LMU 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
SoSe	summer semester
SWS	contact hours per week per 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 http://www.cup.lmu.de/en/study-programs/ and http://www.cup.lmu.de/en/study-information/.

Contacts

Application:
http://www.cup.lmu.de/en/study-programs/bachelor-chemistry-and-biochemistry/application/

Examinations Office:

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

Further Contact Points:

http://www.cup.lmu.de/en/study-information/contact-points/

Introduction Session:

Every semester – usually on the first day (Monday) or some time during the first week of the semester – we offer an introduction to the master's program in chemistry. Detailed information as to the location and time of the event 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 months, always begins in the fall 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**" (60ECTS) where students choose their concentration and prepare their bachelor's thesis. Here, training in inorganic, organic, physical, and theoretical chemistry and biochemistry, or, biology (with genetics, microbiology, physiology or 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 the final two semesters, this phase of the program allows students to choose their concentration 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, immunology, computer science, crystallography, material sciences, neurobiology, patent law, pharmaceutical chemistry, pharmaceutical biology, pharmacology and toxicology, phytochemistry 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.

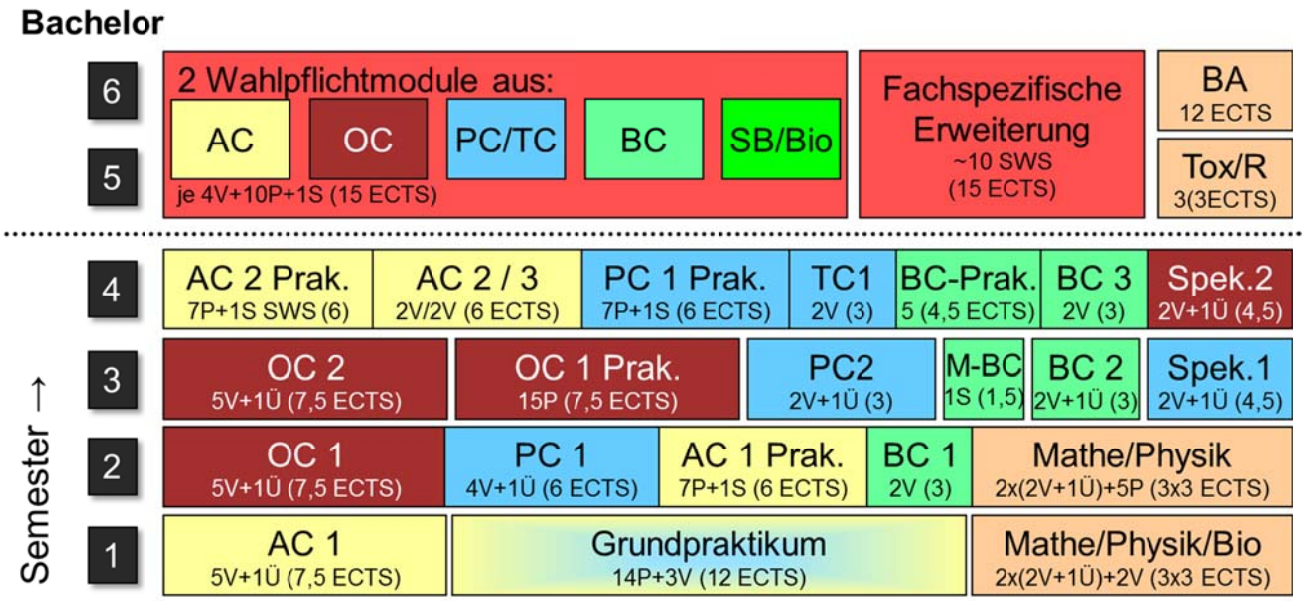


Fig. 2.3.1: The ideal course of study/curriculum for the six-semester bachelor's program in chemistry and biochemistry (AC, OC, PC, TC, BC = inorganic, organic, physical, theoretical and biochemistry; Spek. = spectroscopy; Tox./RE = toxicology and the law, BA= bachelor thesis; V = lecture; S = seminar; Ü = exercise course; P = lab course; the preceding 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	Topics include fundamental aspects of general and inorganic, organic and physical chemistry; the most relevant substances and functional groups, important technical processes, and an introduction into fundamental reaction mechanisms. Details in P 1.1-1.6
Qualification goals	The students should be well versed with the contents of the lecture and should be able to transfer new knowledge onto problems of modern life. The comprehension of the lecture is intensified in the accompanying tutorial. The students are

	encouraged to abstract from the specific example towards a more general principle. 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. Regina de Vivie-Riedle
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	• 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	General principles of inorganic chemistry: Mixtures and separation, chemical reactions and energy turnover, atoms and molecules, hydrogen, atomic shell, noble gases, oxygen, atomic bonding, ozone, metallic bonding, ionic bonding and salts, water, halogens, halogen hydrides, reaction rate and chemical equilibrium, acids and bases, hydrogen peroxide, halogen-oxygen compounds, interhalogen compounds and noble gas compounds, electrochemistry and redox reactions, chalcogens, 5^{th} main group, 4^{th} main group, 3^{rd} main group, 2^{nd} main group, 1^{st} main group.
Qualification goals	The students should be well versed with the contents of the lecture and should be able to transfer new knowledge onto problems of modern life. The comprehension of the lecture is intensified in the accompanying tutorial. The students are encouraged to abstract from the specific example towards a more general principle.
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. Peter Klüfers
Language	German
Additional information	**Recommended literature:** • C. Mortimer,*Das Basiswissen der Chemie*, Thieme, Stuttgart, **2003**. • E. Riedel, *Inorganic Chemistry*, 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	• 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	The learning contents are fundamentals in inorganic and general chemistry consisting of three parts: 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, electrochemitry, solids. Part B: Chemistry of the main group elements Part C: Chemistry of the side group elements
Qualification goals	The educational objective is the task mastery of the contens 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. Andreas Kornath
Language	German

Additional information

Recommended literature:

- C. Mortimer,*Das Basiswissen der Chemie*, 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	• 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 bonding in organic molecules, the most relevant functional groups, important technical processes, fundamental reaction mechanisms, and the foundations of stereochemistry.
Qualification goals	Students have the ability to: a) apply basic models and concepts of chemical bonding in order to predict structural features of organic molecules; b) to recognize the most important functional groups and their associated properties and their reactivity; c) understand the basic concepts of chemical synthesis and the concept of functional group transformations, and can describe these using current chemical notation; d) describe the mechanistic course of typical organic reactions and rationalize their outcome; e) develop a systematic name for organic compounds following the IUPAC rules.
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	Prof. Dr. Dirk Trauner
Language	German
Additional information	**Recommended literature:** • K. P. Vollhardt, *Organische Chemie*, Wiley-VCH, Weinheim, **2005**. • J. Buddrus, *Grundlagen der organischen Chemie*, de

Gruyter, Berlin, **2003**.
- H. Zipse, Grundlagen der organischen Chemie, Shaker Verlag, **2014**.

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	• 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. Dirk Trauner
Language	German
Additional information	**Recommended literature:** • K. P. Vollhardt, *Organische Chemie*, Wiley-VCH, Weinheim, **2005**. • J. Buddrus, *Grundlagen der organischen Chemie*, de Gruyter, Berlin, **2003**. • H. Zipse, Grundlagen der organischen Chemie, Shaker Verlag, **2014**. **Organizational information:** Students register for the tutorial through the faculty website.

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 coursespans 1 semester
Content	The contents of the lecture are phenomenological thermodynamics and the fundamentals of kinetics. The thermodynamics part treats equations of state, ideal and real gases, the laws of thermodynamics, work and heat, internal energy and enthalpy, thermochemistry, calorimetry, heat engines, entropy, free energy and free enthalpy, the chemical potential, phase equilibria in one- and multiple-component systems, phase diagrams, chemical equilibrium and its control by experimental parameters. Also included are the thermodynamic fundamentals of electrochemistry, the electrochemical potential, the Galvani and Nernst potential. The kinetics part treats elementary reactions and rate laws of simple chemical reactions.
Qualification goals	In the thermodynamics part students obtain fundamental insight into the axiomatic structure of a scientific theory. They learn how to use the methods by which the abstract thermodynamic theory can be applied to actual chemical problems. Using the obtained knowledge they are enabled to quantitatively calculate a large number of physical-chemical quantities 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 apply simple differential equations.
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	Prof. Dr. Joost Wintterlin
Language	German
Additional information	**Recommended literature:**

- P. Atkins, *Physical Chemistry*, Wiley-VCH, Weinheim, **2006**.
- G. Wedler, *Lehrbuch der physikalischen Chemie*, Wiley-VCH, Weinheim, **2004**.

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 mentioned in module P 1.5 (lecture Physical Chemistry 1). The exercises intend to enhance the knowledge of the contents of the lecture.
Qualification goals	By solving exercises the students learn to apply the equations developed in the lecture to quantitatively determine macroscopic physical-chemical quantities. This includes, e.g., calculating equilibrium distributions of solutes between several phases, equilibrium partial pressures in gas reactions, and rate constants. The students practice their presentation skills by presenting the solutions to the exercises to their tutorial groups. The general objective is for the students to enhance their insight into phenomenological thermodynamics 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	**Recommended literature:** • P. Atkins, *Physical Chemistry*, Wiley-VCH, Weinheim, **2006**. • G. Wedler, *Lehrbuch der physikalischen Chemie*, Wiley-VCH, Weinheim, **2004**. **Organizational information:** Students register for the tutorials through the faculty website.

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 content of the lecture meets the theoretical background in General and Inorganic Chemistry: the chemical reaction (stoichiometric calculations, fundamental particles of an atom, the periodic table); chemical bonding and chemical equilibrium (reactions of acids and bases, reduction and oxidation, coordination complexes and the application of these type of reactions in the qualitative analysis). Part in physical chemistry: Importance of colors in the analytical chemistry, basics of reaction kinetics and electrochemistry (conductivity, electrolysis, galvanic cells). *Preliminary course:* The content of the practical course meets the basics in general and inorganic chemistry: Introduction in general laboratory works (burner, balances, manipulation of glassware), Handling and evaluation of hazards, stoichiometric calculations, reactions of acids and bases, reduction and oxidation, coordination complexes and the application of these type of reactions in the field of qualitative analysis. *Liebiglaboratorium:* The knowledge of the „Vorpraktikum" is deepened and applied in three projects like the natural cycle of lime, amino acids as polyfunctional molecules, and

	oxidation reactions (bleaching, disinfection, and oxidative stress). The background of the physical chemistry is treated in three chapters: the origin of colors, kinetic of chemical reactions, and important basics in electrochemistry.
Qualification goals	The aim of the qualification is to reach a good knowledge of the theoretical basics in general and inorganic chemistry, in the qualitative analysis as well as in important principles of the physical chemistry. Learning of correct and scientific manipulations in the lab as well as a logical approach in solving chemical problems.
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. Böttcher, Prof. Hartschuh
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	The content of the lecture meets the theoretical background in General and Inorganic Chemistry: the chemical reaction (stoichiometric calculations, fundamental particles of an atom, the periodic table); chemical bonding and chemical equilibrium (reactions of acids and bases, reduction and oxidation, coordination complexes and the application of these type of reactions in the qualitative analysis). Part in physical chemistry: Importance of colors in the analytical chemistry, basics of reaction kinetics and electrochemistry (conductivity, electrolysis, galvanic cells).
Qualification goals	The aim of the qualification is to reach a good knowledge of the theoretical basics in general and inorganic chemistry, in the qualitative analysis as well as in important principles of the physical chemistry. Introduction in the subjects of practice in general and inorganic chemistry as well as in physical 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. Böttcher, Prof. Hartschuh
Language	German
Additional information	**Recommended literature:** Jander/Blasius, *Lehrbuch der analytischen und präparativen anorganischen Chemie*, Hirzel, Stuttgart, **2006**. **Script of the preliminary course:** www.cup.lmu.de/ac/boettcher/l_gp_vorkurs_vorlesung.html **Script of the LiebigLab:** www.cup.lmu.de/ac/boettcher

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	*Preliminary course:* The content of the practical course meets the basics in general and inorganic chemistry: Introduction in general laboratory works (burner, balances, manipulation of glassware), Handling and evaluation of hazards, stoichiometric calculations, reactions of acids and bases, reduction and oxidation, coordination complexes and the application of these type of reactions in the field of qualitative analysis. *Liebiglaboratorium:* The knowledge of the „Vorpraktikum“ is deepened and applied in three projects like the natural cycle of lime, amino acids as polyfunctional molecules, and oxidation reactions (bleaching, disinfection, and oxidative stress). The background of the physical chemistry is treated in three chapters: the origin of colors, kinetic of chemical reactions, and important basics in electrochemistry.
Qualification goals	The aim of the qualification is to reach a good knowledge of the theoretical and practical basics in general and inorganic chemistry, in the qualitative analysis as well as in important principles of the physical chemistry. Learning of correct and scientific manipulations in the lab as well as a logical approach in solving chemical problems.
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. Klüfers, Prof. Böttcher, Prof. Hartschuh
Language	German

Additional information

Recommended literature:

Jander/Blasius, *Lehrbuch der analytischen und präparativen anorganischen Chemie*, Hirzel, Stuttgart, **2006**.

Script of the preliminary course:

www.cup.lmu.de/ac/boettcher/L_gp_vorkurs.pdf

Script of the LiebigLab:

www.cup.lmu.de/ac/boettcher/L_gp_liebiglab.pdf

Organizational information:

Registration for the lab course through the faculty website.

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.

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	Topics include fundamental aspects in natural sciences of mathematics, physics, and biology. Details in P 3.1-3.10
Qualification goals	The students should be well versed with the contents of the lecture and should be able to transfer new knowledge onto problems of modern life. The comprehension of the lecture is intensified in the accompanying tutorial. The students are encouraged to abstract from the specific example towards a more general principle. 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. Regina de Vivie-Riedle
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	Contents are set theory, vector operations, matrices, series, functions of one variable: differentiation, integration. The students exercise the contents of the lecture course with problem sets.
Qualification goals	Having passed the module the student should be familiar with integer, real and complex numbers and their properties and in the last case should know in particular the representation via the exponential function; should be familiar with the basic vector and matrix calculus as dot- and cross-product as well as matrix-vector- and matrix-matrix-multiplication; should know how to differentiate and integrate functions of one variable and be able to handle the most important techniques of numerical analysis as interpolation, linear approximation and numerical integration.
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. Ebert
Language	German
Additional information	**Recommended literature:** N. Rösch, *Mathematik für Chemiker*, Springer-Verlag, Berlin, Heidelberg, NewYork, **2013**.

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	Contents are set theory, vector operations, matrices, series, functions of one variable: differentiation, integration. The students exercise the contents of the lecture course with problem sets.
Qualification goals	Having passed the module the student should be able to work with integer, real and complex numbers and in the last case should be able in particular to make use of the representation via the exponential function as well as Euler's formula; to apply the vector and matrix calculus among others to discuss straight lines and planes in geometry as well as distances and angles between these; to determine the properties of functions of one variable by Taylor expansion and to perform detailed discussions of their properties as well as to apply interpolation, linear approximation and numerical integration in practice.
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. Ebert
Language	German
Additional information	**Recommended literature:** N. Rösch, *Mathematik für Chemiker*, Springer-Verlag, Berlin, Heidelberg, NewYork, **2013**. **Organizational information:** Students register for the tutorial through the faculty website.

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	Contents are the methodology of physics, error calculations, units of measurement, mechanics, hydrostatics, hydrodynamics, oscillations and waves, thermodynamics. The students exercise the contents of the lecture course with problem sets.
Qualification goals	The students have command of the contents of the lecture course and are able to transfer the knowledge to current problems. The understanding of the contents of the lecture course is deepened, the generalization of knowledge is promoted.
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. Lipfert
Language	German
Additional information	**Recommended literature:** P. Tipler, *Physik*, Spektrum Akademischer Verlag, Heidelberg, **2009**.

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	Contents are the methodology of physics, error calculations, units of measurement, mechanics, hydrostatics, hydrodynamics, oscillations and waves, thermodynamics. The students exercise the contents of the lecture course with problem sets.
Qualification goals	The students have command of the contents of the lecture course and are able to transfer the knowledge to current problems. The understanding of the contents of the lecture course is deepened, the generalization of knowledge is promoted.
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. Lipfert
Language	German
Additional information	**Recommended literature:** P. Tipler, *Physik*, Spektrum Akademischer Verlag, Heidelberg, **2009**. **Organizational:** Students register for the tutorial through the faculty website.

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 fundamental topics in biology: biologically relevant macromolecules, cells, gene expression, genetics, evolution and phylogeny, basics of physiology, immunology, neurobiology and ecology. We aim for an general understanding of these processes and their interplay within biological systems. The reprise-lecture aims for an interactive repetition of the weekly topic with practical examples from research or – where appropriate – current topics from the general news.
Qualification goals	Students acquire specific knowledge on fundamental topics in biology. They can assign biological phenomena to an appropriate topic or discipline and can explain the basic principles that underlie these phenomena. They can discuss basic problems from e.g. evolutionary biology or physiology and can establish the connections between the individual topics that describe a given biological process.
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:** • W. Purves, D.Sadava, *Biologie*, Spektrum Akademischer Verlag, Heidelberg, **2007**. • N. 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. Ebert
Language	German
Additional information	**Recommended literature:** N. Rösch, *Mathematik für Chemiker*, 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. Ebert
Language	German
Additional information	**Recommended literature:** N. Rösch, *Mathematik für Chemiker*, Springer-Verlag, Berlin, Heidelberg, NewYork, **2013**. **Organizational:** Students register for the tutorial through the faculty website.

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	Contents are electrodynamics, optics, nuclear and particle physics. The students exercise the contents of the lecture course with problem sets.
Qualification goals	The students have command of the contents of the lecture course and are able to transfer the knowledge to current problems. The understanding of the contents of the lecture course is deepened, the generalization of knowledge is promoted.
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. Liedl
Language	German
Additional information	**Recommended literature:** P. Tipler, *Physik*, 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	Contents are electrodynamics, optics, nuclear and particle physics. The students exercise the contents of the lecture course with problem sets.
Qualification goals	The students have command of the contents of the lecture course and are able to transfer the knowledge to current problems. The understanding of the contents of the lecture course is deepened, the generalization of knowledge is promoted.
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. Liedl
Language	German
Additional information	**Recommended literature:** P. Tipler, *Physik*, Spektrum Akademischer Verlag, Heidelberg, **2009**. **Organizational:** Students register for the tutorial through the faculty website.

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	Contents are experiments in mechanics, thermodynamics, oscillations and waves, optics, and electrodynamics.
Qualification goals	The students have command of the experimental techniques and are able to transfer the knowledge to current problems.
Submodule assessment	A written exam, scientific protocoland 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:** P. Tipler, *Physik*, Spektrum Akademischer Verlag, Heidelberg, **2009**. **Organizational information:** Registration for the lab course through the faculty website. Information to the practical course of experimental physics: *http://www-alt.physik.uni-muenchen.de/studium/praktikum/chemie/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	Introduction to the analytical separation process in inorganic chemistry and extended knowledge of the periodic system of the elements. Furthermore occurrence of the elements and their compounds in industrial processes is presented. Qualitative analysis of alkali- and earth alkaline metals, ammonium sulfide- und hydrogene sulfide-groups, as well as a full analysis.
Qualification goals	Advanced skills in inorganic qualitative analysis of the elements as well as their preparation. The learning aims are to achieve a command of the knowledge of the contents of the lecture and to develop the ability to transfer that knowledge to current problems. Understanding of the lecture content will be developed in more detail through problem-solving exercises. Furthermore, abstracting the principles used for specifically chosen examples to general situations will be promoted. Knowledge of chemical background of the performed analyses and application to unknown mixtures and

	substances.
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. Klapötke
Language	German
Additional information	**Organizational information:** Registration for the lab course through the faculty website. 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.

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 the chemical composition of biomolecules (carbohydrates, nucleic acids, proteins, lipids), their biosynthesis, transformation (e.g. replication, transcription, translation etc.) and degradation processes as well as their cell biological context (compartimentalization, transport of molecules across membranes, protein targeting, cytoskeleton etc.). In our discussion of metabolic principles we also cover basic principles of enzymology (reaction equilibria and thermodynamics, reaction mechanisms, enzyme kinetics, regulation and inhibition of enzymes etc.), metabolic communication between organs and drug development.
Qualification goals	Students acquire specific knowledge on the chemical basis of living systems. They can reproduce the lecture topics, discuss qualitative and quantitative aspects as well as the connections between individual topics (molecules and cellular structures, alternative substrates for enzymes etc.). They can transfer their knowledge to analogous problems, identify the components involved and analyze their

	interactions. Independent work to repeat and confirm the acquired knowledge is fostered by accompanying exercises, which are in part available online.
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
Language	German
Additional information	

P 5.1: Biochemistry 1 (T1BI)

Type of the submodule	Required course.
Applicability of the submodule 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 course spans 1 semester.
Content	The lecture introduces the chemical composition of biomolecules (carbohydrates, nucleic acids, proteins, lipids) and their transformation (e.g. replication, transcription, translation etc.) in a cell biological context. We further discuss selected aspects of cell cycle, chromatin structure, protein targeting and signal transduction.
Qualification goals	Students acquire specific knowledge on the chemical basis of living systems. They can reproduce the lecture topics, discuss qualitative and quantitative aspects as well as the connections between individual topics (e.g. molecules and cellular structures). They can transfer their knowledge to analogous problems, identify the components involved and analyze their interactions.
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, Stryer, *Biochemistry*, W.H. Freeman, New York, **2006**.

P 5.2: Biochemistry 2 (T1CF)

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	• 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 lecture introduces the biosynthesis and degradation of major cellular metabolites (glycolysis and energy metabolism, photosynthesis, degradation of nitrogen-containing metabolites). In our discussion of metabolic principles we also cover basic principles of enzymology (reaction equilibria and thermodynamics, reaction mechanisms, enzyme kinetics, regulation and inhibition of enzymes etc.), metabolic communication between organs and drug development.
Qualification goals	Students acquire specific knowledge on the chemical basis of living systems. They can reproduce the lecture topics, discuss qualitative and quantitative aspects as well as the connections between individual topics (compartimentalization of reactions, alternative substrates for enzymes etc.). They can transfer their knowledge to analogous problems, identify the components involved and analyze their interactions. Independent work to repeat and confirm the acquired knowledge is fostered by an accompanying online quiz module.
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, Stryer, *Biochemistry*, W.H. Freeman, New York, **2006**.

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

Type of the submodule	Required course.
Applicability of the submodule to other degree programs	• 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 actively use their acquired knowledge to address analogous problems. Small groups are accompanied by a tutor who moderates the discussion and validates the proposed solutions. We aim for independent work by the students ahead of the exercise hour so that this will not only ensure full understanding but also leave time to train presentation skills.
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	**Recommended literature:** Berg, Tymoczko, Stryer, *Biochemistry*, W.H. Freeman, New York, **2006**. **Organizational information:** Students register for the tutorial through the faculty website.

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	Topics include radicals and radical reactions, nucleophilic substitution at saturated carbon, elimination reactions, additions to C-C multiple bonds, the chemistry of aromatic compounds, reduction and oxidation reactions, aldehydes and ketones, carboxylic acids and their derivatives, reactions of C-H acidic compounds, rearrangements. Topics covered in the lectures are mirrored by experimental work in the lab course. The students achieve skills for basic practical procedures during the introductory weeks of the lab course. Subsequently, students prepare organic compounds and carry out chemical and spectroscopic analysis of these samples, which includes a training in handling of solvents and reagents and safety aspects.
Qualification goals	Students have the ability to synthesize organic compounds following written synthesis procedures and to handle hazardous materials using current safety and environmental rules. Students understand the theoretical basis of their experiments and know how to document their laboratory

	activity in a professional way. Students have the ability to use spectroscopic methods to characterize simple organic molecules.
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. Hendrik Zipse, PD Dr. Armin Ofial
Language	German
Additional information	

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 1 semester.
Content	Topics include radicals and radical reactions, nucleophilic substitution at saturated carbon, elimination reactions, additions to C-C multiple bonds, the chemistry of aromatic compounds, reduction and oxidation reactions, aldehydes and ketones, carboxylic acids and their derivatives, reactions of C-H acidic compounds, rearrangements.
Qualification goals	Students have the ability to: a) synthesize important classes of organic compounds on laboratory scale; b) describe the mechanistic course of important organic reactions; c) develop a systematic name for synthetically relevant organic compounds following the IUPAC rules.
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. Hendrik Zipse, PD Dr. Armin Ofial
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**. • K. P. C. Vollhardt, Neil E. Schore, *Organische Chemie*, Wiley-VCH Verlag, Weinheim, **2011**.

P 6.2: Exercises to the Lecture Organic Chemistry 2 („Gattermann-Lab“) (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 1 semester.
Content	Topics include radicals and radical reactions, nucleophilic substitution at saturated carbon, elimination reactions, additions to C-C multiple bonds, the chemistry of aromatic compounds, reduction and oxidation reactions, aldehydes and ketones, carboxylic acids and their derivatives, reactions of C-H acidic compounds, rearrangements.
Qualification goals	Students have the ability to develop independent synthetic strategies for selected model cases and can describe the reaction mechanisms of the underlying elementary 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. Hendrik Zipse, PD Dr. Armin Ofial
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**. • K. P. C. Vollhardt, Neil E. Schore, *Organische Chemie*, Wiley-VCH Verlag, Weinheim, **2011**. **Organizational information:** Students register for the tutorial through the faculty website.

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	Topics covered in the "Organic Chemistry 2" lecture are matched by experimental work in the lab course. The students achieve skills for basic practical procedures during the introductory weeks of the lab course. Subsequently, students prepare organic compounds and carry out chemical and spectroscopic analysis of these samples. Documentation of chemical experiments in scientific protocols. Safety in the chemical laboratory.
Qualification goals	The students understand how to execute common synthetic transformations for the most relevant substrate classes in organic chemistry and to predict the respective reaction mechanisms. The students are able to conduct organic syntheses based on known procedures. The students understand the theoretical background of their experimental work and know how to document their experiments in scientific protocols. The students are able to handle typical organic solvents and reagents, and understand the associated safety aspects. The students know how to use spectroscopic methods in order to characterize simple organic compounds.
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. Hendrik Zipse
Language	German
Additional information	**Recommended literature:** • K. Schwetlick, *Organikum*, Wiley-VCH Verlag, Weinheim, **2009.** • S. Hünig, G. Märkl, J. Sauer, P. Kreitmeier, A. Ledermann,

J. Podlech, *Arbeitsmethoden in der Organischen Chemie*, Lehmann Media, 3. Aufl., **2014.**

Organizational information:

Registration for the lab course through the faculty website.

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.

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 1 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, 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 relates to 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 interprete atomic and molecular spectra. They are familiar with approximative methods to solve the Schrödingerequation 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

P 7.1: Physical Chemistry 2 (T1CD)

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	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.
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 Schrödingerequation 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. Ochsenfeld
Language	German
Additional information	**Recommended literature:** • P. Atkins, *Physikalische Chemie*, Wiley-VCH Verlag, Weinheim, **2006**. • G. Wedler, *Lehrbuch der Physikalischen Chemie*, Wiley-VCH Verlag, Weinheim, **2004**.

P 7.2: Exercises to the Lecture Physical Chemistry 2 (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 1 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.
Qualification goals	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 interprete 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.
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. Ochsenfeld
Language	German
Additional information	**Recommended literature:** • P. Atkins, *Physikalische Chemie*, 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.

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 and quantum theory.
Qualification goals	The students learn to: • 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. Competences: Presentation of scientific topics, understanding and knowledge of concepts and methods in Physical Chemistry.
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	**Recommended literature:** P. Atkins, Physical Chemistry, Wiley-VCH Verlag, Weinheim, 2006.

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	Successful participation at • 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	Experiments on thermodynamics, electrochemistry,kinectics and quantum theory: thermodynamics, electrochemistry, kinetics, spectroscopy.
Qualification goals	After completing this course the students can: • 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-	ECTS-points are awarded for passing the lab course.

Points	
Responsible person	Prof. Hartschuh
Language	German
Additional information	**Recommended literature:** P. Atkins, Physical Chemistry, Wiley-VCH Verlag, Weinheim, 2006. **Organizational information:** Registration for the lab course through the faculty website. The students will receive a folder with experimental instructions and all organizational information about 1-2 weeks before the start of the lab course. 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.

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 1 semester.
Content	In lectures and a practical lab-course we present advanced theoretical and basic practical skills of biochemistry. We cover advanced topics of protein biochemistry (protein structure, folding, membrane proteins, advanced enzymology, multi-subunit protein complexes, Protein-DNA interaction, catalytic nucleic acids, biotechnology) and basic biochemical laboratory techniques in lectures. The latter are then also applied in a practical lab-course that covers enzyme kinetic measurements, nucleic acid and protein analytical techniques.
Qualification goals	Students acquire advanced theoretical knowledge on protein biochemistry and the interaction between proteins and nucleic acids. They can transfer this to analogous situations or biotechnological problems. In addition, they learn basic biochemical laboratory techniques from both, a theoretical (especially analytical principles and limitations) and a practical perspective. They will be able to develop experimental approaches and even simple, multi-step procedures to solve analogous problems. The protocols and

	deadlines train written presentation and 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	Dr. Heidi Feldmann
Language	German
Additional information	**Recommended literature:** Berg, Tymoczko, Stryer, *Biochemistry*, W.H. Freeman, New York,**2006**.

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	Students acquire theoretical knowledge on basic biochemical laboratory techniques (especially analytical principles and limitations). They will be able to address a basic, practical problem in biochemistry by applying protein and nucleic acid analytical techniques. Finally, they will be able to provide complete information on the experiments in their protocols because they are aware of everything that is needed for full interpretation of the results.
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. Heidi Feldmann
Language	German
Additional information	**Recommended literature:** K. Wilson, J. Walker, *Principlesand Techniques of Biochemistry and Molecular Biology*, Cambridge University Press, Cambridge, **2010**.

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	This lecture covers advanced theoretical aspects of protein biochemistry (protein structure, folding, membrane proteins, advanced enzymology, multi-subunit protein complexes, Protein-DNA interaction, catalytic nucleic acids, biotechnology). Classical and modern approaches to characterize protein-nucleic acid interactions and medical application of biological macromolecules are also presented.
Qualification goals	Students will be able to evaluate catalytic mechanisms of protein and nucleic acid enzymes. They are furthermore able to transfer this knowledge in the context of protein design and biotechnology. Finally, they have learnt to choose appropriate methods for the determination of protein and nucleic acid structures.
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	**Recommended literature:** • C. Cantor, R. Schimmel, *Biophysical Chemistry Part I + II*, WH Freeman, New York, **1980**. • W. Borchardt-Ott, *Kristallographie*, Springer Verlag, Berlin, **2008**. • B. Alberts, *MolecularBiologyoftheCell*, Taylor & Francis, New York, **2007**.

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 weeks of this practical course are structured into enzyme kinetics, DNA analysis and protein analysis. Students perform experiments that have been introduced in the lecture "Methods in biochemistry 1". Students work in teams of two and will prepare detailed written protocols of their results.
Qualification goals	Students learn the basic experimental techniques of biochemistry. They execute detailed protocols but in several places certain aspects of the experiments must be developed and/or calculated. Students will also develop reasonable combinations of individual experiments. The independent writing of experimental protocols trains written presentation skills and the deadlines require time-management capabilities.
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	Dr. Feldmann
Language	German
Additional information	**Recommended literature:** Berg, Tymoczko, Stryer, *Biochemistry*, W. H. Freeman, New York, **2006**. **Organizational information:** Registration for the lab course through the faculty website. The lab course is synchronized with the physical chemistry 1 P7.4 and inorganic chemistry 2 P10.4 laboratory courses running in parallel. Additional information on: www.genzentrum.lmu.de

ModuleP 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	Topics include fundamental aspects of spectroscopy; the most relevant methods, and the interpretation of spectra. Details in P 9.1-9.4
Qualification goals	The students should be well versed with the contents of the lecture and should be able to transfer new knowledge onto problems of modern life. The comprehension of the lectures is intensified in the accompanying tutorials. The students are encouraged to abstract from the specific example towards a more general principle. Details in P 9.1-9.4
Module assessment	Written or oral examinations.
Grading	The module is graded.
Requirements for granting ECTS-	ECTS-points are awarded for passing the exam, which is

Points	allocated to the module.
Responsible person	Prof. Dr. Hubert Ebert, Dr. David Stephenson
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	Contents are group theory, IR, UV, and VIS spectroscopy, mass spectrometry. The students exercise the contents of the lecture course with problem sets.
Qualification goals	Having passed the module the student should be familiar with the basic principles of group theory and the corresponding possibilities to characterize molecules and to predict their properties in a qualitative way; to know the most important apparative and formal basic principles of IR and UV-VIS absorption and Raman spectroscopy. This includes the phenomenological description as well as the quantum-mechanical treatment of rotation, vibration and electronic structure. In addition, the student should be able to explain the corresponding transition probabilities and be familiar with the possibilities to apply molecular spectroscopy in analytics.
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. Ebert
Language	German
Additional information	**Recommended literature:** J. Hollas, *Moderne Methoden in der Spektroskopie*, Vieweg, Braunschweig, **1995**.

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	Contents are group theory, IR, UV, and VIS spectroscopy, mass spectrometry. The students exercise the contents of the lecture course with problem sets.
Qualification goals	Having passed the module the student should be able to determine the point group of a molecule und to derive the selection rules for vibration and UV-VIS spectroscopy in its absorption and Raman modes using the corresponding character tables; to apply the adopted basic principles of rotation, vibration and electron spectrospcopy to determine characteristic quantities as rotation and anharmonicity constants or absoption edges and to know their relation to the strcutural and electronic properties of an investigated molecule.
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. Ebert
Language	German
Additional information	**Organizational information:** Students register for the tutorials through the departamental website. **Recommended literature:** J. Hollas, *Moderne Methoden in der Spektroskopie*, Vieweg, Braunschweig, **1995**.

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	**NMR Spectroscopy:** The fundamentals of 1H and 13C NMR spectroscopy is solution, chemical shift, spin-spin couplings, empirical rules for determining shifts, spectra of first and higher order, 2D NMR spectroscopy, relaxation, experimental methods. **Mass Spectrometry:** Components of mass spectrometers, various ionisation methods such as EI, CI, APCI, ESI, FAB, MALDI, various injection methods such as GC, LC, SFC, CE, fragmentation mechanisms.
Qualification goals	The students have command of the contents of the lecture course and are able to transfer this knowledge to topical problems. The students can interpret spectra independently and can determine the structure of chemical compounds using these spectra. The ability to determine the structure of unknown substances using mass spectrometry and NMR spectroscopy and the ability to prove the structure of known substances.
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. Rasmus Linser
Language	German
Additional information	**Organizational information:** Students register for the exam through the departamental website.

Grading: 70 % NMR-spectroscopy, 30 % mass spectrometry.

Recommended literature:

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	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 Spectroscopy 2 lecture.
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. Rasmus Linser
Language	German
Additional information	**Organizational information:** Students register for the tutorials through the departamental website. Grading: 70 % NMR-spectroscopy, 30 % 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 1 semester.
Content	Concepts and models of inorganic chemistry: Periodicity of atomic properties, sizes of atoms, electronegativity, chemical bonding concepts, VB-theory, Molecular orbital schemes, ligand group orbitals, isolobal concept, Ionic crystals, lattice energy, multiple bonds, basics of magnetism, structure and bonding.
Qualification goals	The students deepen their knowledge in inorganic chemistry. They should be able to identify the conceptual and abstracting character of some inorganic chemistry principles with the aid of examples given in the lecture.
Module assessment	Written or oral exams and scientific protocol.
Grading	The module is graded.
Requirements for granting ECTS-	ECTS-points are awarded for passing the exam, which is

Points	allocated to the module.
Responsible person	Prof. Klüfers
Language	German
Additional information	**Recommended literature:** Holleman-Wiberg, *Lehrbuch der Anorganischen Chemie*, 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: 4
Duration	The course spans 1 semester
Content	Concepts and models of inorganic chemistry: Periodicity of atomic properties, sizes of atoms, electronegativity, chemical bonding concepts, VB-theory, Molecular orbital schemes, ligand group orbitals, isolobal concept, Ionic crystals, lattice energy, multiple bonds, basics of magnetism, structure and bonding.
Qualification goals	The students deepen thier knowledge in inorganic chemistry. They should be able to identify the conceptual and abstracting character of some inorganic chemistry principles with the aid of examples given in the lecture.
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	**Organizational information:** Students register for the exam through the departamental website. **Recommended literature:** • Holleman-Wiberg, *Lehrbuch der Anorganischen Chemie*, De Gruyter, Berlin, **2007**. • B. Douglas, D. Mc. Daniel, J. Alexander, *Concepts and Models of Inorganic Chemistry,* 3rd Ed., John Wiley & Sons,**1994.** • J. E. Huheey, *Inorganic Chemistry – Prinzipien von Struktur und Reaktivität,* Walter de Gruyter 5. Auflage **2014**.

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	Spatial structure of coordination compunds (coordination number and polyhedra), isomerism (constitutional isomers, *cis/trans*, *fac/mer*, enantiomers, ambident ligands). Thermodynamics (stability constants, species distribution, chelate effect) and kinetics (inert and labile complexes, associative and dissociative ligand substitution, inner- and outer-sphere redox reactions) of complex formation. Properties of ligands (modulation of acidity and electrophilicity), bonding in coordination entities: MO scheme of an octahedral complex, crystal field model as approximation to the frontier orbitals; electronic spectrum and electronic structure, spectroscopic selection rules, Jahn-Teller distortion. Para-magnetic and diamagnetic complexes, spin-only formula, ferro- and antiferromagnetic spin coupling, superexchange. Strong- and weak-field ligands, σ-donor, π-donor and π-acceptor ligands, spectrochemical series, metal contribution to the crystal-field splitting, spin states (high-, low-spin), spin-crossover. Strong-field ligands: carbonyl, nitrosyl and cyanido complexes, 18-e rule, metal-metal bonds. Basic types of organometallic ligands, basic steps of organometallic reactions [oxidative addition, reductive eliminination, nucleophilic attack on the ligand („insertion"), β-H elimination].
Qualification goals	The students should know the basic principles of coordination chemistry as a prerequisite to attend advanced-level courses such as bioInorganic Chemistry and advanced topics of coordination 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. P. Klüfers
Language	German
Additional information	**Organizational information:** Students register for the exam through the departamental website. Website of the Lecture: http://www.cup.uni-muenchen.de/ac/kluefers/homepage/L_kc.html

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	Theoretical basics concerning the lab course Inorganic Chemistry 2 are deepened in this seminar. Contents: occurence, production and structure of the elements, sphere packings and derived structures, omprotant solid state structure types, silicates, phase diagrams, imtermetallic compounds, crystal growth methods, powder diffractometry, anhydrous halogenides, chemical transport reactions, metal-organic chemistry, origin of colour in chemical compounds. The seminar is an importand basis for the final oral exam.
Qualification goals	The students shall be able to • understand and explain the theroretical background of the lab course experiments. • discuss the applications of the compounds in the context of structure-property relations. • independently perform literature research and develop synthetic conceps. • suggest and perform suitable analytic methods for the identification of the expected reaction products and to discuss the respective results.
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	Dr. Constantin Hoch, Prof. Dr. Wolfgang Schnick
Language	German
Additional information	**Organizational information:** Registration for the seminar through the internet portal ofthe faculty.

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	Experimental skills and methods for characterisation of inorganic substances by executing advanced syntheses of didactically chosen compounds from all fields of modern inorganic chemistry. Theroretical basics are intensified in the accompanying seminar.
Qualification goals	The student shall be able to • independently perform literature research for the experiments, to project and perform them and to discuss aternative synthetic approaches. • to discuss the safety-related issues of all employed dangerous substances and to perform an appropriate disposal. • to deploy the basic inorganic chemical analytical methods and to evaluate the results. • to work independently and autonomously in the laboratory. • to transfer the basic concepts of inorganic chemistry into practical laboratory work.
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	Prof. Dr. Wolfgang Schnick, Dr. Constantin Hoch
Language	German
Additional information	**Recommended literature:** Holleman-Wiberg, Lehrbuch der Anorganischen Chemie, De Gruyter, Berlin, **2007**. **Organizational information:** Registration for the lab course through the internet portal

ofthe 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	The students have command of the contents of the lecture course and are able to transfer the knowledge to current problems. Assessment of risks, safety aspects, Environmental Protection Law. Provide solid knowledge to enable participants to take over the responsibility as supervisor in the area of industrial safety.
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
Duration	The course spans 1 semester.
Content	Aufgaben und Definition der Toxikologie; krebserzeugende, erbgutverändernde, fortpflanzungsgefährdende und fruchtschädigende Stoffe; toxische Wirkungen von Atemgiften, Metallen, Lösemitteln, Insektiziden, Herbizide, Rodentiziden, Fungiziden pflanzlichen- und tierischen Gifte, Arzneimitteln, Drogen, chemischen und biologischen Kampfstoffen und Ökotoxikologe; Vergiftungsbehandlung. Contents are the most relevant aspects of toxicology for chemists: 1. Introduction 2. Toxicokinetics/-dynamics 3. Xenobiotica metabolism 4. Measuring toxicity 5. Mutagenesis und DNA-repair 6. Cancinogenesis 7. Solvents and inhalation toxins 8. Dioxine and polychlorinated Biphenyls 9. Biocides and biogenic toxins 10. Metals and metallorg. compounds 11. Smoking and second hand smoke 12. Cell signaling
Qualification goals	Erläuterung toxikologischer Aspekte, die in Hinsicht auf die Laborarbeit als Chemiker relevant sind. Grundlagen zu toxischen Wirkprinzipien ausgewählter Substanzgruppen. The lectures have the objective to introduce students into a toxicologic approach of working with chemicals. Biology of toxicity, mechanisms of toxicity, genetic polymorphisms,

	metabolism and environmental pollutants will be discussed.
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	**Recommended literature:** • Toxikologie, W. Dekant, S. Vamvakas, ISBN 3827414520 • Lehrbuch der Toxikologie, H. Marquardt ISBN3-8274-0271-9 • Humantoxikologie, Oehlmann, Markert, ISBN 3804714838 • Allgemeine und spezielle Pharmakologie und Toxikologie: Aktories et. al., 978-3-437-42523-3

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	Important legal aspects with regard to laboratory work performed by chemists; Overview of institutions actively involved in the area of industrial safety. Subjects covered include fundamentals of: • Chemicals Act • REACH-Regulation • Chemicals Prohibition Regulation • Regulation on Harzardous 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
Qualification goals	The students have command of the contents of the lecture course and are able to transfer the knowledge to current problems. Assessment of risks, safety aspects, Environmental Protection Law. Competence according to §5(1)7 Chemicals Prohibition Regulation. Provide solid knowledge to enable participants to take over the responsibility as supervisor in the area of industrial safety.

	The ability to weigh safety risks and consequences in a chemist's everyday life.
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	This module enhances knowledge in the subject of inorganic chemistry by selecting two of three lectures. Students (mostly in pairs) will produce advanced compounds in assistants' labs during a mini lab course (6 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 draw up a scientific protocol. Contents are the theoretical backgrounds for the laboratory course.
Qualification goals	The students have command of advanced experimental techniques and can plan and perform experiments independently. The learning aims are to achieve a command of the knowledge of the contents of the lecture and to develop the ability to transfer that knowledge to current problems. Understanding of the lecture content will be developed in more detail through problem-solving exercises. Furthermore, abstracting the principles used for specifically chosen examples to general situations will be promoted.
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
Language	German
Additional information	

WP 1.1: Seminar for Inorganic-chemical Lab 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	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. 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 in 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 the lab course or their 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	The seminar takes places bi-annually during semester breaks (March and September), 2 days preceding to the inorganic-chemical lab course AC 3.

WP 1.2: Inorganic-chemical 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	Students (mostly in pairs) will produce advanced compounds in assistants' labs during a mini lab course (6 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 draw up a scientific protocol. Contents are the theoretical backgrounds for the laboratory course.
Qualification goals	The students have command of advanced experimental techniques in inorganic chemistry and can plan and perform experiments individually. 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	**Recommended literature:** Holleman-Wiberg, Lehrbuch der Anorganischen Chemie, De Gruyter, Berlin, **2007**. **Organizational information:** Registration for the lab course through the internet portal of the faculty. The lab course takes places bi-annually during semester breaks (March and September), 18 days plus 2 days preceding to the inorganic-chemical lab course AC 3.

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	The lecture offers an overview ofthe molecular chemistry of main group elements. It comprises the most important classes of compounds and for every class syntheses, structures, bonding and chemical properties are discussed. Main topics are: hydrogen, element hydrogen compounds (element = alkali, earth alkali, beryllium, boron, silicon, nitrogen, phosphorus, oxygen), super acids, halogens and interhalogen compounds, nitrogen and phosphorus halides, element nitrogen compounds, element oxides and selected compounds of main group elements with the heavier chalcogens, compounds of the noble gases.
Qualification goals	The students will acquire strong and detailed basic knowledge on the molecular chemistry of main group elements and will be able to use this knowledge for the treatment of simple chemical problems as well as for future specialized studies of inorganic molecular chemistry. The learning aims are to achieve a command of the knowledge of the contents of the lecture and to develop the ability to transfer that knowledge to current problems. Understanding of the lecture content will be developed in more detail through problem-solving exercises. Furthermore, abstracting the principles used for specifically chosen examples to general situations will be promoted. Solid and detailed knowledge of the inorganic molecular chemistry of main group elements.
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 Gryter, Berlin, **2003**. • Holleman-Wiberg, *Lehrbuch der Anorganischen Chemie*, De Gruyter, Berlin, **2007**.

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	Basic principles of solid-state chemistry: selected examples for structure-property relations. Properties, crystal structures and application of important electric, optical and magnetic solid materials. Fundamental preparation strategies are developed based on thermopdynamics and kinetics of solid-state reactions. The impact of phase transitions and defects is discussed. The influence of temperature and pressure is illustrated with basic synthetic processes of solid compounds. Moreover, a classification of simple crystal structure types is developed.
Qualification goals	The students shall be able • to understand simple crystal structures of solids and their fundamental principles • to explain the relation between structures and properties of solid materials • to explain synthesis and resctivity of solid materials based on thermodynamik and kinetic fundamentals • discuss important examples for contemporary application of solid materials
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. Wolfgang Schnick
Language	German
Additional information	**Recommended literature:** U. Müller, Anorganische Strukturchemie, Teubner **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	Contents in the field of bioinorganic chemistry are the active centres of enzymes: acid/base catalysis at physiological pH (zinc enzymes); function and inhibition of catalytic centres (urease); Catalysis of redox reactions (Mn- and Fe-superoxide dismutase, rubredoxin, ferredoxin, Rieskecentres), hemerythrine, myoglobin, hemoglobin; redox catalysis with heme centres (cytochrome C, catalase, cytochrome P450); redox and oxidation processes mediated by copper proteins; Metals in photosynthesis; biomineralisation; hydrogenases and nitrogenases; organometallic chemistry in organisms, metal complexes in therapy and diagnostic medicine
Qualification goals	The students should be able to: • to apply principles of coordination chemistry to metalloproteins • to know the most important biological ligands and to recognize and apply ligand influences (neutral/anionic, hard/soft) • to explain coherences between abundance, availability and biological importance of metals • to know important metalloenzymes and their biological function and mechanism of action as well to recognize structural similarities to biomimetic and bioinspired complexes • to explain common features and differences between biologically important metal ions • to state current important research questions in bioinorganic chemistry • to transfer this knowledge and skills into other fields of inorganic and organic 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. Daumann
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	This module enhances knowledge in the subject of organic chemistry by selecting two of three lectures. Documentation of chemical information in the chemical literature. Search strategies for finding chemical information in databases (e.g. SciFinder). Important methods in organic synthesis (chromatography, solid phase synthesis, protecting groups, enzymatic catalysis,

	organocatalysis, microwave reactors, ionic liquids). Application of important analytical methods such as ^{1}H and ^{13}C NMR spectroscopy, UV/Vis spectroscopy, IR spectroscopy, mass spectrometry. Documentation of chemical experiments in synthetic projects. Safety in the chemical laboratory.
Qualification goals	Students have the ability to: a) follow the current literature in important areas of organic chemistry (bioorganic and organometallic chemistry, theoretical organic chemistry); b) understand current research directions in bioorganic, organometallic and theoretical organic chemistry; c) search for organic synthetic procedures in the chemical literature and online databases; d) plan and execute the synthesis of organic compounds following synthetic procedures from the chemical literature, and characterize the reaction products using spectroscopic methods; e) document their experimental work using professional guidelines and explain the theoretical basis of the respective experiments.
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. Hendrik Zipse
Language	German
Additional information	

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, conformational analysis, Ramachandran diagrams, solid-phase peptide synthesis, chemistry and mass spectrometry of peptide sequencing, ligation strategies for protein synthesis, proteins as drugs. Structure of DNA and RNA, noncovalent interactions, synthesis of nucleosides and nucleotides, solid-phase synthesis of oligonucleotides, the chemistry of sequencing, nucleosides and nucleotides as drugs. Structure of saccharides, stereoelectronic effects (anomeric effect, gauche effect), synthesis of sugars and oligosaccharides, oligosaccharides in nature.
Qualification goals	Students have the ability to: 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; The students understand the conceptual basis of synthetic protocols for peptides, oligonucleotides, oligosaccharides, and can apply these methods to simple target molecules.
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	The lecture course covers the most relevant organometallic reagents such as lithium-, magnesium-, zink-, boron-, cerium-, iron-, copper-, nickel-, palladium-, titanium-, rhodium- and ruthenium-compounds. For each of these classes methods of preparation as well as their synthetic utility is discussed.
Qualification goals	Students have the ability to: a) follow the current literature in the area of organometallic chemistry; b) understand the bonding situation and structural complexity of organometallic compounds; c) explain the mechanisms of important reactions involving organometallic compounds; d) use organometallic reagents in the (stereoselective) synthesis of defined target compounds; e) employ the most relevant homogeneous catalysis methods based on transition metal catalysts in synthetic projects.
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. Paul Knochel
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: 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: 6
Duration	The course spans 1 semester
Content	Strategies for the synthesis of demanding organic compounds including basis aspects of protecting group chemistry and the formation of strategically important bonds. Conceptual basis of modern separation and purification methods.
Qualification goals	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.
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. Henry Dube
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: 6
Duration	The course spans 1 semester
Content	Documentation of chemical information in the chemical literature. Search strategies for finding chemical information in databases (e.g. SciFinder). Important methods in organic synthesis (chromatography, solid phase synthesis, protecting groups, enzymatic catalysis, organocatalysis, microwave reactors, ionic liquids). Application of important analytical methods such as ^{1}H and ^{13}C NMR spectroscopy, UV/Vis spectroscopy, IR spectroscopy, mass spectrometry. Documentation of chemical experiments in synthetic projects. Safety in the chemical laboratory.
Qualification goals	Students have the ability to search for organic synthetic procedures in the chemical literature and online databases. Based on literature information the students know how to independently apply current synthetic methodology and modern laboratory equipment in the synthesis of organic compounds. Students understand the theoretical basis of the reactions used in synthetic protocols. Students have the ability to employ spectroscopic methods (1H and 13C NMR spectroscopy, UV/Vis and IR spectroscopy, mass spectrometry) for the characterization of organic compounds. Students know how to handle hazardous compounds following current safety and environmental guidelines.
Submodule assessment	Written examination 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. Henry Dube
Language	German
Additional information	**Recommended literature:**

- K. Schwetlick, *Organikum*, Wiley-VCH Verlag, Weinheim, **2009**.
- J. Clayden, N. Greeves, S. Warren, *Organic Chemistry*, 2. Auflage, Springer, **2013**.
- R. Brückner, *Reaktionsmechanismen*, Spektrum Akademischer Verlag, Heidelberg, **2011**.

Organizational information:

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

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.

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	This module enhances knowledge in the subject of physical chemistry by selecting two of three lectures. Contents are experiments on spectroscopy, microscopy, surface chemistry as well as computer simulations. Contents are the theoretical backgrounds for the laboratory course.
Qualification goals	The students have command of advanced experimental techniques and can plan and perform experiments independently. The learning aims are to achieve a command of the knowledge of the contents of the lecture and to develop the ability to transfer that knowledge to current problems. Understanding of the lecture content will be developed in more detail through problem-solving exercises. Furthermore, abstracting the principles used for specifically chosen examples to general situations will be promoted.
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. Regina de Vivie-Riedle
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	The students learn to: • 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. Competences: Presentation of research topics, understanding and knowledge of concepts and methods in Physical Chemistry.
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. A. Hartschuh
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	Contents are experiments on spectroscopy, microscopy, surface chemistry as well as computer simulations. Contents are the theoretical backgrounds for the laboratory course.
Qualification goals	After completing this course the students can: • 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. A. Hartschuh
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	During this course, we teach how to use quantum chemical program packages like Gaussian, MOLPRO, Q-Chem, TURBOMOLE. 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 follow a chemical reaction. 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 examplary cases it is shown that quantum chemicalcalculations 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.
Qualification goals	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 use the program packages on their own 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 applications. The students should be able to present and visualize the calculated results.
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. Ochsenfeld, Prof. Dr. R. de Vivie-Riedle
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, Boltzmann statistics, Bose-Einstein and Fermi-Dirac statistics, introduces ensembles, the partition function, and the relationship between partition functions and thermodynamic functions.
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, and calculate various thermodynamic parameters including thermodynamic equations of states (e.g Inner Energy, Enthalpy, Entropy, Free Energy), heat capacity, and the equilibrium constants of reactions based on spectroscopic data and the partition function.
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, especially the biological cell, classes of biomolecules, and experimental techniques.
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, fluorescence spectroscopy, electron microscopy, force spectroscopy and correlation spectroscopy) and knowledge of the factors involved in protein stability and folding. In addition, they 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 understanding of the function and dynamics of lipid membranes, the biophysics of nerve propagation as well as the metabolism of the cell.
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 the modern developments in physical chemistry with special emphasis on biophysical chemistry, solid state spectroscopy, femtochemistry, surface chemistry, nanosystems and quantum theory.
Qualification goals	The students obtain insight into current research areas of physical chemistry. They are able to understand the scientific literature from these areas and work in teams 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	Profs. Bein, Hartschuh, Lamb, Ochsenfeld, Wintterlin
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	The lecture provides an overview of quantum-chemical methods for calculating molecular systems: Hartree-Fock (HF); density-functional theory (DFT); configuration interaction (CI); second quantization formalism; coupled cluster (CC).
Qualification goals	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.
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	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. Part 2: 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. Separation of the stationary Schrödinger equation for the nuclei in the case of electronically coupled and uncoupled states. Presentation of various search algorithms to locate minima, transition states and minimum energy paths. Advanced methods for electron correlation and to describe electronically excited states. The focus is on configuration interactions and related methods like Complete Active Space –SCF.
Qualification goals	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.
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. R. de Vivie-Riedle

Language	German
Additional information	The allocated exercises in theoretical Chemistry can only be awarded in Module P12 (s. P 12.0.45). **Literature:** • 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 lectures and a practical lab class comprise advanced theoretical knowledge in cellular biochemistry (in particular biochemistry of cellular organelles, membrane biology and signal transduction) and biochemical laboratory techniques (protein purification, protein folding, in vitro analysis techniques).

Qualification goals	Students acquire advanced and specific knowledge on the cellular context of biochemical reactions and can reproduce the content of the lectures. They develop their skills of self-study and can transfer their knowledge to analogous problems. Advanced practical techniques for biochemistry are mastered and can be combined into advanced analytical schemes in biochemistry.
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	Dr. Heidi Feldmann
Language	German

Additional information

WP 4.1: Seminar for Biochemistry Laboratory Course 2 (T1EQ)

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	The lecture covers the theoretical basis for protein mass spectrometry, database research, analysis of protein-protein interactions and quantitative analysis of nucleic acids. These techniques are presented in consideration of the contents of the advanced biochemistry lab course. The methods are discussed according to their application potential and their limitations.
Qualification goals	Students acquire theoretical knowledge on more advanced biochemical laboratory techniques. They will be able to address practical problems in biochemistry by choosing and applying appropriate analytical techniques. They will be able to provide complete information on the experiments in the form of protocols because they are aware of everything that is needed for full interpretation of the results.
Submodule assessment	s. WP 4.2
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	Dr. Beatrix
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 context of this practical lab-class students will learn advanced approaches for the preparation (extraction, chromatography, affinity purification etc.) and analysis (stability, interactions etc.) of proteins. Furthermore, gene expression analysis (e.g. reportergene readout) is presented. Independent work both in the lab and during protocol writing is an additional goal of this course.
Qualification goals	The students are capable of reproducing the experiments and to analyze the results both qualitatively and quantitatively. They are able to devise multistep experimental and analytical approaches, carry out these experiments and analyze the results obtained. Students can also transfer their knowledge to published experiments in scientific publications and thus start to develop a critical view on scientific manuscripts. Finally, the students learn to appreciate the time requirements for the experiments and can thus plan daily activities with multiple 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	Contents are structures, regulations, and interactions of macromolecules in biochemical processes. The students exercise the contents of the lecture course with problem sets from the literature.
Qualification goals	The students should know and can explain the basic facts, concepts and models of cellular biochemistry. Furthermore, they understand corresponding experimental data, can scrutinize it for potential errors and offer an interpretation based on their theoretical knowledge.
Submodule assessment	A written or oral examination 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 submodule.
Responsible person	Prof. Dr. Ulrike Gaul
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	Students actively use their acquired knowledge to address analogous problems. Small groups are accompanied by a tutor who moderates the discussion and validates the proposed solutions. We aim for independent work by the students ahead of the exercise hour so that this will not only ensure full understanding but also leave time to train presentation skills.
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. Ulrike Gaul
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	Students gain specific knowledge on the presented biological phenomena and the biochemical techniques derived from them. They are able to transfer their knowledge to analogous situations and choose the appropriate technique for a given experimental problem. The lecture also trains their ability to identify when a novel phenomenon may be exploited and re-contextualized for experimental purposes.
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	This seminar deals with original literature covering various biochemical research areas. The articles are chosen to cover a broad range of biochemical, molecular and structural biology methods.
Qualification goals	In this seminar students learn critically evaluate and present biochemical original literature. The students have to report on and briefly discuss short articles and prepare a written elaboration summarizing the joint course discussion. By a close interaction with the supervisor the students will appreciate and work out the essence of a paper. They develop their skills to judge and critically assess scientific publications.
Submodule assessment	Presentation (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 and Structural 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 Structural Biology 1	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	WP 5.0.2 Microbiology	WiSe	30 h (2 SWS)	60 h	(3)
* Exercise	WP 5.0.3 Exercises to the lecture Microbiology	WiSe	45 h (3 SWS)	45 h	(3)
Lecture	WP 5.0.4 Genetics 1	WiSe	30 h (2 SWS)	60 h	(3)
* Exercise	WP 5.0.5 Exercises to the lecture Genetics 1	WiSe	15 h (1 SWS)	15 h	(1)
* Exercise	WP 5.0.6 Exercise Genetics 1	WiSe	30 h (2 SWS)	30 h	(2)
Lecture	WP 5.0.7 Structural Biology 2	SoSe	30 h (2 SWS)	60 h	(3)
Seminar	WP 5.0.8 Seminar to the Structural Biology Laboratory Course	SoSe	15 h (1 SWS)	30 h	(1,5)
* Lab course	WP 5.0.9 Structural Biology Laboratory Course	SoSe	150 h (10 SWS)	75 h	(7,5)
Lecture	WP 5.0.10 Animal Physiology	SoSe	23 h (1,5 SWS)	67 h	(3)
* Exercise	WP 5.0.11 Exercises to Animal Physiology	SoSe	57 h (3,75 SWS)	33 h	(3)
Lecture	WP 5.0.12 Cell Biology 1	SoSe	30 h (2 SWS)	60 h	(3)
* Exercise	WP 5.0.13 Exercise Cell Biology 1	SoSe	45 h (3 SWS)	45 h	(3)
Seminar	WP 5.0.14 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. 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	Master program in Biochemistry.
Elective guidelines	Two optional modules of WP 1 – WP 5 should be elected.

	For this module 15 ECTS credits in total are required from courses WP 5.0.1 to WP 5.0.14.
Entry requirements	none
Study pathway level	Recommended semester: 5 and 6
Duration	The modul spans 2 semesters.
Content	Contents are theoretical fundamentals of biology and structural biology.
Qualification goals	Students can reproduce the presented topics and address analogous questions in structural biology. Their in-depth understanding enables them to discuss details on both, the experimental side and the interpretation of the obtained results.
Module assessment	Wtitten 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	Dr. Heidi Feldmann
Language	German
Additional information	

WP 5.0.1: Structural Biology 1 (T1ES)

Type of the submodule	Optional course.
Applicability of the submodule to other degree programs	Master program in Biochemistry
Elective guidelines	s. WP 5
Entry requirements	none
Study pathway level	Recommended semester: 5
Duration	The course spans 1 semester.
Content	The lecture covers in detail the theoretical basis of techniques applied to elucidate the three-dimensional structure of biomolecules (crystallography, cryo-EM and NMR). We cover both the principles as well as aspects of practical relevance.
Qualification goals	Students can reproduce the presented topics and transfer their knowledge to analogous problems in structural biology. They can plan a structural biology project in its individual experimental steps.
Submodule assessment	Written exam 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. Hopfner
Language	English
Additional information	

WP 5.0.2 and WP 5.0.3: Lecture and Exercises in Microbiology

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	WP 5.0.2 Microbiology (U1BC)	WiSe	30 h (2 SWS)	60 h	(3)
Exercise	WP 5.0.3 Exercises to the lecture Microbiology (U1BD)	WiSe	45 h (3 SWS)	45 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	• Bachelor program in Biology • Education program in Biology
Elective guidelines	s. WP 5
Entry requirements	none
Study pathway level	Recommended semester: 5
Duration	The course spans 1 semester.
Content	The lecture course introduces into basic aspects of microbiology including structure and function of the prokaryotic cell, diversity of the microbial metabolism, molecular cell differentiation and signal transduction, ecology and phylogeny of microorganisms as well as the medical and biotechnological relevance of microorganisms. The exercise class teaches experimental techniques for handling and investigation of microorganisms including phase contrast microscopy, fluorescence microscopy, enrichment and cultivation of bacteria, analyses of microbial and metabolic diversity, cell differentiation and medical microbiology.
Qualification goals	The students are proficient in the contents of the lecture course and are able to transfer the knowledge to current problems of microbiology. The students understand theoretical and applied contents of the exercise class and can reliably reproduce and discuss all presented aspects.

Submodule assessment	Written examinations and scientific protocol.
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. Kirsten Jung
Language	German
Additional information	

WP 5.0.4 to WP 5.0.6: Lecture and Exercises in Genetics 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	WP 5.0.4 Genetics 1 (U1BE)	WiSe	30 h (2 SWS)	60 h	(3)
Exercise	WP 5.0.5 Exercises to the lecture Genetics 1 (U1BJ)	WiSe	15 h (1 SWS)	15 h	(1)
Exercise	WP 5.0.5 Exercise Genetics 1 (U1BF)	WiSe	30 h (2 SWS)	30 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 module with compulsory courses.
Applicability of the submodule to other degree programs	• Bachelor program in Biology • Educationprogramin Biology
Elective guidelines	s. WP 5
Entry requirements	none
Study pathway level	Recommended semester: 5
Duration	The course spans 1 semester.
Content	The lecture series introduces fundamental aspects of genetics. These are in particular; fundamentals of classical genetics, the structure of nucleic acids, the central dogma of molecular biology, replication, transcription, posttranscriptional modification, genetic code, translation, mutation and DNA repair, recombination, regulation of gene-expression in prokaryotes, E. coli genetics, phage genetics, gene technology, recombinant DNA technology and cloning. The students exercise the contents of the lecture course. This class will focus on the genetics of lower eukaryotes, prokaryotes and phages. Experiments include transformation, conjugation, transduction, complementation, mutagenesis, DNA- repair, as well as some molecular biological techniques such as construction of a gene bank, PCR and molecular diagnostics.
Qualification goals	The students have testable proficiency of lecture series content and ability to apply 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. Martin Parniske
Language	German

Additional information

WP 5.0.7: Structural Biology 2 (T1FL)

Type of the submodule	Optional course.
Applicability of the submodule to other degree programs	Master program in Biochemistry
Elective guidelines	s. WP 5
Entry requirements	Successful participation in Structural Biology 1 (WP 5.0.1).
Study pathway level	Recommended semester: 6
Duration	The course spans 1 semester.
Content	The lecture builds upon the topics covered in the lecture Structural Biology 1 but aims for a more detailed and applied understanding of the experiments and data analysis. Work with primary literature from the field of structural biology is an important part of our teaching.
Qualification goals	Students acquire expertise for work in research: • independent, target-oriented literature search • critical interpretion and evaluation of experimental data • appraisal, presention and discussion of research data and results • integration of the content of a specific scientific publication into the broader context of the subject Structural Biology
Submodule assessment	Written exam or presentation or scientific journal 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. Hopfner
Language	English
Additional information	

WP 5.0.8: Seminar to the Structural Biology Laboratory Course (T1FN)

Type of the submodule	Optional course.
Applicability of the submodule to other degree programs	Master program in Biochemistry
Elective guidelines	s. WP 5
Entry requirements	none
Study pathway level	Recommended semester: 6
Duration	The course spans 1 semester.
Content	In this seminar we discuss the particular methods appleid in the practical course (crystallography, cryo-EM) and the approaches to analyze the data and derive 3D models for biolmolecules.
Qualification goals	The students know the required steps to perform data analysis and build 3D models with structural biology methods. During the entire process, they are able to judge the quality of the measurements and the emerging reconstructions.
Submodule assessment	s. WP 5.0.9
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	Englisch
Additional information	

WP 5.0.9: Structural Biology Laboratory Course (T1FO)

Type of the submodule	Optional course.
Applicability of the submodule to other degree programs	Master program in biochemistry
Elective guidelines	s. WP 5
Entry requirements	Successful participation in Structural Biology 1 (WP 5.0.1).
Study pathway level	Recommended semester: 6
Duration	The course spans 1 semester.
Content	With the help of available raw data and powerful computers students perform 3D models based on cryo-EM and crystallographic experiments. In close collaboration with tutors, students are introduced to the corresponding software packages and appreciate their use.
Qualification goals	Students are able to independently perform (relatively simple) 3D reconstructions based on high-quality experimental data. They can transfer their knowledge to new problems in structural biology and suggest strategies for data analysis and reconstructions.
Submodule assessment	Written report on or assessment of the practical laboratory course or written report on and assessment of the practical laboratory course
Grading	The course is graded.
Requirements for granting ECTS-Points	ECTS-points are awarded for passing the lab course.
Responsible person	Prof. Hopfner
Language	English
Additional information	

WP 5.0.10 and WP 5.0.11: Lecture and Exercises in Animal Physiology

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	WP 5.0.10 Animal Physiology (U1BO)	SoSe	23 h (1,5 SWS)	37 h	(2)
Exercise	WP 5.0.11 Exercises to Animal Physiology (U1BP)	SoSe	57 h (3,75 SWS)	63 h	(4)

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 module with compulsory courses.
Applicability of the submodule to other degree programs	• Bachelor program in Biology • Education program in Biology
Elective guidelines	s. WP 5
Entry requirements	none
Study pathway level	Recommended semester: 6
Duration	The course spans 1 semester.
Content	The lecture course introduces in basic aspects of animal physiology, these are in particular: osmoregulation, muscle physiology, heart- and circulation physiology, ion transport with membranes and nernst- equilibrium, simulation of neurons (PC), vision, hearing and EEG. Contents are experiments to the topics of the lecture course.
Qualification goals	The students are proficient in the contents of the lecture course and are able to transfer the knowledge to current problems. The students understand the theoretical and applied contents of the exercise class and can reproduce them surely.
Submodule assessment	Written examination and a scientific protocol.
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. Lutz Wiegrebe
Language	German
Additional information	

WP 5.0.12 and WP 5.0.13: Lecture and Exercises in Cell Biology 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	WP 5.0.12 Cell Biology 1 (U1BQ)	SoSe	30 h (2 SWS)	60 h	(3)
Exercise	WP 5.0.3 Exercises to the lecture Cell Biology 1 (U1BD)	SoSe	45 h (3 SWS)	45 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 module with compulsory courses.
Applicability of the submodule to other degree programs	• Bachelor program in Biology • Education program in Biology
Elective guidelines	s. WP 5
Entry requirements	none
Study pathway level	Recommended semester: 6
Duration	The course spans 1 semester.
Content	The lecture course introduces fundamental aspects of cell biology, these are in particular: the cell, bio membranes, compartimentation, function and organisation of compartimentation and of organelles, cytosol, nucleus, mitochondria, plastids, intracellular membranes as well as special cell types, differentiation, evolution and cell cycle. Within the exercise class experiments are conducted to the following topics: cell compartimentation, marker enzymes, membrane enzymes, GFP, transcription- translation, lipid analysis of different organisms, archaea, animals, plants, bacteria, cytoskeleton, membrane transport, and organelles.
Qualification goals	The students are proficient in the contents of the lecture course and are able to transfer the knowledge to current problems. The students understand the theoretical and applied contents of the exercise class and can reproduce them surely.
Submodule assessment	Written examination and a scientific protocol.

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. Ute Vothknecht, Prof. Dr. Angelika Böttger
Language	German

Additional information

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	This seminar deals with original literature covering various biochemical research areas. The articles are chosen to cover a broad range of biochemical, molecular and structural biology methods.
Qualification goals	In this seminar students learn critically evaluate and present biochemical original literature. The students have to report on and briefly discuss short articles and prepare a written elaboration summarizing the joint course discussion. By a close interaction with the supervisor the students will appreciate and work out the essence of a paper. They develop their skills to judge and critically assess scientific publications.
Submodule assessment	Presentation (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)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.2 (=WP 1.3.2) Inorganic Chemistry 5 (Solid State Chemistry)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.3 (=WP 2.1.1) Organic Chemistry 3 (Bioorganic Chemistry)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.4 (=WP 3.3.1) Physical Chemistry 3 (Statistical Thermodynamics)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.5 (=WP 3.3.2) Physical Chemistry 4 (Biophysical Chemistry)	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.6 (=WP 4.3.1) Biochemistry 4	WiSe	45 h (3 SWS)	105 h	(5)
* Exercise	P 12.0.7 (=WP 3.3.2) Exercises to the lecture Biochemistry 4	WiSe	15 h (1 SWS)	15 h	(1)
Lecture	P 12.0.8 (=WP 5.0.1) Structural Biology 1	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.9 Structural Analysis	WiSe	60 h (4 SWS)	75 h	(4,5)
* Exercise	P 12.0.10 Exersices to the lecture Structural Analyses	WiSe	15 h (1 SWS)	30 h	(1,5)
Lecture	P 12.0.12 Quantum Chemistry 1 / Theoretical Chemistry 3	WiSe	30 h (2 SWS)	90 h	(4)
* Exercise	P 12.0.13 Exercises to the lecture Quantum Chemistry 1 / Theoretical Chemistry 3	WiSe	30 h (2 SWS)	30 h	(2)
Lecture	P 12.0.14 Subject specific enhancement	WiSe/ SoSe	45 h (3 SWS)	75 h	(4)
* Exercise	P 12.0.15 Exercises for subject specific enhancement	WiSe/ SoSe	30 h (2 SWS)	30 h	(2)
Lecture	P 12.0.16 (=WP 5.0.2) Microbiology	WiSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.17 (=WP 5.0.4) Genetics 1	WiSe	30 h (2 SWS)	60 h	(3)
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	WiSe	45 h (3 SWS)	75 h	(4)
* Exercise	P 12.0.22 Exercise to the lecture Quantum Mechanics	WiSe	15 h (1 SWS)	45 h	(2)
Lecture	P 12.0.23 Lecture of Astronomy, Astrophysics, Cosmology	WiSe	45 h (3 SWS)	75 h	(4)
* Exercise	P 12.0.24 Exercise to the lecture ofAstronomy, Astrophysics, Cosmology	WiSe	15 h (1 SWS)	45 h	(2)
Lecture	P 12.0.25 Lecture of Molecular Biophysics, Statistical Physics	WiSe	45 h (3 SWS)	75 h	(4)
* Exercise	P 12.0.26 Exercise to the lecture of Molecular Biophysics, Statistical Physics	WiSe	15 h (1 SWS)	45 h	(2)
Lecture	P 12.0.27 Lecture to Solid State Physics and Nanophysics	WiSe	45 h (3 SWS)	75 h	(4)
* Exercise	P 12.0.28 Exercise to the lecture to Solid State Physics and Nanophysics	WiSe	15 h (1 SWS)	45 h	(2)
Lecture	P 12.0.29 Introduction to Informatics: Systems and Applications	WiSe	30h (2 SWS)	60 h	3
* Exercise	P 12.0.30 Exercise to the lecture Introduction to Informatics: Systems and Applications	WiSe	45 h (3 SWS)	45 h	3
Lecture	P 12.0.31 Introduction to Meteorology 2	WiSe	45 h (3 SWS)	75 h	(4)
* Exercise	P 12.0.32 Exercise to the lecture Introduction to Meteorology 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)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.35 (=WP 2.1.2) Organic Chemistry 4 (Organometallic Chemistry)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.36 (=WP 2.1.3) Organic Chemistry 5 (Theoretial Concepts in Organic Chemistry)	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.37 (=WP 3.3.3) Physical Chemistry 5 (ModernDevelopments in Physical Chemistry)	SoSe	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)
Lecture	P 12.0.39 (=WP 5.0.7) Structural Biology 2	SoSe	30 h (2 SWS)	60 h	(3)
Seminar	P 12.0.40 (=WP 5.0.14) Literature and Methods Seminar in Biochemistry	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.41 (=WP 5.0.10) Animal Physiology	SoSe	22,5 h (1,5 SWS)	67,5 h	3
Lecture	P 12.0.42 (=WP 5.0.12) Cell Biology 1	SoSe	30 h (2 SWS)	60 h	(3)
Lecture	P 12.0.44 Quantum Chemistry 2 / Theoretical Chemistry 4	SoSe	30 h (2 SWS)	90 h	(4)
* Exercise	P 12.0.45 Exercises to the lecture Quantum Chemistry 2 / Theoretical Chemistry 4	SoSe	30 h (2 SWS)	30 h	(2)
Seminar	P 12.0.47 Patent Law	WiSe/ SoSe	30 h (2 SWS)	60 h	(3)
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	SoSe	45 h (3 SWS)	75 h	(4)
Lecture	P 12.0.51 Exercise to the lecture Introduction to Metereology I	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 to 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 12.0.9-12.0.53
Qualification goals	The students will be lead in the lectures to new topics in chemistry or related fields. Hereby, they extend their knowledge with current and specific information. The information should be sorted into existing knowledge to discuss scientific questions.
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	Prof. Dr. Regina de Vivie-Riedle
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 to 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 crystallography, solid state NMR spectroscopy, and diverse diffraction methods. The students exercise the contents of the lecture course with problem sets.
Qualification goals	The students have command of the contents of the lecture course and are able to transfer the knowledge to current problems. The understanding of the contents of the lecture course is deepened, the generalization of knowledge is promoted.
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	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 to 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	The lecture provides an overview of quantum-chemical methods for calculating molecular systems: Hartree-Fock (HF); density-functional theory (DFT); configuration interaction (CI); second quantization formalism; coupled cluster (CC). 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.
Qualification goals	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. 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.
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:** • 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 Discipline 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 Discipline Specific General Education (T1EV)	WiSe/ SoSe	30 h (2 SWS)	75 h	(4)
Übung	P 12.0.15 Exercise to the lecture Discipline 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 thesub- 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	Contents are continuative theoretical and practical knowledge adopted to chemistry. The goal is to obtain a broad scientific education with specific content.
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 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	Prof. Dr. Regina de Vivie-Riedle
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	The module provides knowledge in the basic principles of pharmacology and toxicology and covers the mechanisms of various drug actions. • Survey of pharmacodynamics and pharmacokinetics • Principle mechanisms by which drugs affect physiology and biochemistry of different biological systems • Basic principles of toxicology (toxic compounds; treatment of poisonings)
Qualification goals	The aim of this course is to provide students with an understanding of basic pharmacology and toxicology and the ability to critically analyze a pharmacological problem.
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
Language	German
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 to 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	Concepts and theoretical methods of quantum mechanics: Physical principles of quantum mechanics, mathematical representations, Schrödinger, Heisenberg and interaction picture, orbital angular momentum and spin, application to quantum systems (e.g. harmonic oscillator, H-atom). Tutorials accompanying the lecture series
Qualification goals	Substantial learning targets are the knowledge and the comprehension of the above mentioned issues and the required mathematics for this as well as the ability to use and to combine them. Moreover, the familiarity with methods of theoretical physics and the ability of modelling and to 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	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 to 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 12.0.25 and P 12.0.26: Lecture and Exercise in Molecular Biophysics, Statistical 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 12.0.25 Molecular Biophysics, Statistical Physics (W1.B1)	WiSe	45 h (3 SWS)	75 h	(4)
Exercise	P 12.0.26 Exercise to the lecture Molecular Biophysics, Statistical Physics (W1.B2)	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 inPhysics
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 "molecular biophysics, statistical physics" 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	Dean of studies in physics
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 to 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	Contents are fundamentals of solid state physics: crystal structures, lattice vibrations, electronic properties of crystalline solids, optical and magnetic properties of solids. The understanding of the lecture course is deepened in tutorials.
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. U. Kleineberg

Language	German

Additional information

P 12.0.29 and P 12.0.30: Lecture and Exercise Introduction to Informatics: Programming and Software Engineering

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 Introduction to Informatics: Systems and Applications	WiSe	30h (2 SWS)	60 h	3
Exercise	P 12.0.30 Exercise to the Introduction to Informatics: Systems and Applications	WiSe	45 h (3 SWS)	45 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 inInformatics
Elective guidelines	none
Entry requirements	none
Study pathway level	Recommended semester: 5
Duration	The course spans 1 semester.
Content	The lecture introduces in particular data types, functions and recursion, evaluation and termination of programs, halting problem, semantics of programming languages. The concepts introduced in the lecture are practiced with concrete examples.
Qualification goals	The students should achieve a deeper understanding of ideas and principles of data modelling and constructs and phenomena in programming languages. Practical experience with data modelling and functional programming languages is acquired.
Submodule assessment	Written or oral examination.
Grading	The course is graded.
Requirements for granting ECTS-	ECTS-points are awarded for passing the exam, which is

Points	allocated to the module.
Responsible person	Prof. Dr. Christian Böhm
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, geostropic 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. Tutorials accompanying the lecture series.
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 (Z1ZF)

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	In the seminar „Geschäftsplanung" (Business Planning) you learn to think and act like an entrepreneur. In small teams you write a business plan for an own business idea. You are welcome to mention first ideas already when registering for the course. In the seminar you will learn business administration basics, e.g. Market and Competition Analysis, Marketing and Sales, Financial Planning. The seminar is conducted by entrepreneurial lecturers from the LMU Entrepreneurship Center, supported by experienced guest speakers from the field of Entrepreneurship.
Qualification goals	The goal is to sharpen entrepreneurial thinking and acting, to empower the seminar participants to found their own company or acta s „intrapreneurs" within a company or team - with theoretical background and practical tools.
Submodule assessment	Manuscript and presentation, in detail: Written business plan, several midterm and a final presentation in teams.
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	Dr. Robert Redweik
Language	German
Additional information	www.entrepreneurship-center.lmu.de/geschaeftsplanung

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	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. Part 2: 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. Separation of the stationary Schrödinger equation for the nuclei in the case of electronically coupled and uncoupled states. Presentation of various search algorithms to locate minima, transition states and minimum energy paths. Advanced methods for electron correlation and to describe electronically excited states. The focus is on configuration interactions and related methods like Complete

	Active Space –SCF. 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.
Qualification goals	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. Exercise: The students are able to solve optimization problems for selected examples of model potentials and are able to calculate minimum energy pathways for these 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 analyze 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 module.
Responsible person	Prof. Dr. C. Ochsenfeld, Prof. Dr. R. de Vivie-Riedle
Language	German
Additional information	**Literature:** • 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 12.0.47: Patent Law (T1FP)

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 and 6
Duration	The course spans 1 semester.
Content	**Content of Teaching:** • Introduction into Patent Law, historic developement of Patent Law and international conventions for the protection of intellectual property • Requirements for grant of a patent; patent filing process to the German and European Patent Office • Rights of the patentee, the inventor and the employed inventor • Impact of patent right, patent infringement, claims of patentee in case of patent infringements • Court procedure with patent infringements and nullity actions • Introduction into utility model right **Learning Target:** Understandig of the principles of German and European Patent Law. Basic knowledge of patent filing process and patent grant requirements. As well as content, scope and restrcitions of Patent Law. Possession of principles of utility model right. The understanding of Patent Law for science and technology as well as a functioning economic system is aimed.
Qualification goals	• Basic knowledge of the German and European Patent System • Knowledge of patent grant requirements • Basic skills of patent filing process to German and European Patent Offices • General acquirements of court proceedings in case of patent infringements and nutility actions
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. Hansen
Language	German
Additional information	**Recommended literature:** • Ilzhöfer, Volker: Patent-, Marken- und Urheberrecht, 7. Auflage, München 2007 • Osterrieth, Christian: Patentrecht, 3. Auflage, München 2007

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: 5
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. Tutorials accompanying the lecture series
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 Atomicand 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 electrical and magnetic fields, X-rays, simple molecules, spectroscopic techniques. Tutorials accompanying the lecture series
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 experimental methods and the ability to interpret the experimental results, either verification or falsification are general learning targets. The students should become aware of the association to phenomena in nature as well as to current research.
Sub-mdule 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

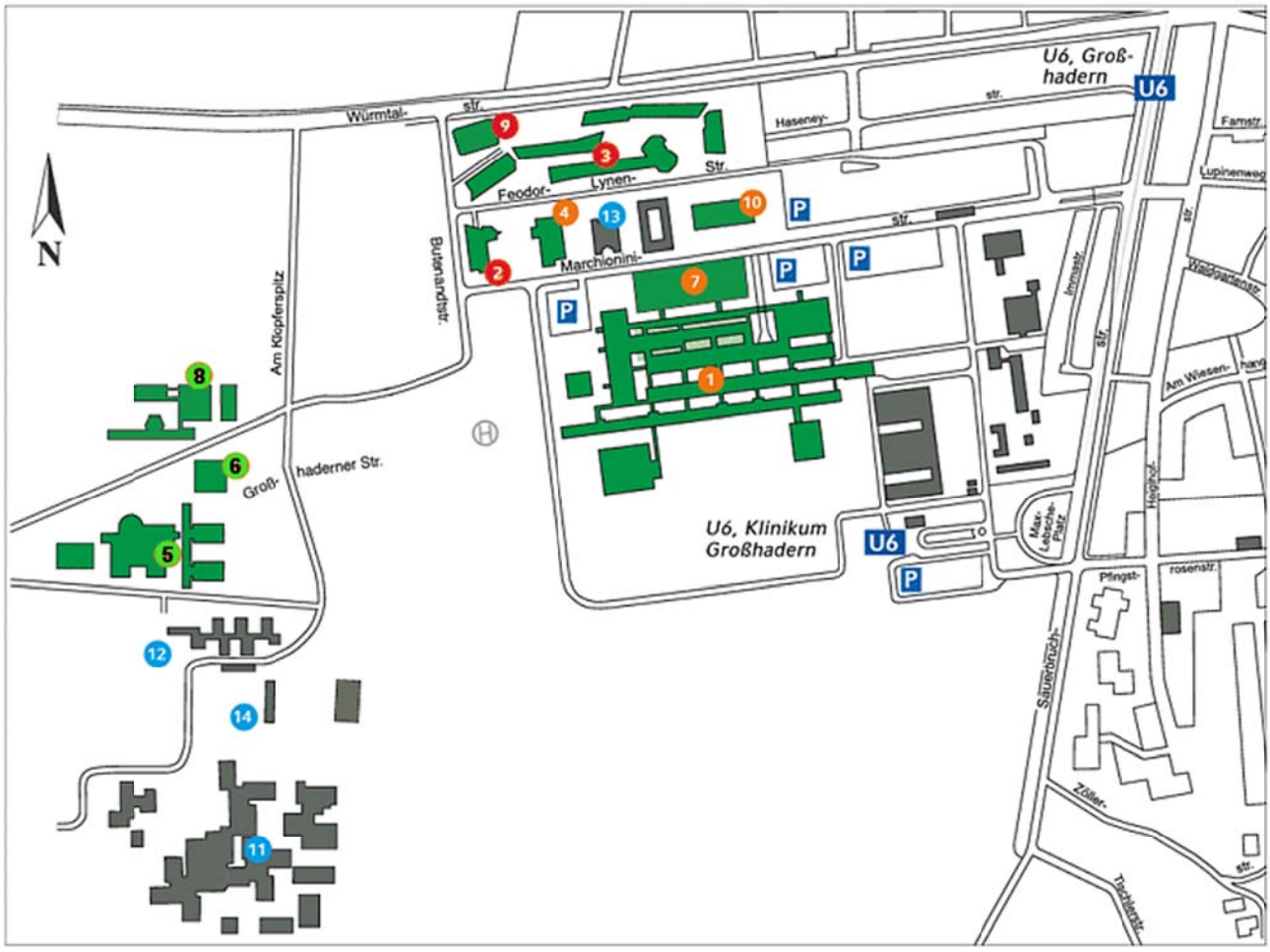
This module is comprised of 12 ECTS-points. Total time, including self-directed studies, is about 360 hrs.

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	Focus of the thesis is the work on a special chemical/biochemical question, including a written scientific report.
Qualification goals	Competence to compile and present a focused topic during 10 weeks in a complete manner. Ability to work in a team or a project. The students get theoretical and practical understanding in specific challenges in chemistry and biochemistry. They may design and realize experiments correctly, as well as present and discuss the results in a report in form and content properly.
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	Prof. Dr. Regina de Vivie - Riedle
Language	German/English

Additional information

Map of the area of the HighTechCampus^{LMU} Großhadern

Address:
Ludwig-Maximilians-Universität München
Fakultät für Chemie und Pharmazie
Butenandtstr. 5-13
81377 Munich / Germany



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