Strong and weak field ligands. • σ-donor-, π-donor- and π-acceptor ligands. • Spectrochemical series of ligands and metals. • Spin states and spin crossover Carbonyl, Nitrosyl and Cyanido complexes. • 18 electron rule. • metal-metal-bonding. • Basic types of organometallic ligands. • Selected organometallic elementary steps.
Qualification goals	<p>Students are able to:</p> <ul style="list-style-type: none"> • Deduce spatial and electronic structure also of unknown coordination compounds. • Decide, which bonding model should describes best various coordination compounds and apply this model to the respective compound. • Identify type, energetic position and probability of an electronic transition. • Deduce factors that determine thermodynamic stability of a given metal/ligand combination. • Recognize everyday relevance of covered topics. • Transfer acquired skill to other areas of chemistry

Submodule assessment	Written or oral examination.
Grading	The course 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. Ivana Ivanovi-Burmazović
Language	German
Additional information	Organizational information: Students register for the exam through the departmental website. Website of the Lecture: https://moodle.lmu.de/course/view.php?id=5265

P 10.3: Seminar for Inorganic Chemistry Laboratory Course 2 (T1DC)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 4
Duration	The course spans 1 semester.
Content	<p>The seminar for Inorganic Chemistry Laboratory Course 2 deals with the theoretical background necessary for the understanding of the preparations in the lab course. Main topics of the seminar: occurrence, production and structures of the elements, sphere packing concepts and derived solid-state structure types, binary phase diagrams, intermetallic phases, crystal growth methods, X-ray powder diffractometry, EPR spectroscopy, anhydrous metal halogenides, chemical transport reactions, metal organic chemistry, the colour and chromacity of compounds. The seminar is the base for the final oral exam of the module, and also for the short preliminary colloquium prior to the individual lab preparations.</p>
Qualification goals	<p>After the basic lab course and the lab course Inorganic Chemistry 1 and after the related lectures, the students remember the basic principles of inorganic and general chemistry, as well as the overall reactivity trends of the chemical elements on the periodic table. Furthermore, the students remember the basics of spectroscopic methods, their respective unique features and areas of application.</p> <p>This seminar provides understanding of the modern synthetic concepts, with regard to efficiency and applicability. The topics discussed during the seminar allow for a well-founded discussion on alternative synthetic routes and their pros and cons. The seminar contains, apart from theoretical basic knowledge, practical information on tools and methods for a modern and efficient literature search. This enables the students to independent research on basic literature on synthetic concepts, their evaluation and finally choosing the best appropriate sythetic route for the lab course.</p>
Submodule assessment	s. P 10.4
Grading	The course 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. Constantin Hoch

Language

German

Additional information**Organizational information:**

Registration for the seminar through the internet portal of the faculty. The seminar will be conducted as a 3-day block seminar prior to the start of the lab course.

Recommended literature:

Holleman-Wiberg, *Lehrbuch der Anorganischen Chemie*, De Gruyter, Berlin, **2007**.

P 10.4: Inorganic Chemistry Laboratory Course 2 (T1DD)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	Successful participation at Inorganic Chemistry 1 (P 4).
Study pathway level	Recommended semester: 4
Duration	The course spans 1 semester.
Content	<p>This module addresses advanced methods for the preparation and characterisation of chemical compounds from all segments of inorganic chemistry (e.g. coordination, molecular and solid state compounds, intermetallic phases, modern functional materials and nano materials). The advanced synthetic methods include syntheses under mild conditions (such as precipitation, sol-gel or combustion syntheses), as well as more complex apparatusive methods (e.g. high pressure, high temperature, inert gas or reactive gas syntheses), which are represented by selected examples from modern inorganic and material chemistry. The respective theoretical basis is provided in the seminar accompanying this lab course.</p> <p>For each prepared compound, a modern analytical method (X-ray powder diffraction, IR, UV-vis, Raman, EPR, NMR spectroscopy, ICP-AAS spectrometry) is performed. The safe handling of hazardous substances and safety-relevant apparatus of all kinds (including very high temperatures, extremely low temperatures, high pressure, vacuum, air-sensitive materials, very poisonous, environmentally harmful and KMR substances) is trained under intense assistance. Prior to each individual synthesis, a short oral colloquium ensures the basic understanding and all safety-relevant details. The preparative work is performed mostly independently in groups of two students. The outcome of the preparations and respective analytical data are compiled in a scientific protocol.</p>
Qualification goals	<p>Subsequent to the module Inorganic Chemistry 1 (P 4) the students remember the safe handling of inorganic compounds and simple laboratory techniques as well as the relevant safety procedures and waste disposal rules.</p> <p>The students have understanding for the theoretical basis of the individual lab preparations which are taught in the seminar belonging to this lab course. They also understand the methods for literature research relevant</p>

for the syntheses and the rules of good scientific practice which are important for the protocols. Furthermore, they understand the in many cases complex synthetic apparatuses and a plethora of modern analytical methods used for the characterisation of the prepared samples.

The students employ not only modern methods for literature research and modern laboratory techniques, but also analytical characterisation methods. Here, they evaluate a number of alternative methods available with respect to preparation and to analysis, in order to chose the most appropriate one. The results of the analyses is used to evaluate the aptitude of a chosen synthetic process and to, if necessary, change to a more promising alternative. Repeating a preparation under modified parameters or trying an alternative synthetic route is possible within the lab course time and also is explicitly desirable.

On a voluntary basis, the lab course provides the possibility to develop a new idea for a new AC2 lab preparation within the frame of a "mini project". The ideas for these potential new experiments come from the lab course organiser, the advisers or from the students.

The results of each experiment are documented and discussed in a scientific report, according to the rules of good scientific practice.

Submodule assessment	Oral examination, scientific protocol and lab course assessment.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the lab course.
Responsible person	PD Dr. Constantin Hoch
Language	German
Additional information	<p>Teaching materials:</p> <p>The theoretical basics are taught in the accompanying seminar. All respective materials (pdf, prezi presentations) are available freely for the students. This also holds for the safety seminar which is held for each of the individual lab courses and which is explicitly adapted to the situation of the AC2 lab course. There is no scriptum for the lab course. The students evaluate individually a plausible synthetic route by literature research with the means available at the department. The advisors ensure a working and tested synthetic standard procedure for each experiment. All information concerning every aspect of the AC2 lab</p>

course is available freely for registered users on a dedicated web server.

Recommended literature:

Holleman-Wiberg, Lehrbuch der Anorganischen Chemie, De Gruyter, Berlin, **2007**.

G. Brauer, Handbuch der präparativen Anorganischen Chemie, W. Enke, Stuttgart, **1968**.

Organizational information:

Registration for the lab course through the internet portal of the faculty.

The lab course is synchronized with the Biochemistry 1 P8.3 and physical chemistry 1 laboratory courses P7.4 running in parallel.

Module P 11: Toxicology and Law

Degree programme Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact hours	Self-directed studies	ECTS
Lecture	P 11.1: Toxicology for chemists	WiSe	15 h (1 SWS)	30 h	(1,5)
Lecture	P 11.2: Law for chemists	WiSe	15 h (1 SWS)	30 h	(1,5)

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

Type of the module	Compulsory module with required courses.
Applicability to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 5
Duration	The modul spans 1 semester.
Content	Topics include aspects necessary for the German "Sachkundenachweises gemäß § 5 der Chemikalien-Verbotsverordnung". Details in P 11.1-11.2
Qualification goals	Explanation of toxicological aspects relevant to laboratory work as a chemist. Assessment of risks, safety aspects, environmental protection law. Weighing up safety risks and consequences in the everyday life of a chemist. Basics of toxic principles of selected substance groups.
Module assessment	Written or oral examinations.
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	Dr. Krauss, Dr. Weiss

Language German

Additional information s. P 11.1

P 11.1: Toxicology for Chemists (T1ET)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 5 (but is offered from 1 st to 6 th semester)
Duration	The course spans 1 semester.
Content	Tasks and definition of toxicology; fields of toxicology, toxicokinetics, toxicodynamics and general mechanisms of action of poisons, carcinogenic, mutagenic, reprotoxic and teratogenic substances; toxic effects of respiratory poisons, toxicology of metals and other inorganics, toxicology of solvents, toxicology of insecticides, herbicides, rodenticides, fungicides, plant and animal poisons, toxicology of pharmaceuticals and drugs, chemical and biological warfare agents, aspects of ecotoxicology; treatment of poisoning and use of common antidotes.
Qualification goals	<p>Explain toxicological aspects that are relevant to laboratory work as a chemist.</p> <p>Describe the toxic principles of action of selected substance groups.</p> <p>Assess the hazard potential of common toxic substances.</p> <p>Identify toxic substances by comparing their structure with known toxic substances.</p>
Submodule assessment	Written or oral examination.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Dr. Krauss
Language	German
Additional information	<p>Recommended literature:</p> <ul style="list-style-type: none"> • Toxikologie, W. Dekant, S. Vamvakas, ISBN 978-3-8274-2673-4

- Lehrbuch der Toxikologie, H. Marquardt, Schäfer, Barth, ISBN 9783804736573
- Humantoxikologie, J. Oehlmann, B. A. Markert, ISBN 3804714838
- Allgemeine und spezielle Pharmakologie und Toxikologie: Aktories et. al., 978-3-437-42523-3
- J. Krauß: Kurzschrift zum Seminar:
<https://bracher.cup.uni-muenchen.de/teaching/toxikologie-der-hilfsstoffe-und-schadstoffe/>

P 11.2: Law for Chemists (T1EU)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 5
Duration	The course spans 1 semester.
Content	<p>Important legal aspects with regard to laboratory work performed by chemists;</p> <p>Overview of institutions actively involved in the area of industrial safety.</p> <p>Subjects covered include fundamentals of:</p> <ul style="list-style-type: none"> • Chemicals Act • REACH-Regulation • Chemicals Prohibition Regulation • Regulation on Hazardous Substances with the corresponding TRGS (in particular TRGS 526, TRGS 900 and TRGS 905) • German laws for the transportation of hazardous goods (Gefahrgutverordnung) • Regulation on Industrial Safety and Health • Maternity Protection Act (with the Ordinance on Maternity Protection) • Recycling and Waste Management Act including List of Wastes Ordinance • Regulation for Waste Management Officers • Competence according to §5(1)7 Chemicals Prohibition Regulation.
Qualification goals	<p>Assessing legal and other risks, in particular safety aspects, risks in the area of chemical safety, environmental protection and duty of care as a supervisor.</p> <p>Assessing and analyzing safety risks and their possible consequences, particularly in relation to chemical professions.</p> <p>Knowledge base to be able to assume responsibility as a supervisor in the day-to-day work of a chemist.</p>

Submodule assessment	Written or oral examination.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the module.
Responsible person	Dr. Weiss
Language	German
Additional information	

Module WP 1: Inorganic Chemistry 3

Degree programme

Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (optional courses)	Rotation	Contact hours	Self-directed studies	ECTS
Seminar	WP 1.1 Seminar for Inorganic-chemical Lab Course 3	WiSe/ SoSe	15 h (1 SWS)	30 h	(1,5)
Lab course	WP 1.2 Inorganic-chemical Laboratory Course 3	WiSe/ SoSe	150 h (10 SWS)	75 h	(7,5)
Lecture	WP 1.3.1 Inorganic Chemistry 4 (Molecular Chemistry)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 1.3.2 Inorganic Chemistry 5 (Solid State Chemistry)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 1.3.3 Inorganic Chemistry 6 (Bioinorganic Chemistry)	SoSe	30 h (2 SWS)	60 h	(3)

This module is comprised of 15 ECTS-points. 6 ECTS should be achieved from optional courses. Class attendance is 15 contact hours per week. Total time, including self-directed studies, is about 450 hrs.

Type of the module	Optional module with optional and compulsory courses.
Applicability to other degree programs	Master programs in Chemistry and Biochemistry, as minor subject.
Elective guidelines	Two optional modules of WP 1 – WP 5 should be elected. For this module two of the courses WP 1.3.1 – 1.3.3 must be elected.
Entry requirements	Entry requirements for WP 1.2: successful participation at Inorganic-chemical laboratory and seminar (P 10.3, P 10.4).
Study pathway level	Recommended semester: 5 and 6
Duration	The modul spans 2 semesters.
Content	<p>This module enhances knowledge in the field of inorganic chemistry by selecting two of three lectures.</p> <p>In the lab course, students (usually in groups of two) will produce advanced compounds as part of a mini-internship (6 days) with laboratory staff. This part is completed with a protocol and a final colloquium in the presence of the respective assistants and lecturers.</p> <p>The learning content includes the underlying theoretical concepts of the practical course material.</p>

Details s. WP 1.1-1.3

Qualification goals

Students are introduced to special topics in inorganic chemistry in the lectures. In doing so, they expand their previously acquired knowledge with current specialist information. Students master the content of the lectures and are able to transfer their knowledge to current problems.

Students can produce sophisticated inorganic preparations, record their experiments correctly and have a good command of the theoretical background to their experimental work. Responsible and clean working methods in the laboratory, as well as independent literature research on the preparations.

Details s. WP 1.1-1.3

Module assessment

Written or oral exams, scientific protocol and lab course assessment.

Grading

The module is graded.

Requirements for granting ECTS-Points

ECTS credits will be granted when the examination of potential elective compulsory module parts have been completed successfully.

Responsible person

Prof. Dr. Thomas Klapötke, Prof. Dr. Dirk Johrendt, Prof. Dr. George Cutsail

Language

German

Additional information

WP 1.1: Seminar for Inorganic Chemistry Laboratory Course 3 (T1EE)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	Master programs in Chemistry and Biochemistry, as minor subject.
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 5 or 6
Duration	The course spans 1 semester.
Content	The so-called "Days in Inorganic Chemistry", are preceding the inorganic-chemical lab course 3. The current research of the three sub-disciplines Molecular-/Solid state-/Coordination-Chemistry is introduced by the chairs or substitutes. Additionally, lectures of selected advanced methods in Inorganic Chemistry will be given by professors of Inorganic Chemistry in changing sequence.
Qualification goals	The students get into contact with the research groups and gain insight into advanced methods in Inorganic Chemistry which they have to apply in the lab course. Furthermore, they can evaluate the research topics with regard to research practical course or bachelor thesis.
Submodule assessment	s. WP 1.2
Grading	The course is not graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the lab course, which is allocated to the module.
Responsible person	Dr. Burkhard Krumm
Language	German
Additional information	<p>Organizational information:</p> <p>Registration for the lab course through the internet portal of the faculty.</p> <p>The lab course takes places bi-annually during semester breaks (March and September), 15 days plus two preceding seminar days for the presentation of the inorganic chemistry research groups (seminar).</p>

WP 1.2: Inorganic Chemistry Laboratory Course 3 (T1EF)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	Master programs in Chemistry and Biochemistry, as minor subject.
Elective guidelines	none
Entry requirements	Successful participation at Inorganic-chemical laboratory and seminar (P 10.3, P 10.4).
Study pathway level	Recommended semester: 5 or 6
Duration	The course spans 1 semester.
Content	<p>The students (mostly in pairs) will produce advanced compounds in assistants' labs during a mini lab course (5 days). The course will be completed with an oral exam in the presence of the instructor and the assistant. Students will also learn how to design a scientific protocol.</p> <p>Contents are the theoretical backgrounds for the laboratory course.</p>
Qualification goals	The students apply advanced experimental techniques in inorganic chemistry and are able to plan and perform experiments individually with application of their theoretical backgrounds. They learn to operate in the lab in a responsible and tidy manner, to search in the literature and to record the results correctly in a report.
Submodule assessment	An oral examination, scientific protocol and laboratory assessment.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the the lab course.
Responsible person	Dr. Burkhard Krumm
Language	German
Additional information	<p>Recommended literature:</p> <p>Holleman-Wiberg, Lehrbuch der Anorganischen Chemie, De Gruyter, Berlin, 2007; and other textbooks of Inorganic Chemistry.</p>

WP 1.3.1: Inorganic Chemistry 4 (Molecular Chemistry) T1EA

Type of the submodule	Optional course.
Applicability of the submodule to other degree programs	Master programs in Chemistry and Biochemistry, as minor subject.
Elective guidelines	s. WP 1
Entry requirements	none
Study pathway level	Recommended semester: 5
Duration	The course spans 1 semester
Content	A broad overview of the molecular chemistry of the main group elements is provided. The content includes the most important compound classes as well as the corresponding syntheses, structures, binding ratios and chemical properties for each compound class. Specifically covered are: Hydrogen, element-hydrogen compounds (element = alkali metals, alkaline earth metals, boron, silicon, nitrogen, phosphorus, oxygen), superacids, halogens and interhalogen compounds, nitrogen and phosphorus halides, element-nitrogen compounds, element-oxides and selected element compounds of the heavy chalcogens as well as noble gas compounds.
Qualification goals	After completing the module, students will be able to name and categorize the most important classes of compounds in the molecular chemistry of the main group elements. They will be able to precisely describe the syntheses, structures, binding ratios and chemical properties of these compound classes. In addition, they are able to analyze chemical problems and develop suitable solutions. They can transfer their acquired knowledge to new chemical issues and develop abstractions from concrete examples to general chemical principles.
Submodule assessment	Written or oral examination.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the submodule.
Responsible person	Prof. Dr. Thomas Klapötke
Language	German
Additional information	Recommended literature:

- C. Janiak, T. M. Klapötke, H.-J. Meyer, *Moderne Inorganic Chemistry*, E. Riedel Hrsg., 2. Auflage, de Gruyter, Berlin, **2003**.
- Holleman-Wiberg, *Lehrbuch der Anorganischen Chemie*, De Gruyter, Berlin, **2017**.

WP 1.3.2: Inorganic Chemistry 5 (Solid State Chemistry) T1EB

Type of the submodule	Optional course.
Applicability of the submodule to other degree programs	Master programs in Chemistry and Biochemistry, as minor subject.
Elective guidelines	s. WP 1
Entry requirements	none
Study pathway level	Recommended semester: 5
Duration	The course spans 1 semester.
Content	The course content includes the basics of crystal structure analysis, the composition of simple solid state structures, important structure families, description principles of solid state structures, principles of the composition of solid state structures, structure-property relationships using selected examples, applications of solid state materials in the environment as well as industry and technology, bonding principles in solids, properties of metals, semiconductors and insulators, synthesis of solid-state compounds, defects and non-stoichiometry, diffusion in solids, principles of ion conduction, phase diagrams, phase transformations, and high-pressure chemistry with large-volume presses and diamond stamping cells.
Qualification goals	<p>After participating in the module course, students will be able to</p> <ul style="list-style-type: none"> • Understand simple solid state structures • Explain the composition of solid state structures • Analyse bonds in solids • Explain properties resulting from structures • Create synthesis methods for solid-state compounds • Explain physical properties such as electrical and thermal conductivity, ductility, metallic luster, transparency, ionic conductivity, fluorescence, colour, and dielectric properties • categorise the importance of solid-state chemistry in modern society
Submodule assessment	Written or oral examination.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the submodule.
Responsible person	Prof. Dr. Dirk Johrendt

Language

German

Additional information

Recommended literature:

- Solid State Materials Chemistry - Patrick Woodward, Cambridge University Press
- Anorganische Chemie - Erwin Riedel, Christoph Janiak, DeGruyter
- Allgemeine und Anorganische Chemie - Micheal Binnewies, Springer Nature
- „Solid State Chemistry and its Applications“, Anthony R. West, Wiley, 2014
- „Anorganische Strukturchemie“, Ulrich Müller, Teubner Verlag, 2006

Organizational information:

Registration for the written exam through the internet portal of the faculty.

WP 1.3.3: Inorganic Chemistry 6 (Bioinorganic Chemistry) T1FA

Type of the submodule	Optional course.
Applicability of the submodule to other degree programs	Master programs in Chemistry and Biochemistry, as minor subject.
Elective guidelines	s. WP 1
Entry requirements	none
Study pathway level	Recommended semester: 6
Duration	The course spans 1 semester
Content	<ul style="list-style-type: none"> • Active Centers of Enzymes. • Acid/Base Catalysis at Physiological pH: Zinc enzymes; function and inhibition of catalytic centers (e.g., urease). • Catalysis of Redox Reactions: <ul style="list-style-type: none"> • Mn- and Fe-superoxide dismutase, rubredoxin, ferredoxin, and Rieske centers. • Hemerythrin, myoglobin, and hemoglobin. • Redox catalysis at heme centers (cytochrome c, catalase, cytochrome P450). • Redox and oxidation processes catalyzed by copper proteins. • Metals in Photosynthesis. • Biomineralization. • Hydrogenases and Nitrogenases. • Organometallics in Organisms. • Metal Complexes in Therapeutics and Diagnostics.
Qualification goals	<p>Students are able to:</p> <ul style="list-style-type: none"> • Apply principles of coordination chemistry to metalloproteins and metalloenzymes. • Identify and assess the most important biological ligands and ligand influences. • Explain correlations between the occurrence, abundance, and relevance of metals in biological systems. • Recognize structural and functional similarities of biomimetic and bioinspired coordination compounds with metalloproteins and metalloenzymes. Explain similarities and differences of various biologically relevant metal ions. • Identify the relevance of covered topics to current research in bioinorganic chemistry.

- Transfer acquired bioinorganic skills to other areas of chemistry, as well as biochemistry and medicine

Submodule assessment	Written or oral examination.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the submodule.
Responsible person	Prof. Dr. George Cutsail
Language	German
Additional information	Recommended literature: Additional slides provided Organizational information: Registration for the written exam through the internet portal of the faculty.

Module WP 2: Organic Chemistry 2

Degree programme Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (optional courses)	Rotation	Contact hours	Self-directed studies	ECTS
Lecture	WP 2.1.1 Organic Chemistry 3 (Bioorganic Chemistry)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 2.1.2 Organic Chemistry 4 (Organometallic Chemistry)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 2.1.3 Organic Chemistry 5 (Theoretical Concepts in Organic Chemistry)	SoSe	30 h (2 SWS)	60 h	(3)
Seminar	WP 2.2 Seminar for Organic Chemistry Laboratory Course 2	SoSe	15 h (1 SWS)	30 h	(1,5)
Lab course	WP 2.3 Organic Chemistry Laboratory Course 2	SoSe	150 h (10 SWS)	75 h	(7,5)

This module is comprised of 15 ECTS-points. 6 ECTS should be achieved from optional courses. Class attendance is 15 contact hours per week. Total time, including self-directed studies, is about 450 hrs.

Type of the module	Optional module with optional and compulsory courses.
Applicability to other degree programs	Master programs in Chemistry and Biochemistry, as minor subject.
Elective guidelines	Two optional modules of WP 1 – WP 5 should be elected. For this module two of the courses WP 2.1.1- 2.1.3 must be elected.
Entry requirements	Entry requirements for WP 2.3: successful participation at the module Organic Chemistry 1 (P 6).
Study pathway level	Recommended semester: 5 and 6
Duration	The modul spans 2 semesters.
Content	Lecture topics are: nucleophilic substitutions on saturated carbon; elimination reactions; additions to C-C multiple bonds; nucleophilic addition and substitution on the carbonyl group; enolate chemistry; sulphur, silicon and phosphorus in organic chemistry; pericyclic reactions; rearrangements and fragmentations; reductions and oxidations; radical reactions; aromatic chemistry; organometallic chemistry and transition metal catalysis; protecting group chemistry; synthesis of complex

compounds. These are supplemented by a practice-oriented introduction to analytical methods for molecular chemistry.

The organic chemistry practical course 1 begins with a two-week preliminary course where important preparative techniques (e.g. drying of solvents, extraction, crystallization, distillation, column chromatographic separation) and the application of analytical methods (e.g. refractive index, melting point, UV/VIS, IR, NMR, GC/TLC-MS, elemental analysis) are learned. Students will also have access to short videos and a working method video quiz on the moodle learning platform. In the following eight-week main part, students will independently prepare selected compounds according to literature procedures and from current research projects of research groups and examine them using analytical/spectroscopic methods. By carrying out analyses, the structure of unknown organic compounds is to be identified on the basis of their physical and spectroscopic data.

Safe laboratory work, the handling of hazardous substances and the proper disposal of chemical waste are practiced in the practical course. The experimental protocols to be drawn up by the students serve as proof of the documentation of scientific results and their critical evaluation. Students will also learn how to use chemical drawing programs and programs for evaluating spectroscopic data.

Qualification goals

After successfully completing the module students will be able to:

- Know synthetic methods for important classes of organic compounds as they are used on laboratory scale.
- Formulate the mechanisms of important synthetic reactions in detail.
- Routinely carry out basic synthetic operations, work-up and purification procedures in organic chemistry in compliance with occupational safety regulations.
- Apply basic knowledge of spectroscopic analysis methods in organic chemistry to determine the structure of their synthesized products.
- Prepare protocols for their experiments in accordance with current scientific standards and comply with the rules of good scientific practice.
- Maintain an objective, open and cooperative relationship with the laboratory community, support each other and carry out joint tasks responsibly.

Module assessment

Written or oral examinations, scientific protocol and lab course assessment.

Grading

The module is graded.

Requirements for granting ECTS-Points	ECTS credits will be granted when the examination of potential elective compulsory module parts have been completed successfully.
Responsible person	Prof. Dr. Andrea Rentmeister, Prof. Anne Schütz, Prof. Dr. Hendrik Zipse, Dr. Bernhard Kempf.
Language	German
Additional information	Literature references: 1) K. Schwetlick, Organikum, 24. Aufl., Wiley-VCH, Weinheim, 2015; S. Hünig, P. Kreitmeier, G. Märkl, J. Sauer, Arbeitsmethoden in der organischen Chemie, 3. Aufl., Lehmanns Media, Berlin, 2019. 2) K. P. C. Vollhardt, N. E. Schore, Organische Chemie, 6. Aufl., Wiley-VCH, Weinheim, 2020. 3) R. Brückner, Reaktionsmechanismen, 3. Aufl., Springer Spektrum, 2015. 4) M. Hesse, H. Meier, B. Zeeh, Spektroskopische Methoden in der Organischen Chemie, 8. Aufl., Thieme, Stuttgart, 2011.

WP 2.1.1: Organic Chemistry 3 (Bioorganic Chemistry) T1EG

Type of the submodule	Optional course.
Applicability of the submodule to other degree programs	Master programs in Chemistry and Biochemistry, as minor subject.
Elective guidelines	s. WP 2
Entry requirements	none
Study pathway level	Recommended semester: 5
Duration	The course spans 1 semester.
Content	Structure and composition of peptides, basic principles of stereochemistry, conformational analysis, Ramachandran diagrams, solid-phase peptide synthesis, chemistry and mass spectrometry of peptide and peptide sequencing, ligation strategies for protein synthesis, proteins as therapeutics. Structure of DNA and RNA, stereoelectronic effect and conformational analysis, non-covalent interactions, synthesis of nucleosides and nucleotides, solid-phase synthesis of oligonucleotides, the chemistry of sequencing, nucleosides and nucleotides as pharmaceuticals and vaccines. Structures of saccharides, stereoelectronic effects (anomeric effect, gauche effect), synthesis of sugars and oligosaccharides, oligosaccharides in nature.
Qualification goals	Students have the ability to: <ul style="list-style-type: none"> a) follow the current literature in the area of bioorganic chemistry; b) rationalize the structure of important biological compound classes (peptide, oligonucleotides, oligosaccharides); c) explain the interplay of covalent and ionic bonding forces with non-covalent interactions (hydrogen bonds, electrostatic interactions, London dispersion forces) typical for the extended systems in biological chemistry; d) to understand the conceptual basis of synthetic protocols for peptides, oligonucleotides, oligosaccharides, and can apply these methods to simple target molecules. e) will understand stereoelectronic effects and how they determine conformational preferences of organic compounds.
Submodule assessment	Written or oral examination.
Grading	The course is graded.

Requirements for granting ECTS-Points

ECTS-points are awarded for passing the exam, which is allocated to the submodule.

Responsible person

Prof. Dr. Thomas Carell

Language

German

Additional information

Organizational information:

Registration for the written exam through the internet portal of the faculty.

WP 2.1.2: Organic Chemistry 4 (Organometallic Chemistry) T1FB

Type of the submodule	Optional course.
Applicability of the submodule to other degree programs	Master programs in Chemistry and Biochemistry, as minor subject.
Elective guidelines	s. WP 2
Entry requirements	none
Study pathway level	Recommended semester: 6
Duration	The course spans 1 semester.
Content	<p>The lecture includes the following topics of organometallic chemistry in chronological order:</p> <ul style="list-style-type: none"> a) characterization of organometallic compounds, especially organometallic complexes and the resulting reactivities therein; b) traditional and modern synthesis methods, as well as the (stereoselective) applications of organometallic compounds, in particular lithium, Grignard, zinc, boron, silicon, titanium, zirconium and copper compounds; c) applications of transition metal-based catalysts based on the most important applications or name reactions, in particular chromium (Nozaki-Hiyama-Kishi reaction), molybdenum and ruthenium (metathesis reactions), cobalt (Pauson-Khand reaction), nickel and palladium (cross-coupling reactions, Heck reaction, Wacker oxidation, allylic substitution), Rh (hydroformylation) and Au compounds (Lewis acid catalysis).
Qualification goals	<p>After completing the lecture, students will be capable of</p> <ul style="list-style-type: none"> a) determine and predict the basic binding characteristics, as well as the resulting reactivities in organometallic compounds; b) application organometallic compounds in the (stereoselective) synthesis of defined target compounds; c) explain the reaction mechanisms for the synthesis and application of organometallic compounds; d) apply the most important methods of homogeneous catalysis, relying on transition metals, in organic synthesis; e) recognize similarities in formally different organometallic reactions and apply them to

	previously unknown reaction conditions and catalysts.
Submodule assessment	Written or oral examination.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the submodule.
Responsible person	Dr. Dino Berthold
Language	German
Additional information	Organizational information: Registration for the written exam through the internet portal of the faculty.

WP 2.1.3: Organic Chemistry 5 (Theoretical Concepts in Organic Chemistry) T1FC

Type of the submodule	Optional course.
Applicability of the submodule to other degree programs	Master programs in Chemistry and Biochemistry, as minor subject.
Elective guidelines	s. WP 2
Entry requirements	none
Study pathway level	Recommended semester: 6
Duration	The course spans 1 semester.
Content	Quantitative aspects of organic reactivity and the foundations of reaction mechanisms are covered including the following subtopics: qualitative MO theory, perturbation MO theory, the HSAB principle, and the Klopmann-Salem equation. These concepts are applied to chemo-, regio- and stereo-selective reactions of ionic compounds as well as pericyclic reactions. The latter class includes sigmatropic rearrangements, cycloaddition reactions, and cheletropic reactions. The lectures also cover fundamental aspects of mechanistic organic chemistry: kinetic vs. thermodynamic control, concerted vs. stepwise reactions, trapping experiments, crossing experiments, Curtin-Hammett- principle.
Qualification goals	Students have the ability to: <ul style="list-style-type: none"> a) derive the structure of the molecular orbitals for simple organic molecules using qualitative molecular orbital theory and symmetry rules; b) to recognize organic reactions under kinetic or under thermodynamic control; c) apply conventional reactivity models (HSAB principle, Klopmann-Salem equation; Marcus theory; FMO theory) to reactions in organic synthesis; d) develop labeling-, competition-, crossing-experiments suitable for the investigation of organic reaction mechanisms; e) apply the Woodward-Hoffmann rules to pericyclic reactions.
Submodule assessment	Written or oral examination.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the submodule.
Responsible person	Prof. Dr. Hendrik Zipse

Language

German

Additional information

Organizational information:

Registration for the written exam through the internet portal of the faculty.

WP 2.2: Seminar for Organic Chemistry Laboratory Course 2 (T1FD)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	Master programs in Chemistry and Biochemistry, as minor subject.
Elective guidelines	s. WP 2
Entry requirements	none
Study pathway level	Recommended semester: 5 or 6
Duration	The course spans 1 semester
Content	The practical course is complemented by the presentation of scientific articles. For the presentation, students will choose a recent research article to learn about the latest advances in organic chemistry and familiarise themselves with the scientific literature.
Qualification goals	<p>Training in the preparation of presentations and its presentation to an audience.</p> <p>The students can design, plan and execute the synthesis of known compounds, and know how to document their experimental work using professional guidelines. Students understand the theoretical basis of synthetically used organic reactions and have the ability to apply these reactions for the synthesis of new compounds.</p>
Submodule assessment	s. WP 2.3
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the the lab course, which is allocated to the module.
Responsible person	Dr. Pavel Kielkowski
Language	German
Additional information	

WP 2.3: Organic Chemistry Laboratory Course 2 (T1FE)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	Master programs in Chemistry and Biochemistry, as minor subject.
Elective guidelines	s. WP 2
Entry requirements	Successful participation at the module Organic Chemistry 1 (P 6).
Study pathway level	Recommended semester: 5 or 6
Duration	The course spans 1 semester
Content	<p>In the organic chemistry practical course 2, students learn advanced methods of synthetic organic chemistry (e.g. chromatography, solid phase synthesis, protective group chemistry, enzyme catalysis, organocatalysis, microwave reactors, working in an inert gas atmosphere) as well as the application of advanced analytical and spectroscopic methods (e.g. NMR-spectroscopy, MS-spectroscopy) in compliance with the regulations for safe working in chemical laboratories.</p> <p>The practical course takes place in the research laboratories of various working groups and enables students to gain an insight into current research activities and the working methods used there.</p> <p>Search strategies for finding chemical information in databases (e.g. SciFinder) are learned in this practical course, as is the documentation of scientific results.</p>
Qualification goals	<p>After successfully completing the organic chemistry practical course 2, students will be able to</p> <ul style="list-style-type: none"> • Independently find information on the synthesis of organic compounds in the chemical literature and online databases. • Carry out advanced synthesis operations independently using current working techniques and modern experimental setups according to synthesis instructions available in the chemical literature. • Use spectroscopic methods to characterize organic compounds. • Handle hazardous substances responsibly and safely in compliance with current safety and environmental regulations. • Document experimental results according to current scientific standards and comply with the rules of good scientific practice.
Submodule assessment	Scientific protocol and lab course assessment.

Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the lab course.
Responsible person	Dr. Bernhard Kempf
Language	German
Additional information	<p>Recommended literature:</p> <ul style="list-style-type: none">• K. Schwetlick, Organikum, 24. Aufl., Wiley-VCH, Weinheim, 2015;• S. Hünig, P. Kreitmeier, G. Märkl, J. Sauer, Arbeitsmethoden in der organischen Chemie, 3. Aufl., Lehmanns Media, Berlin, 2019;• K. P. C. Vollhardt, N. E. Schore, Organische Chemie, 6. Aufl., Wiley-VCH, Weinheim, 2020;• J. Clayden, N. Greeves, S. Warren, Organic Chemistry, 2. Auflage, Springer, 2013;• R. Brückner, Reaktionsmechanismen, 3. Aufl., Springer Spektrum, 2015;• M. Hesse, H. Meier, B. Zeeh, Spektroskopische Methoden in der Organischen Chemie, 8. Aufl., Thieme, Stuttgart, 2011. <p>Organizational information:</p> <p>Registration for the lab course through the faculty website.</p> <p>The practical courses take place in the research laboratories by arrangement with the assigned working groups.</p>

Module WP 3: Physical Chemistry 2 / Theoretical Chemistry

Degree programme

Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (optional courses)	Rotation	Contact hours	Self-directed studies	ECTS
Seminar	WP 3.1 Seminar for Physical Chemistry Laboratory Course 2	WiSe	15 h (1 SWS)	30 h	(1,5)
Lab course	WP 3.2 Physical Chemistry Laboratory Course 2	WiSe	150 h (10 SWS)	75 h	(7,5)
Lecture	WP 3.3.1 Physical chemistry 3 (Statistical Thermodynamics)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 3.3.2 Physical chemistry 4 (Biophysical Chemistry)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 3.3.3 Physical chemistry 5 (Modern Developments in Physical Chemistry)	SoSe	30 h (2 SWS)	60 h	(3)
Lab course	WP 3.3 Lab Course in Theoretical Chemistry	WiSe/SoSe	150 h (10 SWS)	75 h	(7,5)
Lecture	WP 3.3.4 Quantum Chemistry 1 / Theoretical Chemistry 3	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 3.3.5 Quantum Chemistry 2 / Theoretical Chemistry 4	SoSe	30 h (2 SWS)	60 h	(3)

This module is comprised of 15 ECTS-points. 6 ECTS should be achieved from optional courses. Class attendance is 15 contact hours per week. Total time, including self-directed studies, is about 450 hrs.

Type of the module

Optional module with optional and compulsory courses.

Applicability to other degree programs

Master Programs in Chemistry and Biochemistry, as subsidiary subject.

Elective guidelines

Two optional modules of WP 1 – WP 5 should be elected.
For this module two of the courses WP 3.3.1- 3.3.5 must be elected.

Entry requirements

Entry requirements for WP 3.2: successful participation at the Physical Chemistry lab course 1 and the accompanying seminar (P 7.3 and P 7.4).

Entry requirements for WP 3.3: successful participation at the lectures of Theoretical Chemistry 3 (WP 3.3.4) and 4 (WP 3.3.5).

Study pathway level	Recommended semester: 5 and 6
Duration	The modul spans 2 semesters.
Content	<p>This module enhances knowledge in the field of physical and theoretical chemistry by selecting two of three lectures.</p> <p>The content of the practical course includes experiments in spectroscopy, microscopy, surface chemistry and computer-aided simulations. The learning content is the theoretical background for the practical course material.</p> <p>For details see WP 3.1-3.3</p>
Qualification goals	<p>In the lectures, students are introduced to special topics in physical and theoretical chemistry. In doing so, they expand their previously acquired knowledge with current specialist information. The information is to be integrated into existing knowledge in order to formulate and discuss scientific questions. Students master the content of the lectures and are able to transfer knowledge to current problems.</p> <p>In the practical course, students are able to carry out demanding operations in physical and theoretical chemistry independently, record their experiments correctly and master the theoretical background of their work.</p> <p>For details see WP 3.1-3.3</p>
Module assessment	Written or oral examinations, scientific protocol and lab course assessment.
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS credits will be granted when the examination of potential elective compulsory module parts have been completed successfully.
Responsible person	Prof. Dr. Knut Müller-Caspary, Prof. Dr. Fingerhut, Prof. Dr. Ochsenfeld, Prof. Dr. Don. C. Lamb, Prof. Dr. Philip Tinnefeld
Language	German
Additional information	You can select one of the two lab courses and any two lectures of this module, independent of the lab course.

WP 3.1: Seminar for Physical Chemistry Laboratory Course 2 (T1EK)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	Master programs in Chemistry and Biochemistry, as minor subject.
Elective guidelines	s. WP 3
Entry requirements	none
Study pathway level	Recommended semester: 5
Duration	The course spans 1 semester
Content	Oral presentations of the students on modern methods and research topics in Physical Chemistry.
Qualification goals	<p>The students learn to:</p> <ul style="list-style-type: none"> • Independently introduce themselves into current research topics in Physical Chemistry and to develop an understanding of the underlying concepts and methods. • Autonomously work out an in-depth understanding of a contemporary scientific publication. • Prepare and present advanced topics and methods of Physical Chemistry in free-speech presentations. • Competences: Presentation of research topics, understanding and knowledge of concepts and methods in Physical Chemistry, literature research, evaluate scientific references (quality assessment, peer-review).
Submodule assessment	s. WP 3.2
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the the lab course, which is allocated to the module.
Responsible person	Prof. Dr. Knut Müller-Caspary
Language	German
Additional information	

WP 3.2: Physical Chemistry Laboratory Course 2 (T1EL)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	Master programs in Chemistry and Biochemistry, as minor subject.
Elective guidelines	s. WP 3
Entry requirements	Successful participation at the module Physical Chemistry 1 (P 7.4).
Study pathway level	Recommended semester: 5
Duration	The course spans 1 semester.
Content	<p>Contents are experiments on spectroscopy, electron microscopy, light/fluorescence microscopy, DNA-origami, surface chemistry as well as computer simulations.</p> <p>Contents are the exemplary introductions to handle contemporary experimental setups in the groups of the Physical Chemistry unit, as well as the theoretical backgrounds for the laboratory courses.</p>
Qualification goals	<p>After completing this course, the students are enabled to:</p> <ul style="list-style-type: none"> • Perform laboratory experiments using different advanced methods of Physical Chemistry. • Analyze and discuss measurement data in the context of theoretical model descriptions. • Competences: Independent experimental work, writing of scientific protocols, analytical capabilities, hands on expertise on advanced methods of Physical Chemistry, Good scientific practice.
Submodule assessment	Scientific protocol, lab course assessment, oral examination and presentation.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the lab course.
Responsible person	Prof. Dr. Knut Müller-Caspary
Language	German
Additional information	The lab course comprises the performance as well as the preparation and the follow-up of six different experiments on three consecutive days each

WP 3.3: Lab Course in Theoretical Chemistry (T1TB)

Type of the Module	Optional module
Applicability to other degree programmes	Master programs in Chemistry and Biochemistry, as minor subject.
Elective guidelines	s. WP 3
Entry requirements	Successful participation at the courses Theoretical Chemistry 1 and 2 (WP 3.3.4, WP 3.3.5).
Study pathway level	Recommended semester: 5 or 6
Duration	The course spans 1 semester.
Content	<p>During this course, we teach how to use quantum chemical program packages like Gaussian, MOLPRO, Q-Chem, TURBOMOLE, FermiONS++. Different basis sets and methods (HF, MP2, DFT, CI, CASSCF) to solve the electronic Schrödinger equation are introduced and tested. Single point calculations, structure optimizations and frequency analysis are performed for the electronic groundstate. Potential energy surfaces are calculated and characterized by their critical points like minima, transition states and minimum energy paths to characterize chemical reactions. Methods for electron correlation and multiconfiguration character are compared. Their efficiency is tested for excited state calculations and conical intersection searches that are relevant for photochemical processes. We introduce continuum models to describe solvation effects. Furthermore, the ab initio calculation of NMR chemical shifts and electronic circular dichroism is introduced. For exemplary cases it is shown that quantum chemical calculations can be crucial for, e.g., the structure determination by assigning experimental spectra as well as for determining the absolute configuration of molecules. In addition, different tools for visualization of the calculated molecular properties are presented.</p>
Qualification goals	<p>Upon completion of this course, the student should have a solid understanding of the operating principles of quantum chemical program codes and should be able to independently use the program packages and critically judge the obtained results. They should know in detail different quantum chemical methods to solve the electronic Schrödinger equation and be able to decide which method should be used for a given application. The students should be able to present and visualize the calculated results.</p>
Module assessment	Lab assessment

Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the lab course.
Responsible person	Prof. Dr. Fingerhut, Prof. Dr. Ochsenfeld
Language	German/English
Additional information	

WP 3.3.1: Physical Chemistry 3 (Statistical Thermodynamics) T1EI

Type of the submodule	Optional course.
Applicability of the submodule to other degree programs	Master programs in Chemistry and Biochemistry, as minor subject.
Elective guidelines	s. WP 3
Entry requirements	none
Study pathway level	Recommended semester: 5
Duration	The course spans 1 semester
Content	This course covers the basics of statistical thermodynamics. In specific: Boltzmann statistics; statistics probabilities, the concept of ensembles, the molecular partition function for translation, vibration and rotation; the system partition function; the relationship between partition functions and thermodynamic functions: Internal Energy, Entropy, Enthalpy, Helmholtz Free Energy, Gibbs Free Energy, pressure, heat capacity, the configuration integral, Debye theory for the temperature dependence of the heat capacity of crystals; equilibrium constants of gas reactions; Maxwell's velocity distribution
Qualification goals	The students are expected to have command of the contents of the lecture and be able to transfer this knowledge to solve problems in statistical thermodynamics. They should be able to derive the Boltzmann Distribution using Boltzmann statistics, calculate the partition function and various thermodynamic parameters from the molecular partition function including thermodynamic equations of states (e.g Internal Energy, Enthalpy, Entropy, Helmholtz Free Energy), heat capacity, and the equilibrium constants of reactions based on spectroscopic data.
Submodule assessment	Written or oral examination.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the submodule.
Responsible person	Prof. Dr. Don. C. Lamb
Language	German
Additional information	Organizational information: Registration for the written exam through the internet portal of the faculty.

WP 3.3.2: Physical Chemistry 4 (Biophysical Chemistry) T1EJ

Type of the submodule	Optional course.
Applicability of the submodule to other degree programs	Master programs in Chemistry and Biochemistry, as minor subject.
Elective guidelines	s. WP 3
Entry requirements	none
Study pathway level	Recommended semester: 5
Duration	The course spans 1 semester.
Content	Contents are the fundamentals of biophysical chemistry and molecular biophysics. This includes: the concept of the cell; classes of biomolecules; experimental techniques including optical and electron microscopy, fluorescence microscopy and spectroscopy, force spectroscopy and fluorescence correlation spectroscopy; diffusion processes; the stability of proteins and protein folding; conformational substates; polymer statistics; the properties of lipids, membranes and propagation of nerve action potentials.
Qualification goals	The students are expected to have command of the contents of the lecture and to be able to transfer the knowledge to solve biophysical problems. This includes a deep understanding of the various methods used in biophysics (including optical microscopy, electron microscopy, fluorescence microscopy and spectroscopy, electron microscopy, super resolution microscopy, force spectroscopy and fluorescence correlation spectroscopy) and knowledge of the factors involved in protein stability and folding. In addition, they should know the meaning of conformational substates and can calculate the properties of molecular motors, rates involved in enzyme kinetics, or the properties of nucleic acids using polymer statistics. Furthermore, they are expected to have an understanding of the function and dynamics of lipid membranes and the biophysics of nerve propagation.
Submodule assessment	Written or oral examination.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the submodule.
Responsible person	Prof. Dr. Don C. Lamb

Language

German/English

Additional information

Organizational information:

Registration for the written exam through the internet portal of the faculty.

WP 3.3.3: Physical Chemistry 5 (Modern Developments in Physical Chemistry) T1EF

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	Master programs in Chemistry and Biochemistry, as minor subject.
Elective guidelines	s. WP 3
Entry requirements	none
Study pathway level	Recommended semester: 6
Duration	The course spans 1 semester.
Content	Contents are modern developments in Physical Chemistry in the fields of quantum dynamics, femto chemistry, nano spectroscopy, protein design, biophysical chemistry, photo chemistry, energy conversion, electron microscopy, optical microscopy, quantum chemistry, molecular self-assembly, time-resolved spectroscopy, surface chemistry.
Qualification goals	The students obtain insight into current research areas of Physical Chemistry. They are enabled to understand the scientific literature from these areas and work in teams of two to extract the main points. They learn to present results from the original literature and discuss them with a larger audience.
Submodule assessment	Presentation (20 min).
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the submodule.
Responsible person	Prof. Dr. Philip Tinnefeld
Language	German
Additional information	

WP 3.3.4: Quantum Chemistry 1 / Theoretical Chemistry 3 (T1EM)

Type of the submodule	Optional submodule with compulsory courses.
Applicability of the submodule to other degree programs	Master programs in Chemistry and Biochemistry, as minor subject
Elective guidelines	s. WP 3
Entry requirements	none
Study pathway level	Recommended semester: 5
Duration	The course spans 1 semester.
Content	<p>The lecture provides an overview of quantum-chemical methods for calculating molecular systems: Hartree-Fock (HF); density-functional theory (DFT); electron correlation and configuration interaction (CI); second quantization formalism; coupled cluster (CC).</p> <p>Exercise: The students practise the contents of the lecture based on selected examples. They formulate expectation values in the basis of atomic and molecular orbitals for the different HF and post HF methods.</p>
Qualification goals	<p>Basic understanding of quantum chemical methods and their importance for calculations in chemistry. The students are able to identify, classify and discuss the advantages and disadvantages of the various methods. They acquire criteria how to judge which method is appropriate for which application.</p> <p>Exercise: The students practise the contents of the lecture based on example problems. They know how to handle the relevant equations mathematically. They are able to formulate expectation values in the basis of atomic and molecular orbitals for HF- and post-HF-methods and to apply the fundamental concept of basis functions.</p>
Submodule assessment	Written or oral examination.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the submodule.
Responsible person	Prof. Dr. C. Ochsenfeld
Language	German
Additional information	The allocated exercises in theoretical Chemistry can only be awarded in Module P12 (s. P 12.0.13).

Literature:

- Szabo, N. S. Ostlund, Modern Quantum Chemistry (Introduction to Advanced Electronic Structure Theory), Dover Publications
- F. Jensen; Introduction to Computational Chemistry; Wiley-VCH
- Ira N. Levine; Quantum Chemistry; Pearson International Edition

WP 3.3.5: Quantum Chemistry 2 / Theoretical Chemistry 4 (T1FI)

Type of the submodule	Optional submodule with compulsory courses.
Applicability of the submodule to other degree programs	Master program in Chemistry and Biochemistry as minor subject
Elective guidelines	s. WP 3
Entry requirements	none
Study pathway level	Recommended semester: 6
Duration	The course spans 1 semester
Content	<p>Part 1: The lecture provides deeper insights into quantum-chemical methods and the quantum-chemical calculation of molecular properties: HF, DFT, CI, CC; fundamental aspects with respect to the computational effort and the scaling behavior; energy gradients; higher energy derivatives; response equations, CPSCF theory; calculation of properties such as IR, Raman, NMR, etc.</p> <p>Part 2: Born-Oppenheimer approximation and electronic Schrödinger equation. Presentation of various search algorithms to locate minima, transition states and minimum energy paths. Advanced methods for electron correlation suitable to describe electronically excited states. The focus is on configuration interactions and related methods like Complete-Active-Space –SCF. Discussion of the Born-Oppenheimer approximation including topics like conical intersections and their role in photochemistry. Within this context diabatic and adiabatic potential energy curves as well as non-adiabatic couplings are introduced.</p> <p>Exercise: The students practise the contents of the lecture based on example problems, where methods to calculate energy gradients, optimized geometries and reaction pathways have to be applied. They discuss the fundamental equations of the response theory and the criteria for the scaling behavior of different electronic structure methods. They learn how to formulate the Eigenwert equation for different excited states methods.</p>
Qualification goals	<p>Advanced understanding of quantum-chemical methods as well as of the ab-initio calculation of molecular properties. Application of the matrix formalism and density matrix formalism to simplify the equations expectation values. Solid understanding of advanced quantum chemical problems and methods to calculate potential energy surfaces of electronically excited states. Understanding of search algorithms to characterize multidimensional energy surfaces.</p> <p>Exercise: The students are able to solve optimization problems for selected examples of model potentials and molecular</p>

potential landscapes. They are able to formulate the coupled perturbed SCF equations, the fundamental equations of the response theory and to analyse the scaling behavior of different electronic structure methods. Transformation between adiabatic and diabatic representation. They are able to set up and analyse CI-matrices for selected multi electron systems.

Submodule assessment	Written or oral examination.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the submodule.
Responsible person	Prof. Dr. C. Ochsenfeld, Prof. Dr. B. Fingerhut
Language	German
Additional information	<p>The allocated exercises in theoretical Chemistry can only be awarded in Module P12 (s. P 12.0.45).</p> <p>Literature:</p> <ul style="list-style-type: none">• Szabo, N. S. Ostlund, Modern Quantum Chemistry (Introduction to Advanced Electronic Structure Theory), Dover Publications Inc. (1996). ISBN 0-486-69186-1• F. Jensen, Introduction to Computational Chemistry, WILEY-VCH, Weinheim.• Ira N. Levine, Quantum Chemistry, Pearson US Imports & PHIPE (1991/2000). ISBN 0136855121

Module WP 4: Biochemistry 2

Degree programme

Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (optional courses)	Rotation	Contact hours	Self-directed studies	ECTS
Seminar	WP 4.1 Seminar for Biochemistry laboratory course 2	WiSe	15 h (1 SWS)	30 h	(1,5)
Lab course	WP 4.2 Biochemistry laboratory course 2	WiSe	150 h (10 SWS)	75 h	(7,5)
Lecture	WP 4.3.1 Biochemistry 4	WiSe	45 h (3 SWS)	105 h	(5)
* Exercise	WP 4.3.2 Exercises in Biochemistry 4	WiSe	15 h (1 SWS)	15 h	(1)
Lecture	WP 4.3.3 Molecular Genetics	SoSe	30 h (2 SWS)	60 h	(3)
Seminar	WP 4.3.4 Literature and Methods Seminar in Biochemistry	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)

* This and above mentioned courses have to be elected together.

This module is comprised of 15 ECTS-points. 6 ECTS should be achieved from optional courses. Class attendance is 15 contact hours per week. Total time, including self-directed studies, is about 450 hrs.

Type of the module	Optional module with optional and compulsory courses.
Applicability to other degree programs	Master program in Chemistry as minor subject.
Elective guidelines	Two optional modules of WP 1 – WP 5 should be elected. For this module two of the courses WP 4.3.1- 4.3.4 must be elected.
Entry requirements	Entry requirements for WP 4.2: successful participation at the Biochemical laboratory course 1 (P 8.3).
Study pathway level	Recommended semester: 5 and 6
Duration	The modul spans 2 semesters.
Content	The courses provide advanced theoretical knowledge in biochemistry (in particular cell biochemistry, membrane biology and cell communication). In addition, advanced, current working methods in biochemistry (protein purification, protein folding, in vivo systems) are explored in a lecture, a practical course and a seminar.

Qualification goals

After participating in the module courses, students are able to reproduce the advanced, subject-specific knowledge they have acquired about the cellular context of biochemical reactions. By developing their self-study skills, students will be able to apply their knowledge to analogous problems. In the accompanying seminar, the transfer of the acquired knowledge to analog experimental problems and the ability to give presentations are trained.

Module assessment

Written or oral examinations, scientific protocol and lab course assessment.

Grading

The module is graded.

Requirements for granting ECTS-Points

ECTS credits will be granted when the examination of potential elective compulsory module parts have been completed successfully.

Responsible person

Prof. Stingle, Prof. Dr. K. Förstemann, Prof. Beckmann

Language

German

Additional information

WP 4.1: Seminar/ Methods in Biochemistry 2 (T1EQ-BM)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	Master program in Chemistry as minor subject.
Elective guidelines	s. WP 4
Entry requirements	none
Study pathway level	Recommended semester: 5
Duration	The course spans 1 semester.
Content	Students are introduced to advanced methods for the expression and characterization of proteins and their interactions with each other or with nucleic acids (database research, analysis of protein-protein interactions, spectroscopic methods, quantitative nucleic acid analysis, microscopy, mass spectroscopy) in preparation for the Biochemistry Practical Course 2 (T1ER). The presented working techniques are explained in terms of their applicability and their advantages and disadvantages using selected examples in order to deepen the understanding and assessment of the applicability or combination of methods.
Qualification goals	Students acquire subject-specific knowledge (working and analysis techniques in biochemistry) and can explain how the methods work. They can implement tasks from biochemical laboratory practice in experimental sequences based on the lecture content. In particular, students are now able to record and evaluate the experiments appropriately (qualitatively and quantitatively).
Submodule assessment	Written exam and scientific protocol.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the the lab course, which is allocated to the module.
Responsible person	Prof. Stingele
Language	German
Additional information	

WP 4.2: Biochemistry Laboratory Course 2 (T1ER)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	Master program in Chemistry as minor subject.
Elective guidelines	s. WP 4
Entry requirements	Successful participation at the Biochemical laboratory course 1 (P 8.3).
Study pathway level	Recommended semester: 5
Duration	The course spans 1 semester.
Content	In the laboratory, advanced techniques for the analysis (extraction, protein stability, interactions, quantification, detection, reporter gene analysis) and preparative representation (chromatography, affinity purification) of biomolecules are carried out. Emphasis is placed on participants working as independently as possible and on detailed documentation and interpretation of the results.
Qualification goals	The students are able to carry out the experiments presented and can evaluate the results obtained qualitatively and quantitatively. They are able to develop, prepare and implement multi-stage experimental strategies for biochemical experiments. They can also transfer these findings to published experimental results and critically question them. Furthermore, the participants acquire the competence to estimate the duration of experiments and thus independently plan the experimental daily schedule of several parallel experiments.
Submodule assessment	Written exam and scientific protocol.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the lab course.
Responsible person	Dr. Beatrix und docents of Biochemistry
Language	German
Additional information	

WP 4.3.1: Biochemistry 4 (T1EO)

Type of the submodule	Optional course.
Applicability of the submodule to other degree programs	Master program in Chemistry as minor subject.
Elective guidelines	s. WP 4
Entry requirements	none
Study pathway level	Recommended semester: 5
Duration	The course spans 1 semester.
Content	This lecture covers various current aspects of cell biology and biochemistry. It begins with an introduction to cell contacts, cell-substrate interactions and basic signal transduction pathways. It then covers the following topics: cell death, cytoskeleton structure and function, the cell cycle, intracellular compartments and transport, the role of mitochondria in energy metabolism, carcinogenesis, the innate and adaptive immune system in the context of pathogenicity and infection, and stem cells and tissue renewal.
Qualification goals	After attending the module course, students are able to reflect and explain the basic facts, concepts and models of cellular biochemistry. They will be able to identify and categorize the important factors and processes within the cell. Furthermore, students will be able to describe and classify the complex interplay of these cellular processes and the interaction between cells. After attending the course, they will be able to scrutinize corresponding experimental data and results in cellular biochemistry with regard to possible sources of error and interpret them in the context of the theoretical principles they have learned.
Submodule assessment	A written examination
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the submodule.
Responsible person	Prof. Dr. Veit Hornung
Language	German
Additional information	

WP 4.3.2: Exercises in Biochemistry 4 (T1EP)

Type of the submodule	Optional course.
Applicability of the submodule to other degree programs	Master program in Chemistry as minor subject.
Elective guidelines	s. WP 4
Entry requirements	none
Study pathway level	Recommended semester: 5
Duration	The course spans 1 semester.
Content	The topics presented correspond to those covered in the biochemistry 4 lecture.
Qualification goals	In this exercise, the subject-specific knowledge acquired in the lecture is to be reproduced by answering questions and transferred to analogous situations. The exercise enables a self-assessment of the level of knowledge and thus also serves to further practice the deepening of the learning content through independent work with textbooks.
Submodule assessment	s. WP 4.3.1
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the submodule.
Responsible person	Prof. Dr. Veit Hornung
Language	German
Additional information	

WP 4.3.3: Molecular Genetics (T1FG)

Type of the submodule	Optional course.
Applicability of the submodule to other degree programs	Master program in Chemistry as minor subject.
Elective guidelines	s. WP 4
Entry requirements	none
Study pathway level	Recommended semester: 6
Duration	The course spans 1 semester.
Content	In this lecture we cover current topics in biochemistry with particular emphasis on those biological phenomena that gave rise to current and highly specific experimental techniques. This includes targeted genetic manipulations both in vitro and in vivo, artificial gene regulation, modulation of chromatin structure etc.
Qualification goals	The students describe the presented experiments and the laboratory techniques that may have been derived from these. They are able to transfer these methods to analogous situations. They use this knowledge to plan corresponding experiments in a simple form and can thus elaborate a basis for their own experiments. They critically evaluate the use of modern molecular biological methods, considering ethical and societal aspects.
Submodule assessment	Written or oral examination.
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the submodule.
Responsible person	Prof. Dr. K. Förstemann
Language	German
Additional information	

WP 4.3.4: Literature and Methods Seminar in Biochemistry (T1FM)

Type of the submodule	Optional course.
Applicability of the submodule to other degree programs	-
Elective guidelines	s. WP 4
Entry requirements	none
Study pathway level	Recommended semester: 5 or 6
Duration	The course spans 1 semester.
Content	The seminar deals with original literature from various biochemical research areas. The articles are selected in such a way that students get to know a wide range of biochemical, molecular, and structural biological questions and methods.
Qualification goals	Students present the contents of biochemical original literature. They can summarize, evaluate, and discuss short and easy-to-understand articles. In addition, they design a written elaboration ('handout' including follow-up), which also summarizes the joint discussion during the seminar and documents the research of related original and review articles. The students recognize the essence of a research paper and also learn the critical evaluation of experimental data as well as an assessment of the significance of a publication in the research field.
Submodule assessment	Presentation and discussion (20-30 min).
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the submodule.
Responsible person	Prof. Beckmann
Language	German
Additional information	

Module WP 5: Biology

Degree programme

Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (optional courses)	Rotation	Contact hours	Self-directed studies	ECTS
Lecture	WP 5.0.1 Molecular- and Cell Biology	WiSe	60 h (4 SWS)	120 h	(6)
Exercise	WP 5.0.2 Methods of Molecular- and Cell Biology	SoSe	90 h (6 SWS)	90 h	(6)
Seminar	WP 5.0.14 Literature and Methods Seminar in Biochemistry	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)

This module is comprised of 15 ECTS-points. 15 ECTS should be elected from optional courses. Class attendance is 15 contact hours per week. Total time, including self-directed studies, is about 450 hrs.

Type of the module	Optional module with optional and compulsory courses.
Applicability to other degree programs	Bachelor program in Biology.
Elective guidelines	Two optional modules of WP 1 – WP 5 should be elected.
Entry requirements	none
Study pathway level	Recommended semester: 5 and 6
Duration	The modul spans 2 semesters.
Content	Students are provided with basic knowledge and practical experience in molecular and cell biology.
Qualification goals	Students can reproduce the presented topics and address analogous questions in molecular and cell biology. Their in-depth understanding enables them to discuss details on both, the experimental side and the interpretation of the obtained results.
Module assessment	Written or oral examinations, scientific protocol and lab course assessment.
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS credits will be granted when the examination of potential elective compulsory module parts have been completed successfully.
Responsible person	Prof. Parniske

Language

German

Additional information

WP 5.0.1 Molecular and Cell Biology

Degree programme Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact hours	Self-directed studies	ECTS
Lecture	Molecular Biology	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	Cell Biology	WiSe	30 h (2 SWS)	60 h	(3)

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

Type of the submodule	Optional submodule with compulsory courses.
Applicability of the submodule to other degree programs	Can be used for the Bachelor's degree courses in Biology and for the teaching degree courses at grammar schools, secondary schools, secondary modern schools or elementary school with Biology as a teaching subject.
Elective guidelines	s. WP 5
Entry requirements	none
Study pathway level	Recommended semester: 5
Duration	The course spans 1 semester.
Content	<p>The Molecular and Cell Biology module builds on the level of of the university entrance qualification. The students acquire basic knowledge of cell biology and in molecular and classical genetics.</p> <p>The lecture Molecular Biology introduces the basic aspects of aspects of genetics. These are in particular the basics of classical genetics, the structure of nucleic acids, replication, DNA damage, DNA repair, mutation, recombination, the central dogma of molecular biology, transcription, the genetic code, translation, regulation of gene expression, as well as recombinant DNA technology and DNA cloning. This content is taught by way of example and comparison for the two systems Escherichia coli and humans.</p> <p>The cell biology lecture teaches the fundamentals of biological systems at the cellular level. The cell is defined as the basic unit of life. The following central topics are covered:</p> <ul style="list-style-type: none"> • Structure, composition and differences between prokaryotic and eukaryotic cells • Structure and function of cell organelles

- Extracellular structures
- Development of organelles and endosymbiotic theory

Qualification goals	Students will be able to recognize the basic structures, components and processes in cell and molecular biology describe them using the relevant technical terms and apply them to subject-specific questions. They are able to transfer this knowledge to other organisms and current to other organisms and current issues.
Submodule assessment	Written examination
Grading	The course 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. Parniske
Language	German
Additional information	The module consists of the lectures Molecular Biology and Cell Biology, each with 2 SWS in the winter semester and a final exam on both lectures.

WP 5.0.2 Methods of Molecular and Cell Biology**Degree programme**Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)**Assigned courses**

Course Type	Course Title (compulsory)	Rotation	Contact hours	Self-directed studies	ECTS
Exercise	Exercise Methods of Molecular Biology	SoSe	30 h (2 SWS)	30 h	(2)
Tutorial	Tutorial for the exercise Methods of Molecular Biology	WiSe	15 h (1 SWS)	15 h	(1)
Exercise	Exercise Methods of Cell Biology	WiSe	30 h (2 SWS)	30 h	(2)
Lecture	Lecture Methods of Cell Biology	SoSe	15 (1 SWS)	15	(1)

This module is comprised of 6 ECTS-points. Class attendance is 6 contact hours per week. Total time, including self-directed studies, is about 160 hrs.

Type of the submodule	Optional module with compulsory courses.
Applicability of the submodule to other degree programs	Can be used for the Bachelor's degree courses in Biology and for the teaching degree courses at grammar schools, secondary schools, secondary modern schools or elementary school with Biology as a teaching subject.
Elective guidelines	s. WP 5
Entry requirements	none
Study pathway level	Recommended semester: 5
Duration	The course spans 1 semester.
Content	<p>The module Methods of Molecular and Cell Biology builds on the module Molecular and Cell Biology. Students deepen the content of the previous module using laboratory experiments and also acquire basic practical knowledge of molecular and cell biology laboratory work.</p> <p>In the Methods of Cell Biology exercise, students carry out experiments in which they learn basic laboratory techniques. These include pipetting with microliter pipettes, weighing, diluting, mixing, measurements on photometers, extraction of biological macromolecules (DNA, proteins) from cells, concentration determinations, as well as the documentation of experiments and the statistical evaluation and assessment of experimental results. In addition, the students receive a briefing on safe working and rules of conduct in the laboratory.</p>

In the exercise Methods of Molecular Biology, students carry out experiments on the topics of mutations, DNA repair, recombination, genotyping and gene technology. They learn basic techniques in dealing with microorganisms, as well as gene cloning, transformation, DNA isolation, polymerase chain reaction, agarose gel electrophoresis and sequence analysis.

In the lecture Methods of Cell Biology, the theory of the methods learned is discussed.

In the tutorial for the exercise Methods of Molecular Biology, the technical contents of the modules Molecular and Cell Biology and Methods of Molecular and Cell Biology are repeated, linked and discussed in small groups.

Qualification goals

Students will be able to recognize the basic structures, components and processes in cell and molecular biology describe them using the relevant technical terms and apply them to subject-specific questions. They are able to transfer this knowledge to other organisms and other current issues.

Students are able to operate common laboratory equipment independently and are able to carry out basic molecular biology methods and name the most common errors. On the basis of a detailed protocol, they can set up and document genetic and molecular genetic experiments and explain the individual steps and their significance.

They can apply methods to evaluate larger and sometimes heterogeneous data sets, evaluate and weigh up individual data, graphically represent experimental data and view it statistically. Students are able to formulate hypotheses (expectations) regarding the results of experiments and to discuss and evaluate the results obtained in relation to these expectations. The acquired knowledge is deepened, discussed and can be transferred to current issues. By applying various molecular biology methods, students acquire a deeper understanding of processes and technical possibilities. This enables them to objectively assess socially relevant issues relating to genetic engineering and genome research.

Submodule assessment

Protocol or written examination.

Grading

The course is graded.

Requirements for granting ECTS-Points

ECTS points are awarded for passing the module examination assigned to the module examination assigned to the module (or the assigned compulsory and, if applicable, compulsory elective examination parts)

Responsible person

Prof. Parniske

Language

German

Additional information

The module part consists of the exercises and tutorials in molecular biology and cell biology, each with 3 SWS in the summer semester.

WP 5.0.14: Literature and Methods Seminar in Biochemistry (T1FM)

Type of the submodule	Optional course.
Applicability of the submodule to other degree programs	-
Elective guidelines	s. WP 5
Entry requirements	none
Study pathway level	Recommended semester: 5 or 6
Duration	The course spans 1 semester.
Content	The seminar deals with original literature from various biochemical research areas. The articles are selected in such a way that students get to know a wide range of biochemical, molecular, and structural biological questions and methods.
Qualification goals	Students present the contents of biochemical original literature. They can summarize, evaluate, and discuss short and easy-to-understand articles. In addition, they design a written elaboration ('handout' including follow-up), which also summarizes the joint discussion during the seminar and documents the research of related original and review articles. The students recognize the essence of a research paper and also learn the critical evaluation of experimental data as well as an assessment of the significance of a publication in the research field.
Submodule assessment	Presentation and discussion (20-30 min).
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exam, which is allocated to the submodule.
Responsible person	Prof. Beckmann
Language	German
Additional information	

Module P 12: Specific Supplements

Degree programme

Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (optional courses)	Rotation	Contact hours	Self-directed studies	ECTS
Lecture	P 12.0.1 (=WP 1.3.1) Inorganic Chemistry 4 (Molecular Chemistry) (T1EA)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.2 (=WP 1.3.2) Inorganic Chemistry 5 (Solid State Chemistry) (T1EB)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.3 (=WP 2.1.1) Organic Chemistry 3 (Bioorganic Chemistry) (T1EG)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.4 (=WP 3.3.1) Physical Chemistry 3 (Statistical Thermodynamics) (T1EI)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.5 (=WP 3.3.2) Physical Chemistry 4 (Biophysical Chemistry) (T1EJ)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.6 (=WP 4.3.1) Biochemistry 4 (T1EO)	WiSe	45 h (3 SWS)	105 h	(5)
* Exercise	P 12.0.7 (=WP 3.3.2) Exercises on the lecture Biochemistry 4 (T1EP)	WiSe	15 h (1 SWS)	15 h	(1)
Lecture	P 12.0.9 Structural Analysis (T1EC)	WiSe	60 h (4 SWS)	75 h	(4,5)
* Exercise	P 12.0.10 Exercises on the lecture Structural Analyses (T1ED)	WiSe	15 h (1 SWS)	30 h	(1,5)
Lecture	P 12.0.12 Quantum Chemistry 1 / Theoretical Chemistry 3 (T1EM)	WiSe	30 h (2 SWS)	90 h	(4)
* Exercise	P 12.0.13 Exercises on the lecture Quantum Chemistry 1 / Theoretical Chemistry 3 (T1EN)	WiSe	30 h (2 SWS)	30 h	(2)
Lecture	P 12.0.14 Subject-specific General Education (T1EV)	WiSe/ SoSe	45 h (3 SWS)	75 h	(4)
* Exercise	P 12.0.15 Exercises on Subject-specific General Education (T1EW)	WiSe/ SoSe	30 h (2 SWS)	30 h	(2)
Lecture	P 12.0.16 (=WP 5.0.1) Molecular- and cell biology	WiSe	60 h (4 SWS)	120 h	(6)
Lecture	P 12.0.18 Pharmaceutic- Medicinal Chemistry 1	WiSe	30 h (2 SWS)	60 h	(3)

Lecture	P 12.0.19 Pharmaceutical Biology 1	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.20 Pharmacology and Toxicology	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.21 Quantum Mechanics (T2p)	WiSe	45 h (3 SWS)	75 h	(4)
* Exercise	P 12.0.22 Exercise on the lecture Quantum Mechanics (T2p)	WiSe	15 h (1 SWS)	45 h	(2)
Lecture	P 12.0.23 Lecture on Astronomy, Astrophysics, Cosmology (W1.A1)	WiSe	45 h (3 SWS)	75 h	(4)
* Exercise	P 12.0.24 Exercise on the lecture of Astronomy, Astrophysics, Cosmology (W1.A2)	WiSe	15 h (1 SWS)	45 h	(2)
Lecture	P 12.0.27 Lecture on Solid State Physics and Nanophysics (W1.F1)	WiSe	45 h (3 SWS)	75 h	(4)
* Exercise	P 12.0.28 Exercise on the lecture to Solid State Physics and Nanophysics (W1.F2)	WiSe	15 h (1 SWS)	45 h	(2)
Lecture	P 12.0.29 Introduction to Computer Sciences	WiSe	60h (4 SWS)	120 h	(6)
* Exercise	P 12.0.30 Tutorial in Introduction to Computer Sciences	WiSe	30 h (2 SWS)	60 h	(2)
Lecture	P 12.0.31 Introduction to Meteorology 2 (Met2.1)	WiSe	45 h (3 SWS)	75 h	(4)
* Exercise	P 12.0.32 Exercise to the Lecture Introduction to Meteorology 2 (Met2.2)	WiSe	15 h (1 SWS)	45 h	(2)
Seminar	P 12.0.33 Seminar Business planing	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.34 (=WP 1.3.3) Inorganic Chemistry 6 (Bioinorganic Chemistry) (T1FA)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.35 (=WP 2.1.2) Organic Chemistry 4 (Organometallic Chemistry) (T1FB)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.36 (=WP 2.1.3) Organic Chemistry 5 (Theoretical Concepts in Organic Chemistry) (T1FC)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.37 (=WP 3.3.3) Physical Chemistry 5 (Modern Developments in Physical Chemistry) (T1EF)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.38 (=WP 4.3.3) Molecular Genetics	SoSe	30 h (2 SWS)	60 h	(3)
Seminar	P 12.0.40 (=WP 5.0.14)	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)

	Literature and Methods Seminar in Biochemistry (T1FM)				
Lecture	P 12.0.44 Quantum Chemistry 2 / Theoretical Chemistry 4 (T1FI)	SoSe	30 h (2 SWS)	90 h	(4)
* Exercise	P 12.0.45 Exercises on the lecture Quantum Chemistry 2 / Theoretical Chemistry 4 (T1FJ)	SoSe	30 h (2 SWS)	30 h	(2)
Lecture	P 12.0.48 Pharmaceutic-Medicinal Chemistry 2	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.49 Pharmaceutical Biology 2	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.50 Introduction to Metereology I (Met1.1)	SoSe	45 h (3 SWS)	75 h	(4)
Lecture	P 12.0.51 Exercise on the lecture Introduction to Metereology I (Met1.2)	SoSe	15 h (1 SWS)	45 h	(2)
* Exercise	P 12.0.52 Atom and Molecular Physics	SoSe	45 h (3 SWS)	75 h	(4)
Lecture	P 12.0.53 Exercises on the lecture Atom and Molecular Physics	SoSe	15 h (1 SWS)	45 h	(2)

*This and above mentioned courses have to be elected together.

This module is comprised of 15 ECTS-points. 15 ECTS should be elected from optional courses. Class attendance is 9.5-12 contact hours per week. Total time, including self-directed studies, is about 450 hrs.

Type of the module	Required module with optional courses.
Applicability to other degree programs	-
Elective guidelines	15 ECTS in total should be elected from the optional courses P 12.0.1 to P 12.0.53.
Entry requirements	none
Study pathway level	Recommended semester: 5 and 6
Duration	The modul spans 2 semesters
Content	This module extends knowledge in Chemistry and also in related fields by selecting up to five lectures. Details in P 12.0.1-12.0.53
Qualification goals	In the lectures, students are introduced to new topics in chemistry or areas related to chemistry. After attending the module courses, students are able to expand their previously acquired knowledge with current and specialized technical information.

The information can be integrated into existing knowledge in order to formulate and discuss scientific questions.

For details see P 12.0.1-12.0.53

Module assessment	Written and oral examinations, presentations.
Grading	The module is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the exams, which are allocated to the module.
Responsible person	Dean of studies
Language	German
Additional information	

P 12.0.9 and P 12.0.10: Lecture and Exercise in Structural Analysis**Degree programme**Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)**Assigned courses**

Course Type	Course Title (compulsory)	Rotation	Contact hours	Self-directed studies	ECTS
Lecture	P 12.0.9 Structural Analysis (T1EC)	WiSe	60 h (4 SWS)	75 h	(4,5)
Exercise	P 12.0.10 Exercise on the lecture Structural Analysis (T1ED)	WiSe	15 h (1 SWS)	30 h	(1,5)

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

Type of the submodule

Optional submodule with compulsory courses.

Applicability of the submodule to other degree programs

-

Elective guidelines

none

Entry requirements

none

Study pathway level

Recommended semester: 5

Duration

The course spans 1 semester

Content

Contents are fundamentals of symmetry, especially the one of 3D space groups, basics of crystallography, single crystal structural analysis and powder diffractometry, as well as X-ray spectroscopic methods and the basics of NMR spectroscopy of crystalline solids. Exercises on the individual topics deepen the understanding and serve as preparation for the exams.

Qualification goals

Following the lecture „spectroscopic methods I“ the students remember the basics of symmetry. They realise the need of an explanation for the basis on which all the crystal structure diagrams they have knowledge of from preliminary lectures come from. Furthermore, they understand that they have exploited the analytical method of powder X-ray diffractometry during the AC2 lab course without understanding the necessary theoretical background.

On the basis of the three-dimensional space group symmetry, the students understand the method of describing periodic crystal structures. The mathematical background for geometric and kinematic diffraction theory leads to an understanding of the technique of single crystal structure analysis on the basis of diffraction data. The practical aspects thereof are presented

on exemplary showcases. Also powder diffraction techniques are explained and exercised on practical examples.

Modern X-ray spectroscopical methods are explained on a theoretical level, and the students develop the understanding of their individual fields of application in analytical chemistry of solids.

From earlier lectures and lab courses, the students remember the basics of NMR spectroscopy on liquids and solutions. They understand the implications of these basics on the special case of crystalline solid samples in NMR spectroscopy. On the basis of appropriately chosen examples, the students develop the capability of deriving structural details from solid state NMR spectroscopic data.

Submodule assessment	Two written or two oral examinations.
Grading	The course 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. Constantin Hoch, Prof. Dr. Dirk Johrendt, Dr. Thomas Bräuniger
Language	German
Additional information	

P 12.0.12 and P 12.0.13: Lecture and Exercise in Quantum Chemistry 1 / Theoretical Chemistry 3

Degree programme

Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact hours	Self-directed studies	ECTS
Vorlesung	P 12.0.12 Quantum Chemistry 1 / Theoretical Chemistry 3 (T1EM)	WiSe	30 h (2 SWS)	75 h	(4)
Übung	P 12.0.13 Exercise on the lecture Quantum Chemistry 1 / Theoretical Chemistry 3 (T1EN)	WiSe	30 h (2 SWS)	45 h	(2)

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

Type of the submodule	Optional submodule with compulsory courses.
Applicability of the submodule to other degree programs	Master programs in Chemistry and Biochemistry, as minor subject
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 5
Duration	The course spans 1 semester.
Content	<p>The lecture provides an overview of quantum-chemical methods for calculating molecular systems: Hartree-Fock (HF); density-functional theory (DFT); electron correlation and configuration interaction (CI); second quantization formalism; coupled cluster (CC).</p> <p>Exercise: The students practise the contents of the lecture based on selected examples. They formulate expectation values in the basis of atomic and molecular orbitals for the different HF and post HF methods.</p>
Qualification goals	<p>Basic understanding of quantum chemical methods and their importance for calculations in chemistry. The students are able to identify, classify and discuss the advantages and disadvantages of the various methods. They acquire criteria how to judge which method is appropriate for which application.</p> <p>Exercise: The students practise the contents of the lecture based on example problems. They know how to handle the relevant equations mathematically. They are able to formulate</p>

expectation values in the basis of atomic and molecular orbitals for HF- and post-HF-methods and to apply the fundamental concept of basis functions.

Submodule assessment	Written or oral examination.
Grading	The course 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. C. Ochsenfeld
Language	German
Additional information	Literature: <ul style="list-style-type: none">• Szabo, N. S. Ostlund, Modern Quantum Chemistry (Introduction to Advanced Electronic Structure Theory), Dover Publications• F. Jensen; Introduction to Computational Chemistry; Wiley-VCH• Ira N. Levine; Quantum Chemistry; Pearson International Edition

P 12.0.14 and P 12.0.15: Lecture and Exercise in Subject-specific General Education

Degree programme

Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact hours	Self-directed studies	ECTS
Vorlesung	P 12.0.14 Subject-specific General Education (T1EV)	WiSe/ SoSe	30 h (2 SWS)	75 h	(4)
Übung	P 12.0.15 Exercise on the lecture Subject-specific General Education (T1EW)	WiSe/ SoSe	30 h (2 SWS)	45 h	(2)

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

Type of the sub- module	Optional module with compulsory courses.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 5 and 6
Duration	The course spans 1 semester.
Content	Course content includes advanced theoretical and, in some cases, practical knowledge from general courses, which can be based on chemistry and biochemistry. The aim is to acquire a broader general education with subject-specific content.
Qualification goals	After participating in the module courses, students are able to reproduce, present and apply what they have learned in the course.
Submodule assessment	Written or oral examination or a scientific protocol.
Grading	The course is not 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
Additional information	

P 12.0.20: Pharmacology and Toxicology

Type of the submodule	Optional course.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 5
Duration	The course spans 1 semester.
Content	<p>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.</p> <p>The students will learn the basics of pharmacology and toxicology, e.g.:</p> <ul style="list-style-type: none"> • 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.
Submodule assessment	A written exam.
Grading	The course 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. I. Boekhoff and other employees of the Walther-Straub-Institute for Pharmacology and Toxicology
Language	English
Additional information	

P 12.0.21 and P 12.0.22: Lecture and Exercise in Quantum Mechanics

Degree programme Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact hours	Self-directed studies	ECTS
Lecture	P 12.0.21 Quantum mechanics (T2p.1)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	P 12.0.22 Exercise on the lecture Quantum mechanics (T2p.2)	WiSe	15 h (1 SWS)	45 h	(2)

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

Type of the submodule	Optional submodule with compulsory courses.
Applicability of the submodule to other degree programs	Bachelor program in Physics
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 5
Duration	The course spans 1 semester.
Content	Introduction to the concepts and theoretical methods of quantum mechanics: Physical foundations of quantum mechanics, mathematical representations of quantum mechanics, Schrödinger picture, applications to simple quantum systems.
Qualification goals	<p>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.</p> <p>In addition, knowledge of methods of theoretical physics and the ability to form 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.</p>
Submodule assessment	Written examination.
Grading	The course 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

P 12.0.23 and P 12.0.24: Lecture and Exercise in Astronomy, Astrophysics, Cosmology

Degree programme

Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact hours	Self-directed studies	ECTS
Lecture	P 12.0.23 Astronomy, Astrophysics, Cosmology (W1.A1)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	P 12.0.24 Exercise on the lecture Astronomy, Astrophysics, Cosmology (W1.A2)	WiSe	15 h (1 SWS)	45 h	(2)

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

Type of the submodule	Optional submodule with compulsory courses.
Applicability of the submodule to other degree programs	Bachelor program in Physics
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 5
Duration	The course spans 1 semester.
Content	The courses are introducing to the area "astronomy and astrophysics, cosmology" at the faculty of physics at LMU.
Qualification goals	The students have command of the contents of the lecture course and are able to transfer the knowledge to current problems.
Submodule assessment	Written examination.
Grading	The course 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. H. Lesch
Language	German
Additional information	

P 12.0.27 and P 12.0.28: Lecture and Exercise in Solid State Physics and Nanophysics

Degree programme

Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact hours	Self-directed studies	ECTS
Lecture	P 12.0.27 Solid State Physics and Nanophysics (W1.F1)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	P 12.0.28 Exercise on the lecture Solid State Physics and Nanophysics (W1.F2)	WiSe	15 h (1 SWS)	45 h	(2)

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

Type of the submodule	Optional submodule with compulsory courses.
Applicability of the submodule to other degree programs	Bachelor program in Physics
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 5
Duration	The course 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.
Submodule assessment	Written examination.
Grading	The course 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 inPhysics

Language German

Additional information

P 12.0.29 and P 12.0.30: Introduction to Computer Science: Programming and Software Development (minor subject)

Degree programme

Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact hours	Self-directed studies	ECTS
Lecture	P 12.0.29 Lecture Introduction to Computer Science	WiSe	45h (3 SWS)	45 h	3
Exercise	P 12.0.30 Tutorial in Introduction to Computer Science	WiSe	30 h (2 SWS)	60 h	3

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

Type of the submodule

Optional submodule with compulsory courses.

Applicability of the submodule to other degree programs

- Master program in Chemistry as minor subject
- Subsidiary bachelor programs in Informatics

Elective guidelines

none

Entry requirements

none

Study pathway level

Recommended semester: 5

Duration

The course spans 1 semester.

Content

This module provides an introduction to the basic terms and concepts of computer science. Techniques for the representation, structuring and processing of data and for the development of algorithms are covered. This module also provides an introduction to object-oriented programming, with which the concepts learned are put into practice. Emphasis is placed on conceptual clarity and a precise mathematical foundation.

The following are taught in detail:

- Basic concepts of programs and their execution,
- Syntax of programming languages and their description,
- Basic data types and composite data structures,
- Design and discussion of algorithms: Searching, sorting,
- Imperative control structures,
- Introduction to object-oriented program design,
- Object-oriented structuring principles: Classes, interfaces, inheritance, modules

- Complexity and correctness of imperative programs.

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

Students will be able to algorithmically implement solutions for smaller and manageable problems and realize them as executable programs using a higher programming language. Furthermore, students develop an understanding of the general principles of programming and programming languages.

Submodule assessment

Written or oral examination.

Grading

The course is graded.

Requirements for granting ECTS-Points

ECTS-points are awarded for passing the exam, which is allocated to the module.

Responsible person

Dirk Beyer

Language

German

Additional information

P 12.0.31 and P 12.0.32: Lecture and Exercise Introduction to Meteorology 2

Degree programme

Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact hours	Self-directed studies	ECTS
Lecture	P 12.0.31 Introduction to Meteorology 2 (Met2.1)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	P 12.0.32 Exercise to Introduction to Meteorology 2 (Met2.2)	WiSe	15 h (1 SWS)	45 h	(2)

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

Type of the submodule

Optional submodule with compulsory courses.

Applicability of the submodule to other degree programs

Bachelor program of Physics

Elective guidelines

none

Entry requirements

none

Study pathway level

Recommended semester: 5

Duration

The course spans 1 semester.

Content

Introduction to meteorological concepts concerning atmosphere and measurement techniques: maintenance of impuls, energy and mass, derivation of fundamental atmospheric equations, geostrophic balance, vorticity equation, shallow water approximation, structure of global circulation, basics of atmospheric radiation transport, trace gases, air chemistry, basics of meteorological measurement strategies, examples of modern measurement techniques.

Qualification goals

Substantial learning targets are the knowledge and the comprehension of the above mentioned issues as well as the ability to use and to combine them.

Moreover, the knowledge of methods and the ability to interpret observations and experimental results, to model and deduct results from models are general learning targets.

The students should become aware of the association to phenomena in nature as well as to current research.

Submodule assessment

Two written examinations

Grading

The course 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

P 12.0.33: Business Planing: Starting Up - From Ideas to Successful Business (T1ZF)

Type of the submodule	Optional course.
Applicability of the submodule to other degree programs	-
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 5 or 6
Duration	The course spans 1 semester.
Content	<p>In the seminar "Business Planning," students systematically learn to think and act entrepreneurially. The seminar provides foundational business knowledge (e.g., market and competitor analysis, marketing, financial planning) in the context of a real or fictional startup idea, with the inclusion of students' own ideas being highly encouraged. The seminar consists of six modules on business model development, based on the <i>Business Model Canvas</i> framework (Osterwalder & Pigneur, 2010), which are worked on in interdisciplinary teams. The seminar is taught in a hybrid format, meaning that weekly online content (e.g., videos, slides, quizzes) is made available on Moodle for self-study. Assessment is based on participation in three sessions (kick-off event, midterm, and final presentations of the business plans) as well as group assignments.</p> <p>The seminar is led by lecturers from the LMU Innovation & Entrepreneurship Center, supported by experienced guest speakers from entrepreneurial practice.</p>
Qualification goals	<p>After participating in the seminar, students will be able to apply business methods of business model development to a real or fictional start-up idea. Based on this, students will be enabled to analyze the start-up project and evaluate its market-related and financial feasibility.</p> <p>The goal is to encourage participants to start their own business and to empower them to think and act entrepreneurially.</p>
Submodule assessment	The assessment consists of the written development of a business plan (pitch deck) within an interdisciplinary team, several interim presentations per team, as well as a final presentation of the results.
Grading	The course is not graded.

Requirements for granting ECTS-Points	ECTS-points are awarded for passing the seminar, which is allocated to the module.
Responsible person	Philipp Dahl
Language	German/English
Additional information	Link to the website: https://www.iec.lmu.de/en/our-services/educational-services/starting-up/

P 12.0.44 and P 12.0.45: Lecture and Exercise in Quantum Chemistry 2 / Theoretical Chemistry 4

Degree programme

Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact hours	Self-directed studies	ECTS
Lecture	P 12.0.44 Quantum Chemistry 2 / Theoretical Chemistry 4 (T1FI)	SoSe	30 h (2 SWS)	75 h	(4)
Exercise	P 12.0.45 Exercise to the lecture Quantum Chemistry 2 / Theoretical Chemistry 4 (T1FJ)	SoSe	30 h (2 SWS)	45 h	(2)

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

Type of the submodule	Optional submodule with compulsory courses.
Applicability of the submodule to other degree programs	Master program in Chemistry and Biochemistry as minor subject
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 6
Duration	The course spans 1 semester
Content	<p>Part 1: The lecture provides in-depth insights into quantum chemical calculation methods and the quantum chemical calculation of molecular properties: HF, DFT, CI, CC; basic aspects of computational complexity / scale behavior; energy gradients; higher derivatives of energy; response equations, CPSCF theory; calculation of properties such as IR, Raman, NMR, etc.</p> <p>Part 2: Born-Oppenheimer approximation and electronic Schrödinger equation. Presentation of various search algorithms for the search and optimization of critical points such as minima, transition states and minimum energy paths. Advanced methods to improve the description of electron correlation and to calculate excited electronic states. Configuration change methods and related methods such as complete-active-space SCF are discussed in particular. Discussion of the limits of the Born-Oppenheimer approximation with an introduction to the topic of conical intersections and their significance in photochemistry.</p>

Introduction of the concepts of diabatic and adiabatic potential surfaces and non-adiabatic couplings.

Exercise: The students practise the content of the lecture on example tasks in which the methods for calculating energy gradients, optimizations and reaction paths are to be used. They deal with the basic equations of response theory and the criteria for the scaling behavior of different electron structure methods. You will learn how to formulate the eigenvalue equation for various methods for calculating excited electronic states.

Qualification goals	<p>In-depth understanding of quantum chemical methods and the ab-initio calculation of molecular properties. Application of the matrix formalism and the density matrix formalism to simplify the equations for expectation values. Understanding of quantum chemical questions and methods for the calculation of potential surfaces of electronically excited states as well as search algorithms for the characterization of multidimensional potential surfaces.</p> <p>Exercise: Independent solution of optimization tasks using selected model examples for potential landscapes. Setting up the Coupled Perturbed SCF equations, the basic equations for response theory and analysis of the scale behavior of different methods for calculating the electron structure. Transforming between adiabatic and diabatic representation. Setting up and analyzing CI matrices for selected multi-electron systems</p>
Submodule assessment	Written or oral examination.
Grading	The course 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. C. Ochsenfeld, Prof. Dr. B. Fingerhut
Language	German
Additional information	<p>Literature:</p> <ul style="list-style-type: none"> • Szabo, N. S. Ostlund, Modern Quantum Chemistry (Introduction to Advanced Electronic Structure Theory), Dover Publications Inc. (1996). ISBN 0-486-69186-1 • F. Jensen, Introduction to Computational Chemistry, WILEY-VCH, Weinheim. • Ira N. Levine, Quantum Chemistry, Pearson US Imports & PHIPE (1991/2000). ISBN 0136855121

P 12.0.50 and P 12.0.51: Lecture and Exercise Introduction to Meteorology 1

Degree programme

Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact hours	Self-directed studies	ECTS
Lecture	P 12.0.50 Introduction to Meteorology 1 (Met1.1)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise	P 12.0.51 Exercise to the lecture Introduction to Meteorology 1 (Met1.2)	SoSe	15 h (1 SWS)	45 h	(2)

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

Type of the submodule

Optional submodule with compulsory courses.

Applicability of the submodule to other degree programs

Bachelor program in Physics

Elective guidelines

none

Entry requirements

none

Study pathway level

Recommended semester: 6

Duration

The course spans 1 semester.

Content

Introduction to fundamental principles of meteorology concerning thermodynamics and methods of analysis: structure of atmosphere, climate zones, meteorological dimensions, hydrostatical equilibrium, thermodynamics, humid thermodynamics, thermodynamical diagrams, physics of clouds, forms of precipitation, synoptic analysis, weather maps, structure of synop informations, concept of air masses and fronts, analysis of synoptic situation via actual maps, treatment and interpretation of numerical prognosis maps.

Qualification goals

Substantial learning targets are the knowledge and the comprehension of the above mentioned issues as well as the ability to use and to combine them.

Moreover, the knowledge of methods and the ability to interpret observations and experimental results, to model and deduct results from models are general learning targets.

The students should become aware of the association to phenomena in nature as well as to current research.

Submodule assessment

Two written examinations.

Grading	The course 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	

P 12.0.52 and P 12.0.53: Lecture and Exercise in Atomic and Molecular Physics

Degree programme

Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact hours	Self-directed studies	ECTS
Lecture	P 12.0.52 Atomic and Molecular Physics (E4p.1)	SoSe	45 h (3 SWS)	75 h	(4)
Exercise	P 12.0.53 Exercise to the Lecture Atomic and Molecular Physics (E4p.2)	SoSe	15 h (1 SWS)	45 h	(2)

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

Type of the submodule	Optional submodule with compulsory courses.
Applicability of the submodule to other degree programs	Bachelor program in Physics
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 6
Duration	The course spans 1 semester.
Content	Introduction to the concepts and experimental methods of atomic and molecular physics: hydrogen atom, alkali atoms, atoms in external electric and magnetic fields, X-rays, simple molecules, spectroscopic methods.
Qualification goals	<p>The main learning objectives are knowledge and understanding of the above learning content, the ability to apply it and link it to one another.</p> <p>In addition, knowledge of the methods of experimental physics and the ability to interpret experimental results and to verify or falsify them are general learning objectives. Students should become aware of the connection to phenomena in nature and to current research.</p>
Sub-module assessment	Two written examinations.
Grading	The course 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 P 13: Bachelor's Degree Module

Degree programme Bachelor's degree: Chemistry and Biochemistry
(Bachelor of Science, B.Sc.)

Assigned courses

Course Type	Course Title (compulsory)	Rotation	Contact hours	Self-directed studies	ECTS
	P 13.1 Bachelor thesis	WiSe/ SoSe		360 h	12

This module is comprised of 12 ECTS-points. Total time, including self-directed studies, is about 360 hrs.

Type of the module Compulsory module with required course.

Applicability to other degree programs -

Elective guidelines none

Entry requirements Successful participation in P 1 to P 10

Study pathway level Recommended semester: 6

Duration The modul spans 1 semester

Content The content of the Bachelor's thesis is the independent processing of a specific chemical/biochemical problem, including the preparation of a written scientific research report.

Qualification goals After participating this final module, students are able to comprehensively develop and present a narrowly defined subject area within 10 weeks; project and teamwork skills and other acquired competencies are further developed.
They will be able to carry out scientific experiments correctly and present and discuss their results in a research report in the correct form and content.

Module assessment Bachelor 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

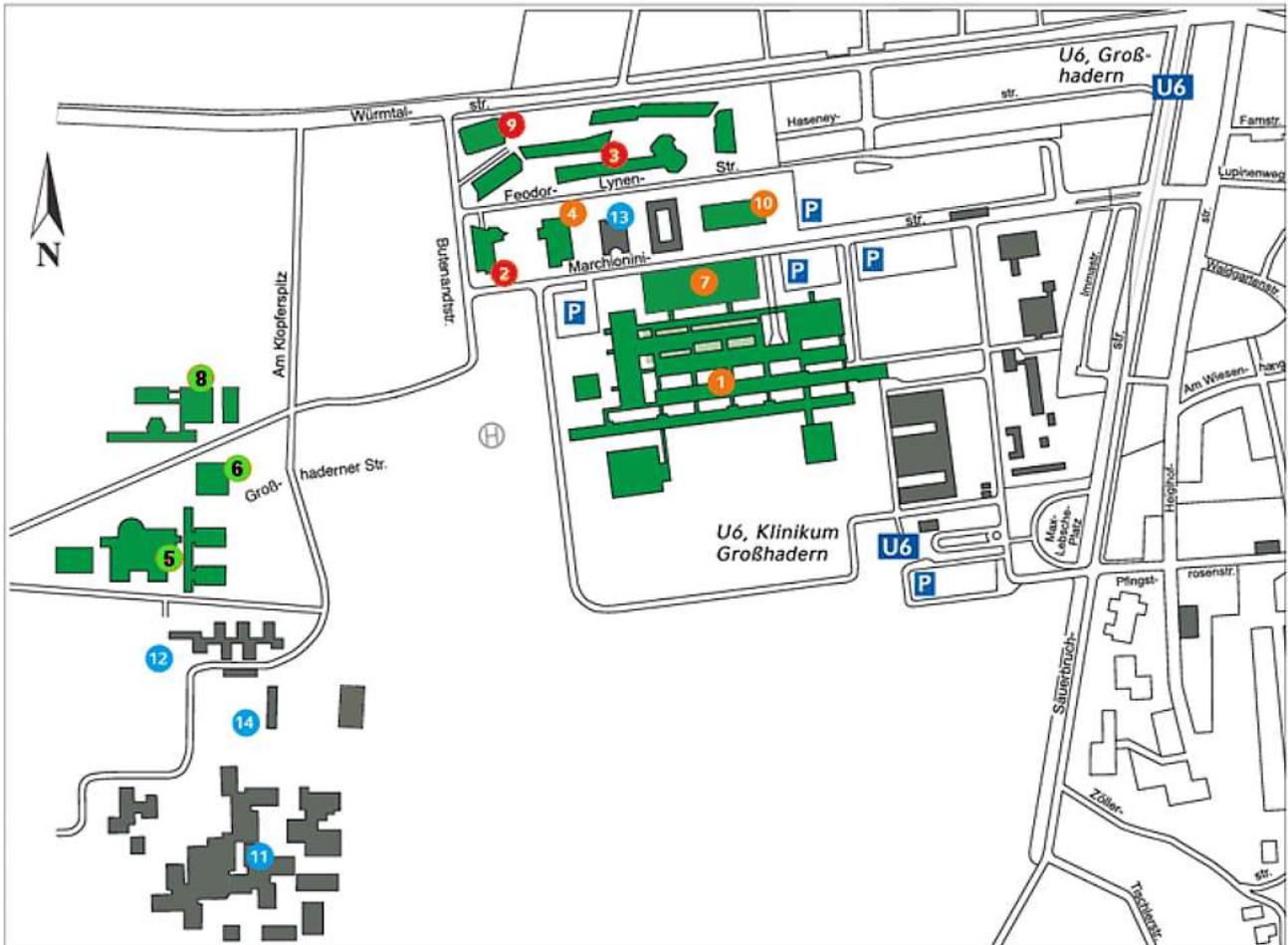
Language German/English

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