Module Handbook

Master of Science Chemistry

Contents / Modules

available only in German language

Specialisation 1 „Applied Analytical Chemistry“

Module 1.1	**1.1 Applied Analytical Chemistry**					**[Modul-Kennnummer]**
Mandatory or elective Module	**Mandatory in the specialisation „Advanced Analytical Chemistry“ or elective**					
Creditpoints (LP) and workload	**6 LP = 180 h**					
Module duration (according to course plan)	**1 Semester**					
Courses/ Learning formats	**Type**	**Regular term when starting in Winter term (Summer term)**	**Mandatory/ elective**	**Contact Time (SWH)**	**Self Study**	**Creditpoints**
a) Lecture „ Environmental Analytical Chemistry”	L	2 (1)	M	2	69 h	3
b) Lecture „Tools for Material Analysis”	L	2 (1)	M	2	69 h	3
In order to complete the module, you have to fulfil the following requirements:						
Compulsory Attendance						
Active participation	According to § 5 para. 3					
Coursework						
Module examination	Usually written exam (120 min), alternatively oral exam (30 min) on the contents of a) and b)					

Qualification Goals, learning outcome, competences

The students have acquired analytical knowledge in the field of organic analysis and elemental analysis, especially in the special fields of atmospheric research, environmental and material analysis, they can reproduce these according to scientific standards and can transfer the concepts to analogous problems. The students can integrate the knowledge acquired in the lecture into their already existing knowledge and reproduce and evaluate it in a larger context.

The students are able to:

- Reproduce principles for the detection of organic and inorganic analytes in trace concentrations
- identify the fields of application of analytics, such as materials analysis, environmental analysis and atmospheric chemistry, and forensic analysis
- critically analyze and evaluate analytical results from a chemometric point of view
- reproduce the basics of quality control
- understand forensic issues and gain insight into the basics of forensic trace analysis
- relate keywords such as greenhouse gases, climate impact, trace and ultra-trace analysis, on-site analysis or miniaturization of analytical systems to possible analytical methods
- to evaluate analytical methods and to select and develop suitable instrumental methods and procedures according to a set trace analytical task
- to understand the factual knowledge published in analytical textbooks as well as in international journals and to critically evaluate this material

Contents

a) Fundamentals of environmental analysis (water, air) and atmospheric chemistry, ozone formation, ozone hole, special analytical techniques in atmospheric science, in-situ techniques, aerosol analysis.
b) Fundamentals of elemental mass spectrometry, importance of sample preparation and sample introduction techniques, ion sources in mass spectrometry, interface design, mass analyzers, detectors, calibration and evaluation techniques.
Examples of applications of mass spectrometric and other techniques in forensic analysis, environmental and materials analysis.

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	6/66 or 0/66; as elective module: not graded
Frequency of module offer	Only in the summer term

Reasons for compulsory attendance	
Person responsible for the module	Univ.-Prof. Thorsten Hoffmann
Transferability of the module to other degree programs	
Other	

Module 1.2	1.2 Trace Analysis I	[Modul-Kennnummer]
Mandatory or elective Module	**M in the specialisation „Advanced Analytical Chemistry“ or elective**	
Creditpoints (LP) and workload	**6 LP = 180 h**	
Module duration (according to course plan)	**1 Semester**	

Courses/ Learning formats	Type	Regular term when starting in Winter term (Summer term)	Mandatory/ elective	Contact Time (SWH)	Self Study	Creditpoints
a) Lecture „Inorganic Trace and Species Analysis“	L	1 (2)	M	2	69 h	3
b) Lecture „Organic Trace Analysis“	L	1 (2)	M	2	69 h	3

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	
Active participation	According to § 5 para. 3
Coursework	
Module examination	Usually written exam (120 min), alternatively oral exam (30 min) on the contents of a) and b)

Qualification Goals, learning outcome, competences

Building on the analytical content and working techniques already learned in the bachelor's program, students acquire special expertise in the field of advanced instrumental trace analysis. The contents are acquired and deepened in the form of two lectures on organic trace analysis and elemental analysis. Newly acquired knowledge is always integrated into the existing knowledge.

The students are able to:

- reproduce principles for the separation and detection of organic and inorganic analytes
- identify the main areas of application of analysis, such as environmental analysis, technical and industrial analysis, species analysis, medical and diagnostic analysis
- relate keywords such as food safety or water contamination, doping tests, genetic analysis or authenticity detection to the methods used
- evaluate analytical methods and select and develop suitable instrumental methods and procedures according to a set trace analytical task
- to understand the expertise published in analytical textbooks as well as in international journals and to critically evaluate this material

Contents

a) Sampling of organic analytes, preconcentration techniques, head-space techniques, gas and liquid chromatography, electrophoretic separation techniques, bioanalytical separation techniques, miniaturisation of separation techniques, basics of organic mass spectrometry, ionisation techniques, mass spectrometric analysers, applied organic trace analysis (bioanalysis, environmental analysis, forensic analysis).
b) Physical fundamentals of atomic spectrometry, atomic absorption spectrometry, mono-/polychromators, detectors, high-resolution AAS, atomic emission spectrometry with flames and plasmas, sample introduction techniques, arc and spark discharges, microwave plasmas, laser plasmas, atomic and X-ray fluorescence, X-ray fluorescence analysis, total reflection X-ray fluorescence analysis.

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	6/66 or 0/66; as elective: not graded
Frequency of module offer	Only in the winter term
Reasons for compulsory attendance	
Person responsible for the module	Univ.-Prof. Nicolas. H. Bings
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry
Other	

Module 1.3	1.3 Trace Analysis II	[Modul-Kennnummer]

Mandatory or elective Module	**Mandatory in specialisation „Advanced Analytical Chemistry“ or elective**					
Creditpoints (LP) and workload	**6 LP = 180 h**					
Module duration (according to course plan)	**1 Semester**					
Courses/ Learning formats	**Type**	**Regular term** when starting in **Winter term (Summer term)**	**Mandatory/ elective**	**Contact Time (SWH)**	**Self Study**	**Creditpoints**
a) Practical course „Trace Analysis II“	APr	2 (1)	M	4	78 h	4
b) Supporting Seminar to a)	Seminar	2 (1)	M	2	39 h	2
In order to complete the module, you have to fulfill the following requirements:						
Compulsory Attendance	APr, S					
Active participation	According to § 5 para. 3					
Coursework						
Module examination						

Qualification Goals, learning outcome, competences

Building on analytical contents and working techniques already learned in the Bachelor's degree programme, students acquire special expertise in the field of advanced instrumental trace analysis in the module Instrumental Trace Analysis II (practical course). The contents are developed, deepened and practically implemented in the form of an advanced practical course on organic trace analysis and elemental analysis and a lecture seminar. Newly acquired knowledge is always integrated into the existing knowledge. The students acquire in-depth knowledge of the current methods of instrumental trace analysis (chromatography, atomic spectrometry, molecular spectroscopy, mass spectrometry).

The students are able to:

- apply advanced analytical-instrumental working techniques
- statistically evaluate recorded measurement data
- carry out trace analysis work independently and on their own responsibility
- scientifically record, interpret and present the results of their experiments
- agree on individual work steps when working in groups of two, to plan them together and to implement them in a coordinated manner
- realise demanding research-related experiments in parallel within a time window (self-, time- and resource management)
- analyse and evaluate current scientific literature
- independently prepare and present a scientific Presentation on a (given) current analytical-chemical topic.

Contents

a) Experiments in groups of two on the determination of organic analytes by means of GC-MS and HPLC-MS (mode of operation, set-up, column types, ionisation techniques, detectors, analysers, MS/MS, derivatisation), by means of ambient MS (set-up and mode of operation of corresponding ion sources, advantages and disadvantages, areas of application), and by means of aerosol mass spectrometry (AMS). Experiments in groups of two on inorganic trace analysis based on analyte samples of different matrices by means of mass and emission spectrometry in connection with inductively coupled plasma (ICP-OES, ICP-MS) and X-ray spectroscopy (TXRF). Consideration of different sample preparation/digestion methods and systems of sample introduction.
b) Current analytical-chemical topics are discussed. The students independently prepare a scientific presentation on one of these given topics and present it within the framework of the seminar. Independent research and evaluation of relevant literature are important.

Compulsory entrance requirements	Module „Trace Analysis I“
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	Not graded

Frequency of module offer	Only in the summer term
Reasons for compulsory attendance	According to HochSchG § 26 para. 2 (7), Practical Course; Practical Course accompanying upper seminar according to § 5 para. 5: Discussion of safety-relevant details of and discussion of practical course experiments.
Person responsible for the module	Univ.-Prof. Nicolas H. Bings
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry
Other	

Module 1.4	**1.4 Radiochemical Analysis**					**[Modul-Kennnummer]**
Mandatory or elective Module	**Mandatory in the specialisation „Advanced Analytical Chemistry“ or elective**					
Creditpoints (LP) and workload	**6 LP = 180 h**					
Module duration (according to course plan)	**1 Semester**					
Courses/ Learning formats	**Type**	**Regular term when starting in Winter term (Summer term)**	**Mandatory/ elective**	**Contact Time (SWH)**	**Self Study**	**Creditpoints**
a) Lecture „Radiochemical Analysis”	L	1 (2)	M	3	103,5 h	4,5
b) Supporting practical exercise to a)	E	1 (2)	M	1	34,5 h	1,5
In order to complete the module, you have to fulfil the following requirements:						
Compulsory Attendance	E					
Active participation	According to § 5 para. 3					
Coursework						
Module examination	Usually written exam (120 min), alternatively oral exam (30 min)					

Qualification Goals, learning outcome, competences

The students are able to:

- - to reproduce the mode of operation of the various detectors for the measurement of α-, β-, γ-radiation and of neutrons and to compare their possible applications
- - to select the most suitable measuring method for specific radioanalytical problems and, if necessary, to combine it with other analytical methods
- - to evaluate measured α-, β- and γ-spectra independently and to interpret the results
- - state what information XPS spectra and XAFS spectra contain and are able to evaluate the measurement data in basic terms

Contents

a) Measurement of nuclear radiation: activity and count rate, gas-filled detectors (ionization chamber, proportional counter, Geiger-Müller counter), scintillation detectors, semiconductor detectors, neutron counters, track detectors, detectors in radiation protection; statistical considerations in radioactivity measurements; special analytical methods: Ultra-trace analysis using neutron activation, β-delayed neutrons and RIMS; surface analysis using XPS, TOF-SIMS, laser SNMS; X-ray absorption spectroscopy (XANES, EXAFS) of radioactive samples using synchrotron radiation.
b) Exercises deepen the material of the lecture; the students learn the evaluation of α-, β- and γ-spectra by means of the program GENIE 2000 and of XPS and XAFS spectra by means of the program packages CasaXPS and EXAFSPAK, respectively.

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	6/66 or 0/66; as elective module: not graded
Frequency of module offer	Only in the winter term

Reasons for compulsory attendance	According to HochSchG § 26 para. 2 (7), practical exercise
Person responsible for the module	Univ.-Prof. Tobias Reich
Transferability of the module to other degree programs	
Other	Recommended Literature: Radiation Detection in Handbook of Nuclear Chemistry, vol. 5 (eds. A. Vertés, S. Nagy, Z. Klencsár, R.G. Lovas, and F. Rösch), Springer (2011).

Specialisation 2 „Nuclear Chemistry“

Module 2.1	**2.1 Introduction in Nuclear Chemistry**					**[Modul-Kennnummer]**
Mandatory or elective Module	**Mandatory in the specialisation „Nuclear Chemistry“ (without prior knowledge) or elective**					
Creditpoints (LP) and workload	**6 LP = 180 h**					
Module duration (according to course plan)	**1 Semester**					
Courses/ Learning formats	**Type**	**Regular term** when starting in **Winter term (Summer term)**	**Mandatory/ elective**	**Contact Time (SWH)**	**Self Study**	**Creditpoints**
a) Lecture „Introduction in Nuclear Chemistry”	L	1 or 2 (1 or 2)	M	2	69 h	3
b) Supporting exercise to a)	E	1 or 2 (1 or 2)	M	1	34,5 h	1,5
c) Supporting Seminar to a)	S	1 or 2 (1 or 2)	M	1	34,5	1,5
In order to complete the module, you have to fulfil the following requirements:						
Compulsory Attendance	S					
Active participation	According to § 5 para. 3					
Coursework						
Module examination	Usually written exam (120 min), alternatively oral exam (30 min)					
Qualification Goals, learning outcome, competences						
The students are able to: • reproduce the basics of nuclear and radiochemistry • to work out special topics of applied nuclear chemistry on their own, to point out correlations and to reproduce them • to become familiar with the radiation protection and legal boundary conditions for handling radioactive materials						
Contents						
a) history of radioactivity / structure of atom and nucleus: mass and binding energy of nuclei, nucleon-nucleon interaction, liquid droplet model and shell model / instability of nuclei and nuclear transformation principles / mathematical relations of transformations, units of radioactivity, natural radionuclides / primary transformations: α-conversion, β-conversion, cluster radioactivity, spontaneous fission / secondary conversions: electromagnetic transitions, conversion electrons / post effects: Annihilation, X-rays, Auger electrons / interaction with matter: photoelectric effect, Compton effect, pair formation / measurement of nuclear radiation: different types of detectors / nuclear reactions: Energetics, cross section, direct reactions, compound nuclei, heavy ion reactions, high energy reactions, induced fission. b) In the exercises, exercise assignments are calculated. c) Presentations will be given on topics that complement the lecture content, e.g..: α-/β-/ɣ-spectrometry; Radiometric age determination; Discovery and properties of the neutron; Discovery of nuclear fission; Natural radioactivity in the environment; The tracer principle and its applications in chemistry and medicine; Particle accelerators; Production and application of radionuclides in life sciences; Nuclear medicine diagnostics; Biological radiation effects; Nuclear reactor design and operation; Neutron activation analysis; Nuclear fuel cycle; The Chernobyl and Fukushima reactor disasters; Nuclear fusion; Production and properties of transuranium elements; Solar and atmospheric neutrinos.						
Compulsory entrance requirements						
Recommended participation requirement(s) for the module and/or individual courses of the module						
Language(s) of instruction and examination	German					
Weight of the module grade in the overall grade	6/66 or 0/66; as elective module: not graded					
Frequency of module offer	Every term					
Reasons for compulsory attendance	Seminar according to § 5 para. 5: The learning objectives are based on direct interaction between students. In addition to practical professional competence, important learning objectives are literature research, presentation and discussion skills.					
Person responsible for the module	Univ.-Prof. Tobias Reich					

Transferability of the module to other degree programs	Bachelor of Science Biomedical Chemistry, Bachelor of Science Chemistry, Bachelor of Science Geoscience, Master of Science Biomedical Chemistry, Master of Science Physics
Other	Recommended Literature: • J.-V. Kratz, K. H. Lieser: Nuclear and Radiochemistry, Wiley-VCH, 2013 • F. Rösch: Nuclear and Radiochemistry, De Gruyter, 2014 • Vértes, S. Nagy, Z. Klencsár, R. G. Lovas, F. Rösch (Eds.), Handbook of Nuclear Chemistry, Springer, 2011

Module 2.2	2.2 Lab Course Nuclear Chemistry 1	[Modul-Kennnummer]
Mandatory or elective Module	**Mandatory in the specialisation „Nuclear Chemistry“ (without or only with theoretical prior knowledge) or elective**	
Creditpoints (LP) and workload	**6 LP = 180 h**	
Module duration (according to course plan)	**1 Semester**	

Courses/ Learning formats	Type	Regular term when starting in Winter term (Summer term)	Mandatory/ elective	Contact Time (SWH)	Self Study	Creditpoints
a) Lab Course „Nuclear Chemistry 1”	APr	1 or 2 (1 or 2)	P	6	72 h	4,5
b) Supporting Seminar to a)	S	1 or 2 (1 or 2)	P	1	34,5h	1,5

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	APr, S
Active participation	According to § 5 para. 3
Coursework	
Module examination	Oral exam (30 minutes, not graded)

Qualification Goals, learning outcome, competences

The students are able to:

- deal with overt radioactivity and analyse different radioelements using measurement techniques for radioactive radiation
- describe the basics of dosimetry and practical radiation protection
- to plan and carry out work processes on their own responsibility within a given period of time using effective time and resource management
- to organise themselves in small groups and to work together effectively

Contents

Production and handling of radioactive preparations, measurement of alpha, beta, gamma radiation, mother-daughter equilibrium, interaction of radiation with matter, gamma spectroscopy, dosimetry and radiation protection, basics of positron emission tomography, nuclear reactions with neutrons, detection of nuclear fission, application of radioisotopes, chemical behaviour of neptunium.

Compulsory entrance requirements	Module „Introduction in nuclear Chemistry“
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German
Weight of the module grade in the overall grade	Not graded
Frequency of module offer	Every term
Reasons for compulsory attendance	In accordance with HochSchG § 26 para. 2 (7), practical course; seminar accompanying practical course in accordance with § 5 para. 5: discussion of safety-relevant details of and discussion of practical course experiments.
Person responsible for the module	Univ.-Prof. Thorsten Hoffmann
Transferability of the module to other degree programs	Bachelor of Science Biomedical Chemistry, Bachelor of Science Chemistry, Bachelor of Science Geoscience, Master of Science Biomedical Chemistry, Master of Science Physics
Other	Recommended Literature: • P. Hoffmann, K. H. Lieser: Methoden der Kern- und Radiochemie, VCH 1991 • W. Stolz: Radioaktivität, Teubner, 2005 • H.-G. Vogt, H. Schultz: Grundzüge des praktischen Strahlenschutzes, Hanser, 2011

Module 2.3	2.3 Modern Methods and Applications of Nuclear and Radiochemistry	[Modul-Kennnummer]

Mandatory or elective Module	**Mandatory in the specialisation „Nuclear Chemistry“ or elective**
Creditpoints (LP) and workload	**6 LP = 180 h**
Module duration (according to course plan)	**1 Semester**

Courses/ Learning formats	Type	Regular term when starting in Winter term (Summer term)	Mandatory/ elective	Contact Time (SWH)	Self Study	Creditpoints
a) Lecture „Modern Methods and Applications of Nuclear and Radiochemistry”	L	1(2)	M	3	103,5 h	4,5
b) Supporting exercise to a)	E	1(2)	M	1	34,5 h	1,5

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	
Active participation	According to § 5 para. 3
Coursework	
Module examination	Usually oral exam (30 min), alternatively written exam (120 min)

Qualification Goals, learning outcome, competences

The students are able to:

- reproduce the important methods and applications of modern nuclear and radiochemistry.

Contents

a) The following areas are treated as modern methods and applications of nuclear and radiochemistry: Discovery of light radioelements; radioactivity in the life sciences; nuclear fuel cycle and environmental behaviour of actinides; synthesis of radioelements in the nuclear reactor, at particle accelerators and in astrophysical processes; applications of exotic radioisotopes in basic research; age determination; physics of ultracold neutrons; modern methods of isotope separation and enrichment.
b) In the exercises, the material of the lecture "Modern Methods and Applications of Nuclear and Radiochemistry" is deepened through exercises and short presentations.

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	Modules „Introduction to Nuclear Chemistry“ and „Lab Course Nuclear Chemistry 1“
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	6/66 or 0/66; as elective module: not graded
Frequency of module offer	Only in the winter term
Reasons for compulsory attendance	
Person responsible for the module	Univ.-Prof. Michael Block
Transferability of the module to other degree programs	Master of Science Physics
Other	Recommended Literature: • Vértes, S. Nagy, Z. Klencsár, R. G. Lovas, F. Rösch (Eds.), Handbook of Nuclear Chemistry, Springer, 2011

Module 2.4	2.4 Chemistry and Physics of Actinides and Transactinides	[Modul-Kennnummer]

Mandatory or elective Module	**Mandatory in the specialisation „Nuclear chemistry“ (with only theoretical prior knowledge or with theoretical and practical prior knowledge) or elective**
Creditpoints (LP) and workload	**6 LP = 180 h**
Module duration (according to course plan)	**1 Semester**

Courses/ Learning formats	**Type**	**Regular term when starting in Winter term (Summer term)**	**Mandatory/ elective**	**Contact Time (SWH)**	**Self Study**	**Creditpoints**
a) Lecture „Chemistry and Physics of Actinides and Transactinides”	L	2 (1)	M	3	103,5 h	4,5
b) Supporting exercise to a)	E	2 (1)	M	1	34,5 h	1,5

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	
Active participation	According to § 5 para. 3
Coursework	
Module examination	Usually oral exam (30 min), alternatively written exam (120 min)

Qualification Goals, learning outcome, competences

The students are able to:

- reproduce chemical and physical properties of actinides and transactinides.
- comprehend the discovery of the individual radioelements and modern synthesis methods.

Contents

a) The following topics are covered: Discovery of transuranics; relativistic effects; binary compounds of actinides; coordination chemistry of actinides; aquatic chemistry of plutonium; chemical interactions of actinides in the environment; speciation of actinides and case studies; organometallic complexes of actinides; electron spectra of actinides; magnetic properties of actinides; nuclear synthesis of the heaviest elements (particle accelerators, separators); mass measurements; nuclear and atomic properties from laser spectroscopic methods; ion mobilities; chemistry of transactinides.
b) In the exercises the material of the lecture is supplemented and deepened by exercises and short presentations.

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	Modules „Introduction to Nuclear Chemistry“ and „Lab Course Nuclear Chemistry 1“
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	6/66 or 0/66 (without prior knowledge: 9/66); as elective module: not graded
Frequency of module offer	Only in the summer term
Reasons for compulsory attendance	
Person responsible for the module	Univ.-Prof. Christoph. Düllmann
Transferability of the module to other degree programs	Master of Physics
Other	

Module 2.5	2.5 Radiopharmaceutical Chemistry	[Modul-Kennnummer]
Mandatory or elective Module	**Mandatory in the specialisation „Nuclear Chemistry“ (with only theoretical prior knowledge or with theoretical and practical prior knowledge) or elective in the specialisation „Nuclear Chemistry” (without prior knowledge) or elective**	
Creditpoints (LP) and workload	**6 LP = 180 h**	
Module duration (according to course plan)	**2 Semester**	

Courses/ Learning formats	Type	Regular term when starting in Winter term (Summer term)	Mandatory/ elective	Contact Time (SWH)	Self Study	Creditpoints
a) Lecture „Radiopharmaceutical Chemistry 1”	L	1 (2)	M	2	69h	3
b) Lecture „Radiopharmaceutical Chemistry 2”	L	2 (1)	M	2	69 h	3

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	
Active participation	According to § 5 para. 3
Coursework	
Module examination	Usually oral exam (30 min), alternatively written exam (120 min) on the contents of a) and b)

Qualification Goals, learning outcome, competences

After completing the module, students have understood the basics of radiopharmaceutical chemistry. They have dealt with the most important radiopharmaceutical procedures (SPECT, PET & endoradiotherapy) and the relevant radionuclides and have familiarised themselves with their properties, production and chemistry. In addition, the students should have grasped the high importance of interdisciplinary work in the development of new radiopharmaceuticals.

Contents

The lectures in Radiopharmaceutical Chemistry (RPC) are offered as block courses over 2 semesters. Contents are:

- - Introduction and basics of RPC: decay modes, shielding & detection.
- - preclinical and clinical imaging techniques,
- - radionuclide production in RPC: cyclotron, reactor & generator,
- - radiopharmaceutical procedures in diagnostics and therapy: SPECT, PET & endoradiotherapy,
- - properties, production, labelling chemistry & application of relevant nuclides
- - RPC in oncology, neurology and other fields of application.
- This module builds on the basic knowledge of the lecture "Introduction to Nuclear Chemistry".

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	Module „Introduction to Nuclear Chemistry”
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	6/66 or 0/66 (without prior knowledge: 9/66); as elective module: not graded
Frequency of module offer	a) Only in the winter term b) Only in the summer term
Reasons for compulsory attendance	
Person responsible for the module	Univ.-Prof. Patrick Riß
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry
Other	

Module 2.6	2.6 Internship at the Nuclear Reactor					[Modul-Kennnummer]
Mandatory or elective Module	**Mandatory in the specialisation „Nuclear Chemistry“ (with prior knowledge) or elective**					
Creditpoints (LP) and workload	**6 LP = 180 h**					
Module duration (according to course plan)	**1 Semester**					
Courses/ Learning formats	**Type**	**Regular term** when starting in **Winter term (Summer term)**	**Mandatory/ elective**	**Contact Time (SWH)**	**Self Study**	**Creditpoints**
a) Practical Course „Internship at the Nuclear Reactor“	APr	1 o. 2 (1 o. 2)	M	6	117 h	6

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	APr
Active participation	According to § 5 para. 3
Coursework	
Module examination	Oral exam (30 min), not graded

Qualification Goals, learning outcome, competences
The students receive an introduction to reactor physics and reactor technology as well as radiation protection at the research reactor TRIGA Mainz. In the practical exercises, the typical processes in the operation of TRIGA Mainz are dealt with and experiments are carried out on the reactor. Since the experiments are carried out in small groups, the students learn to plan and implement work processes as a team. In addition, a guided tour of the cyclotron installed at the TRIGA site since 2016 is offered, whereby the students are introduced to the practical application of particle accelerators and their use in the production of radioactive isotopes, especially for the production of radiopharmaceuticals for preclinical and clinical use.
Contents
The practical exercises on reactor technology and physics include: Reactor start-up and shutdown checklist, control rod calibration, fuel element measurement, power control, running the reactor in pulsed mode, excess reactivity measurements. Regarding the use of the reactor as a strong neutron source, experiments on neutron flux measurement, neutron activation analysis and gamma spectroscopy will be carried out.

Compulsory entrance requirements	Module „Introduction to Nuclear Chemistry”, Background check according to § 12 AtG min. 8 weeks before the start of the Practical Course
Recommended participation requirement(s) for the module and/or individual courses of the module	Module “Lab Course in Nuclear Chemistry 1”
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	Not graded
Frequency of module offer	Every term
Reasons for compulsory attendance	According to HochSchG § 26 Para. 2 (7), Practical Course
Person responsible for the module	Dr. Klaus Eberhardt
Transferability of the module to other degree programs	Master of Science Physics
Other	Recommended Literature: • Script for the "Reactor Practical Course

Specialisation 3 „Macromolecular Chemistry“

Module 3.1	**3.1 Modern and Industrial Aspects of Polymer Materials**					**[Modul-Kennnummer]**
Mandatory or elective Module	**Mandatory in the specialisation „Macromolecular Chemistry“ or elective**					
Creditpoints (LP) and workload	**6 LP = 180 h**					
Module duration (according to course plan)	**1 Semester**					
Courses/ Learning formats	**Type**	**Regular term** when starting in **Winter term (Summer term)**	**Mandatory/ elective**	**Contact Time (SWH)**	**Self Study**	**Creditpoints**
a) Lecture Part 1: "Synthesis and Use of Polymer Materials" Part 2: "Physical Chemistry of Polymeric Materials	L	1 (2)	M	3	103,5 h	4,5
b) Seminar „Modern and Industrial Aspects of Polymer Materials”	S	1 (2)	M	1	34,5 h	1,5

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	
Active participation	According to § 5 para. 3 (usually successful delivery of a presentation in the Seminar)
Coursework	
Module examination	Usually written exam (120 min), alternatively oral exam (30 min)

Qualification Goals, learning outcome, competences

An in-depth insight into customised manufacturing as well as the multi-layered structure and dynamics of polymer systems and materials is provided.
The students are able to:

- describe central challenges and solution approaches of modern and industrial polymer syntheses, and understand current research questions of an academic nature: For example, sequence control, thermoplastic elastomers, composite materials, weak interactions in polymer science, self-assembly, responsive materials and bio-inspired material design,
- describe the rheology of polymers in the melt and solution states methodologically, conceptually and phenomenologically, both qualitatively and quantitatively.
- reproduce the basic characteristics of the structure and dynamics of polymeric solutions, gels, glasses and crystals.

Contents

Modern methods of polymer synthesis:

- Advanced composite materials, high performance materials
- Responsive and switchable materials
- Biomimetic concepts in polymer science
- Phase-segregated polymer systems in application, thermoplastic elastomers
- Polymer nanoparticles and self-assembled nanostructures

Fundamentals of rheology:

- viscoelasticity
- Complex rheological material properties
- Time-temperature superposition
- Rheology of polymer systems: Reptation in melt and solution, rubber elasticity of networks, dynamic glass transition.

Building on this: comprehensive and in each case separate treatment of the structure, dynamics and properties of polymers in the state of melts, semi-dilute solutions, gels, crystals and partial crystals Glasses

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	Module “Macromolecular Chemistry”
Language(s) of instruction and examination	English
Weight of the module grade in the overall grade	6/66 or 0/66; as elective module: not graded
Frequency of module offer	Every term
Reasons for compulsory attendance	

Person responsible for the module	Univ.-Prof. Dr. Andreas Walther
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry
Other	Recommended Literature: • Koltzenburg, Maskos, Nuyken – Polymere: Synthese, Eigenschaften und Anwendungen (Springer) • Lechner, Gehrke, Nordmeier – Makromolekulare Chemie (Springer) • Rubinstein, Colby – Polymer Physics (Oxford University Press)

Module 3.2	3.2 Practical Course Modern Aspects of Macromolecular Chemistry	[Modul-Kennnummer]
Mandatory or elective Module	**Mandatory in the specialisation „Macromolecular Chemistry“ or elective**	
Creditpoints (LP) and workload	**6 LP = 180 h**	
Module duration (according to course plan)	**1 Semester**	

Courses/ Learning formats	Type	Regular term when starting in Winter term (Summer term)	Mandatory/ elective	Contact Time (SWH)	Self Study	Creditpoints
a) Practical Course “Macromolecular Chemistry 2”	APr	1 o. 2 (1 o. 2)	M	6	117 h	6

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	APr
Active participation	According to § 5 para. 3 (including preliminary discussion, protocols)
Coursework	
Module examination	

Qualification Goals, learning outcome, competences

An overview of modern polymer synthesis methods and advanced polymer characterisation methods is provided.
The students are able to

- acquire the basics of polymerisation types and mechanisms,
- deal effectively with their time and resources by planning work processes independently and realising them within a defined time window,
- to analyse and evaluate the current literature from a scientific point of view in preparation for the given experiments.
- analyse and evaluate the current literature

to realise demanding experiments in parallel within defined time frames.

Contents

According to the previous knowledge of the students, practical experiments are selected from the following areas:
Experiments on polymer synthesis (step growth, chain growth): Radical polymerisation, polycondensation, living/controlled polymerisation, copolymerisation, polymerisation in heterophase, networks.
Furthermore practical experiments on typical physical properties of polymers (solubility, molecular weights, conformation in solution), determination of thermal and mechanical properties of polymers as well as crystallinity, supramolecular polymerisation, DNA nanoscience systems, advanced analytics.

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	Module “Macromolecular Chemistry”
Language(s) of instruction and examination	English
Weight of the module grade in the overall grade	Not graded
Frequency of module offer	Every term
Reasons for compulsory attendance	According to HochSchG § 26 Para. 2 (7), Practical Course
Person responsible for the module	Univ.-Prof. Dr. Andreas Walther
Transferability of the module to other degree programs	M.Sc. Soft Matter and Materials
Other	

Module 3.3	3.3 Colloid Chemistry and Medical Polymers					[Modul-Kennnummer]
Mandatory or elective Module	**Mandatory in the specialisation „Macromolecular Chemistry“ or elective**					
Creditpoints (LP) and workload	**6 LP = 180 h**					
Module duration (according to course plan)	**1 Semester**					
Courses/ Learning formats	**Type**	**Regular term when starting in Winter term (Summer term)**	**Mandatory/ elective**	**Contact Time (SWH)**	**Self Study**	**Creditpoints**
a) Lecture „Colloid Chemistry”	L	1 (2)	M	2	69 h	3
b) Lecture „Medically relevant polymers”	L	1 (2)	M	2	69 h	3

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	
Active participation	According to § 5 para. 3
Coursework	
Module examination	a) Usually written exam (60 min), alternatively oral exam (30 min) b) Usually written exam (60 min), alternatively oral exam (30 min). Both exams must be passed, the module grade results from the arithmetic mean of both exams.

Qualification Goals, learning outcome, competences

An in-depth insight into the production as well as the structure of polymer systems and materials, their characterisation, and medical applications is provided.
The students are able to:

- reproduce and explain methods for the investigation of nanostructures and (polymer) surfaces,
- discuss colloidal systems with regard to their characteristic time, length and energy scales,
- work out and reproduce synthesis methods for materials for use in medicine and their biodegradability.

Contents

a) Interfacial and colloid chemistry, structured nanoparticles and microgels (basics and production), functional nanoparticles with different properties for different applications, characterisation.
b) Synthesis methods for materials for use in medicine, implants for dental applications or as prostheses; basic principles of biodegradation of polymeric materials; biocompatibility and biodegradability of polymer classes for medical applications (aliphatic polyesters, polyethylene glycol, silicones, polypeptides and duromer resins); carrier materials for active substances and vaccines; artificial extracellular matrix materials.

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	Module “Macromolecular Chemistry”
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	6/66 or 0/66; as elective module: not graded
Frequency of module offer	Only in the winter term
Reasons for compulsory attendance	
Person responsible for the module	Univ.-Prof. Dr. Holger Frey
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry
Other	

Module 3.4	3.4 Complex (Supra)Molecular Systems and Biopolymers	[Modul-Kennnummer]

Mandatory or elective Module	**Mandatory in the specialisation „Macromolecular Chemistry“ or elective**
Creditpoints (LP) and workload	**6 LP = 180 h**
Module duration (according to course plan)	**1 Semester**

Courses/ Learning formats	Type	Regular term when starting in Winter term (Summer term)	Mandatory/ elective	Contact Time (SWH)	Self Study	Creditpoints
a) Lecture „Complex (Supra)Molecular Systems”	L	2 (1)	M	2	69 h	3
b) Lecture „Biopolymers”	L	2 (1)	M	2	69 h	3

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	
Active participation	According to § 5 para. 3
Coursework	
Module examination	a) Usually written exam (60 min), alternatively oral exam (30 min) b) Usually written exam (60 min), alternatively oral exam (30 min). Both exams must be passed, the module grade results from the arithmetic mean of both exams.

Qualification Goals, learning outcome, competences

An in-depth insight into the structure, dynamics and characterisation of natural polymers, supramolecular chemistry and the dynamics of complex systems is provided.
The students are able to:

- evaluate biologically relevant polymer classes and understand them with regard to their structure and assembly,
- understand and apply recognition motifs, weak interactions and organisational principles in natural and synthetic systems,
- understand and reproduce biological and chemical reaction networks and their dynamics.
- Distinguish equilibrium and non-equilibrium systems.
- Understand the basics of systems chemistry and concepts of adaptive and interactive material systems.

Contents

a) Supramolecular Chemistry and Supramolecular Polymerisation; Systems Chemistry; Dynamic Combinatorial Chemistry, Networks and Systems; Non-equilibrium States; Chemical Reaction Networks, Dynamic DNA Nanoscience, Dissipative, Adaptive and Interactive Materials.
b) Polysaccharides (cellulose and derivatives, chitin, starch, glycogen); Lignins; Polyesters (polyhydroxyalkanoates), polyisoprenoids and natural rubber); Nanocellulose/nanochitin/bacterial cellulose; Polynucleotides in materials context (DNA, RNA); Proteins and scleroproteins (collagen, keratin, silk fibroin and spider silk); Mechanics of soft biopolymer tissues.

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	Module “Macromolecular Chemistry”
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	6/66 or 0/66; as elective module: not graded
Frequency of module offer	Only in the summer term
Reasons for compulsory attendance	
Person responsible for the module	Univ.-Prof. Dr. Pol Besenius
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry
Other	

Specialisation 4 „Matter, Materials and Methods“

Module 4.1	**4.1 Biophysical Chemistry**					**[Modul-Kennnummer]**
Mandatory or elective Module	**Mandatory in the specialisation „Matter, Materials and Methods“ or elective**					
Creditpoints (LP) and workload	**6 LP = 180 h**					
Module duration (according to course plan)	**1 Semester**					
Courses/ Learning formats	**Type**	**Regular term** when starting in **Winter term (Summer term)**	**Mandatory/ elective**	**Contact Time (SWH)**	**Self Study**	**Creditpoints**
a) Lecture „Biophysical Chemistry”	L	2 (1)	M	2	69 h	3
b) Supporting exercise to a)	E	2 (1)	M	2	69 h	3
In order to complete the module, you have to fulfil the following requirements:						
Compulsory Attendance						
Active participation	According to § 5 para. 3					
Coursework						
Module examination	Usually written exam (120 min), alternatively oral exam (30 min)					
Qualification Goals, learning outcome, competences						
Building on the basic knowledge of physical chemistry (thermodynamics), physics and biochemistry, this module introduces the physical-chemical fundamentals of selected biological and medical phenomena. Modern and current methods for the characterisation of such molecular, biological processes are also presented. After successful completion of the module, students should have an understanding of the physical-chemical fundamentals of biological processes as well as be familiar with modern molecular characterisation methods of physical chemistry from these fields. The students should be able to select the appropriate methods for new experimental questions in order to successfully get to the bottom of unknown phenomena.						
Contents						
a) Basics of modern biophysical methods with examples from their field of application. Topics include: Membrane transport, phase transitions in membranes, nanoparticle sensors, rate equations and dynamics in cells, molecular motors, single molecule techniques, Raman scattering, thermodynamics of chemical bonds, physical-chemical parameters in the drug discovery process. b) In-depth or supplementary topics from the area of the lecture with practical exercises and applications.						
Compulsory entrance requirements						
Recommended participation requirement(s) for the module and/or individual courses of the module						
Language(s) of instruction and examination	German or English					
Weight of the module grade in the overall grade	6/66 or 0/66; as elective module: not graded					
Frequency of module offer	Only in the summer term					
Reasons for compulsory attendance						
Person responsible for the module	N.N.					
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry					
Other						

Module 4.2	4.2 Modern Methods of Physical Chemistry	[Modul-Kennnummer]
Mandatory or elective Module	**Mandatory in the specialisation „Matter, Materials and Methods“ or elective**	
Creditpoints (LP) and workload	**6 LP = 180 h**	
Module duration (according to course plan)	**1 Semester**	

Courses/ Learning formats	Type	Regular term when starting in Winter term (Summer term)	Mandatory/ elective	Contact Time (SWH)	Self Study	Creditpoints
a) Lecture „Modern Methods of Physical Chemistry”	L	1 o. 2 (1 o. 2)	P	3	103,5h	4,5
b) Supporting exercise to a)	E	1 o. 2 (1 o. 2)	P	1	34,5 h	1,5

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	
Active participation	According to § 5 para. 3
Coursework	
Module examination	Usually written exam (120 min), alternatively oral exam (30 min)

Qualification Goals, learning outcome, competences

Building on the basic knowledge of physical chemistry (thermodynamics, electrochemistry, quantum mechanics, kinetics and spectroscopy) and physics, this module introduces modern and current methods of physical chemistry for the characterisation of molecular processes, in particular also imaging methods as they are used in wide areas of material sciences, chemistry and modern medicine. After successful completion of the module, students should be familiar with modern microscopic and molecular characterisation methods of physical chemistry, understand the basics and be able to name possible areas of application. The students should be able to select the appropriate methods for different experimental questions and interpret the corresponding measurement data in order to successfully get to the bottom of new phenomena.

Contents

a) Basics of modern microscopic methods with examples from their field of application. Topics are for example:
- Imaging microscopy methods (confocal microscopy, scanning probe microscopy, electron microscopy).
- Current topics in modern molecular spectroscopy, e.g. single molecule spectroscopy FRET
- Microscopy methods for the analysis of dynamic processes and intermolecular interactions (FRAP)
- Modern methods for the characterisation of molecular physico-chemical parameters (NanoSPR)

b) In-depth or supplementary topics from the lecture area with practical exercises and applications

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	6/66 or 0/66; as elective module: not graded
Frequency of module offer	Every term
Reasons for compulsory attendance	
Person responsible for the module	apl. Prof. Dr. Gerald Hinze
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry
Other	

Module 4.3	4.3 Condensed Matter					[Modul-Kennnummer]
Mandatory or elective Module	**Mandatory in the specialisation „Matter, Materials and Methods“ or elective**					
Creditpoints (LP) and workload	**6 LP = 180 h**					
Module duration (according to course plan)	**1 Semester**					
Courses/ Learning formats	**Type**	**Regular term** when starting in **Winter term (Summer term)**	**Mandatory/ elective**	**Contact Time (SWH)**	**Self Study**	**Creditpoints**
a) Lecture „Condensed Matter”	L	1 (2)	M	2	69 h	3
b) Supporting Seminar to a)	S	1 (2)	M	2	69 h	3
In order to complete the module, you have to fulfil the following requirements:						
Compulsory Attendance						
Active participation						
Coursework						
Module examination	Usually written exam (120 min), alternatively oral exam (30 min)					
Qualification Goals, learning outcome, competences						
Students should be introduced to the physical-chemical fundamentals of condensed matter, leading to an understanding of the material nature and properties of functional materials, especially on the nanometre scale. The spectrum of suitable topics includes e.g. structure and properties of amorphous and crystalline condensed matter, structure and properties of polymers and colloids, intermolecular interactions and molecular assemblies, nanomaterials. On one or more special topics, an in-depth understanding of a research-related special field of condensed matter is to be gained, which provides a basis for successfully carrying out a Master's thesis in this or a related field.						
Contents						
a) Fundamentals of hard and soft condensed matter; intermolecular interactions; structure, dynamics and related characteristic properties of crystalline-hard as well as amorphous-soft matter; scattering from complex matter; electronic and magnetic order; relaxation dynamics; energy storage capacity and dissipation, viscoelasticity. The lecture is offered in digital form via an e-learning platform. b) In the accompanying seminar, the contents of the digital lecture are deepened in group work, using interactive teaching and learning forms (here: inverted classroom and just-in-time teaching).						
Compulsory entrance requirements						
Recommended participation requirement(s) for the module and/or individual courses of the module						
Language(s) of instruction and examination	English					
Weight of the module grade in the overall grade	6/66 or 0/66; as elective module: not graded					
Frequency of module offer	Only in the winter term					
Reasons for compulsory attendance						
Person responsible for the module	Univ.-Prof. Dr. Sebastian Seiffert					
Transferability of the module to other degree programs	Master of Science Physics, M.Sc. Soft Matter and Materials					
Other	The module consists of two sections, on about hard and one about soft matter. The first one is taught by Prof. M. Kläui (FB08), the second one by Prof. S. Seiffert (FB09)					

Module 4.4	4.4 Practical Course Modern Methods of Spectroscopy and Microscopy	[Modul-Kennnummer]
Mandatory or elective Module	**Mandatory in the specialisation „Matter, Materials and Methods“ or elective**	
Creditpoints (LP) and workload	**6 LP = 180 h**	
Module duration (according to course plan)	**1 Semester**	

Courses/ Learning formats	Type	Regular term when starting in Winter term (Summer term)	Mandatory/ elective	Contact Time (SWH)	Self Study	Creditpoints
a) Practical Course “Modern Methods of Spectroscopy and Microscopy”	APr	1 or 2 (1 or 2)	M	3	103,5 h	4,5
b) Supporting seminar to a)	S	1 or 2 (1 or 2)	M	1	34,5 h	1,5

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	APr
Active participation	According to § 5 para. 3
Coursework	
Module examination	

Qualification Goals, learning outcome, competences

a) The students are able to handle modern examination methods of physical chemistry, to apply them practically and to work out the basics independently. They can organise themselves in small groups, coordinate work processes and summarise the scientific investigation results in writing.
b) The students can independently familiarise themselves with a given topic and prepare an oral presentation on it according to scientific standards. In discussion rounds, their own and other people's presentations are critically assessed.

Contents

6-8 practical experiments from the field of experimental physical chemistry are carried out. Examples include

- time-resolved fluorescence and electronic energy transfer
- confocal fluorescence microscopy and single molecule microscopy
- scanning tunneling microscopy
- light microscopy
- transmission electron microscopy
- Synthesis of CdSe nanocrystals
- FRAP (fluorescence recovery after photobleaching)

Topics for the oral presentation are chosen from the field of practical experiments and related areas.

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	Not graded
Frequency of module offer	Every term
Reasons for compulsory attendance	According to HochSchG § 26 Para. 2 (7), Practical Course
Person responsible for the module	Apl. Prof. Dr. Gerald Hinze
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry
Other	

Specialisation 5 „Molecular Functional Materials“

Module 5.1	**5.1 Electrons in Molecules**					**[Modul-Kennnummer]**
Mandatory or elective Module	**Mandatory in the specialisation „Molecular Functional Materials“ or elective**					
Creditpoints (LP) and workload	**6 LP = 180 h**					
Module duration (according to course plan)	**1 Semester**					
Courses/ Learning formats	**Type**	**Regular term** when starting in **Winter term (Summer term)**	**Mandatory/ elective**	**Contact Time (SWH)**	**Self Study**	**Creditpoints**
a) Lecture „Electrons in Molecules”	L	1 (2)	M	3	103,5 h	4,5
b) Supporting exercise to a)	E	1 (2)	M	1	34,5 h	1,5
In order to complete the module, you have to fulfil the following requirements:						
Compulsory Attendance						
Active participation	According to § 5 para. 3					
Coursework						
Module examination	Usually written exam (120 min), alternatively oral exam (30 min)					

Qualification Goals, learning outcome, competences

The students:

- can reproduce knowledge on the terms mentioned in a structured way,
- can describe the basic concepts and methods,
- can work out and deepen partial contents independently,
- can transfer the learned contents to unknown tasks,
- can establish connections and links between topics and contents within the subject and with related sub-disciplines,
- have gained an understanding of the significance of the electron structure of molecular systems in the natural sciences.

Contents

Magnetic properties of organic molecules or coordination compounds with one or more paramagnetic centres. Basic concepts, application examples from bio-inorganic chemistry, spin crossover compounds, single molecule magnets. Electrical properties of molecular compounds: Electron transfer in discrete and conductivity in extended systems. Application examples from bio-inorganic chemistry. Introduction to molecular spintronics for resource-efficient data processing.

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	6/66 or 0/66; as elective module: not graded
Frequency of module offer	Only in the winter term
Reasons for compulsory attendance	
Person responsible for the module	Univ.-Prof. Dr. Eva Rentschler
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry
Other	

Module 5.2	5.2 Molecular Photochemistry	[Modul-Kennnummer]
Mandatory or elective Module	**Mandatory in the specialisation „Molecular functional Materials“ or elective**	
Creditpoints (LP) and workload	**6 LP = 180 h**	
Module duration (according to course plan)	**1 Semester**	

Courses/ Learning formats	Type	Regular term when starting in Winter term (Summer term)	Mandatory/ elective	Contact Time (SWH)	Self Study	Creditpoints
a) Lecture „Molecular Photochemistry”	L	1 (2)	M	3	103,5 h	4,5
b) Supporting exercise to a)	E	1 (2)	M	1	34,5 h	1,5

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	
Active participation	According to § 5 para. 3
Coursework	
Module examination	Usually written exam (120 min), alternatively oral exam (30 min)

Qualification Goals, learning outcome, competences

The students
- can reproduce knowledge on the terms mentioned in a structured way,
- can describe the basic concepts and methods,
- can work out and deepen partial contents independently,
- can establish connections and links between topics and contents within the subject and with related sub-disciplines,
- are able to transfer the contents they have learned to unfamiliar tasks,
- gain a comprehensive overview of the cross-sectional discipline of photochemistry, with an equal focus on fundamental concepts and trends in current research.

Contents

Electron transfer, fundamentals of photochemistry, photophysics and photochemistry of metal complexes and organic chromophores, photokinetics, optical spectroscopy, photocatalysis, solar energy conversion, natural and artificial photosynthesis, photochemical probes, supramolecular photochemistry, organic photoreactions, isomerisations, rearrangements, fragmentations, photochemistry in biological systems.

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	6/66 or 0/66; as elective module: not graded
Frequency of module offer	Only in the winter term
Reasons for compulsory attendance	
Person responsible for the module	Univ.-Prof. Dr. Katja Heinze
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry
Other	

Module 5.3	5.3 Supramolecular Catalysis	[Modul-Kennnummer]
Mandatory or elective Module	**Mandatory in the specialisation „Molecular functional Materials“ or elective**	
Creditpoints (LP) and workload	**6 LP = 180 h**	
Module duration (according to course plan)	**1 Semester**	

Courses/ Learning formats	Type	Regular term when starting in Winter term (Summer term)	Mandatory/ elective	Contact Time (SWH)	Self Study	Creditpoints
a) Lecture „Supramolecular Catalysis”	L	2 (1)	M	3	103,5 h	4,5
b) Supporting exercise to a)	E	2 (1)	M	1	34,5 h	1,5

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	
Active participation	According to § 5 para. 3
Coursework	
Module examination	Usually written exam (120 min), alternatively oral exam (30 min)

Qualification Goals, learning outcome, competences

The students

- can reproduce knowledge on the terms mentioned in a structured way,
- can describe the basic concepts and methods,
- can work out and deepen partial contents independently,
- can establish connections and links between topics and contents within the subject and with related sub-disciplines,
- can transfer the learned contents to unknown tasks.

Contents

Use of supramolecular interactions as control parameters to control catalytic processes. For homogeneous systems, thermal and light-driven catalyses are discussed with emphasis on the correlation between catalyst structure, supramolecular interactions and resulting catalytic activity. Catalysis mechanisms including enantioselective catalysis, catalysis under spatial confinement, inhibition and feedback loops, and autocatalysis are discussed. For heterogeneous systems, supramolecular effects in colloids, polymers and solids, e.g. metal organic frameworks (MOFs) are discussed.

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	6/66 or 0/66; as elective module: not graded
Frequency of module offer	Only in the summer term
Reasons for compulsory attendance	
Person responsible for the module	Univ.-Prof. Dr. Carsten Streb
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry
Other	

Module 5.4	5.4 Advanced Laboratory Course on Functional Molecular Materials	[Modul-Kennnummer]

Mandatory or elective Module	**Mandatory in the specialisation „Molecular Functional Materials“ or elective**
Creditpoints (LP) and workload	**6 LP = 180 h**
Module duration (according to course plan)	**1 Semester**

Courses/ Learning formats	Type	Regular term when starting in Winter term (Summer term)	Mandatory/ elective	Contact Time (SWH)	Self Study	Creditpoints
a) Lab Course „Functional Molecular Materials”	APr	2 (1)	M	9	40,5 h	4,5
b) Supporting Seminar to a)	S	2 (1)	M	1	34,5 h	1,5

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	APr, S
Active participation	According to § 5 para. 3
Coursework	
Module examination	

Qualification Goals, learning outcome, competences

The students
- can independently carry out synthesis and analysis procedures in the chemistry of functional molecules, evaluate them and assess the success
- are proficient in the theoretical background of their experimental work and can document their experiments according to the rules of good scientific practice
- are able to handle hazardous substances responsibly and safely in compliance with the applicable safety and environmental regulations.

Contents

Conducting experiments to elaborate concepts of functional molecules, demonstrating function by advanced spectroscopic and analytical methods, e.g. investigation of electronic and magnetic properties, luminescence or time-resolved spectroscopic experiments, determination of turnover curves of catalyses or photocatalyses, mechanistic investigations; linking experimental results with theoretical expectations.

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	Modules „Molecular Photochemistry“, „Supramolecular Catalysis“ and „Electrons in Molecules“
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	Not graded
Frequency of module offer	Only in the summer term
Reasons for compulsory attendance	According to HochSchG § 26 para. 2 (7), Practical Course; Practical Course accompanying upper seminar according to § 5 para. 5: discussion of safety-relevant details of and discussion of practical course experiments.
Person responsible for the module	Univ.-Prof. Dr. Carsten Streb
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry
Other	

Specialisation 6 „Preparative chemistry“

Module 6.1	**6.1 Chemistry of Aromatic / Heterocyclic Compounds**					**[Modul-Kennnummer]**
Mandatory or elective Module	**Mandatory in the specialisation „Preparative Chemistry“ or elective**					
Creditpoints (LP) and workload	**6 LP = 180 h**					
Module duration (according to course plan)	**1 Semester**					
Courses/ Learning formats	**Type**	**Regular term** when starting in **Winter term (Summer term)**	**Mandatory/ elective**	**Contact Time (SWH)**	**Self Study**	**Creditpoints**
a) Lecture „Aromatics / Heterocycles”	L	1 or 2 (1 or 2)	M	2	69 h	3
b) Supporting exercise to a)	E	1 or 2 (1 or 2)	M	1	34,5 h	1,5
c) Seminar “Practical Seminar”	S	1 or 2 (1 or 2)	M	1	34,5 h	1,5
In order to complete the module, you have to fulfil the following requirements:						
Compulsory Attendance	S					
Active participation	According to § 5 para. 3					
Coursework						
Module examination	Usually written exam (120 min), alternatively oral exam (30 min) on the contents of a) and b)					

Qualification Goals, learning outcome, competences

a) and b) The students should work on advanced topics in organic chemistry at the level of Brückner, Gilchrist, Joule/Mills (aromatics/heterocycles) and acquire in-depth knowledge of the chemistry of the classes of substances dealt with. The students are then able to,

- reproduce in-depth specialist knowledge from the field of aromatics and heterocyclic chemistry, describe modern concepts and methods from these fields and classify them with regard to their significance.
- to work out and deepen contents from the field of aromatics and heterocyclic chemistry independently.
- to establish connections and links between topics and contents from the field of aromatics and heterocyclic chemistry within the subject and with related subject areas.
- to transfer the learned lecture contents to unknown tasks
- to identify problems in the development of synthesis strategies and in the answering of complex questions, to work out possible solutions independently by linking the acquired knowledge with their own ideas and to evaluate them critically
- present their results in a comprehensible way and in scientifically correct terminology and defend them in discussions
- to critically question and evaluate the solution strategies developed.

c) The specialisation unit serves individual specialisation and personal profile building in preparation for later independent research. The students are able to

- work independently on research-related topics in preparative organic chemistry,
- develop their preparative skills independently
- to analyse the results of independent literature research.
- to extend their methodological knowledge by implementing new apparatus and analytical procedures,
- to work out and plan their experiments and to implement them independently,
- to debate with their supervisors how to carry out the experiments and to correct them,
- to work out solutions when dealing with scientific problems,
- assess the safety aspects of chemicals and experiments and take appropriate action,
- to develop their English language skills through English language literature and supervisors,
- to plan tasks together in a team and to carry out preliminary work,
- to work responsibly in a team and to deal with hazardous substances, to analyse and correct experimental results on the basis of theoretical knowledge through technical literature
- assess and optimise the results of the experiments.

Contents

a)

- Aromaticity (criteria), systematic treatment of annulenes, non-alternating systems, PAHs, methods of preparation and properties of selected systems,
- Classification and nomenclatures of heterocycles, physical properties (solubility, pKs, dipole moments, ...)
- Systematic treatment of small rings with up to two heteroatoms, medium rings with up to four heteroatoms, seven- and eight-membered rings in their occurrence and production as well as specific reactivity.
- Application as active substances and in materials science.

b)

- Consolidation of the lecture material and applications in transfer exercises.

c)

- Preparative methods, reagents in organic synthesis, reaction types and reaction mechanisms.

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	6/66 or 0/66; as elective module: not graded
Frequency of module offer	Every term
Reasons for compulsory attendance	Seminar according to § 5 para. 5: The learning objectives are based on direct interaction between students. In addition to practical professional competence, important learning objectives are literature research, presentation and leading discussions.
Person responsible for the module	N.N.
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry
Other	Recommended Literature: • Gilchrist: Heterocyclenchemie, Joule/Mills: Heterocyclic Chemistry, Brückner: Reaktionsmechanismen

Module 6.2	6.2 Electrochemistry	[Modul-Kennnummer]
Mandatory or elective Module	**Mandatory in the specialisation „Preparative Chemistry“ or elective**	
Creditpoints (LP) and workload	**6 LP = 180 h**	
Module duration (according to course plan)	**1 Semester**	

Courses/ Learning formats	Type	Regular term when starting in Winter term (Summer term)	Mandatory/ elective	Contact Time (SWH)	Self Study	Creditpoints
a) Lecture „Electrochemistry”	L	2 (1)	M	4	138 h	6

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	
Active participation	According to § 5 para. 3
Coursework	
Module examination	Usually written exam (120 min), alternatively oral exam (30 min)

Qualification Goals, learning outcome, competences

The students have acquired theoretical expertise in the field of electrochemistry and electroorganic synthesis and

- are able to describe methods and reactions from these areas and to classify them with regard to their significance.
- are able to independently work out and deepen contents from the subject area of electrochemistry.
- have developed an awareness of the connections and links between topics and contents within this highly interdisciplinary field.

Contents

- Physical basics and terms (conductivity in ionic systems; potentials and structures at phase boundaries; potentials and currents).
- Electrode materials, electrolyte science, mediators, separators and cell geometries; cyclic voltammetry, spectroelectrochemistry, Marcus theory
- Corrosion, electrochemical milling and machining; electroplating/metal deposition
- Production of basic inorganic chemicals
- Cathode reactions (mediated systems, direct methods, technical applications)
- Anode reactions (couplings, fluorination, modern concepts)
- Natural product synthesis
- Technical electroorganic synthesis
- Electrochemical surface treatment
- Electropolymerisation, conducting polymers
- Ion exchangers
- Bioelectrochemistry, electroenzymatics

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	9/66 or 0/66; as elective module: not graded
Frequency of module offer	Only in the summer term
Reasons for compulsory attendance	
Person responsible for the module	N.N.
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry
Other	

Module 6.3	6.3 Chemistry of Natural Products	[Modul-Kennnummer]
Mandatory or elective Module	**Mandatory in the specialisation „Preparitive Chemistry“ or elective**	
Creditpoints (LP) and workload	**6 LP = 180 h**	
Module duration (according to course plan)	**1 Semester**	

Courses/ Learning formats	Type	Regular term when starting in Winter term (Summer term)	Mandatory/ elective	Contact Time (SWH)	Self Study	Creditpoints
a) Lecture „Chemistry of Natural Products”	L	2 (1)	M	2	69 h	3
b) Supporting exercise to a)	E	2 (1)	M	1	34,5 h	1,5
c) Seminar “Retrosynthesis”	S	2 (1)	M	1	34,5 h	1,5

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	
Active participation	According to § 5 para. 3
Coursework	
Module examination	Usually written exam (120 min), alternatively oral exam (30 min) on the contents of a), b) and c)

Qualification Goals, learning outcome, competences

Students should learn advanced aspects of the organic chemistry of natural products at the level of Nuhn: Naturstoffchemie, Habermehl/Hammann/Krebs/Ternes: Naturstoffchemie and acquire in-depth knowledge of the chemistry of the classes of substances covered. The students are then able to

- reproduce in-depth specialised knowledge from the field of natural products chemistry, describe modern concepts and methods from these fields and classify them with regard to their significance
- to independently work out and deepen contents from the field of natural products chemistry.
- to establish connections and links between topics and contents from the field of natural products chemistry within the subject and with related subject areas.
- to transfer the contents of the lecture to unknown tasks.
- to identify problems in the development of synthesis strategies and in the answering of complex questions, to independently work out possible solutions by linking the acquired knowledge with own ideas and to critically evaluate them
- to critically question and evaluate the solution strategies developed.

Contents

a)

- - Organic Chemistry 5: Classes of natural products: Nucleosides, nucleotides and nucleic acids, nucleic acid synthesis.
- - Amino acids, peptides and proteins, peptide synthesis
- - Terpenes and steroids
- - Lipids and eicosanoids
- - Polyketides
- - carbohydrates
- - Biogenic amines and alkaloids
- - nitrogenous cofactors of proteins
- - synthesis and biosynthesis and analysis of natural products.

b)

- consolidation of the lecture material and applications in transfer exercises

c)

- Methods of organic synthesis and retrosynthesis on concrete examples.

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	9/66 or 0/66; as elective module: not graded
Frequency of module offer	Only in the summer term

Reasons for compulsory attendance	
Person responsible for the module	Univ.-Prof. Dr. Till Opatz
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry
Other	Recommended Literature: • Nuhn: Naturstoffchemie • Habermehl/Hammann/Krebs/Ternes: Naturstoffchemie

Module 6.4	6.4 Integrated Analytical-Preparative Lab Course	[Modul-Kennnummer]
Mandatory or elective Module	**Mandatory in the specialisation „Preparative Chemistry“ or elective**	
Creditpoints (LP) and workload	**6 LP = 180 h**	
Module duration (according to course plan)	**1 Semester**	

Courses/ Learning formats	Type	Regular term when starting in Winter term (Summer term)	Mandatory/ elective	Contact Time (SWH)	Self Study	Creditpoints
a) Lecture „Analytical Methods”	L	1 or 2 (1 or 2)	M	1	34,5 h	1,5
b) Analytical Preparative Lab Course	APr	1 or 2 (1 or 2)	M	9	40,5 h	4,5

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	APr
Active participation	According to § 5 para. 3
Coursework	
Module examination	

Qualification Goals, learning outcome, competences

a) The block lecture conveys knowledge in relevant analytical methods (e.g. EI mass spectrometry, 2D NMR spectroscopy), which have not been the subject of compulsory courses in the degree programme so far.
b) The practical course serves the individual specialisation and personal profile formation in preparation for later independent research using common analytical procedures and, if applicable, isotope labelling.
The students are able to:

- work independently on research-related topics in preparative organic chemistry and to examine and critically evaluate the results of their work by analytical methods.
- work out and plan their experiments and implement them independently,
- debate with their supervisors the performance of the experiments and the analytical techniques used and to correct them,
- work out solutions when dealing with scientific problems and combine practice and theory,
- assess the safety aspects of chemicals and experiments and take appropriate action,
- develop their English language skills through English-language literature and supervisors,
- work responsibly in a team and to handle hazardous substances,
- analyse and correct experimental results based on theoretical knowledge through technical literature,
- assess and optimise the results of experiments and measurements.

Contents

Preparation of 2-4 research-related preparations of 1-4 steps in size, 6-8 steps in total. The preparation instructions are taken e.g. from current chemical journals or Organic Syntheses. The obtained pure substances or substance mixtures are analysed with the analytical methods presented in the block lecture, among others, and the results are discussed in the protocol. Depending on the preparation, labelling with stable isotopes is also used.

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	Module “Practical Course on Molecular Synthesis”
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	Not graded
Frequency of module offer	Every term
Reasons for compulsory attendance	According to HochSchG § 26 Para. 2 (7), Practical Course
Person responsible for the module	apl. Prof. Dr. Heiner Detert
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry
Other	Recommended Literature: • Organic Syntheses, Organic Reactions, Houben-Weyl

Module 6.5	6.5 Practical Course on Molecular Synthesis	[Modul-Kennnummer]
Mandatory or elective Module	**Mandatory in the specialisation „Preparative Chemistry“ or elective**	
Creditpoints (LP) and workload	**6 LP = 180 h**	
Module duration (according to course plan)	**1 Semester**	

Courses/ Learning formats	Type	Regular term when starting in Winter term (Summer term)	Mandatory/ elective	Contact Time (SWH)	Self Study	Creditpoints
a) Practical Course on Molecular Synthesis	APr	1 o. 2 (1 o. 2)	M	12	54 h	6

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	APr
Active participation	According to § 5 para. 3
Coursework	
Module examination	

Qualification Goals, learning outcome, competences

The specialisation unit serves individual specialisation and personal profile building in preparation for later independent research. The students are able to:

- work independently on research-related topics in preparative organic chemistry,
- develop their preparative skills independently
- analyse the results of independent literature research.
- extend their methodological knowledge by implementing new apparatus and analytical procedures,
- work out and plan their experiments and to implement them independently,
- debate with their supervisors how to carry out the experiments and to correct them,
- work out solutions when dealing with scientific problems,
- assess the safety aspects of chemicals and experiments and take appropriate action,
- develop their English language skills through English-language literature and supervisors,
- plan tasks together in a team and to carry out preliminary work,
- work responsibly in a team and to handle hazardous substances,
- analyse and correct the experimental results on the basis of theoretical knowledge through technical literature,
- assess and optimise the results of the experiments.

Contents

Preparation of 3-4 research-related preparations of 2-5 steps, 8-12 steps in total. The preparation instructions are taken e.g. from current chemical journals or Organic Synthesis.

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	Not graded
Frequency of module offer	Every term
Reasons for compulsory attendance	According to HochSchG § 26 Para. 2 (7), Practical Course
Person responsible for the module	Univ.-Prof. Dr. Till Opatz
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry
Other	Recommended Literature: • Gilchrist: Heterocyclenchemie, • Joule/Mills: Heterocyclic Chemistry, • Brückner: Reaktionsmechanismen • Organic Synthesis, Organic Reactions, Houben-Weyl

Specialisation 7 „Theoretical Chemistry and Computer Chemistry“

Module 7.1	**7.1 Principles of Quantum Chemistry**					**[Modul-Kennnummer]**
Mandatory or elective Module	**Mandatory in the specialisation „Theoretical Chemistry and Computer Chemistry“ or elective**					
Creditpoints (LP) and workload	**6 LP = 180 h**					
Module duration (according to course plan)	**1 Semester**					
Courses/ Learning formats	**Type**	**Regular term** when starting in **Winter term (Summer term)**	**Mandatory/ elective**	**Contact Time (SWH)**	**Self Study**	**Creditpoints**
a) Lecture „Principles of Quantum Chemistry”	L	1 (2)	M	3	103,5 h	4,5
b) Supporting exercise to a)	E	1 (2)	M	1	34,5 h	1,5
In order to complete the module, you have to fulfil the following requirements:						
Compulsory Attendance						
Active participation	According to § 5 para. 3					
Coursework						
Module examination	Usually written exam (120 min), alternatively oral exam (30 min)					

Qualification Goals, learning outcome, competences

Using Hartree-Fock theory, i.e., one of the simplest quantum chemical methods, the students learn how to implement a quantum chemical method in a computer program step by step starting from the initial ansatz for the wavefunction.
They acquire a profound understanding of quantum chemical basics and gain confidence in handling mathematical formulae in the context of quantum chemistry. They will be able to perform the derivation of the corresponding equations. They learn how the equations are solved and are able to design a corresponding computer program.

Contents

- Molecular orbitals and multi-electron wave function
- Hartree-Fock theory (general idea, detailed derivation of the corresponding equations)
- Self-consistent field method for solving the HF equations
- Basis set representation and Roothaan-Hall equations
- Implementation of HF-SCF and performance of corresponding calculations
- Molecular properties within the framework of HF theory

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	9/66 or 0/66; as elective module: not graded
Frequency of module offer	Only in the winter term
Reasons for compulsory attendance	
Person responsible for the module	Univ.-Prof. Dr. Jürgen Gauß
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry
Other	

Module 7.2	7.2 Contemporary Topics of Theoretical Chemistry	[Modul-Kennnummer]
Mandatory or elective Module	**Mandatory in the specialisation „Theoretical Chemistry and Computer Chemistry“ or elective**	
Creditpoints (LP) and workload	**6 LP = 180 h**	
Module duration (according to course plan)	**1 Semester**	

Courses/ Learning formats	Type	Regular term when starting in Winter term (Summer term)	Mandatory/ elective	Contact Time (SWH)	Self Study	Creditpoints
a) Lecture „Contemporary Topics of Theoretical Chemistry”	L	2 (1)	M	3	103,5 h	4,5
b) Supporting exercise to a)	E	2 (1)	M	1	34,5 h	1,5

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	
Active participation	According to § 5 para. 3
Coursework	
Module examination	Usually written exam (120 min), alternatively oral exam (30 min)

Qualification Goals, learning outcome, competences

The students have detailed knowledge of the theory of modern methods of theoretical chemistry and their fields of application. They are able to independently familiarise themselves with technical literature. They are able to carry out differentiated assessments of complexity, accuracy, computational effort and feasibility in computer-assisted calculations in the field of TC.
They have developed the theoretical foundations for the calculations required in the module "Computational Chemistry in Practice".

Contents

- Advanced quantum chemical methods
- Theoretical description of many-particle systems: Second quantisation, electron correlation

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	9/66 or 0/66; as elective module: not graded
Frequency of module offer	Only in the summer term
Reasons for compulsory attendance	
Person responsible for the module	Univ.-Prof. Dr. Jürgen Gauß
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry
Other	

Module 7.3	7.3 Practical Computational Chemistry	[Modul-Kennnummer]
Mandatory or elective Module	**Mandatory in the specialisation „Theoretical Chemistry and Computer Chemistry“ or elective**	
Creditpoints (LP) and workload	**6 LP = 180 h**	
Module duration (according to course plan)	**1 Semester**	

Courses/ Learning formats	Type	Regular term when starting in Winter term (Summer term)	Mandatory/ elective	Contact Time (SWH)	Self Study	Creditpoints
a) Practical Course Computer Chemistry	APr	2 (1)	M	3	103,5 h	4,5
b) Supporting Seminar to a)	S	2 (1)	M	1	34,5 h	1,5

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	APr, S
Active participation	According to § 5 para. 3
Coursework	
Module examination	

Qualification Goals, learning outcome, competences

- The students are able to include computer chemical investigations in experiments in order to answer chemical questions. They are familiar with the necessary computer programs. They are able to select and use meaningful methods from the field of theoretical chemistry. They can evaluate and interpret the data obtained.

Contents

Carrying out 2-4 exemplary experiments in which chemical issues are investigated from a combination of experiments from the fields of AC, OC, PC, KC and/or biochemistry and computer simulations or computer chemical calculations.

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	Modules “Contemporary Topics of Quantum Chemistry” and “Principles of Theoretical Chemistry”
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	Not graded
Frequency of module offer	Only in the summer term in the semester break
Reasons for compulsory attendance	According to HochSchG § 26 Para. 2 (7), Practical course; Practical course accompanying upper seminar according to § 5 Para. 5: Discussion of the tasks to be carried out or carried out in the practical course with the help of licensed programmes on computers within the working group.
Person responsible for the module	Univ.-Prof. Dr. Jürgen Gauß
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry
Other	Block practical course

Module 7.4	7.4 Programming in Quantum Chemistry	[Modul-Kennnummer]
Mandatory or elective Module	**Mandatory in the specialisation „Theoretical Chemistry and Computer Chemistry“ or elective**	
Creditpoints (LP) and workload	**6 LP = 180 h**	
Module duration (according to course plan)	**1 Semester**	

Courses/ Learning formats	Type	Regular term when starting in Winter term (Summer term)	Mandatory/ elective	Contact Time (SWH)	Self Study	Creditpoints
a) Practical Course „Programming in Quantum Chemistry”	Apr	1 (2)	M	3	103,5 h	4,5
b) Supporting Seminar to a)	S	1 (2)	M	1	34,5 h	1,5

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	Apr, S
Active participation	According to § 5 para. 3
Coursework	
Module examination	

Qualification Goals, learning outcome, competences

The students acquire (possibly initial) programming skills. They are able to plan, design and implement a quantum chemical computer program. They can check self-written programmes for correctness, find errors and revise them if necessary. They are able to use the programme to deal with chemical problems and to document and critically discuss the results.

Contents

- Basics of programming
- Planning and conception of a computer program
- Implementation of quantum chemical methods in a computer programme

Compulsory entrance requirements	Module „Principles of Quantum Chemistry”
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	Not graded
Frequency of module offer	Only in the winter term in the semester break
Reasons for compulsory attendance	According to HochSchG § 26 Para. 2 (7), Practical course; Practical course accompanying upper seminar according to § 5 Para. 5: Discussion of the tasks to be carried out or carried out in the practical course with the help of licensed programmes on computers within the working group.
Person responsible for the module	Univ.-Prof. Dr. Jürgen Gauß
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry
Other	Block practical course

Elective Modules

Module 32	**Elective Module 32 Inorganic Solid State Chemistry**					**[Modul-Kennnummer]**
Mandatory or elective Module	**Elective**					
Creditpoints (LP) and workload	**6 LP = 180 h**					
Module duration (according to course plan)	**1 Semester**					
Courses/ Learning formats	**Type**	**Regular term** when starting in **Winter term (Summer term)**	**Mandatory/ elective**	**Contact Time (SWH)**	**Self Study**	**Creditpoints**
a) Lecture „Solid State Chemistry"	L	1 or 3 (2)	M	3	103,5 h	4,5
b) Supporting Seminar to a)	S	1 or 3 (2)	M	1	34,5 h	1,5

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	
Active participation	According to § 5 para. 3
Coursework	Written elaboration of the seminar presentation
Module examination	Oral exam (30 min) on the contents of a) and b)

Qualification Goals, learning outcome, competences

The students

- are able to apply concepts and principles of inorganic solid state chemistry in a structured manner
- have the ability to transfer chemical bonding concepts to structure types
- can critically evaluate the relationship between structure types and material classes in terms of reactivities and properties
- can correlate electronic band structures and phononic dispersions with material properties and are able to formulate and discuss applicability considerations

Contents

The courses cover the following topics on inorganic solid state chemistry:

- Introduction to crystallographic basics
- Structural systematics of element and compound classes
- Reactivity of solids and defects (from synthesis to catalytic activity of surfaces)
- Description of phonons and electrons in k-space
- Band structures - crystal orbitals, Peierls transitions and charge density waves, Mott-Hubbard model
- correlated systems (magnetism)
- Contents of the seminar: (i) Discussion of technically relevant material properties; (ii) Introduction to solid state chemical analysis methods and basic data evaluation.

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	Not graded
Frequency of module offer	Only in the winter term
Reasons for compulsory attendance	
Person responsible for the module	Univ.-Prof. Dr. Angela Möller
Transferability of the module to other degree programs	
Other	Selected scientific literature (mainly publications)

Module 33	Elective Module 33 Bioinorganic Chemistry					[Modul-Kennnummer]
Mandatory or elective Module	**Elective**					
Creditpoints (LP) and workload	**6 LP = 180 h**					
Module duration (according to course plan)	**1 Semester**					
Courses/ Learning formats	**Type**	**Regular term when starting in Winter term (Summer term)**	**Mandatory/ elective**	**Contact Time (SWH)**	**Self Study**	**Creditpoints**
a) Lecture „Bioinorganic Chemistry"	L	2 (1 o. 3)	M	3	103,5 h	4,5
b) Supporting Seminar to a)	S	2 (1 o. 3)	M	1	34,5 h	1,5

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	S
Active participation	According to § 5 para. 3
Coursework	
Module examination	Usually written exam (120 min), alternatively oral exam (30 min) on the contents of a)

Qualification Goals, learning outcome, competences

The students
- have knowledge of bioinorganic chemistry
- with a focus on coordination chemistry and mechanistic aspects
- are able to reproduce knowledge on the terms mentioned in a structured manner,
- can work out and deepen partial contents independently,
- can transfer the learned contents to unknown tasks,
- can establish connections and links between topics and contents within the subject and with related sub-disciplines,
- have gained an understanding of the significance of metal ions in living nature.

Contents

Bioinorganic chemistry is a cross-sectional discipline of biochemistry and coordination chemistry.
The lecture serves to identify the specific roles of certain metal ions in chemical-biochemical processes.
Biological processes such as photosynthesis or cellular respiration are discussed.
Selected examples of metalloproteins responsible for the binding and activation of small molecules (H2, N2, O2) are discussed in more detail as well as electron transfer proteins or metalloproteins for substrate binding or conversion.

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	Not graded
Frequency of module offer	Only in the summer term
Reasons for compulsory attendance	Upper seminar according to § 5 para. 5: The learning objectives are based on direct interaction between students. In addition to practical professional competence, important learning objectives are literature research, presentation and leading discussions.
Person responsible for the module	Univ.-Prof. Dr. Eva Rentschler
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry
Other	

Module 35	Elective Module 35 Macromolecular Chemistry					[Modul-Kennnummer]
Mandatory or elective Module	**Elective**					
Creditpoints (LP) and workload	**6 LP = 180 h**					
Module duration (according to course plan)	**1 Semester**					
Courses/ Learning formats	**Type**	**Regular term when starting in Winter term (Summer term)**	**Mandatory/ elective**	**Contact Time (SWH)**	**Self Study**	**Creditpoints**
a) Lecture Part 1: "Synthesis and use of polymers". Part 2: "Physical Chemistry of Polymers".	L	1 - 3 (1 - 3)	M	3	103,5 h	4,5
b) Supporting exercise to a)	E	1 - 3 (1 - 3)	M	1	34,5 h	1,5

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	
Active participation	b) According to § 5 para. 3 (usually exercise assignments)
Coursework	
Module examination	Usually written exam (120 min), alternatively oral exam (30 min)

Qualification Goals, learning outcome, competences

The students acquire the basics of polymer chemistry, types of polymerisation, chain and step growth. An overview of relevant polymer materials as well as the central methods of polymer characterisation and basic properties of polymers in solution as well as in the solid state is taught.
The students are able to:

- reproduce basic physical properties and material properties of polymers and special features of polymers in comparison to other material classes, especially to low-molecular compounds.
- acquire the basics of polymer chemistry, types of polymerisation, chain and step growth,
- critically evaluate polymerisation methods, both with regard to the achievable molecular weights and with regard to the respective limitations concerning polydispersity,
- get to know basic characterisation methods and to evaluate them with regard to their suitability for specific questions
- conceptually understand and quantitatively discuss the structure and dynamics of macromolecules and to thermodynamically describe macromolecular multi-substance systems.

Contents

Part 1:
General basics: tasks of polymer science, polymer structures, nomenclature.
Polymer synthesis: Polycondensation (step growth), Carothers equation, polymerisations with chain growth,
Radical and ionic methods of polymer synthesis, kinetics, chain transfer, copolymerisation, catalytic polymerisation, polyinsertion
Polymerisation, polyinsertion, catalysts (initiators).
Polymerisation in heterophase (emulsion, dispersion, suspension).
Polymer modification: cellulose, rubber, polymer analogue reactions.
Controlled and living polymerisation processes, ring opening reactions, solid phase synthesis.

Part 2:
Polymer structure: block copolymers, conformation of macromolecules, errant statistics, RIS model, ideal and real chain statistics, entropy elasticity, Flory exponent and scale laws.
Molecular characterisation of polymers in solution: colligative methods, gel permeation chromatography, mass spectrometry, static light scattering.
Polymer dynamics: Rouse and Zimm model.
Polymer thermodynamics: Flory-Huggins theory, phase diagrams.

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	English
Weight of the module grade in the overall grade	Not graded
Frequency of module offer	Every term

Reasons for compulsory attendance	
Person responsible for the module	Prof. Dr. Andreas Walther
Transferability of the module to other degree programs	Bachelor of Science Biomedical Chemistry, Bachelor of Science Chemistry, Master of Science Biomedical Chemistry
Other	Recommended Literature: • Tieke – Makromolekulare Chemie. Eine Einführung (Wiley). • Koltzenburg, Maskos, Nuyken – Polymere: Synthese, Eigenschaften und Anwendungen (Springer) • Lechner, Gehrke, Nordmeier – Makromolekulare Chemie (Springer) • Seiffert – Physical Chemistry of Polymers: A Conceptual Introduction (DeGruyter)

Module 36	Elective Module 36 Practical Course Macromolecular Chemistry	[Modul-Kennnummer]
Mandatory or elective Module	**Elective**	
Creditpoints (LP) and workload	**6 LP = 180 h**	
Module duration (according to course plan)	**1 Semester**	

Courses/ Learning formats	Type	Regular term when starting in Winter term (Summer term)	Mandatory/ elective	Contact Time (SWH)	Self Study	Creditpoints
a) Practical Course Advanced Macromolecular Chemistry 1	APr	1 - 3 (1 - 3)	M	6	117 h	6

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	APr
Active participation	According to § 5 para. 3
Coursework	
Module examination	

Qualification Goals, learning outcome, competences

An overview of relevant polymer synthesis methods, the central methods of polymer characterisation, and the central polymer properties is provided.
The students are able to:

- acquire the basics of polymer chemistry, and types of polymerisation,
- deal effectively with their time and resources by planning work processes independently and realising them within a defined time window,
- analyse and evaluate the current literature from a scientific point of view in preparation for the given experiments.
- analyse and evaluate the current literature
- realise demanding experiments in a parallel manner within defined time frames.

Contents

Practical experiments are selected from the following areas: Experiments on polymer synthesis (step growth, chain growth): Radical polymerisation, polycondensation, living/controlled polymerisation, copolymerisation, polymerisation in heterophase, networks.
Furthermore, practical experiments on typical physical properties of polymers (solubility, molecular weights, conformation in solution), determination of thermal and mechanical properties of polymers as well as crystallinity.

Compulsory entrance requirements	Module „Macromolecular Chemistry“
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	Not graded
Frequency of module offer	Every term
Reasons for compulsory attendance	According to HochSchG § 26 Para. 2 (7), Practical course
Person responsible for the module	Prof. Dr. Andreas Walther
Transferability of the module to other degree programs	Bachelor of Science Chemistry
Other	

Module 37	Elective Module 37 Biomolecules, Biocatalysis and Signal Transfer	[Modul-Kennnummer]
Mandatory or elective Module	**Elective**	
Creditpoints (LP) and workload	**6 LP = 180 h**	
Module duration (according to course plan)	**1 Semester**	

Courses/ Learning formats	Type	Regular term when starting in Winter term (Summer term)	Mandatory/ elective	Contact Time (SWH)	Self Study	Creditpoints
a) Lecture "Biomolecules, Biocatalysis and Signal Transfer	L	1 - 3 (1 - 3)	M	2	69 h	3
b) Supporting Seminar to a)	S	1 - 3 (1 - 3)	M	2	69 h	3

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	
Active participation	According to § 5 para. 3
Coursework	
Module examination	Usually written exam (120 min), alternatively oral exam (30 min) on the contents of a) and b)

Qualification Goals, learning outcome, competences

The students are able to:

- reproduce and structure basic contents of biochemistry and related fields such as physiology, cell biology and molecular biology
- use the subject-specific terminology in a meaningful way
- show connections and differences between biochemical processes
- work out and present a (given) biochemical topic independently
- discuss biochemical topics appropriately.

Contents

Lecture and seminar include the following topics:

- Principles of biochemistry
- Biomolecules
- Amino acids and proteins
- Enzymes: concepts, kinetics, regulation
- Nucleic acids and the flow of genetic information
- Replication, recombination and repair of DNA
- Tools of genetic research
- Control of gene expression
- Protein biosynthesis
- Lipids and cell membranes
- Membrane transport
- Principles of signal transduction

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German
Weight of the module grade in the overall grade	Not graded
Frequency of module offer	Every term
Reasons for compulsory attendance	
Person responsible for the module	Univ.-Prof. Dr. Dirk Schneider
Transferability of the module to other degree programs	Bachelor of Science Biomedical Chemistry, Bachelor of Science Chemistry, Bachelor of Science Molecular Biotechnology
Other	

Module 38	Elective Module 38 Metabolic Biochemistry	[Modul-Kennnummer]
Mandatory or elective Module	**Elective**	
Creditpoints (LP) and workload	**6 LP = 180 h**	
Module duration (according to course plan)	**1 Semester**	

Courses/ Learning formats	Type	Regular term when starting in Winter term (Summer term)	Mandatory/ elective	Contact Time (SWH)	Self Study	Creditpoints
a) Lecture „Metabolic Biochemistry"	L	1 - 3 (1 - 3)	M	2	69 h	3
b) Supporting Seminar to a)	S	1 - 3 (1 - 3)	M	2	69 h	3

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	
Active participation	According to § 5 para. 3
Coursework	
Module examination	Usually written exam (120 min), alternatively oral exam (30 min) on the contents of a) and b)

Qualification Goals, learning outcome, competences

The students are able to
- reproduce and structure basic contents of metabolic biochemistry.
- use the subject-specific terminology in a meaningful way.
- discuss metabolic biochemical topics appropriately.
- to show correlations and differences between biochemical processes.
- to work out and present a (given) biochemical topic independently.

Contents

Lecture and seminar include the following topics:
- Concepts and basic patterns of metabolism
- Carbohydrate metabolism
- Citrate cycle
- Oxidative phosphorylation
- Photosynthesis
- Lipid and fat metabolism
- Protein turnover and amino acid metabolism
- Nucleotide metabolism
- Biosynthetic pathways of important biomolecules
- Coordination and integration of metabolism

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	Not graded
Frequency of module offer	Every term
Reasons for compulsory attendance	
Person responsible for the module	Univ.-Prof. Dr. Dirk Schneider
Transferability of the module to other degree programs	Bachelor of Science Biomedical Chemistry, Bachelor of Science Chemistry, Bachelor of Science Molecular Biotechnology
Other	

Module 39	Elective Module 39 Molecular and Cellular Biochemistry	[Modul-Kennnummer]

Mandatory or elective Module	**Elective**
Creditpoints (LP) and workload	**6 LP = 180 h**
Module duration (according to course plan)	**1 Semester**

Courses/ Learning formats	Type	Regular term when starting in Winter term (Summer term)	Mandatory/ elective	Contact Time (SWH)	Self Study	Creditpoints
a) Lecture „Molecular and Cellular Biochemistry"	L	2 (1 o. 3)	M	4	138 h	6

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	
Active participation	According to § 5 para. 3
Coursework	
Module examination	Usually written exam (120 min), alternatively oral exam (30 min)

Qualification Goals, learning outcome, competences

The students are able to

- reproduce essential contents of cellular biochemistry, molecular biology and related fields
- explain and evaluate principles of gene regulation and genetic engineering experiments
- evaluate the opportunities and risks of genetic engineering, develop their own point of view on this and take this into account in their own work
- Assign and explain the principles of signal transduction.
- to understand and reproduce the biochemical and cell biological basics of structure-giving processes
- to use relevant technical terms of cellular biochemistry correctly
- to critically evaluate the factual knowledge covered in biochemical, cellular and molecular biology textbooks as well as the primary literature published in international journals

Contents

- Mechanisms of cellular signal transduction, signalling pathways, receptors, genome
- Transcriptional regulation, epigenetics, stem cells
- Gene transfer in cells and organisms, plasmids, phages, transfection methods; expression systems
- RNA structures, ribozyme, spliceosome, RNAses, riboswitches
- Innate and adaptive immunity, haematopoiesis, phagocytosis, Toll-like receptors,
- B- and T-cell receptors, cytokines, immunoglobulins, MHC, monoclonal antibodies, autoimmunity
- Receptors, membrane domains, caveolae, ligand binding, G protein coupled receptors (GPCR), arrestins
- GPCR-associated diseases, heterotrimeric G proteins, signal silencing, adenylate cyclases, phospholipases
- Second messengers (cAMP, cGMP, Ca2+, NO, inositol phosphates), guanylyl cyclases, PI3K/Akt pathway
- Protein kinase families, PKA, PKC, calmodulin, CaM kinases
- Receptor tyrosine kinases, growth factors, cytokine receptors, TGF?-Smad, Jak-STAT pathway
- Ras family, MAP kinases, regulated proteolysis, secretases, Notch signalling pathway, SREBP
- Nucleolar receptors (steroid receptors, retinoid X receptors, Toll-like receptors)
- Membrane transport, signal sequences, translocation to organelles, protein sorting
- Protein modifications, unfolded protein response, secretory pathway, hormone processing
- Cytoskeleton (microtubules, actin, intermediate filaments), dynamics
- Cell-cell, cell-matrix connections, extracellular matrix, cell adhesion
- Cell cycle and apoptosis: cyclins, CDKs, IAPs, Bcl proteins, caspases, apoptosome, TNF, FasR
- Neuronal signal transduction: basics in electrophysiology, ion channels

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	Not graded
Frequency of module offer	Only in the summer term
Reasons for compulsory attendance	

Person responsible for the module	Univ.-Prof. Dr. Dirk Schneider
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry, Bachelor of Science Molecular Biotechnology
Other	

Module 40	Elective Module 40 Biochemical Methods	[Modul-Kennnummer]
Mandatory or elective Module	**Elective**	
Creditpoints (LP) and workload	**6 LP = 180 h**	
Module duration (according to course plan)	**1 Semester**	

Courses/ Learning formats	Type	Regular term when starting in Winter term (Summer term)	Mandatory/ elective	Contact Time (SWH)	Self Study	Creditpoints
a) Lecture „Methods of Biochemistry"	L	1 or 3 (2)	M	2	69 h	3
b) Supporting Seminar to a)	S	1 or 3 (2)	M	2	69 h	3

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	
Active participation	According to § 5 para. 3 b) The student elaborates and presents a given, current biochemical topic and engages in a discussion on the topic.
Coursework	
Module examination	Usually written exam (120 min), alternatively oral exam (30 min) on the contents of a) and b)

Qualification Goals, learning outcome, competences

The students are able to:

- to assign suitable methods to questions from the fields of protein and membrane biochemistry.
- be able to analyse typical data of these methods.
- assess the results of bioanalytical experiments.
- to understand the limitations of the respective methods based on their physical principles.
- to assess the applicability of the methods to new questions.
- to critically assess the significance of the respective experiments in publications in international journals.
- independently acquire in-depth knowledge of current topics in biochemical analysis and related fields.
- analyse and evaluate scientific literature from a scientific point of view.
- independently prepare, present and defend a scientific paper on a (given) current biochemical-analytical topic.

Contents

- Methods of protein expression
- Principles and methods of protein isolation and identification
- Immune techniques in biochemistry
- Spectroscopic methods in biochemistry
- Methods of protein structure analysis
- Protein stability
- Protein dynamics
- Chemical modification of proteins
- Biochemistry and biophysics of lipid membranes
- Membrane proteins
- In vivo and in vitro studies of protein-protein and protein-lipid interactions
- Microscopic techniques
- Expression and protein characterisation in vivo

Compulsory entrance requirements	
Recommended participation requirement(s) for the module and/or individual courses of the module	Elective Module 38 "Metabolic Biochemistry"
Language(s) of instruction and examination	English
Weight of the module grade in the overall grade	Not graded
Frequency of module offer	Only in the winter term
Reasons for compulsory attendance	
Person responsible for the module	Univ.-Prof. Dr. Dirk Schneider

Transferability of the module to other degree programs	Master of Science Biomedical Chemistry, Master of Science Moleculare Biotechnology
Other	

Module 41	Elective Module 41 Biochemical Working Techniques	[Modul-Kennnummer]
Mandatory or elective Module	**Elective**	
Creditpoints (LP) and workload	**6 LP = 180 h**	
Module duration (according to course plan)	**1 Semester**	

Courses/ Learning formats	Type	Regular term when starting in Winter term (Summer term)	Mandatory/ elective	Contact Time (SWH)	Self Study	Creditpoints
a) Advanced Practical Course „Biochemical Working Techniques"	APr	1 - 3 (1 - 3)	M	7	76,5 h	5
b) Supporting Seminar to a)	S	1 - 3 (1 - 3)	M	1	19,5 h	1

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	Apr, S
Active participation	According to § 5 para. 3
Coursework	
Module examination	

Qualification Goals, learning outcome, competences

The students are able to:
- apply basic biochemical working techniques
- deal experimentally with different biochemical substance classes
- carry out biochemical and cell biological experiments largely independently on the basis of course instructions
- document the results of their experiments in an appropriate form and evaluate them correctly
- agree on individual work steps, plan them together and implement them in a coordinated manner
- reproduce and explain the theory on which the experiments are based

Contents

In the practical course, the following contents are worked on experimentally:
- Nucleic acids: DNA, RNA
- Protein fractionation and analysis
- enzymes
- Cell fractionation and lead enzymes
- Carbohydrates: separation and analysis
- Lipids: extraction, fractionation and analysis
- Eukaryotic cells (e.g. immunocytochemistry)

Compulsory entrance requirements	Elective Module 37 „Biomolecules, Biocatalysis and Signal Transfer" or Elective Module 38 "Metabolic Biochemistry"
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German
Weight of the module grade in the overall grade	Not graded
Frequency of module offer	Every term
Reasons for compulsory attendance	In accordance with HochSchG § 26 para. 2 (7), practical course; seminar accompanying practical course in accordance with § 5 para. 5: discussion of safety-relevant details of and discussion of practical course experiments.
Person responsible for the module	apl. Prof. Dr. Gerald Gimpl
Transferability of the module to other degree programs	Bachelor of Science Biomedical Chemistry, Bachelor of Science Chemistry, Bachelor of Science Molecular Biotechnology
Other	

Module 42	Elective Module 42 Practical Course in Molecular Biology and Biochemistry	[Modul-Kennnummer]
Mandatory or elective Module	**Elective**	
Creditpoints (LP) and workload	**6 LP = 180 h**	
Module duration (according to course plan)	**1 Semester**	

Courses/ Learning formats	Type	Regular term when starting in Winter term (Summer term)	Mandatory/ elective	Contact Time (SWH)	Self Study	Creditpoints
a) Practical Course in Molecular Biology and Biochemistry	APr	1 - 3 (1 - 3)	M	9	40,5 h	4,5
b) Supporting Seminar to a)	S	1 - 3 (1 - 3)	M	1	34,5 h	1,5

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	APr
Active participation	According to § 5 para. 3
Coursework	
Module examination	

Qualification Goals, learning outcome, competences

The students are able to,

a)

- apply complex biochemical and molecular biological working techniques.
- carry out experiments independently and on their own responsibility using course instructions.
- to work carefully and in a coordinated manner.
- interpret the results of their experiments correctly and document them in an appropriate form.
- apply effective time and resource management.

b)

- work out and present a current topic in biochemistry and defend it in a discussion in front of the whole audience.
- critically question and scientifically discuss presented seminar lectures.

Contents

a)

- Molecular biology: Production of an expression plasmid, production and characterisation of genetically modified bacteria.
- Generation of a bacterial strain suitable for protein expression.
- Heterologous protein expression in E. coli and protein purification.
- Characterisation of the protein and activity assay.
- 2D gel electrophoresis: Treatment of cells with different stressors (heat, oxidants, etc.), use of protein-specific physical parameters (isoelectric point, size) for two-dimensional separation of complex protein mixtures.
- Analysis of the phosphorylation pattern of a stress protein by 2D gel electrophoresis and Western blot analysis
- Staining techniques for protein gels
- Purification of lysozyme: ion exchange chromatography, protein precipitation, SDS-PAGE, photometric assay to check the function of the enzyme

b)

- The student elaborates and presents a given, current topic in biochemistry and faces the audience to discuss the presentation.
- The student analyses and discusses the contents of the presentations of the other seminar participants.

Compulsory entrance requirements	Elective Module 41 Biochemical Working Techniques
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	Not graded
Frequency of module offer	Every term during semester break
Reasons for compulsory attendance	According to HochSchG § 26 Para. 2 (7), Practical Course
Person responsible for the module	Univ.-Prof. Dr. Dirk Schneider

Transferability of the module to other degree programs	Bachelor of Science Molecular Biotechnology, Master of Science Biomedical Chemistry
Other	Only during semester break

Compulsory Modules

Module 43	**43 Research Project**					**[Modul-Kennnummer]**
Mandatory or elective Module	**Mandatory**					
Creditpoints (LP) and workload	**12 LP = 360 h**					
Module duration (according to course plan)	**1 Semester**					
Courses/ Learning formats	**Type**	**Regular term** when starting in **Winter term (Summer term)**	**Mandatory/ elective**	**Contact Time (SWH)**	**Self Study**	**Creditpoints**
a) Practical Course “Research Paper”	Apr	3 (3)	M	22	99,0 h	11
b) Supporting Seminar "Guidance for independent scientific work"	S	3 (3)	M	1	19,5 h	1
In order to complete the module, you have to fulfil the following requirements:						
Compulsory Attendance	Apr (according to the task and agreement with the supervisor)					
Active participation	According to § 5 para. 3, presentation on the research module (30 min)					
Coursework	Maintenance of a laboratory notebook					
Module examination	Research report					
Qualification Goals, learning outcome, competences						
The students work on a current research project of a working group. By solving complex tasks, they acquire in-depth knowledge as well as basic knowledge in planning and designing experiments. They are enabled to carry out demanding experiments under supervision. They can confidently assess the importance of control experiments. The results are to be recorded reproducibly in a laboratory book and interpreted in the final report, taking into account current research literature. By working in a working group, the students expand their communication and teamwork skills.						
Contents						
a) Participation in a current research project in the chosen working group involved in the study programme. b) Introduction to planning, execution and documentation of more complex scientific experiments. Presentation of the results in a report (protocol) and seminar lecture.						
Compulsory entrance requirements	According to PO					
Recommended participation requirement(s) for the module and/or individual courses of the module						
Language(s) of instruction and examination	German or English					
Weight of the module grade in the overall grade	Not graded					
Frequency of module offer	Every term					
Reasons for compulsory attendance	According to HochSchG § 26 para. 2 (7), scientific (practical) research work/practical course (according to assignment and agreement with the supervisor).					
Person responsible for the module	All full-time lecturers involved in the degree programme					
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry					
Other	The module takes place 6 weeks full time. Individual supervision; the number of internships offered in a participating working group may vary from semester to semester. External research work possible on application.					

Module 44	44 Master Thesis					[Modul-Kennnummer]
Mandatory or elective Module	**Mandatory**					
Creditpoints (LP) and workload	**30 LP = 900 h**					
Module duration (according to course plan)	**1 Semester**					
Courses/ Learning formats	**Type**	**Regular term** when starting in **Winter term (Summer term)**	**Mandatory/ elective**	**Contact Time (SWH)**	**Self Study**	**Creditpoints**
Master Thesis		4 (4)	M	6 months all day	900 h	30

In order to complete the module, you have to fulfil the following requirements:	
Compulsory Attendance	Master thesis (according to assignment and agreement with the supervisor)
Active participation	According to § 5 Para. 3, presentation on the Master's thesis (30 min)
Coursework	Maintenance of a laboratory notebook
Module examination	Master thesis

Qualification Goals, learning outcome, competences
The students are able to scientifically work on a topic in their chosen field of specialisation. They are able to introduce this topic in the form of a scientific paper (master's thesis), to describe and document their findings and to interpret and discuss them in the light of the relevant literature. They are also able to present and defend their master's thesis as a scientific paper, answering questions on the topic as well as on peripheral areas.
Contents
Master's thesis: Composition of a scientific paper on the topic, consisting of the following parts: Summary (max. 1 page), introduction including objectives, material & methods as well as results, discussion, bibliography; an appendix may be added to document further primary data. Presentation of the results as a lecture (20-30 min) and discussion.

Compulsory entrance requirements	According to § 15 para. 4
Recommended participation requirement(s) for the module and/or individual courses of the module	
Language(s) of instruction and examination	German or English
Weight of the module grade in the overall grade	30/66
Frequency of module offer	Every term
Reasons for compulsory attendance	According to HochSchG § 26 Para. 2 (7), scientific (practical) research work/internship (according to assignment and agreement with the supervisor).
Person responsible for the module	All full-time lecturers involved in the degree programme
Transferability of the module to other degree programs	Master of Science Biomedical Chemistry
Other	The module takes place full-time for 6 months. Individual supervision; the number of internships offered in a participating working group may vary from semester to semester. External Master's thesis possible on application.

Remarks

Depending on the type of course, different conversion factors are used to calculate a certain number of ECTS.

In general: 1 ECTS corresponds to 30h total workload (time hours),
1 corresponds to 10.5h attendance time per semester (14 weeks à 0.75h)

Contact time (SWH)	1	2	3	4
Total attendance time	10,5h	21h	31,5h	42h

Lectures and/or Exercises

A factor of 1.5 is applied, i.e. 2 SWH lectures or exercises correspond to 3 ECTS.

4,5 ECTS	3 (e.g. 2L+1E), 31,5h attendance time, 103.5h self-study, 135h total workload
6,0 ECTS	4 (e.g. 3L+1E), 42h attendance time, 138h self-study, 180h total workload
7,5 ECTS	5 (e.g. 3L+2E), 52,5h attendance time, 172,5h self-study, 225h total workload

Practical Courses

A factor of 0.50 or 0.75 or 1.00 is applied, depending on the extent of preparation and follow-up, e.g. with reports, ...

6,0 ECTS	Factor 0,50	12, 126h attendance time, 54h self-study, 180h total workload
		e.g. 10 weeks of 12,6h
7,5 ECTS	Factor 0,50	15, 157,5h attendance time, 67,5h self-study, 225h total workload
		e.g. 10 weeks of 15h
7,5 ECTS	Factor 0,75	10, 105h attendance time, 120h self-study, 225h total workload
		e.g. 10 weeks of 10,5h
6,0 ECTS	Factor 1,00	6, 63h attendance time, 117h self-study, 180h total workload
		e.g. 10 weeks of 6,3h

Seminars

A factor of 1.0 or 1.5 is applied, depending on the amount of preparation and follow-up, e.g. with lectures, new learning material, ...

1,0 ECTS	Factor 1,0	1, 10,5h attendance time, 19,5h self-study, 30h total workload
2,0 ECTS	Factor 1,0	2, 21h attendance time, 39h self-study, 60h total workload
1,5 ECTS	Factor 1,5	1, 10,5h attendance time, 34,5h self-study, 45h total workload
3,0 ECTS	Factor 1,5	2, 21h attendance time, 69h self-study, 90h total workload

Abbreviations

Abbreviation	Meaning
BMC	Biomedical Chemistry
e.g.	For example
ECTS / CP(LP)	European Credit Transfer System / Credit Point
IUPAC	International Union of Pure and Applied Chemistry
SWH(SWS)	Hours per Semester Week
S	Seminar
E	Exercise
Apr	Advanced Practical Course
L	Lecture