UNIVERSITÄT DUISBURG ESSEN

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University of Duisburg-Essen

Module Handbook

Master course

Water Science

(March 21st, 2022)

Contents

Introduction

The Module Handbook aims at providing a general overview on the Master Program, its modules and courses. The document also provides additional information on registration and assessment procedures, such as guidelines, forms and recommendations. Since the content is subject to frequent changes in curricula and procedures, please always check the relevant websites for actual information. This includes deviations from the course descriptions announced by individual teachers during the term.

Aims of the Master Program Water Chemistry

The aims and learning targets of the study program are provided in the following table:

Study aims for the Master Program Water Science

Superior Aims of the study program	Learning outcomes	Target oriented module
Graduated students of the program of master water science have deepened their knowledge of the chemistry of the water.	Graduated Students of the Master Program Water Science: • use their knowledge of microbiological, chemical and chemical analytical and technological processes to assess water quality.	Modules WatChem, EnvBi, ApplMibi, PracAnalChem, ApplAnaChem, EnviChem, StabIso, Electrochem, WatPolMonit, OxProcess, MicrobPhys, Metrol
Graduated students of the program of master water science can network connection in subarea of the Water technologies represent systematically and classify in the context of research as well as international water standards.	Graduated Students of the Master Program Water Science: • know the legal foundation in the area of the international water standards • Use this knowledge to evaluation and regulation of the research and test results • have an overview of the current research status in the waste water treatment, technology of membrane, environmental	Modules WatPolMonit, EnviChem, WatChem, AppMiBi Modules WatChem, EnviBi, ApplMibi, PracAnalChem, ApplAnalChem, EnviChem, StabIso, Electrochem, WatPolMonit, OxProcess Modules MemTech, TechEngWat, WastewatTreat,

	chemistry, water analysis; can critically interpret the results of the above mentioned research • can describe due to chemical and chemical-analytical, biological and technological complex relationship of the water area • can comprehend the contribution to the scientific discussion of society relevant issues in the areas particularly in the areas collect assessment of water quality and sustainability and resource protection; objective establish and their individually and society relevance	Modules ResPrac, StabIso, Biofoul, ApplAnaChem Module WatChem, ApplAnaChem, ApplMiBi, Management, WastewatTreat, Modules WatChem, ApplAnaChem, ApplMiBi, Management, WastewatTreat,
Graduated students of the program of master water science apply the modern methods of the laboratory work.	Graduated Students of the Master Program Water Science: • know various modern methods and techniques for chemical and microbiological analysis and Treatment of aqueous systems • can the advantage and disadvantage of those methods in relation to the answer question critically and essentially estimate • apply these methods independently in the lab.	Modules EnviMiBi, ApplAnaChem, Electrochem, MemTech, StabIso, TechEngWat, WastewatTreat, WatPolMonit
Graduated students of	Graduated Students of the	All Modules, but especially

the program of master water science can carry out scientific works independently and take up of PhD.	Master Program Water Science: • develop independently research questions and hypotheses • plan research projects under limitated time and resources • carry out research projects independently using appropriate methods and techniques also work in research teams • evaluate results, interpret results critically and objectively, put the results into an interdisciplinary and social context • present results in oral or written presentations to different stakeholders.	Modul ResPrac,
Graduated students of the program of master water science can work in a leading position in the industry / gouvernmental agency/NGO	Graduated Students of the Master Program Water Science: • edit and evaluate traditional and new problems of water technologies in the context of previous research results • act responsible • are prepared for the takeover of leadership responsibility • have created by individual areas of specialization a separate profile.	All Modules, but especially Modul ResPrac,

Curriculum Master Program Water Science

First Term	SWS				Cr	Exam
	L	S	P	S		
Chemometrics and Statistics	2	1			5	1
Environmental Microbiology	2	1			5	1
Water Chemistry	2	1			5	1
Optional Courses					**15**	**2-3**
Membrane Technologies	1	1			3	1
Waste Water Treatment	2	1			5	1
Nanopartikel und Kolloide	2	1			5	1
Foodomics	2	1			5	1
Excursions				1-5	1-5	
Sum					**30**	**5-6**
Second Term	**SWS**				**Cr**	**Exam**
	L	**S**	**P**	**S**		
Applied AnaC	2	1			5	1
Env-MiBi-P			8	1	7	
Applied Microbiology	4				6	1
Optional Courses					**12**	**2-3**
Advanced Mass Spectrometry	1	1			3	1
Quality Management	1	1			3	
Metrology in Chemistry	1				2	1
Oxidative Processes	2	1			5	1
Stable Isotope Analysis	2	1	3		9	1
Technical Engineering Water	2	1			5	1
Nano-Biophotonik	2	1			5	1
Advanced Gas Chromatography	2				3	1
Lebensmittel	2	1			5	1
ElectroCat	3		3		5	1
Excursions				1-5	1-5	
Sum					**30**	**4-5**
Third Term	**SWS**				**Cr**	**Exam**
	L	**S**	**P**	**S**		
AnaC-P			15		10	
Research-P			15		10	

Optional Courses					**5**	**1**
Project Management	2				3	1
Membrane Technologies	1	1			3	1
Technical Engineering Water-Practical Course			3		4	1
Waste Water Treatment	2	1			5	1
Nanopartikel und Kolloide	2	1			5	1
Foodomics	2	1			5	1
Excursions				1-5	1-5	
Sum					**30**	**2**
Fourth Term						
Master-Arbeit					30	1
Sum					**30**	**1**
Total Sum					**120**	**11-12**

Module Descriptions

Required Modules

Module Name	Abbreviation Module
Applied Analytical Chemistry	ApplAnaC
Responsible for the Module	Faculty
Prof. Dr. Oliver J. Schmitz	Chemistry

Relevance for following study programmes:	Module Level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
2	1 Semester	C	5

Prerequisites	Recommended Prerequisites
none	none

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Applied Analytical Chemistry	C	3	150 h
Sum (Compulsory and Supplementary Courses)			3	150 h

Learning Outcomes of the Module
Students will understand the opportunities and limitations of instrumental analytical methods to obtain information on environmental systems. The students dispose of detailed knowledge of the analytic chemistry and arrange results of the research in the historical context and they get knowledge about principles and mechanisms of the chemistry. The students are able, to understanding the analytic process of the sampling and the sample preparation through the determination method up to the evaluation and estimation. The students have knowledge of advanced instrumentally analysis methods. They can apply the analysis methods in different areas, e.g., environment, industry.

Associated Key Qualifications
basic knowledge, systemic thinking, scientific thinking, structural ability, switching ability Ability to choose appropriate analytical methods for their own research questions based on the acquired theoretical and practical knowledge Ability to evaluate the quality of reported or achieved analytical data They have the ability in the knowledge extraction in the context of the teaching form "lecture". The students develop the expertise to assess theoretical and practical handling of the most important methods of instrumental analysis. They have the ability to demonstrate knowledge and understanding of essential concepts and theories relating to the subject matter.
Module examinations to gain grades
Written exam (120 Minutes)
Contribution of the Module Grade for the Final Grade
Share according to the credits (5/120)

Module name	Abbreviation Module	
Applied Analytical Chemistry	ApplAnaC	
Course Name	Abbreviation Course	
Applied Analytical Chemistry		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Oliver J. Schmitz	Chemistry	C

Designated Semester	Frequency	Language	No. students
2	SoSe	english	

SWS	Presence[1]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	105 h	150 h

Education Methodology
Lecture (2 SWS) & Seminar (1 SWS)
Learning Targets
Acquisition of basic theoretical and practical knowledge in applied analytical chemistry. The handling and preparation of samples and the reduction of matrix effects through application of appropriate analytical methods will be addressed. Target analytical niveau: Eurocurriculum
Contents
Concrete knowledge transfer with regard to the chemical and analytical preparation of samples (material and environmental samples, biological samples): Handling of samples and analytical methodology with respect to the most important instrumental techniques of atomic, isotopic and molecular analysis. • Sampling, sample storage and sample preparation. • X-ray analyses (powder diffractometry, fluorescence), chromatography (GC, LC, IC), mass spectrometry (EI, CI, ICP) and hyphenated methods (GC/MS, LC/AFS, etc.) • Qualitative and quantitative determination of main, trace and ultratrace components as well as the ratio of stable and unstable isotopes. • Sample fractionation, determination of total content and relevant parameters, mass balance
Examination
Written exam (120 Minutes)

[1] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Literature
Kellner, Mermet, Otto, Widmer: Analytical Chemistry, Wiley-VCH 1998
Further Information on the course

Module name	Abbreviation Module
Applied Microbiology	ApplMiBi
Responsible for the Module	Faculty
Prof. Dr. Alexander Probst	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
2	1 Semester	C	6

Prerequisites according to examination regulations	Recommended Prerequisites
none	none

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Geomicrobiology	C	2	90 h
II	Hygiene	C	2	90 h
Sum (Compulsory and Supplementary Courses)			4	180 h

Learning Outcomes of the Module
The students have knowledge how deeply microorganisms are involved in geochemical cycles. They are able to understand that microbial ecology, geochemistry and geology are closely connected. They obtain knowledge of the physiology and biochemistry of the microorganisms for the understanding of geochemical processes.
Associated Key Qualifications
The students • gain an overview of geochemical processes • have knowledge of the interactions of microorganisms and materials in their environments • know how microorganisms are classified, the physical constraints governing their growth, molecular approaches to studying microbial diversity, and life in extreme environments • have the ability to the systematic presentation of complex correlations between epidemiology of water-related infectious diseases.
Module examinations to gain grades
Written exam (120 Minutes) for module

Contribution of the Module Grade for the Final Grade
Share according to the credits (6/120)

Module name	Abbreviation Module	
Applied Microbiology	ApplMiBi	
Course Name	Abbreviation Course	
Geomicrobiology		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Alexander Probst	Chemistry	C

Designated Semester	Frequency	Language	No. students
2	SoSe	English	

SWS	Presence[2]	preparation, self tutoring, preparation for exam (h)	Workload
2	30 h	60 h	90 h

Education Methodology
Lecture (2 SWS)
Learning Targets
The students will learn how deeply microorganisms are involved in geochemical cycles and often are the responsible driving agents. They will understand that microbial ecology, geochemistry and geology are closely connected. The students will acquire knowledge of the physiology and biochemistry of the microorganisms involved is of utmost importance for the understanding of geochemical processes and will be intensified where necessary. It shall become obvious to them that Earth as a habitat has been largely created by microorganisms. Processes in this habitat are cyclic processes -Earth as a batch culture- and will be discussed in detail.

[2] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Contents
• History of Geomicrobiology • Microscopy methods in modern geomicrobiology • Omics methods in geomicrobiology • Microbial diversity and introduction to viruses • Ecology of hydrocarbon degradation • Carbon sequestration by microorganisms • Methane oxidation by microorganisms • Concepts in subsurface microbiology • Optional: Geomicrobiology of metal compounds • Optional: Evolutionary history of enzymes involved in carbon cycling
Examination
Written exam (120 Minutes) for Module
Literature
a) Geomicrobiology, 5th edition, 2009, Henry Lutz Ehrlich, Marcel Dekker New York, ISBN 978-0-8493-7906-2 b) Geomikrobiologie, 1998, Manfred Köhler und Fernando Völsgen, Wiley-VCH Weinheim, ISBN 3-527-30083-x; c) Brock Biology of Microorganisms, 2003, Michael T. Madigan, John M. Martinko, Jack Parker, Pearson Education Prentice Hall Upper Saddle River, ISBN 0-13-049147-0
Further Information on the course

Module name		Abbreviation Module	
Applied Microbiology		ApplMiBi	
Course Name		Abbreviation Course	
Hygiene			
Lecturer		Faculty	Module Type (C/S)
Dr. Verena Brauer		Chemistry	C

Designated Semester	Frequency	Language	No. students
2	SoSe	English	Ca. 20

SWS	Presence[3]	preparation, self tutoring, preparation for exam (h)	Workload
2	30 h	60 h	90 h

Education Methodology
Lecture (2 SWS)
Learning Targets
The students will have an overview of the characteristics and epidemiology of water-related infectious diseases. They will learn the relationships between water, sanitation and health. They will acquire basic knowledge on the relevant microbial, human and environmental factors which determine the hygienic status of water and its impact on public health. They will be able to evaluate the role of water-related pathogens for human health and learn approaches to prevent or control water-related infectious diseases.

[3] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Contents
1. Water, sanitation and health – global situation 2. Transmission routes and reservoirs of water-related pathogens 3. Classical and emerging waterborne pathogens – bacteria 4. Waterborne pathogens – viruses 5. Waterborne pathogens – protozoa 6. Vector-borne diseases associated with water 7. Water-related disease caused by cyanobacteria and algae 8. Hygienic aspects of catchment and source water quality 9. Hygienic aspects of water treatment, disinfection and water distribution 10. The indicator concept 11. Risk assessment
Examination
Written exam (120 Minutes) for Module
Literature
Brock Biology of Microorganisms. Madigan, M., Martinko, J., Dunlap, P. (2008) 12th Edition, Addison Wesley Pub Co Inc.
Further Information on the course
Homepage der World Health Organization (WHO), Water, sanitation and health: http://www.who.int/water_sanitation_health/en/

Module name	Abbreviation Module
Chemometrics and Statistics	Chemo
Responsible for the Module	Faculty
Dr. Maik Jochmann	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
1	1 Semester	C	5

Prerequisites according to examination regulations	Recommended Prerequisites
none	none

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Chemometrics and Statistics	C	3	150 h
Sum (Compulsory and Supplementary Courses)			3	150 h

Learning Outcomes of the Module
The students get knowledge about statistics including probability calculus, random variables, interval estimates and regression analysis. They are able to use these in modern chemometric data evaluation methods. They can solve problems within a programming environment.
Associated Key Qualifications
Students have ability to recognize and analyze novel problems and plans strategies to their solution. They can use the Students are able to present statistical facts and solutions in the seminar groups and discuss. They can represent linguistically understandable and technically correct to scientific facts. Students have the ability to formulate problems in mathematical form, to facilitate their analysis and solution. They are in a position as a general tool of expressive to use mathematical recommend.
Module examinations to gain grades
Written exam (120 Minutes)
Contribution of the Module Grade for the Final Grade
Share according to the credits (5/120)

Module name	Abbreviation Module	
Chemometrics and Statistics	Chemo	
Course Name	Abbreviation Course	
Chemometrics and Statistics		
Lecturer	Faculty	Module Type (C/S)
Dr. Gerrit Renner	Chemistry	C

Designated Semester	Frequency	Language	No. students
1	WiSe	English	

SWS	Presence[4]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	105 h	150 h

Education Methodology
Lecture (2 SWS) and Seminar (1 SWS)
Learning Targets
After a brief repetition of classical statistics, the students get acquainted with modern multivariate chemometric methods including factor analysis. Students will learn to grasp the underlying concepts by solving problems in a computer-based environment.
Contents
1. Introduction: Probability, special discrete and continous distributions, limit theorems, confidence intervals, statistical tests, correlation and regression, variance analysis 2. Multivariate methods: Linear statistical models, factor analysis, cluster and discriminant analysis 3. Basic methods of time series analysis 4. Case studies
Examination
Written exam (120 Minutes)

[4] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Literature
a) Peter Dalgaard, Introductory Statistics with R, Springer 2002 b) William N. Venables, Brian D. Ripley, Modern Applied Statistics with S, Springer 2003 c) John Fox, An R and S-Plus Companion to Applied Regression, Sage Publications 2002 d) Brian Everitt, An R and S-Plus Companion to Multivariate Analysis, Springer 2004 e) J.W. Einax et al., Chemometrics in Environmental Analysis, VCH (Wiley) 1997
Further Information on the course

Module name	Abbreviation Module
Environmental Microbiology	Envi MiBi
Responsible for the Module	Faculty
Prof. Dr. Rainer Meckenstock, Prof. Dr. Alexander Probst	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
1-2	2 Semester	C	12

Prerequisites according to examination regulations	Recommended Prerequisites
none	Biochemistry, molecular biology

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Environmental Microbiology	C	3	150 h
II	Practical Course Environmental Microbiology	C	9	210 h
Sum (Compulsory and Supplementary Courses)			3	360 h

Learning Outcomes of the Module
The students get knowledge about drinking water microbiology, microbiology of waste and waste water treatment. They have basic information about biotechnology.
Associated Key Qualifications
Application of the molecular biological approaches to microbial diversity. Knowledge of environmental microorganisms and biotechnological processes. They have ability to interpret data derived from laboratory observation an measurements in term of their significance and relate them to appropriate theory. Students have competence in the planning, design and execution of practical investigations, from the problem recognition stage through to the evaluation and appraisal of results and finding; this to include the ability to select appropriate techniques and procedures.
Module examinations to gain grades
Written exam (120 Minutes)
Contribution of the Module Grade for the Final Grade
Share according to the credits (12/120)

Module name	Abbreviation Module	
Environmental Microbiology	Envi MiBi	
Course Name	Abbreviation Course	
Environmental Microbiology		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Rainer Meckenstock; Prof. Dr. Alexander Probst	Chemistry	C

Designated Semester	Frequency	Language	No. students
1	WiSe	English	

SWS	Presence[5]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	105 h	150 h

Education Methodology
Lecture (2 SWS) & Seminar (1 SWS)
Learning Targets
The students will understand the processes underlying drinking water and waste water purification by biological filtration. They will obtain knowledge about the basics of sediment microbiology and bioremediation and get access to the basics of biotechnology.
Contents
• Drinking water microbiology: bank filtration, groundwater • Microbiology of drinking water treatment • Microbiology of waste and waste water treatment • Sediment – microbiology • Bioremediation • Introduction to biotechnology • Extremophiles (Microorganisms in extreme habitats) • Molecular ecology: Population analysis by classical and molecular approaches; Gene transfer and gene regulation during biofilm formation
Examination
Written exam (120 Minutes)

[5] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Literature
Brock: Biology of Microorganisms 12 th Edition 2002. Prentice Hall, ISBN 0-13-081922-0 Doods, W.K.: Freshwater Ecology. Academic Press, San Diego, 2002, ISBN 0-12-219135-8 Maier, Pepper, Gerba: Environmental Microbiology, Academic Press, 2000, ISBN 0-12-49750-4
Further Information on the course

Module name	Abbreviation Module	
Environmental Microbiology	EnviMiBi	
Course Name	Abbreviation Course	
Practical Course Environmental Microbiology		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Alexander Probst	Chemistry	C

Designated Semester	Frequency	Language	No. students
2	SoSe	English	

SWS	Presence[6]	preparation, self tutoring, preparation for exam (h)	Workload
9	135 h	75 h	210 h

Education Methodology
Practical (8 SWS) & Seminare (1 SWS)
Learning Targets
The students shall get trained in • handling environmental microorganisms • analyses of environmental samples incl. enrichment of relevant metabolic types • staining methods • geomicrobiological cycles and microorganisms • simple biotechnological processes like fermentation • application of molecular biological approaches to address microbial diversity
Contents
• Microscopy of microorganisms • Analysis of microbial communities through biomolecular methods (PCR methods) • Different cultivation methods for water and sediment microorganisms
Examination
Written (120 Minutes) / oral exam (30 – 60 Minutes) & protocol

[6] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Literature
Special script for practical course
Further Information on the course

Module name	Abbreviation Module
Practical Analytical Chemistry	AnaC-P
Responsible for the Module	Faculty
PD Dr. Ursula Telgheder	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
3	1 Semester	C	10

Prerequisites according to examination regulations	Recommended Prerequisites
none	Applied Analytical Chemistry

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Practical Course Analytical Chemistry	C	15	300 h
Sum (Compulsory and Supplementary Courses)			15	300 h

Learning Outcomes of the Module
The students learn different modern methods and special work techniques of analytical chemistry and their applications. They can estimate and evaluate the advantages and disadvantages of these methods critically. They learn how to present their work in a written report.
Associated Key Qualifications
Students have competence in the planning, design and execution of practical investigations, from the problem recognition stage through to the evaluation and appraisal of results and finding; this to include the ability to select appropriate techniques and procedures. They know the principles and procedures used in chemical analysis and the characterization of chemical compounds. Students own the principal techniques of structural investigation, including spectroscopy. They have skills in the monitoring, by observation and measurement, of chemical properties, events or changes, and the systematic and reliable recording and documentation thereof. Students have skills in the presenting scientific material and arguments in writing and orally.
Module examinations to gain grades
Colloquia and report in the practical course (study achievements); conclusion colloquium (30 – 60 Minutes) with an university teacher (test achievement)
Contribution of the Module Grade for the Final Grade
Share according to the credits (10/120)

Module name	Abbreviation Module	
Practical Analytical Chemistry	AnaC-P	
Course Name	Abbreviation Course	
Practical Course Analytical Chemistry		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Torsten Schmidt, Prof. Oliver J. Schmitz, PD Dr. Ursula Telgheder	Chemistry	C

Designated Semester	Frequency	Language	No. students
3	WiSe	english	

SWS	Presence[7]	preparation, self tutoring, preparation for exam (h)	Workload
15	225 h	75 h	300 h

Education Methodology
Experimental project work (14 SWS) & Seminar (1 SWS)
Learning Targets
The students acquire advanced theoretical and practical basic knowledge in applied analytical chemistry. By direct integration into a project-oriented research topic they learn how to set-up and validate analytical methods aiming at answering research questions. The students receive thus also an active insight into the everyday life in a modern analytical laboratory.
Contents
Rather than carrying out pre-set identical experiments on a lab course level as on the Bachelor level, in the Master practical course analytical chemistry students select topics suggested by all research groups involved in analytical chemistry training, covering topics from advanced spectrometry via hyphenation techniques to sophisticated mass spectrometry. Although only a limited and individually selected number of analytical techniques will thus be learned hands-on, this procedure contributes to the development of an individual study profile and due to the research; orientation is much more motivating for the students than carrying out pre-selected experiments with known results.

[7] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Examination
Colloquia and report in the practical course (study achievements); conclusion colloquium (30 – 60 Minutes) with an university teacher (test achievement)
Literature
Research-related primary literature will be distributed at the beginning of the practical course
Further Information on the course

Module name	Abbreviation Module
Research Practical	ResPract
Responsible for the Module	Faculty
Lecturers of the selected subject	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
3	1 Semester	C	10

Prerequisites according to examination regulations	Recommended Prerequisites
Practical Course AnaC + Envi Mibi	

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Research Practical	C	15	300 h
Sum (Compulsory and Supplementary Courses)			15	300 h

Learning Outcomes of the Module
Students learn how to set-up a small-scale research project, to carry out the required experimental work independently in a limited period of time and to present their results in a written report and/or an oral presentation.
Associated Key Qualifications
Students have ability to interpret data derived from the laboratory observation and measurements in term of their significance and relate them to appropriate theory. They own ability to recognize and implement good measurement science and practice. They have communications skills, covering both written and oral communication. Students have competence in the planning, design and execution of practical investigations, from the problem recognition stage through to the evaluation and appraisal of results and finding; this to include the ability to select appropriate techniques and procedures.
Module examinations to gain grades
Written report
Contribution of the Module Grade for the Final Grade
Share according to the credits (10/120)

Module name	Abbreviation Module	
Research Practical	Res Pract	
Course Name	Abbreviation Course	
Research Practical		
Lecturer	Faculty	Module Type (C/S)
Lecturers of the selected subject	Chemistry	C

Designated Semester	Frequency	Language	No. students
3	WiSe	english	

SWS	Presence[8]	preparation, self tutoring, preparation for exam (h)	Workload
15	225 h	75 h	300 h

Education Methodology
Experimental project work (14 SWS) & Seminar (1 SWS)
Learning Targets
Provide deeper knowledge and experimental skills in a chosen scientific subject, developments of skills required in the Master thesis
Contents
For a limited period a defined research project in one of the research groups. IT-supported literature searching, learning of typical experimental laboratory work, oral presentations, written reports
Examination
Written report
Literature
Depending on the chosen subject; initial literature will be made available
Further Information on the course

[8] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Module name	Abbreviation Module
Water Chemistry	WatChem
Responsible for the Module	Faculty
Prof. Dr. Torsten Schmidt	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science, M.Sc. Environmental Toxicology	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
1	1 Semester	C	5

Prerequisites according to examination regulations	Recommended Prerequisites
none	Basic knowledge in physical, organic and aqueous chemistry

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Water Chemistry	C	3	150 h
Sum (Compulsory and Supplementary Courses)			3	150 h

Learning Outcomes of the Module
Students should acquire an advanced understanding of chemical processes relevant in natural and technical aqueous systems, and of conceptual models and quantitative approaches to describe these. Controls of behavior and fate of organic and inorganic contaminants will be emphasized. Students will know how to apply the acquired knowledge by carrying out case studies on the behavior of chemicals in aqueous systems.
Associated Key Qualifications
Students have study skills needed for continuing professional development. They have ability to recognize and analyze novel problems and plans strategies for their solution. Students own presentations and communications skills, covering both written and oral communication. They have interpersonal skills, relating to the ability to interact with other people and to engage in team-working.
Module examinations to gain grades
Written exam (120 Minutes), case study and presentation
Contribution of the Module Grade for the Final Grade
Share according to the credits (5/120)

Module name	Abbreviation Module	
Water Chemistry	WatChem	
Course Name	Abbreviation Course	
Water Chemistry		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Torsten Schmidt	Chemistry	C

Designated Semester	Frequency	Language	No. students
1	WiSe	english	

SWS	Presence[9]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	105 h	150 h

Education Methodology
Lecture and Seminar (2 SWS) and Case Study (1 SWS)
Learning Targets
Students should acquire an advanced understanding of chemical processes relevant in natural and technical aqueous systems, and of conceptual models and quantitative approaches to describe these. Controls of behavior and fate of organic and inorganic contaminants will be emphasized. Students will know how to apply the acquired knowledge by carrying out case studies on the behavior of chemicals in aqueous systems.
Contents
Sorption processes and surfaces in aquatic systems: partitioning, adsorption, ion exchange, surface complexation; sorption coefficients, linear and nonlinear sorption, sorption isotherms, dual mode theory, role of colloids/DOM, role of inorganic surfaces, experimental methods and predictive tools. **Tools in aquatic chemistry:** Linear free energy relationships, mass balances, thermodynamic cycles **Reaction kinetics:** zero-order, first-order and pseudo-first-order reactions, kinetics and thermodynamics. **Transformations:** nucleophilic substitution including hydrolysis, elimination, redox reactions, introduction to photolysis.
Examination
Written exam (120 Minutes), case study and presentation

[9] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Literature
a) Benjamin, M. M. Water Chemistry, McGrawHill: New York, 2002 b) Jensen, J. N. A Problem-Solving Approach to Aquatic Chemistry, Wiley: New York, 2003 c) Schwarzenbach, R. P., Gschwend, P. M., Imboden, D. M. Environmental Organic Chemistry, 2nd ed., Wiley: New York, 2003.
Further Information on the course

Module name	Abbreviation Module
Master Thesis	Master
Responsible for the Module	Faculty
Study Dean	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	Master

Designated Semester	Duration of Module	Module Type (C/S)	Credits
4	1 Semester	C	30

Prerequisites according to examination regulations	Recommended Prerequisites
80 Credits	

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Master Thesis	S		900 h
Sum (Compulsory and Supplementary Courses)				900 h

Learning Outcomes of the Module
The students have the ability • to apply biological and or chemical principles to current fields related to Water Science • to comprehensively deal with a given topic within a limited timeframe • to cooperate with professionals in the practice • to collect topic-related information by means of modern information technology
Associated Key Qualifications
time management, project management, team work, presentation skills
Module examinations to gain grades
Master thesis
Contribution of the Module Grade for the Final Grade
Share according to the credits (30/120)

Module name	Abbreviation Module	
Master Thesis	Master	
Course Name	Abbreviation Course	
Master Thesis		
Lecturer	Faculty	Module Type (C/S)
Coordinator of the Master project	Chemistry	C

Designated Semester	Frequency	Language	No. students
4	SoSe	english	

SWS	Presence[10]	preparation, self tutoring, preparation for exam (h)	Workload
			900 h

Education Methodology
Experimental and theoretical work and evaluation and written documentation
Learning Targets
The Master Thesis is an experimental or theoretical work presented in written form showing that the students can perform and evaluate a scientific topic within 24 weeks' time. The students will gain experiences with modern scientific methods. The students have the ability to effectively apply theoretical/practical knowledge and competencies to real-world problems in water chemistry. They will understand the opportunities and limitations of these methods to obtain information on water chemistry. They are able to use these methods and to assess and interpret their results. They are able to present their results in an oral and written way. The students have an inside about current relevant research topics in special branches. They are able to analyse results. They are able to participate in scientific discussions about current topics and to assess them critically.
Contents
The projects will be provided by the lecturers. The students are free to choose the supervisor by themselves.
Examination
Master Thesis
Literature
Depending on the topic of the master thesis

[10] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Further Information on the course

Optional Modules

Module name	Abbreviation Module
Advanced Mass Spectrometry	Adv MS
Responsible for the Module	Faculty
PD Dr. Wolfgang Schrader	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
2	1 Semester	S	3

Prerequisites according to examination regulations	Recommended Prerequisites
none	

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Advanced Mass Spectrometry and hyphenated techniques	S	2	90 h
Sum (Compulsory and Supplementary Courses)			2	90 h

Learning Outcomes of the Module
Understanding of the use of mass spectrometric methods, technical understanding of fundamental issues, learning to solve problems in analytical chemistry, technical understanding of fundamental issues
Associated Key Qualifications
Learning to solve problems in analytical chemistry. Students know the principles and procedures used in chemical analysis and the characterization of chemical compounds. They have the principal techniques of the structural investigation, including spectrometry.
Module examinations to gain grades
Written (120 Minutes) or oral (30 – 60 Minutes) exam
Contribution of the Module Grade for the Final Grade
Share according to the credits (5/120)

Module name	Abbreviation Module	
Advanced Mass Spectrometry	Adv MS	
Course Name	Abbreviation Course	
Advanced Mass Spectrometry		
Lecturer	Faculty	Module Type (C/S)
PD Dr. Wolfgang Schrader	Chemistry	S

Designated Semester	Frequency	Language	No. students
2	SoSe	english	

SWS	Presence[11]	preparation, self tutoring, preparation for exam (h)	Workload
2	30 h	60 h	90 h

Education Methodology
Lecture (1 SWS) & Seminar (1 SWS)
Learning Targets
Understanding of the use of mass spectrometric methods, technical understanding of fundamental issues, learning to solve problems in analytical chemistry, technical understanding of fundamental issues.
Contents
Fundamentals of mass spectrometry, understanding of ionization, ion selection and detection, mass analyzers, fragmentation of ions in MS, compound characterization from spectra, understanding of hyphenated techniques, advantages and disadvantages of different analytical instruments, usability in regard to problem solving.
Examination
Written (120 Minutes) or oral (30 – 60 Minutes) exam
Literature
i.e. Mass Spectrometry - A Textbook, Jürgen Gross
Further Information on the course

[11] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Module name	Abbreviation Module
Excursions	Excursions
Responsible for the Module	Faculty
All lecturers of Master Programme Water Science	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
1, 2 or 3	1 Semester	S	1-5

Prerequisites according to examination regulations	Recommended Prerequisites
None	None

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Excursions	S	1-5	30-150 h
Sum (Compulsory and Supplementary Courses)			1-5	30-150 h

Learning Outcomes of the Module
Students get to know how large-scale research facilities; advanced water works or wastewater treatment plants work.
Associated Key Qualifications
Writing skills (They are able to create protocols independently and linguistically and professionally correct).
Module examinations to gain grades
Written report (no grades)
Contribution of the Module Grade for the Final Grade
Share according to the credits (1-5/120)

Module name	Abbreviation Module	
Excursions	Excursions	
Course Name	Abbreviation Course	
Excursions		
Lecturer	Faculty	Module Type (C/S)
All lecturers of Master Programme Water Science	Chemistry	S

Designated Semester	Frequency	Language	No. students
1,2 or 3	WiSe / SoSe	english	

SWS	Presence[12]	preparation, self tutoring, preparation for exam (h)	Workload
1-5	15-75 h	15-75 h	30-150 h

Education Methodology
Excursion
Learning Targets
Students get to know how large-scale research facilities; advanced water works or wastewater treatment plants work.
Contents
Excursion options may change according to willingness and ability of companies/operators to host student groups. Regular excursions are currently offered to an ultrafiltration plant for drinking water production in Roetgen, the Alfred-Wegener-Institute in Bremerhaven and the IRMM in Geel/Belgium.
Examination
Written report (no grades)
Literature
Provided on-site of necessary
Further Information on the course

[12] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Module name	Abbreviation Module
Management	Manage
Responsible for the Module	Faculty
PD Dr. Ursula Telgheder	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
2-3	2 Semester	S	6

Prerequisites according to examination regulations	Recommended Prerequisites
none	none

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Quality Management	S	2	90 h
II	Project Management	S	2	90 h
Sum (Compulsory and Supplementary Courses)			4	180 h

Learning Outcomes of the Module
Students get an inside about the application of Quality Assurance techniques. Students learn dealing with international norms at special examples. After the course students should be able to establish and validate quality management and assurance systems.
Associated Key Qualifications
Validate quality management, quality assurance techniques
Module examinations to gain grades
Written exam (120 Minutes) of module
Contribution of the Module Grade for the Final Grade
Share according to the credits (6/120)

Module name		Abbreviation Module	
Management		Manage	
Course Name		Abbreviation Course	
Quality Management		QM	
Lecturer		Faculty	Module Type (C/S)
PD Dr. Ursula Telgheder		Chemistry	S

Designated Semester	Frequency	Language	No. students
2	SoSe	english	

SWS	Presence[13]	preparation, self tutoring, preparation for exam (h)	Workload
2	30 h	60 h	90 h

Education Methodology
Lecture (1 SWS) & Seminar (1 SWS)
Learning Targets
The application of Quality Assurance techniques has led to major improvements in the quality of many products and services. In this course the international guides and concepts regarding quality management are imparted and the essential points elaborated. At special examples students learn dealing with international norms. After the course students should be able to establish and validate quality management and assurance systems.
Contents
Quality assurance in analytics and production; Introduction into the terms Good Laboratory Practice, Accreditation, Certification and the corresponding guides like GLP, GMP, EN 45001 und ISO 9000 ff; Requirements concerning a quality management system, e.g. standard operating standard procedures (SOPs), manuals, test devices, validation of methods; Quality Control Charts; Metrology; Documentation and archiving of data; Software Applications
Examination
Written exam (120 Minutes) for Module

[13] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Literature
• Neidhart, B.; Wegscheider, W.: Quality in Chemical Measurements, Springer-Verlag Berlin Heidelberg New York 2001, ISBN 3-540-65994- 32 • ISO Standards Compendium ISO 9000 – Quality management, 10th edition 2003, ISBN 92-67-10381-43 • ISO Survey of ISO 9000 and ISO 14001 certificates, 12th circle 2002, ISBN 92-67-10377-64 • ISO Management System The International Review of ISO 9000 and ISO 14000, International Organisation for Standardisation
Further Information on the course

Module name		Abbreviation Module	
Management		Manage	
Course Name		Abbreviation Course	
Project Management		PM	
Lecturer		Faculty	Module Type (C/S)
Prof. Dr. Wolf-Dieter Griebler		Chemistry	S

Designated Semester	Frequency	Language	No. students
3	WiSe	english	

SWS	Presence[14]	preparation, self tutoring, preparation for exam (h)	Workload
2	30 h	60 h	90 h

Education Methodology
Lecture (2 SWS)
Learning Targets
Students learn the basic knowledge of Project Management and the application of its fundamental rules to structure, organize and execute common projects with success. Case studies are used for demonstration and training purposes.
Contents
1. Project characteristics and success factors 2. Stakeholder Concept 3. Project Life Cycle Concept 4. Project Initiation and Planning 5. Project Organization 6. Project Execution and Controlling 7. Costs and Budgeting 8. Role of Project Manager and work in Project Teams 9. Risk- and Conflict Management 10. Documentation and Communication

[14] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Examination
Written exam (120 Minutes) for module
Literature
a) Smith, K. A., 2000, Project Management and Teamwork, Boston: McGraw-Hill's BEST b) Verzuh, E., 1999, The Fast Foreward MBA in Project Management, New York: John Willey&Sohns, Inc. c) PMBOK®Guide, 2000 Edition to the Project Management Body of Knowledge, Newton Square, Pennsylvania: Project Management Institute d) Cleland, D. I., Ireland, L.R., Project Manager's Portable Handbook, New York: McGraw-Hill e) Schelle, H., 1999, Projekte zum Erfolg führen, München: C. H. Beck f) Ackoff, R. L., 1994, The Democratic Corporation, Oxford/New York: Oxford University Press
Further Information on the course

Module name	Abbreviation Module
Membrane Technologies	Mem Tech
Responsible for the Module	Faculty
Prof. Dr. Mathias Ulbricht	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
1 or 3	1 Semester	S	3

Prerequisites according to examination regulations	Recommended Prerequisites
none	

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Membrane Technologies	S	2	90 h
Sum (Compulsory and Supplementary Courses)			2	90 h

Learning Outcomes of the Module
On the basis of fundamental knowledge in physical chemistry and (chemical) process engineering, the students will gain detailed insights into the fundamentals of membranes and membrane separations as well as the most important membrane technologies which are applied to water treatment and/or purification.
Associated Key Qualifications
Ability to use membrane technologies in the water treatment and/or purification. They know the principles and procedures used in the membrane technologies. Students hold the study skills needed for continuing professional development.
Module examinations to gain grades
Written Exam (120 Minutes)
Contribution of the Module Grade for the Final Grade
Share according to the credits (3/120)

Module name	Abbreviation Module	
Membrane Technologies	Mem Tech	
Course Name	Abbreviation Course	
Membrane Technologies		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Mathias Ulbricht	Chemistry	S

Designated Semester	Frequency	Language	No. students
1 or 3	WS	english	

SWS	Presence[15]	preparation, self tutoring, preparation for exam (h)	Workload
2	30 h	60 h	90 h

Education Methodology
Lecture (1 SWS) & Seminar (1 SWS)
Learning Targets
On the basis of fundamental knowledge in physical chemistry and (chemical) process engineering, the students will gain detailed insights into the fundamentals of membranes and membrane separations as well as the most important membrane technologies which are applied to water treatment and/or purification.

[15] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Contents
Membranes: • Types (non-porous vs. porous, ion-exchange, affinity) • Processes by type and driving force (gas separation, reverse osmosis, nanofiltration, ultrafiltration, microfiltration, dialysis, electrodialysis, pervaporation, specials) • Materials and preparation / manufacturing • Shape (flat-sheet, hollow fibre) and morphology • Membrane fouling and scaling • Membrane modules and principles of membrane separation engineering • Membrane adsorbers • Membrane reactor concepts • Examples (case studies) with particular relevance to water technologies: Desalination by reverse osmosis, nanofiltration and electrodialysis Purification and ultrapurification by reverse osmosis, nano-, ultra- and microfiltration as well as combined processes Membrane bioreactors
Examination
Written exam (120 Minutes)
Literature
a) M. Mulder, Basic principles of membrane technology, 2nd Ed., Dordrecht: Kluwer Academic Publishers, 1996 b) R. W. Baker, Membrane technology and applications, 2nd Ed., Chichester: John Wiley and Sons, 2004
Further Information on the course

Module name	Abbreviation Module
Metrology in Chemistry	Metrol
Responsible for the Module	Faculty
Prof. Dr. Hendrik Emons	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
2	2 Semester	S	2

Prerequisites according to examination regulations	Recommended Prerequisites
none	none

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Metrology in Chemistry	S	1	60 h
Sum (Compulsory and Supplementary Courses)			1	60 h

Learning Outcomes of the Module
Students shall realize the importance of traceability and other concepts in metrology for the evaluation of analytical results. They shall also obtain fundamental knowledge of the international systems in metrology.
Associated Key Qualifications
Quality management, insight into international regulations in metrology, critical data evaluation. Application of advanced knowledge and skills in inter- and trans-disciplinary discussion of complexes issues.
Module examinations to gain grades
Written(120 Minutes) or oral (30 – 60 Minutes) exam
Contribution of the Module Grade for the Final Grade
Share according to the credits (2/120)

Module name		Abbreviation Module	
Metrology in Chemistry		Metrol	
Course Name		Abbreviation Course	
Metrology in Chemistry			
Lecturer		Faculty	Module Type (C/S)
Prof. Dr. Hendrik Emons		Chemistry	S

Designated Semester	Frequency	Language	No. students
2	SoSe	english	

SWS	Presence[16]	preparation, self tutoring, preparation for exam (h)	Workload
1	20 h	40 h	60 h

Education Methodology
Lecture (4x 5 h)
Learning Targets
Obtain knowledge and understanding on the fundamental concepts of metrology and their application in chemical analysis, on principles and instruments of analytical quality assurance, and on the international measurement infrastructure.
Contents
Metrology and the analytical process, metrological traceability, measurement uncertainty, analytical quality assurance, ISO 17025, method validation, reference materials, international standardisation, European measurement infrastructure.
Examination
Written (120 Minutes) or oral (30 – 60 Minutes) exam
Literature
i.e. K. Danzer 'Analytical Chemistry', Springer Verlag; B. Hibbert 'Quality Assurance for the Analytical Chemistry Laboratory', Oxford University Press
Further Information on the course

[16] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Module name	Abbreviation Module
Nanoparticle and Colloids	Nano
Responsible for the Module	Faculty
Prof. Dr.-Ing. Stephan Barcikowski	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
1 oder 3	1 Semester	S	5

Prerequisites according to examination regulation	Recommended Prerequisites
none	

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Nanoparticle and Colloids (Lecture and Practical Course)	S	3	150 h
Sum (Compulsory and Supplementary Courses)			3	150 h

Learning Outcomes of the Module
The students should learn about the special properties of colloids and the structure and dynamics of these systems. They have the ability to describe interfacial phenomena and analyze. They are also able to investigate the complex transport and self-aggregation processes of nanoparticles, surfactants and polymers. The students have acquired the competence to work with colloidal systems, and they can describe the specific structures and properties of these systems and explain.
Associated Key Qualifications
The students have a working knowledge of nanoparticles and colloids. Judgments skills, self-learning
Module examinations to gain grades
Written (120 Minutes) or oral (30 – 60 Minutes) exam
Contribution of the Module Grade for the Final Grade
Share according to the credits (5/120)

Module name	Abbreviation Module	
Nanoparticle and Colloids	Nano	
Course Name	Abbreviation Course	
Nanoparticle and Colloids		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr.-Ing. S. Barcikowski	Chemistry	S

Designated Semester	Frequency	Language	No. students
1, 2 or 3	WiSe / SoSe	german	

SWS	Presence	preparation, self	SWS
3	39 h	111 h	150 h

Education Methodology
Lecture (2 SWS) & Practical Course (1 SWS)
Learning Targets
Teaching the fundamentals and absorbed the colloid chemistry and properties of nanoparticles. Providing discusses with case examples from the nanotechnology students of functional properties by nanoparticles

Contents
Grundlagen der Kolloidchemie • Historische Entwicklung • Oberflächeneffekte, Elektrochem. Doppelschicht (Helmholtz, Gouy-Chapman) Stern-Potential, Debye-Länge • Nanopartikel-Stabilisierung (Ostwald-Reifung, LSW-Theorie, sterische/elektrosterische Stabilisierung, DLVO-Theorie) **Spezielle Eigenschaften von Nanopartikeln** • Materialklassen (Metalle, Oxide, Halbleiter, Legierungen) Thermodynamische und mechanische Eigenschaften • Optische Nanopartikeleigenschaften (Plasmonenresonanz, Größen- und Morphologieabhängigkeiten, Streuung) • Magnetische Nanopartikeleigenschaften (Magnetismus von Nanopartikeln, Superparamagnetismus, Ferrofluide)- **Synthese von Nanopartikeln** • Top-down Methoden (Mechanische Zerkleinerung, Plasmasynthese, Laserablation etc.) • Bottom-up Methoden (Nasschemische Synthese, Gasphasensynthese, Form-in-place etc.) **Anwendung von Nanopartikeln und –materialien** • Funktionale Nanopartikel, Nanokomposite, Technische Applikation, Nanopartikel im Alltag, biomedizinische Anwendung **Charakterisierung von Nanopartikeln** • Elektronenmikroskopische Methoden, Spektroskopische Methoden, Lichtstreuung
Examination
Written (120 Minutes) or oral (30 – 60 Minutes) exam
Literature
z.B. D. Vollath: Nanomaterials, Wiley-VCH, Weinheim L. Cademartiri, G. Ozin: Concepts of Nanochemistry, Wiley-VCH, Weinheim C. N. R. Rao, A. Müller, A. K. Cheetham: The Chemistry of Nanomaterials, Wiley-VCH, Weinheim
Further Information on the course
Both parts (Exam and Practical Course) must be successfully completed to complete the module.

Modulname	Abbreviation Module
Nano-Biophotonik	NABIP
Responsible for the Module	Faculty
Prof. S. Barcikowski, Prof. M. Epple, Prof. M. Gunzer, Prof. S. Knauer, Prof. S. Schlücker	Chemistry, Biology

Relevance for following study programmes	Module Level
M. Sc.: Chemistry, Water Science, Biology, Medicinal Biology	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
1., 2. or 3.	1 Semester	S	5

Prerequisites according to examination regulations	Recommended Prerequisites
none	

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Nano-Biophotonik - Lecture	S	2	100 h
II	Nano-Biophotonik – Practical Course	S	1	50 h
Sum (Compulsory and Supplementary Courses)			3	150 h

Learning Outcomes of the Module
The students gain basic knowledge at the topical intersections of nano-materials, biology and photonics. They will know modern methods of Nanobiophotonics, how biological and optical functions can be designed using nanomaterials and photonic tools useful in biology and medical diagnosis and therapy. In the case studies, students should be able to find a suitable nanomaterial as solution for a biological or biomedical exercise with the tool "Light". They are able to select synthesis routes, biofunctionalization and appropriate characterization methods for specific problems, these apply and estimate. The theoretical knowledge of these three areas "nano", "bio" and "photonics" will be experimentally proved in the small groups during the internship.
Associated Key Qualifications
Basic knowledge, problem-solving, case study analysis, systems thinking, scientific thinking and working methods, structural capacity, employability
Module examinations to gain grades
Written (120 Minutes) exam to the Contents from the lecture and practical course

Contribution of the Module Grade for the Final Grade
Share according to the credits (5/120)

Modulname	Abbreviation Module	
Nano-Biophotonik	NABIP	
Course Name	Abbreviation Course	
Nano-Biophotonik - Vorlesung	NABIP-V	
Lecturer	Faculty	Module Type (C/S)
Prof. S. Barcikowski, Prof. M. Epple, Prof. M. Gunzer, Prof. S. Knauer, Prof. S. Schlücker	Chemie, Biologie	S

Designated Semester	Frequency	Language	No. students
1. or 3.	WiSe / SoSe	german	

SWS	Presence[17]	preparation, self tutoring, preparation for exam (h)	Workload
2	26 h	74 h	100 h

Education Methodology
Lecture (2 SWS) & Seminar (1 SWS)
Learning Targets
Aufbauend auf ihrem Wissen in der Naturwissenschaft erwerben die Studierenden Grundkenntnisse an den Schnittstellen der Themenfelder Nanomaterialien, Biologie und Photonik. Ziel ist die Einführung in moderne Methoden der Nanobiophotonik, indem erlernt wird, wie biologische und optische Funktionen gezielt mittels Nanomaterialien eingestellt werden um diese mit photonischen Werkzeugen nutzbringend in der Biologie sowie medizinischen Diagnose und Therapie einsetzen zu können. Fallbeispiele sollen die Teilnehmer des Kurses in die Lage versetzten, ein geeignetes Nanomaterial auszuwählen um eine biologische bzw. biomedizinische Aufgabenstellung mit dem „Werkzeug Licht“ zu lösen. In gleicher Weise sollen die Teilnehmer in der Lage sein, für konkrete Problemstellungen Syntheserouten, Biofunktionalisierungen und passende Charakterisierungsmethoden auszuwählen, anzuwenden und zu bewerten.
Contents
Einführung in die NanoBioPhotonik Nanobiomaterialien: • Einsatzgebiete, biologisch und biophotonisch relevante Eigenschaften - Synthese, Fraktionierung, Reinigung

[17] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Charakterisierung:

- Methoden zur Strukturbestimmung und Funktionalitätsbestimmung
- Umgebungsvariable Eigenschaften, Stabilisierung, Protein Corona
- Fallbeispiele aus der Praxis - Methodenkombination

Funktionalisierung:

- Grundlagen, Bindungsarten, Affinitäten, Klick-Chemie
- Markierung (Tagging), Biofunktionalisierung, biomolekulare Erkennung

Biophotonische Methoden, Lösungsstrategien und Fallbeispiele:

- Schwangerschaftstests (Lateral Flow Assays), Endoskopie, Krebs-Targeting, …

Diagnose-Methoden der NanoBiophotonik:

- Molekular: Biosensorik, molekulare Diagnose, SERS
- Intrazellulär: Kopplungen, Pasmonik, FRET, hochauflösende Lebendzellmikroskopie
- Zellulär: Markierung, Differenzierung, Zellsortierung, FACS
- Gewebe/Organ: Immunhistologie, Immunogold, Mikroskopie, Spektroskopie
- Moderne Methoden: Optische Ganzkörperbildgebung, Photoakustik, multimodale Bildgebung

Therapieansätze der NanoBiophotonik:

- Chemische-pharmakologische Ansätze: Solubilisieren, Verkapseln, Release-Systeme
- Physikalische Ansätze: Photothermie, Photodisruption, Laserskalpell
- Ausblick: klinische NanoBioMedizin, Biophotonik in der regenerativen Medizin

Examination

Written (120 Minutes) exam to the Contents from the lecture and practical course

Literature

Aus den folgenden Lehrbüchern werden ausgewählte Kapitel im Semesterapparat zur Verfügung gestellt:

- Jürgen Popp et al., Handbook of Biophotonics, Wiley, 2011, Vol. 1 (ISBN 987-3-527-41047-7), Vol. 2 (ISBN 987-3-527-41048-4), ausgewählte Kapitel
- Ricardo Aroca, Surface-enhanced vibrational spectroscopy: Chapter 2 (The interaction of light with nanoscopic metal particles and molecules on smooth reflecting surfaces), ISBN: 0-471-60731-2
- Greg T. Hermanson, Bioconjugate techniques, ISBN: 978-0-12-370501-3
- S. Schlücker: Surface-enhanced Raman spectroscopy: Analytical, Biophysical and Life Science Applications. ISBN: 978-3-527-32567-2

und um weitere Übersichtsartikel ergänzt (siehe elektronischer Semesterapparat).

Further Information on the course

Die Inhalte der Vorlesung werden im zugehörigen Blockpraktikum/Methodenkurs vertieft

Module name	Abbreviation Module	
Nano-Biophotonik	NABIP	
Course Name	Abbreviation Course	
Nano-Biophotonik - Praktikum	NABIP-P	
Lecturer	Faculty	Module Type (C/S)
Prof. S. Barcikowski, Prof. M. Epple, Prof. M. Gunzer, Prof. S. Knauer, Prof. S. Schlücker	Chemie, Biologie	S

Designated Semester	Frequency	Language	No. students
1. or 3.	WiSe / SoSe	german	

SWS	Presence[18]	preparation, self tutoring, preparation for exam (h)	Workload
1	13 h	37 h	50 h

Education Methodology
Praktikum (Blockpraktikum) und Methodenkurs
Learning Targets
Aufbauend auf ihrem Wissen in der Naturwissenschaft erwerben die Studierenden Grundkenntnisse an den Schnittstellen der Themenfelder Nanomaterialien, Biologie und Photonik. Ziel ist die Einführung in moderne Methoden der Nanobiophotonik, indem erlernt wird, wie biologische und optische Funktionen gezielt mittels Nanomaterialien eingestellt werden um diese mit photonischen Werkzeugen nutzbringend in der Biologie sowie medizinischen Diagnose und Therapie einsetzen zu können. Im Blockpraktikum (praktische Methodenkurse in Kleingruppen zu den drei Bereichen „Nano“, „Bio“, „Photonik“) wird das theoretische Wissen experimentell erprobt, anschaulich begriffen und vertieft.
Contents
NANO: Synthese, (Bio)Funktionalisierung, Charakterisierung, Stabilisierung, BIO: Imaging, Biomoleküle, Nanobiomaterialien, Assays PHOTO: Spektroskopie, Laser/Optik, Plasmonik

[18] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Examination
Written (120 Minutes) exam to the Contents from the lecture and practical course
Literature
Aus den folgenden Lehrbüchern werden ausgewählte Kapitel im Semesterapparat zur Verfügung gestellt (siehe Vorlesung): • Jürgen Popp et al., Handbook of Biophotonics, Wiley, 2011, Vol. 1 (ISBN 987-3-527-41047-7), Vol. 2 (ISBN 987-3-527-41048-4), ausgewählte Kapitel • Ricardo Aroca, Surface-enhanced vibrational spectroscopy: Chapter 2 (The interaction of light with nanoscopic metal particles and molecules on smooth reflecting surfaces), ISBN: 0-471-60731-2 • Greg T. Hermanson, Bioconjugate techniques, ISBN: 978-0-12-370501-3 • S. Schlücker: Surface-enhanced Raman spectroscopy: Analytical, Biophysical and Life Science Applications. ISBN: 978-3-527-32567-2 und um weitere Übersichtsartikel mit ergänzt (siehe elektronischer Semesterapparat).
Further Information on the course

Module name	Abbreviation Module
Oxidative Processes in Water Technology	OxProcess
Responsible for the Module	Faculty
Prof. Dr. Torsten Schmidt	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
2	1 Semester	S	5

Prerequisites according to examination regulations	Recommended Prerequisites
none	Basic knowledge in physical, organic and aqueous chemistry

Associated Courses:

Nr.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Oxidative Processes	S	3	150 h
Sum (Compulsory and Supplementary Courses)			3	150 h

Learning Outcomes of the Module
Students should obtain an overview of routine and state-of-the-art oxidative processes used in water and wastewater treatment. They should acquire an advanced understanding of the fundamental transformation processes involved. By studying exemplary applications they will learn the advantages and drawbacks of oxidative processes. This will aid them in a selection of appropriate technological solutions.
Associated Key Qualifications
Presentations skills, teamwork, problem solving capabilities, scientific method
Module examinations to gain grades
Written (120 Minutes) or oral (30 – 60 Minutes) exam and presentation
Contribution of the Module Grade for the Final Grade
Share according to the credits (5/120)

Module name	Abbreviation Module	
Oxidative Processes in Water Technology	OxProcess	
Course Name	Abbreviation Course	
Oxidative Processes		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Torsten Schmidt, Dr. Jochen Türk	Chemistry	S

Designated Semester	Frequency	Language	No. students
2	SoSe	english	

SWS	Presence[19]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	105 h	150 h

Education Methodology
Lecture (2 SWS) and Seminar (1 SWS)
Learning Targets
Students should obtain an overview of routine and state-of-the-art oxidative processes used in water and wastewater treatment. They should acquire an advanced understanding of the fundamental transformation processes involved. By studying exemplary applications they will learn the advantages and drawbacks of oxidative processes. This will aid them in a selection of appropriate technological solutions.
Contents
Oxidative species/processes of interest: Chlorine, Chlorine dioxide, Ozone, Fenton, UV, Permanganate, Hydroxyl radicals, Other radicals, Ferrate, others Transformation reactions: electron transfer, H-abstraction, electrophilic addition Kinetics of transformation reactions Applications in water treatment (including disinfection) Applications in wastewater treatment Disinfection/transformation by-products: (Eco)toxicological evaluation Economical considerations
Examination
Written (120 Minutes) or oral (30 – 60 Minutes) exam and presentation

[19] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Literature
Will be announced in the course
Further Information on the course

Module name	Abbreviation Module
Stable Isotope Analysis	SIA
Responsible for the Module	Faculty
Dr. Maik Jochmann, Prof. Dr. Torsten Schmidt	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
2	1 Semester	S	9

Prerequisites according to examination regulations	Recommended Prerequisites
none	Basic knowledge in physical, organic and analytical chemistry

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Stable Isotope Analysis	S	3	150 h
II	Practical Course Stable Isotope Analysis	S	3	120 h
Sum (Compulsory and Supplementary Courses)			6	270 h

Learning Outcomes of the Module
Students should get to know the principles and instrumentation in modern stable isotope analysis with emphasis on light elements and will acquire hands-on experience on how to perform stable isotope analysis.
Associated Key Qualifications
Presentations skills, teamwork, problem solving capabilities, scientific method. Students have study skills needed for continuing professional development. They have ability to recognize and analyze novel problems and plans strategies for their solution. Students own presentations and communications skills, covering both written and oral communication. They have interpersonal skills, relating to the ability to interact with other people and to engage in teamworking.
Module examinations to gain grades
Written (120 Minutes) exam, presentation and lab course reports
Contribution of the Module Grade for the Final Grade
Share according to the credits (9/120)

Module name	Abbreviation Module	
Stable Isotope Analysis	SIA	
Course Name	Abbreviation Course	
Stable Isotope Analysis	SIA_1	
Lecturer	Faculty	Module Type (C/S)
Dr. Maik Jochmann, Prof. Dr. Torsten Schmidt	Chemistry	S

Designated Semester	Frequency	Language	No. students
2	SoSe	english	

SWS	Presence[20]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	105 h	150 h

Education Methodology
Lecture (2 SWS) and Seminar (1 SWS)
Learning Targets
Students should get to know the principles and instrumentation in modern stable isotope analysis with emphasis on light elements. By studying exemplary applications and case studies they will learn for which problems in environmental science isotope analysis might provide solutions.
Contents
Isotope fundamentals, isotope fractionation, referencing and calibration; Instrumentation, principles of isotope analysis; Gas source isotope ratio mass spectrometry (C, H, N, and O), bulk techniques: dual inlet, continuous flow, compound specific isotope analysis, position-specific isotope analysis; Isotope analysis of heavy elements: multicollector-ICP-MS, thermal ionization MS (e.g., Fe, Ca, Sr, Pb); Applications of stable isotope analysis in environmental science (source apportionment, transformation (extent and pathways), food sciences (food adulteration, food origin), geosciences (tracing of geochemical pathways by stable isotopes), forensic sciences (doping analysis).
Examination
Written (120 Minutes) exam and presentation (poster or oral)

[20] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Literature
a) Clark, I.; Fritz, P. Environmental Isotopes in Hydrogeology; CRC Press: Boca Raton, 1997 b) b) Kendall, C.; McDonnell, J. J., Eds. Isotope Tracers in Catchment Hydrology; Elsevier: Amsterdam, 1998 c) Frey, B.;Stable Isotope Ecology; Springer: Berlin, 2008 d) Sharp, Z.; Principles of Stable Isotope Geochemistry; Prentice Hall: Upper Saddle River, New Jersey, 2006
Further Information on the course

Module name	Abbreviation Module	
Stable Isotope Analysis	SIA	
Course Name	Abbreviation Course	
Practical Course Stable Isotope Analysis	SIA_2	
Lecturer	Faculty	Module Type (C/S)
Dr. Maik Jochmann, Prof. Dr. Torsten Schmidt	Chemistry	S

Designated Semester	Frequency	Language	No. students
2	SoSe	english	16

SWS	Presence[21]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	75 h	120 h

Education Methodology
Lab Course (3 SWS)
Learning Targets
Acquisition of practical knowledge and hands-on experience in stable isotope analysis. By own measurements students shall realize experimental pitfalls in stable isotope analysis and be able to evaluate isotope data including precision and accuracy.
Contents
Performing stable isotope analyses using modern GC-IRMS instrumentation for selected experiments on: 1. vanillin authentification 2. origin of alcoholic beverages 3. practical isotope mass balance
Examination
Written reports
Literature
Handouts and literature listed therein
Further Information on the course

[21] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Module name	Abbreviation Module
Technical Engineering Water	TechEngWater
Responsible for the Module	Faculty
Prof. Dr.-Ing. Stefan Panglisch, Dr.-Ing. Ralph Hobby	Engineering

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
2-3	2 Semester	S	9

Prerequisites according to examination regulations	Recommended Prerequisites
none	none

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Technical Engineering Water	S	3	150 h
II	Practical Course Technical Engineering Water	S	3	120 h
Sum (Compulsory and Supplementary Courses)			6	270 h

Learning Outcomes of the Module
Students have theoretical and practical knowledge for different water treatment processes.
Associated Key Qualifications
Basic knowledge, systemic thinking, scientific thinking. The possibility to use this knowledge in the praxis. Competence in planning, design and execution of practical investigation, from the problem recognition stage through to the evaluation and appraisal of results and finding; this to include the ability to select appropriate techniques and procedure.
Module examinations to gain grades
Written (120 Minutes) or oral (30 – 60 Minutes) exam
Contribution of the Module Grade for the Final Grade
Share according to the credits (9/120)

Module name		Abbreviation Module	
Technical Engineering Water		TechEngWater	
Course Name		Abbreviation Course	
Technical Engineering Water			
Lecturer		Faculty	Module Type (C/S)
Prof. Dr.-Ing. Stefan Panglisch, Dr.-Ing. Ralph Hobby		Engineering	S

Designated Semester	Frequency	Language	No. students
2	SoSe	english	

SWS	Presence[22]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	105 h	150 h

Education Methodology
Lecture (2 SWS) & Seminar (1 SWS)
Learning Targets
Theoretical basics of different processes in drinking water treatment, and basic knowledge for the practical design.
Contents
Basics knowledge and practical orientated knowledge for the following water treatment processes: • Overview • Oxidation Processes • Decarbonisation • Ion Exchange • Gas Exchange • Flocculation • Sedimentation • Sludge Treatment • Filtration • Adsorption • Membrane Processes

[22] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Examination
Written (120 Minutes) or oral (30 – 60 Minutes) exam
Literature
a) Sontheimer et. al., Activated Carbon for Water Treatment, DVGW-Forschungsstelle am Engler-Bunte Institut der Universität Karlsruhe (TH) 1988 b) Tien, C., Granular Filtration of Aerosols and Hydrosols, Butterworth Publishers 1989, ISBN 0-409-90043-5 c) Filters and Filtration Handbook, 3rd Edition Elsevier Science Publishers LTD, 1996, ISBN 1-85617-078-0
Further Information on the course

Module name	Abbreviation Module	
Technical Engineering Water	TechEngWater	
Course Name	Abbreviation Course	
Practical Course Technical Engineering Water		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr.-Ing. Stefan Panglisch, Dr.-Ing. Ralph Hobby	Engineering	S

Designated Semester	Frequency	Language	No. students
3	SoSe	english	

SWS	Presence[23]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	75 h	120 h

Education Methodology

Practical Course (3 SWS)

Learning Targets

Students have to enhance their theoretical knowledge from the lecture Practical Engineering Water. They have to carry out practical oriented experiments with different pilot plants.

Contents

1. Filtration
2. Deacidification
3. Membrane Filtration

Examination

Written (120 Minutes) exam

Literature

a) Sontheimer et. al., Activated Carbon for Water Treatment, DVGW Forschungsstelle am Engler-Bunte Institut der Universität Karlsruhe (TH) 1988

b) Tien, C., Granular Filtration of Aerosols and Hydrosols, Butterworth Publishers 1989, ISBN 0-409-90043-5

c) Filters and Filtration Handbook, 3rd Edition Elsevier Science Publishers LTD, 1996, ISBN 1- 85617-078-0

Further Information on the course

[23] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Module name	Abbreviation Module
Wastewater Treatment	WWT
Responsible for the Module	Faculty
Prof. Dr.-Ing. Stefan Panglisch, Dr.-Ing. Ralph Hobby	Engineering

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
1 or 3	1 Semester	S	5

Prerequisites according to examination regulations	Recommended Prerequisites
None	none

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Wastewater Treatment	S	3	150 h
Sum (Compulsory and Supplementary Courses)			3	150 h

Learning Outcomes of the Module
The students know the sources a composition of wastewater, their biological processes.
Associated Key Qualifications
Students have knowledge about wastewater biology and chemistry. They understand the fundamentals in the field of Urban Water Management.
Module examinations to gain grades
Written exam (120 Minutes)
Contribution of the Module Grade for the Final Grade
Share according to the credits (5/120)

Module name	Abbreviation Module	
Wastewater Treatment	WWT	
Course Name	Abbreviation Course	
Wastewater Treatment		
Lecturer	Faculty	Module Type (C/S)
Dr.-Ing. Ralph Hobby, Prof. Dr.-Ing. Stefan Panglisch	Engineering	S

Designated Semester	Frequency	Language	No. students
1 or 3	WiSe	english	

SWS	Presence[24]	preparation, self tutoring, preparation for exam (h)	Workload
3	45 h	105 h	150 h

Education Methodology
Lecture (2 SWS) & Seminar (1 SWS)
Learning Targets
The student shall: • gain knowledge of wastewater biology and chemistry • gain understanding the fundamentals in the field of Urban Water Management • master the design of individual facility components of wastewater treatment plants
Contents
Sources and composition of wastewater, basic biological processes, activated sludge plants, trickling filters, nitrification, denitrification, P-elimination, anaerobic processes, sludge treatment, mass balances
Examination
Written (120 Minutes) examination (50 %), laboratory report (50 %)
Literature

[24] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

a) Henze, M., Harremoes, P., Jansen, J. la Cour, Arvin, E. (1996): Wastewater Treatment, Biological and Chemical Processes, Springer Verlag
b) Vesilind, A., Rooke, R.L., (2003): Wastewater Treatment Plant Design, IWA Publishing
c) Bitton, G., (1990): Wastewater Microbiology, Wiley-Liss Verlag
d) DWA Dictionary; The Microbiology of Activated Sludge Second Edition Author(s): Robert Seviour, Linda Blackall NYP ISBN: 1843390329
e) ATV Dictionary; Principles of Water and Wastewater Treatment Processes Editor(s): R Stuetz ISBN: 1843390264
f) Hosang, W., Bischof, W. (1998): Abwassertechnik, Teubner Verlag

Further Information on the course

Module name	Abbreviation Module
Microbial Biotechnology and Biodegradation	Microb Biotec
Responsible for the Module	Faculty
Prof. Dr. Rainer Meckenstock, Prof. Dr. Bettina Siebers	Chemistry

Relevance for following study programmes	Module level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
2	1 Semester	S	3

Prerequisites according to examination regulations	Recommended Prerequisites
None	Environmental Microbiology, Biochemistry, Molecular Biology

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Microbial Biotechnology and Biodegradation	S	2	90 h
Sum (Compulsory and Supplementary Courses)			2	90 h

Learning Outcomes of the Module
The students will get an overview of the use of living systems (i.e. microbial communities, microorganisms or biological molecules such as enzymes) for the production of relevant substances and process optimization for human benefit. Starting with a general overview of biotechnological applications and significance, classical fermentations in food industries, special production strains, biocatalysis by enzymes as well as environmental biotechnology will be discussed
Associated Key Qualifications
Module examinations to gain grades
Written exam (120 Minutes)
Contribution of the Module Grade for the Final Grade
Share according to the credits (3/120)

Module name	Abbreviation Module	
Microbial Biotechnology and Biodegradation	Microb Biotec	
Course Name	Abbreviation Course	
Microbial Biotechnology and Biodegradation		
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Rainer Meckenstock, Prof. Dr. Bettina Siebers	Chemistry	S

Designated Semester	Frequency	Language	No. students
2	SoSe	English	

SWS	Presence[25]	preparation, self tutoring, preparation for exam (h)	Workload
2	30 h	60 h	90 h

Education Methodology
Lecture (2 SWS)
Learning Targets
The students will get an overview of the use of living systems (i.e. microbial communities, microorganisms or biological molecules such as enzymes) for the production of relevant substances and process optimization for human benefit. Starting with a general overview of biotechnological applications and significance, classical fermentations in food industries, special production strains, biocatalysis by enzymes as well as environmental biotechnology will be discussed
Contents
1) Biotechnology (overview) 2) Classical Biotechnology (Fermentations, productions strains etc.) 3) Enzyme Catalysis for production and process optimization 4) Metabolic engineering & Synthetic Biology 5) Selected clean-up technologies of contaminated sites and microbial processes during bioremediation 6) Monitoring methods for bioremediation 7) Oil production and enhanced oil recovery 8) Metal leaching and metal production 9) Biogas production
Examination
Written (120 Minutes) examination

[25] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Literature
a) Brock, Biology of Microorganisms, 2014, 14th Edition, Michael Madigan, John Martinko, Kelly Bender, Daniel Buckley, David Stahl, Pearson Education Prentice Hall Upper Saddle River, ISBN13: 9781292018317, ISBN10: 1292018313 b) Introduction to Biotechnology, William J. Thiemann & Michael A. Palladino, Pearson, ISBN-13: 978-0321766113, ISBN-10: 0321766113 c) Environmental Micobiology, From geneomes to biogeochemistry, Eugene L. Madsen, Wiley Blackwell publishing; ISBN-13: 978-1118439630, ISBN-10: 1118439635
Further Information on the course

Module Name	Abbreviation Module
Microbial Physiology and Biotechnology	Micro BioTech
Responsible for the Module	Faculty
Prof. Dr. Bettina Siebers, Dr. Christopher Bräsen	Chemistry

Relevance for following study programmes:	Module Level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
2	1 Semester	S	7

Prerequisites	Recommended Prerequisites
Environmental Microbiology, Microbial Biotechnology	Biochemistry, Molecular Biology, Microbial Biotechnology

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Microbial Physiology and Biotechnology	S	8	210 h
Sum (Compulsory and Supplementary Courses)			8	210 h

Learning Outcomes of the Module
The class is organized as a block course, with lectures in the morning followed by practical work in the laboratory as well as bioinformatics analyses. During lectures, students will get an overview of biochemical, molecular biological and genetic methods as well as basic bioinformatics skills necessary to approach microbial physiology and to develop biotechnological applications. Students will be introduced to theoretical physiological and metabolic concepts as well as biotechnological application of enzymes and microbes. The lecture will convey basic bioinformatics skills for cloning of genes, prediction of gene function, phylogenetic comparisons. In the practical course, students will perform own projects on topics of scientific interest to the MEB group and will work on novel scientific questions as a small team. Starting with a general overview of physiology, methods and bioinformatics, students will learn state of the art biochemical, molecular biological and genetic methods, advanced physiological, biotechnological concepts as well as basic bioinformatics approaches.

Associated Key Qualifications
Students will learn molecular biological, biochemical and genetic methods applied in physiology and basic bioinformatics approaches.
Module examinations to gain grades
Protocol and presentation of results.
Contribution of the Module Grade for the Final Grade
Share according to the credits (7/120)

Module name	Abbreviation Module	
Microbial Physiology and Biotechnology	Micro BioTech	
Course Name	Abbreviation Course	
Microbial Physiology and Biotechnology	Micro BioTech	
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Bettina Siebers, Dr. Christopher Bräsen	Chemistry	S

Designated Semester	Frequency	Language	No. students
2	SoSe	English	8

SWS	Presence[26]	preparation, self tutoring, preparation for exam (h)	Workload
8	96 h	114 h	210 h

Education Methodology
Lecture with practical course (8 SWS)
Learning Targets
The class is organized as a block course, with lectures in the morning followed by practical work in the laboratory as well as bioinformatics analyses. During lectures, students will get an overview of biochemical, molecular biological and genetic methods as well as basic bioinformatics skills necessary to approach microbial physiology and to develop biotechnological applications. Students will be introduced to theoretical physiological and metabolic concepts as well as biotechnological application of enzymes and microbes. The lecture will convey basic bioinformatics skills for cloning of genes, prediction of gene function, phylogenetic comparisons. In the practical course, students will perform own projects on topics of scientific interest to the MEB group and will work on novel scientific questions as a small team. Starting with a general overview of physiology, methods and bioinformatics, students will learn state of the art biochemical, molecular biological and genetic methods, advanced physiological, biotechnological concepts as well as basic bioinformatics approaches.

[26] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Contents
- Microbial metabolism and physiology - Gene Cloning - Protein expression - Protein purification - Enzyme assays (Analytics) - Possible biotechnological applications - Introduction to basic bioinformatics tools for cloning - Introduction to basic bioinformatics tools to predict gene function - Scientific writing and scientific presenting - Exemplary research project on microbial metabolism, physiology and possible biotechnological applications
Examination
Protocol and presentation of results.
Literature
a) Brock, Biology of Microorganisms, 2014, 14th Edition, Michael Madigan, John Martinko, Kelly Bender, Daniel Buckley, David Stahl, Pearson Education Prentice Hall Upper Saddle River, ISBN13: 9781292018317, ISBN10: 1292018313 b) Detailed literature will be provided in the class
Further Information on the course
The criterion for admission to the module is based on the grade of the exam of the class “Environmental Microbiology”.

Module Name	Abbreviation Module
Ecology of Biodegradation	Eco Biodeg
Responsible for the Module	Faculty
Prof. Dr. Rainer Meckenstock	Chemistry

Relevance for following study programmes:	Module Level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
2	1 Semester	S	7

Prerequisites	Recommended Prerequisites
Passed lecture Environmental Microbiology	Stable Isotope Analysis, Microbial Biotechnology

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
	Ecology of Biodegradation	S	8	210
Sum (Compulsory and Supplementary Courses)			8	210

Learning Outcomes of the Module
The class is organized as a block course, starting with several days of lectures followed by the practical work that will be performed within individual research projects. During lectures, students gain theoretical knowledge about microbial community ecology and microbial biodegradation as well as about analytical techniques to measure and interpret both. The lectures will convey processing of 16S sequences and bioinformatic and statistical downstream analysis as well as stable isotope techniques to measure microbial degradation activity. In the practical part, students will carry out individual research projects on biodegradation of environmental pollutants or remediation technologies concerning current research topics of the group.
Associated Key Qualifications
Students will be able to perform microbial community analysis and measure microbial degradation activities and combine both aspects into a coherent interpretation. Deeper knowledge on biodegradation processes will be gained.
Module examinations to gain grades
Protocol and presentation of results.

Contribution of the Module Grade for the Final Grade
Share according to the credits (7/120)

Module name	Abbreviation Module	
Ecology of Biodegradation	Eco Biodeg	
Course Name	Abbreviation Course	
Ecology of Biodegradation	Eco Biodeg	
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Rainer Meckenstock, Dr. Verena Brauer	Chemistry	S

Designated Semester	Frequency	Language	No. students
2	SoSe	English	8

SWS	Presence[27]	preparation, self tutoring, preparation for exam (h)	Workload
8	96 h	114 h	210 h

Education Methodology
Lecture with practical course (8 SWS)
Learning Targets
The class is organized as a block course, starting with several days of lectures followed by the practical work that will be performed within individual research projects. During lectures, students will get equipped with theoretical knowledge about microbial community ecology and microbial biodegradation and about analytical techniques to measure and interprete both. The lectures will convey processing of 16S sequences and related downstream analysis as well as stable isotope techniques to measure microbial degradation activity. In the practical part, students will carry out small individual research projects involving analysis of microbial community composition and/or microbial activity. Students will learn current concepts of microbial community ecology and biodegradation research and practical techniques in community and stable isotope analysis.

[27] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Contents
- Community ecology - Microbial diversity - Amplicon sequencing - R programming - Univariate and multivariate statistics - Molecular techniques - Biodegradation research - Stable isotope techiques… - … - Scientific presenting - Exemplary research project on analysis of microbial community composition and degradation activity.
Examination
Protocol and presentation of results.
Literature
a) Brock, Biology of Microorganisms, 2014, 14th Edition, Michael Madigan, John Marinko, Kelly Bender, Daniel Buckley, David Stahl, Pearson Education Prentice Hall Upper Saddle River, ISBN13: 9781292018317, ISBN10: 1292018313 b) Detailed literature will be provided in the class.
Further Information on the course

Module Name	Abbreviation Module
Microbial Bioinformatics	Mic Bioinfo
Responsible for the Module	Faculty
Prof. Dr. Alexander Probst	Chemistry

Relevance for following study programmes:	Module Level
M.Sc. Water Science	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
3	1 Semester	S	7

Prerequisites	Recommended Prerequisites
Environmental Microbiology	Biochemistry, Molecular Biology, Microbial Biotechnology

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Ecology and Bioinformatics	S	8	210 h
Sum (Compulsory and Supplementary Courses)			8	210 h

Learning Outcomes of the Module
The class is organized as a block course, with lectures on most mornings and actual research for the rest of the time (morning and afternoon). During lectures, students will be made familiar with: - A programming language for analysis of microbial datasets - Processing of metagenomic datasets - Reconstruction of individual genomes from complex metagenomes - Analysis of microbial genomes including phylogenomics - Identification of viral genomes and linkage of viruses to hosts via CRISPR-Cas systems - Multivariate data analysis for ecology and other purposes - Metatranscriptomic analysis (optional) - Metagenome sequencing (optional; wet lab) The students will be individually integrated into existing research projects of the Group for Aquatic Microbial Ecology (AK Probst) and work on their own research question.

Associated Key Qualifications
Students will be able to perform microbial community analyses and analyze metagenomic datasets as well as interpretation thereof.
Module examinations to gain grades
Presentation of results
Contribution of the Module Grade for the Final Grade
Share according to the credits (7/120)

Module name	Abbreviation Module	
Microbial Bioinformatics	Mic Bioinfo	
Course Name	Abbreviation Course	
Microbial Bioinformatics	Mic Bioinfo	
Lecturer	Faculty	Module Type (C/S)
Prof. Dr. Alexander Probst	Chemistry	S

Designated Semester	Frequency	Language	No. students
3	WiSe	English	8

SWS	Presence[28]	preparation, self tutoring, preparation for exam (h)	Workload
8	96 h	114 h	210 h

Education Methodology
Lecture with practical course (8 SWS)
Learning Targets
The class is organized as a block course, with lectures on most mornings and actual research for the rest of the time (morning and afternoon). During lectures, students will be made familiar with: - A programming language for analysis of microbial datasets - Processing of metagenomic datasets - Reconstruction of individual genomes from complex metagenomes - Analysis of microbial genomes including phylogenomics - Identification of viral genomes and linkage of viruses to hosts via CRISPR-Cas systems - Multivariate data analysis for ecology and other purposes - Metatranscriptomic analysis (optional) - Metagenome sequencing (optional; wet lab) The students will be individually integrated into existing research projects of the Group for Aquatic Microbial Ecology (AK Probst) and work on their own research question.

[28] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Contents
- Microbial diversity - Ecosystem assembly - Amplicon sequencing - Univariate and multivariate statistics - Modeling of ecological principles - Introduction to programming languages - Metagenome sequencing & assembly - Metagenome binning - Genome analyses - Mobile elements and immune systems - Scientific writing and scientific presenting - Exemplary research project on community analyses and metagenomics
Examination
Presentation of results.
Literature
a) Brock, Biology of Microorganisms, 2014, 14th Edition, Michael Madigan, John Martinko, Kelly Bender, Daniel Buckley, David Stahl, Pearson Education Prentice Hall Upper Saddle River, ISBN13: 9781292018317, ISBN10: 1292018313 b) Detailed literature will be provided in the class
Further Information on the course
The criterion for admission to the module is based on the grade of the exam of the class “Environmental Microbiology”.

Module Name	Abbreviation Module
Chemistry and analytics of food and its authenticity	Lebensmittel
Responsible for the Module	Faculty
Prof. Dr. Oliver J. Schmitz	Chemistry

Relevance for following study programmes:	Module Level
M.Sc. Water Science, M.Sc. Chemistry, MA Teacher Program	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
2	1 Semester	S	5

Prerequisites	Recommended Prerequisites

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Chemistry and analytics of food and its authenticity	S	3	150 h
Sum (Compulsory and Supplementary Courses)			3	150 h

Learning Outcomes of the Module
Students gain basic knowledge of the chemical principles of food ingredients (carbohydrates, lipids, proteins, etc.). In the course, typical chemical reactions of the ingredients will be discussed. In addition, an overview of analytical methods will be given in order to characterize the ingredients. Accordingly, the students will acquire the competence about the most important methods and their practical use to determine the authenticity of food.
Associated Key Qualifications
Knowledge of the chemistry of carbohydrates, proteins and lipids in foods and their analysis.
Module examinations to gain grades
Written exam (120 Minutes) or oral exam (30 Minutes) Course Achievement: a lecture in the seminar (10 Minutes)
Contribution of the Module Grade for the Final Grade
Share according to the credits (5/120)

Module name	Abbreviation Module	
Chemistry and analytics of food and its authenticity	Lebensmittel	
Course Name	Abbreviation Course	
Chemistry and analytics of food and its authenticity	Lebensmittel	
Lecturer	Faculty	Module Type (C/S)
Dr. Sven Meckelmann	Chemistry	S

Designated Semester	Frequency	Language	No. students
2	SoSe	German	

SWS	Presence[29]	preparation, self tutoring, preparation for exam (h)	Workload
3	42 h	108 h	150 h

Education Methodology
Lecture (2 SWS) & Seminar (1 SWS)
Learning Targets
Students gain basic knowledge of the chemical principles of food ingredients (carbohydrates, lipids, proteins, etc.). In the course, typical chemical reactions of the ingredients will be discussed. In addition, an overview of analytical methods will be given in order to characterize the ingredients. Accordingly, the students will acquire the competence about the most important methods and their practical use to determine the authenticity of food.
Contents
Fundamentals of the chemistry of carbohydrates, proteins and lipids, analysis of food ingredients using examples, determination of the authenticity of foodstuffs.
Examination
Written exam (120 Minutes) or oral exam (30 Minutes) Course Achievement: a lecture in the seminar (10 Minutes)

[29] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Literature
• Lehrbuch der Lebensmittelchemie von Belitz, Grosch, Schieberle ISBN-10 3540732012 • Lebensmittelchemie von Matissek ISBN-10 3662596687 • Taschenatlas der Lebensmittelchemie: Functional Food, BSE-Analytik, Lebensmittel-qualität von Schwedt ISBN-10 9783527312078
Further Information on the course

Module Name	Abbreviation Module
Foodomics: Biochemistry of nutrition and analytics of functional foods.	Foodomics
Responsible for the Module	Faculty
Prof. Dr. Oliver J. Schmitz	Chemistry

Relevance for following study programmes:	Module Level
M.Sc. Water Science, M.Sc. Chemistry, MA Teacher Program	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
1 or 3	1 Semester	S	5

Prerequisites	Recommended Prerequisites
	Chemistry and analytics of food and its authenticity

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Foodomics: Biochemistry of nutrition and analytics of functional foods	S	3	150 h
Sum (Compulsory and Supplementary Courses)			3	150 h

Learning Outcomes of the Module
Students will gain knowledge of the biochemical principles of nutrition as well as their analytics. Using various examples, the influence of nutrition on different metabolic pathways will be shown and discussed how these processes can be characterized analytically. The students acquire the competence about the function and characterization of certain functional ingredients in food as well as in the human organism.
Associated Key Qualifications
Basic knowledge of the biochemistry of various food ingredients and their analysis.
Module examinations to gain grades
Written exam (120 Minutes) or oral exam (30 Minutes) Course Achievement: a lecture in the seminar (10 Minutes)
Contribution of the Module Grade for the Final Grade
Share according to the credits (5/120)

Module name	Abbreviation Module	
Foodomics: Biochemistry of nutrition and analytics of functional foods.	Foodomics	
Course Name	Abbreviation Course	
Foodomics: Biochemistry of nutrition and analytics of functional foods.	Foodomics	
Lecturer	Faculty	Module Type (C/S)
Dr. Sven Meckelmann	Chemistry	S

Designated Semester	Frequency	Language	No. students
1 or 3	WiSe	German	

SWS	Presence[30]	preparation, self tutoring, preparation for exam (h)	Workload
3	42 h	108 h	150 h

Education Methodology
Lecture (2 SWS) & Seminar (1 SWS)
Learning Targets
Students will gain knowledge of the biochemical principles of nutrition as well as their analytics. Using various examples, the influence of nutrition on different metabolic pathways will be shown and discussed how these processes can be characterized analytically. The students acquire the competence about the function and characterization of certain functional ingredients in food as well as in the human organism.
Contents
Basics of the biochemistry of nutrition, analysis of bioactive food ingredients and their detection in the human organism, targeted analysis of relevant metabolic pathways, non-targeted analysis of foods.
Examination
Written exam (120 Minutes) or oral exam (30 Minutes) Course Achievement: a lecture in the seminar (10 Minutes)

[30] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Literature
• Lehrbuch der Lebensmittelchemie von Belitz, Grosch, Schieberle ISBN-10 3540732012 • Taschenatlas der Lebensmittelchemie: Functional Food, BSE-Analytik, Lebensmittel-qualität von Schwedt ISBN-10 9783527312078 • Biochemie der Ernährung von Rehner und Daniel ISBN-10 3827420415 • Foodomics: Advanced Mass Spectrometry in Modern Food Science and Nutrition von Alejandro Cifuentes ISBN-13 978-1118169452
Further Information on the course

Module Name	Abbreviation Module
Electrocatalysis: From Fundamentals to Density Functional Theory	ElectroCat
Responsible for the Module	Faculty
Jun.-Prof. Dr. Kai S. Exner	Chemistry

Relevance for following study programmes:	Module Level
M.Sc. Water Science, M.Sc. Chemistry	MA

Designated Semester	Duration of Module	Module Type (C/S)	Credits
2	1 Semester	S	5

Prerequisites	Recommended Prerequisites
	Theoretical Chemistry 2, PC-V

Associated Courses:

No.	Course Name	Module Type	Hours per week (SWS)	Workload
I	Electrocatalysis: From Fundamentals to Density Functional Theory	S	6	150 h
Sum (Compulsory and Supplementary Courses)			6	150 h

Learning Outcomes of the Module
This course is organized as a block course, with lectures most mornings and actual research the rest of the time (mornings and afternoons). In the lectures, the students get information on the basics of electrochemistry and electrocatalysis as well as their atomistic description based on density functional theory calculations. The students are individually involved in existing research projects of the working group Theoretical Inorganic Chemistry (WG Exner) and work on their own small research project.
Associated Key Qualifications
The students get acquainted with the theory of catalytic processes on solid-state electrodes including their theoretical description by electronic structure calculations in the density functional theory approximation.
Module examinations to gain grades
Presentation of results

Contribution of the Module Grade for the Final Grade
Share according to the credits (5/120)

Module name	Abbreviation Module	
Electrocatalysis: From Fundamentals to Density Functional Theory	ElectroCat	
Course Name	Abbreviation Course	
Electrocatalysis: From Fundamentals to Density Functional Theory	ElectroCat	
Lecturer	Faculty	Module Type (C/S)
Jun.-Prof. Dr. Kai S. Exner	Chemistry	S

Designated Semester	Frequency	Language	No. students
2	SoSe	English	

SWS	Presence[31]	preparation, self tutoring, preparation for exam (h)	Workload
6	72 h	78 h	150 h

Education Methodology
Lecture with practical course (6 SWS)
Learning Targets
This course is organized as a block course, with lectures most mornings and actual research the rest of the time (mornings and afternoons). In the lectures, the students get information on the basics of electrochemistry and electrocatalysis as well as their atomistic description based on density functional theory calculations. The students are individually involved in existing research projects of the working group Theoretical Inorganic Chemistry (WG Exner) and work on their own small research project.
Contents
Fundamentals of electrochemistry; potentials; Helmholtz double layer; Gouy Chapman model; Butler-Volmer equation; electrode kinetics; overvoltages; electrocatalytic processes; hydrogen evolution; oxygen evolution reaction; chlorine evolution reaction; hydrogen oxidation; oxygen reduction reaction; electrolyzer; fuel cell; metal-air battery; atomic description; density functional theory; computational hydrogen electrode; linear scaling relationships; academic writing and presentation; exemplary small research project in the field of theoretical electrocatalysis.
Examination
Scientific presentation of the research project

[31] Bei der Berechnung der Präsenzzeit wird eine SWS mit 45 Minuten als eine Zeitstunde mit 60 Minuten berechnet. Dies stellt sicher, dass ein Raumwechsel und evt. Fragen an Lehrende Berücksichtigung finden.

Literature
• Modern Electrochemistry 2A von Bockris & Reddy, ISBN: 978-0-306-47605-1 • Grundlagen der Elektrochemie von Schmickler, ISBN: 9783540670452 • Elektrochemie von Hamann & Vielstich, ISBN: 978-3-527-31068-5
Further Information on the course
The admission criterion for the module is based on the exam grade for the PC-V course (M.Sc. Chemistry).

Impressum

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The actual version of the module handbook is to be found under:
www.uni-due.de/chemie/studium_modulhandbücher.shtml