TU Clausthal

Module handbook

Master of Science Chemistry

based on the AFB of 03.05.2022

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1a. Module title (German)	1b. Module title (English)
Moderne Konzepte der Anorganischen Chemie	**Modern Concepts of Inorganic Chemistry**

2. Usability of the module in study programs

M.Sc. Chemistry (mandatory module)

3. Responsible for module	4. Responsible faculty	5. Module number
Prof. Dr. A. Adam	Faculty of Natural and Materials Science	

6. Language	7. CP	8. Duration	9. Offered
English	8	[ ] 1st semester [X] 2nd semester	[ ] every semester [X] every year of study [ ] irregularly

10. Learning / qualification objectives of the module

Students are able to apply their deepened knowledge of substance and material properties, of chemical bonds in solids, of coordination and molecular compounds, and of chemical-physical methods of characterization methods of inorganic chemistry in a target-oriented manner. They significantly extend their theoretical and practical laboratory knowledge of the synthesis of inorganic compounds and materials.

In this module, students develop not only technical and methodological competences (analytical capability and rhetoric) but also social competence (esp. communication skills).

Lecture

11.no.	12. Title of the lecture	13. Lecturer	14. L no.	15. L Type	16. SWS	17. Workload Studies on campus/self-studies
1	Inorganic Structural Chemistry II	adjunct Prof. Dr. M. Gjikaj	W 3030	V/Ü	3	42 h / 78 h
2	Inorganic Synthesis Chemistry II	Prof. Dr. A. Adam	S 3022	V	1	14 h / 46 h
4	Practical Course on Inorganic Chemistry	Prof. Dr. A. Adam adjunct Prof. Dr. M. Gjikaj Dr. J. Wittrock	W 3034	P	3	42 h / 18 h
				Total:	7	98 h / 142 h

Re. no. 1:	
18a. Requirements	Bachelor in Chemistry or comparable achievements
19a. Contents	Building on the lecture "Inorganic Structural Chemistry" of the Bachelor program, this module is concerned with topics like symmetry as principle of order for crystal structures, energy and chemical bonds; the effective size of atoms and ions; element, ion and molecule structure; MO theory and chemical solid bonds as well as structure-property relations. The contents of the lecture will be deepened in the exercises by solving problems.
20a. Type of media	Board, overhead projector, PowerPoint presentations, lecture notes
21a. Literature	• U. Müller „Anorganische Strukturchemie" 7th edition, Springer-Vieweg (2016) • U. Müller „Anorganische Strukturchemie" 8th edition, Springer-Vieweg (2015)
22a. Other	---
Re. no. 2:	
18b. Requirements	Bachelor in Chemistry or comparable achievements
19b. Contents	Building on the lecture "Inorganic Synthesis Chemistry I" of the Bachelor program, this module focuses on inorganic synthesis in non-aqueous solvents.
20b. Type of media	Board, overhead projector, PowerPoint presentations, lecture notes
21b. Literature	• J. Jander, Ch. Lafrenz „Wasserähnliche Lösungsmittel" Verlag Chemie (1968)
22b. Other	---
Re. no. 3:	
18c. Requirements	Bachelor in Chemistry or comparable achievements
19c. Contents	Inorganic synthesis in non-aqueous solvents, solid state reactions, complex formation reactions, modern crystallization methods; analysis of synthesized substances with instrumental methods of inorganic chemistry.
20c. Type of media	--
21c. Literature	• Internship notes
22c. Other	---

Study/examination achievements					
23. no.	**24. Assigned lecture**	**25. Exam type**	**26. CP**	**27. Grading**	**28. Share of the overall module grade**
1	Inorganic Structural Chemistry II	MTP	4	ben.	50%
2	Inorganic Synthesis Chemistry II	MTP	2	ben.	25%
3	Practical Course Inorganic Chemistry	MTP	2	ben.	25%

Re. no. 1:	
29a. Exam form / requirements for achieving CP	Written examination (K, 60 minutes)
30a. Examiner in charge	Prof. Dr. M. Gjikaj
31a. Mandatory exam prerequisites	Participation in the lecture “Inorganic Structural Chemistry II”
Re. no. 2:	
29b. Exam form / requirements for achieving CP	Written examination (K, 60 minutes)
30b. Examiner in charge	Prof. Dr. A. Adam
31b. Mandatory exam prerequisites	Participation in the lecture “Inorganic Synthesis Chemistry II”
Re. no. 3:	
29b. Exam form / requirements for achieving CP	Practical work / conducting of given experiments incl. precolloquia and independent creation of correct protocols (PrA)
30b. Examiner in charge	Prof. Dr. A. Adam, Prof. Dr. M. Gjikaj, Dr. J. Wittrock
31b. Mandatory exam prerequisites	B.Sc. Chemistry or comparable achievements

1a. Module title (German)	1b. Module title (English)
Instrumentelle Analytik	**Instrumental Analysis**

2. Usability of the module in study programs

M.Sc. Chemistry (mandatory module)

3. Responsible for module	4. Responsible faculty	5. Module number
Prof. Dr. U.E.A. Fittschen	Faculty of Natural and Materials Science	

6. Language	7. CP	8. Duration	9. Offered
English	5	[ ] 1st semester [X] 2nd semester	[ ] every semester [X] every year of study [ ] irregularly

10. Learning / qualification objectives of the module

Students have deepened knowledge of chemical analysis of matter, in particular of material analysis and analysis of solids.

They broaden their theoretical and practical knowledge of characterization and analysis of materials and solids.

They are able to communicate and critically discuss their newly developed knowledge of instrumental analysis and modern concepts of inorganic chemistry in a scientific presentation.

In this module, students develop not only technical and methodological competences (analytical capability and rhetoric) but also social competence (esp. communication skills).

Lectures

11.no.	12. Title of the lecture	13. Lecturer	14. L no.	15. L Type	16. SWS	17. Workload Studies on campus/self-studies
1	Instrumental Analysis I	Prof. Dr. U. Fittschen	W 3054	V	1	14 h / 46 h
2	Practical Course on Instrumental Analysis	Prof. Dr. U. Fittschen	W 3056	P	3	40 h / 20 h
3	Seminar on Inorganic and Analytical Chemistry	Prof. Dr. U. Fittschen, Prof. Dr. A. Adam	S 3033	S	1	14 h / 16 h
				Total:	5	68 h / 82 h

Re. no. 1: Instrumental Analysis I

18a. Recomm. requirements	---

19a. Contents	Building on the general fundamentals of analytical chemistry, topics like assay preparation and specific sources of error of material analytics, and analytical figures of merit are deepened. Moreover, topics like speciation, local and time resolution in analytics and non-invasive methods are presented. Selected methods are explained in details and the possibilities of instrument development are discussed. Possible data evaluation and presentation is discussed.
20a. Type of media	Board, overhead projector, PowerPoint presentations, lecture notes
21a. Literature	• K. Cammann: Instrumentelle Analytische Chemie, Spektrum Verlag (2010), • D. Harris, Lehrbuch der quantitativen Analyse, 8th edition, Springer (2011), G. Schwedt, T. Schmidt, O. Schmitz: Analytische Chemie, 3rd edition, Wiley-VCH (2016) • D. A. Skoog, J. J. Leary: Instrumentelle Analytik, Springer (1996) • Van Grieken Handbook of X-Ray Spectrometry, Marcel Dekker 2001 • Klockenkämper and von Bohlen, TXRF, Wiley, 2015
22a. Other	---
Re. no. 2: Practical Course Instrumental Analysis	
18b. Recomm. requirements	---
19b. Contents	Experiment design; selection of methods; sample collection, preparation and conducting of analytical methods especially of methods of atomic spectroscopy
20b. Type of media	--
21b. Literature	• K. Cammann: Instrumentelle Analytische Chemie, Spektrum Verlag (2010), • D. Harris, Lehrbuch der quantitativen Analyse, 8th edition, Springer (2011), G. Schwedt, T. Schmidt, O. Schmitz: Analytische Chemie, 3rd edition, Wiley-VCH (2016) • D. A. Skoog, J. J. Leary: Instrumentelle Analytik, Springer (1996) • Van Grieken Handbook of X-Ray Spectrometry, Marcel Dekker 2001 • Klockenkämper and von Bohlen, TXRF, Wiley, 2015
22b. Other	---

Re. no. 3: Inorganic Chemistry Seminar	
18c. Recomm. requirements	---
19c. Contents	Students' presentations on advanced topics of inorganix and analytical chemistry.
20c. Type of media	---
21c. Literature	---
22c. Other	---

Study/examination achievements

23. no.	24. Assigned lecture	25. Exam type	26. CP	27. Grading	28. Share of the overall module grade
1	Instrumental Analysis I	MTP	2	ben.	70 %
2	Practical Course Instrumental Analysis	MTP	2	ben.	30 %
3	Seminar Inorganic and Analytical Chemistry	LN	1	unben.	0 %

Re. no. 1:	
29a. Exam form / requirements for achieving CP	Oral examination (30 minutes) or written examination (90 minutes) (M od. K)
30a. Examiner in charge	Prof. Dr. U. Fittschen
31a. Mandatory exam prerequisites	None
Re. no. 2:	
29b. Exam form / requirements for achieving CP	Practical work, conducting and analysis with sample preparation and several instrumental methods, preparing protocols (PrA)
30b. Examiner in charge	Prof. Dr. U. Fittschen
31b. Mandatory exam prerequisites	None
Re. no. 3:	
29c. Exam form / requirements for achieving CP	Proof of performance (SL)
30c. Examiner in charge	Prof. Dr. U. Fittschen, Prof. Dr. A. Adam
31c. Mandatory exam prerequisites	None

1a. Module title (German)	1b. Module title (English)
Syntheseplanung	**Design of Organic Synthesis**

2. Usability of the module in study programs

M.Sc. Chemistry (mandatory module)

3. Responsible for module	4. Responsible faculty	5. Module number
Prof. Dr. René Wilhelm	Faculty of Natural and Materials Science	

6. Language	7. CP	8. Duration	9. Offered
English	11	[ ] 1st semester	[ ] every semester
		[X] 2nd semester	[X] every year of study
			[ ] irregularly

10. Learning / qualification objectives of the module

In this seminar students repeat and practice characteristics of different compound classes and the mechanisms of their transformation. Following the method of inductive learning, students work in small groups where they independently solve simple synthesis problems by using all available sources of information (lecture notes, books, notes, internet, databases...). Students prepare the contents didactically, with the possibility to include similar reactions, side reactions or different theories, and present their results in front of all participants. The aim of this course is to thoroughly repeat knowledge students have developed, for all students to reach the same level of knowledge, to promote the team spirit and integration of new students and for students to apply their knowledge in a creative process of answering scientific questions. By the application of “forward oriented” synthesis steps, this seminars prepares students for the course “Design of Organic Synthesis”, in which the focus is placed on retro-analysis, i.e. “backward oriented” synthesis planning.

In the course “Design of Organic Syntheses”, students will develop, evaluate and discuss synthesis possibilities of more complex organic compositions by retro-synthetic analyses. Applying their knowledge on synthesis methods, students learn to recognize strategically relevant structural components of more complex compositions, and to break them down in synthons and finally starting materials so that a realistic, efficient and economical synthesis can be planned.

Students are also able to conduct organic syntheses from ongoing research and to synthesize more complex substances as well as to isolate complex product mixtures.

They develop the practical knowledge on current fields of work and techniques at the Institute, ranging from the fields of organic chemistry and organic material chemistry to organometallic chemistry, possibly including measurement technology from other institutes.

The module focuses on technical and methodological competences. Retro-analyses highly promote systems competence. In the practical course, self-competence is mainly built by training in time management and a sense of responsibility in academic work as well as the documentation and rational-critical interpretation of scientific findings.

Lectures						
11. no.	**12. Title of the lecture**	**13. Lecturer**	**14. L no.**	**15. L Type**	**16. SWS**	**17. Workload** **Studies on campus/self-studies**
1	Mandatory Seminar Synthesizing Methods	Prof. Dr. A. Schmidt	W 3178	S	2	28 h / 62 h
2	Design of Organic Synthesis	Prof. Dr. René Wilhelm	S 3106	V/Ü	3	42 h / 48 h
3	Practical Course in Advanced Organic Chemistry	Prof. Dr. A. Schmidt	W/S 3105	P	7	112 h / 38 h
				Total:	12	182 h / 148 h

Re. no. 1:	
18a. Recomm. requirements	Knowledge of organic chemistry as conveyed in a Bachelor program.
19a. Contents	In small groups, students will solve selected synthesis problems of gradually increasing complexity by filling in "gaps" with reagents, reaction products or mechanisms. The results will be presented afterwards.
20a. Type of media	Mainly board, slides and PowerPoint presentations, if applicable
21a. Literature	• All information sources should be available *in situ.*
22a. Other	---
Re. no. 2:	
18b. Recomm. requirements	---
19b. Contents	Fundamentals of synthesis planning (retrosynthetic analysis) are developed on the basis of typical synthesis problems. Key reactions (cycloaddition, rearrangement reaction, polarity inversion, asymmetric response etc.)
20b. Type of media	Board, slides, PowerPoint
21b. Literature	• Current reviews from research journals • F. A. Carey, R.J. Sundberg, Organische Chemie, VCH, 1995. • R. Brückner, Reaktionsmechanismen, Spektrum, 2009. • S. Warren, P. Wyatt, Organic Syntheses: The Disconnection Approach, Wiley, 2008. • S. Warren, Workbook for Organic Syntheses: The Disconnection Approach, Wiley, 2009.
22b. Other	---
Re. no. 3:	
18c. Recomm. requirements	---

19c. Contents	By the example of 8 synthesis stages from ongoing research, students gain practical insights in the latest fields of work and working techniques of organic chemistry, organic material chemistry and organometallic chemistry. One qualitative micro analysis will be conducted afterwards.
20c. Type of media	---
21c. Literature	• Current reviews from research journals
22c. Other	---

Study/examination achievements

23. no.	24. Assigned lecture	25. Exam type	26. CP	27. Grading	28. Share of the overall module grade
1	Mandatory Seminar Synthesizing Methods	MTP	3	ben.	30 %
2	Design of Organic Synthesis	MTP	3	ben.	70 %
3	Organic-Chemical Advanced Internship	LN	5	unben.	0 %

Re. no. 1:	
29a. Exam form / requirements for achieving CP	Proof of performance Development of solution strategies for synthesis problems, oral participation in the seminar (SL)
30a. Examiner in charge	Prof. Dr. Andreas Schmidt
31a. Mandatory exam prerequisites	None
Re. no. 2:	
29b. Exam form / requirements for achieving CP	Oral examination (M, 45 minutes)
30b. Examiner in charge	Prof. Dr. René Wilhelm
31b. Mandatory exam prerequisites	None
Re. no. 3:	
29c. Exam form / requirements for achieving CP	Practical assignment, 8 synthesis stages from ongoing research, 1 qualitative micro analysis, detailed research protocols (PrA)
30c. Examiner in charge	Prof. Dr. Andreas Schmidt
31c. Mandatory exam prerequisites	None

1a. Module title (German)	1b. Module title (English)
Kolloide und Grenzflächen	**Colloids and Interfaces**

2. Usability of the module in study programs
M.Sc. Chemistry (mandatory module)

3. Responsible for module	4. Responsible faculty	5. Module number
Prof. Dr. D. Johannsmann	Faculty of Natural and Materials Science	

6. Language	7. CP	8. Duration	9. Offered
English	10	[ ] 1st semester [X] 2nd semester	[ ] every semester [X] every year of study [ ] irregularly

10. Learning / qualification objectives of the module

Students have deepened knowledge of the characteristics of thermodynamics and dynamics of interfaces and surfaces. They understand essential phenomena and structures.

They also develop deep understanding of electrochemistry and the double layer model and the Debye-Hückel Theory. They are familiar with dynamic electrochemical processes and methods.

Students are able to apply their knowledge in experiments and to present these in short.

In this module, students develop technical, methodological and social competences (by group works and short presentations in the practical course).

Lectures

11. No.	12. Title of the lecture	13. Lecturer	14. L no.	15. L Type	16. SWS	17. Workload Studies on campus/self-studies
1	Physical Chemistry of Colloids and Interfaces	Prof. Dr. D. Johannsmann	W 3222	V	2	28 h / 62 h
2	Interface Analysis	Prof. Dr. F. Endres	W 8041	V	2	28 h / 62 h
3	Practical Course on Physical Chemistry Master	Prof. Dr. D. Johannsmann, Prof. Dr. J. Adams, Dr. A. Langhoff	W/S 3263	P	4	70 h / 50 h
				Total:	8	126 h / 174 h

Re. no. 1:

18a. Recomm. requirements	---
19a. Contents	Capillarity, nature and thermodynamics of interfaces of liquids, monomolecular films, microstructures, micelles, membranes, surfaces of solids, nucleation and condensation, adsorption
20a. Type of media	Board, slides, PowerPoint

21a. Literature	• Arthur W. Adamson, Alice P. Gast: Physical Chemistry of Surfaces, Wiley-VCH, Weinheim, 1997 • J.N. Israelachvili: Intermolecular and Surface Forces, Academic Press, 1992
22a. Other	---
Re. no. 2:	
18b. Recomm. requirements	Knowledge in physics and mathematics
19b. Contents	Introduction to scanning probe microscopy /STM, AFM), REM, electron spectroscopy (XPS, AES), optical spectroscopy of interfaces (IR, Raman) and quartz crystal microbalance technique
20b. Type of media	Board, slides, PowerPoint
21b. Literature	will be announced/handed out with the start of the lectures
22b. Other	---
Re. no. 3:	
18c. Recomm. requirements	---
19c. Contents	Project-oriented practical course on topics and methods covered in the lectures
20c. Type of media	Board, PowerPoint
21c. Literature	Independent literature research depending on the topic
22c. Other	---

Study/examination achievements

23. no.	24. Assigned lecture	25. Exam type	26. CP	27. Grading	28. Share of the overall module grade
1	Physical Chemistry of Interfaces and Colloids	MTP	3	ben.	30 %
2	Interface Analysis	MTP	3	ben.	30 %
3	Practical Course on Physical Chemistry Master	MTP	4	ben.	40 %

Re. no. 1:	
29a. Exam form / requirements for achieving CP	Oral examination (M, 30 minutes)
30a. Examiner in charge	Prof. Dr. D. Johannsmann
31a. Mandatory exam prerequisites	None
Re. no. 2:	
29b. Exam form / requirements for achieving CP	Oral examination (M, 30 minutes)
30b. Examiner in charge	Prof. Dr. F. Endres

31b. Mandatory exam prerequisites	None
Re. no. 3:	
29c. Exam form / requirements for achieving CP	Practical assignment (PrA). Practical conduct of experiments (group of 6 - 10 students) incl. collaborative evaluation and interpretation Drawing up and presenting the results in a collaborative manner
30c. Examiner in charge	Prof. Dr. D. Johannsmann , Prof. Dr. F. Endres, Prof. Dr. J. Adams
31c. Mandatory exam prerequisites	None

1a. Module title (German)	1b. Module title (English)
Chemische Reaktionstechnik	**Chemical Reaction Technology**

2. Usability of the module in study programs

M.Sc. Chemistry (mandatory module)

3. Responsible for module		4. Responsible faculty	5. Module number
Prof. Dr. S. Beuermann		Faculty of Natural and Materials Science	
6. Language	**7. CP**	**8. Duration**	**9. Offered**
English	10	[ ] 1 semester [X] 2 semesters	[ ] every semester [X] every year of study [ ] irregularly

10. Learning / qualification objectives of the module

In the lecture "Chemical Reaction Engineering", students develop knowledge on the basic concepts of chemical reaction engineering. They are able to understand and apply physicochemical fundamentals of chemical reaction engineering, kinetics of chemical reactions, material transport and chemical reactions of heterogeneous catalysis, as well as principles of technical reaction control and heat balance of chemical reactors individually and in complexes.

In this practical course, students use chosen experiments to theoretically and experimentally apply the knowledge on "Chemical Reaction Engineering" developed in the lecture. Conducting the experiments in groups strengthens the students' team competence.

The module focuses on technical, social and methodological competences.

Lectures

11. No.	12. Title of the lecture	13. Lecturer	14. L no.	15. L Type	16. SWS	17. Workload Studies on campus/self-studies
1	Chemical Reaction Engineering	Prof. Dr. S. Beuermann	W 3332	V	2	28 h / 62 h
2	Practical Master Course 'Chemical Reaction Engineering'	Dr. M. Drache	W/S 3360	P	6	120 h / 90 h
				Total:	8	148 h / 152 h

Re. no. 1:	
18a. Recomm. requirements	---
19a. Contents	– Chemical reaction engineering – Fundamentals of chemical reaction engineering – Basic reactor types – Physicochemical fundamentals of chemical reaction engineering – Kinetics of chemical reactions – Material transport and chemical reaction of heterogeneous catalysis – Principles of technical reaction control – Reaction control - Selection of adequate reactor types – Ideal reactors for homogeneous reaction systems – Real reactors for homogeneous and quasi-homogeneous reaction systems – Introduction: Statistical representation and distribution function, residence time distribution functions, simple residence time models (reactor models), complex residence time models (cell models) – Heat balance of chemical reactors – Microreaction technology
20a. Type of media	Board, PowerPoint (presentations are made available on Stud.IP)
21a. Literature	• M. Baerns, A. Behr, A. Brehm, J. Gmehling, H. Hofmann, U. Onken, A. Renken, Technische Chemie, Viley-VCH • O. Levenspiel: Chemical Reaction Engineering, Wiley & Sons, New York • Current scientific publications
22a. Other	---
Re. no. 2:	
18b. Recomm. requirements	Lecture Chemical Reaction Engineering
19b. Contents	Selected experiments related to “Chemical Reaction Engineering”: discontinuous, semi-continuous and continuous reactors, residence time behavior, reactor stability, heterogeneous catalysis
20b. Type of media	Experiment notes
21b. Literature	• M. Baerns, A. Behr, A. Brehm, J. Gmehling, H. Hofmann, U. Onken, A. Renken, Technische Chemie, Viley-VCH • O. Levenspiel: Chemical Reaction Engineering, Wiley & Sons, New York • W. Reschetilowski, Technisch-Chemisches Praktikum, Wiley VCH Verlag
22b. Other	The practical course may only be commenced with profound knowledge of chemical reaction engineering.

Study/examination achievements					
23. no.	**24. Assigned lecture**	**25. Exam type**	**26. CP**	**27. Grading**	**28. Share of the overall module grade**
1	Chemical Reaction Engineering	MP	3	ben.	100 %
2	Practical Master Course 'Chemical Reaction Engineering'	LN	7	unben.	0%

Re. no. 1:	
29a. Exam form / requirements for achieving CP	Oral examination (M, 45 minutes)
30a. Examiner in charge	Prof. Dr. S. Beuermann
31a. Mandatory exam prerequisites	None
Re. no. 2:	
29b. Exam form / requirements for achieving CP	Practical assignment (PrA)
30b. Examiner in charge	Prof. Dr. S. Beuermann
31b. Mandatory exam prerequisites	None

1a. Module title (German)	1b. Module title (English)
Forschungspraktikum im Science Pool	**Practical Research Course in the Science Pool**

2. Usability of the module in study programs

M.Sc. Chemistry (mandatory module)

3. Responsible for module	4. Responsible faculty	5. Module number
Prof. Dr. J. Adams, Lecturers of chemistry	Faculty of Natural and Materials Science	

6. Language	7. CP	8. Duration	9. Offered
English	3	[X] 1st semester [ ] 2nd semester	[X] every semester [ ] every year of study [ ] irregularly

10. Learning / qualification objectives of the module

To realize a group project, students apply their developed general scientific and special chemical knowledge as well as scientific methods and working techniques. In collaboration with others, they are able to develop a working concept, to evaluate the practicability and to practically implement it.

Together with other students, they can critically reflect, evaluate and present their work.

This module promotes technical and methodological competences, and social competence through the participation in a work group.

Lectures

11. No.	12. Title of the lecture	13. Lecturer	14. L no.	15. L Type	16. SWS	17. Workload Studies on campus/self-studies
1	Practical Research Course in the Science Pool	Prof. Dr. J. Adams Lecturers of chemistry	W 3950	P	5	60 h / 30 h
				Total:	5	60 h / 30 h

18. Recomm. requirements	The contents of the shared mandatory modules of both fields of study are prerequisites.

19. Contents	In team of 6-8 students, students independently work on a research topic, plan experiments and conduct them mostly independently. The results are presented by the group as a whole. The research focuses of at least two work groups are interconnected. This interdisciplinary practical course encourages students to independent scientific group work. Students work on research topics, experiments, their evaluation and interpretation mostly independently while applying their previously developed individual competences (particularly from their Bachelor thesis) in a manner supporting the team.
20. Type of media	---
21. Literature	The choice of literature depends upon the individual research topic. Choosing literature is part of the practical course.
22. Other	---

Study/examination achievements

23. no.	24. Assigned lecture	25. Exam type	26. CP	27. Grading	28. Share of the overall module grade
1	Practical Research Course in the Science Pool	MP	3	ben.	100 %

29. Exam form / requirements for achieving CP	Practical assignment (PrA), oral presentation of the results in the group.
30. Examiner in charge	Prof. Dr. J. Adams, lecturers of chemistry
31. Mandatory exam prerequisites	none

1a. Module title (German)	1b. Module title (English)
Masterarbeit + Kolloquium	**Master Thesis + Colloquium**

2. Usability of the module in study programs

M.Sc. Chemistry (mandatory module)

3. Responsible for module		4. Responsible faculty	5. Module number
Lecturers of chemistry		Faculty of Natural and Materials Science	
6. Language	**7. CP**	**8. Duration**	**9. Offered**
English	30	[X] 1st semester [ ] 2nd semester	[X] every semester [ ] every year of study [ ] irregularly

10. Learning / qualification objectives of the module

Students can work on a chemical problem in detail applying scientific methods in a given period of time under supervision by the lecturer. By the topic and question of the final examination, they are familiar with current research topics of the chemical institutes.

Technical, system and methodological competences are developed.

Other developed competences include:

- Detailed literature research
- Development of working concepts
- Daily work planning, team work in a working group
- Summing up results and critical evaluation of results
- Written description of the work

Presentation of the work in front of an academic audience

Lectures

11. No.	12. Title of the lecture	13. Lecturer	14. L no.	15. L Type	16. SWS	17. Workload Studies on campus/self-studies
1	Master Thesis + Colloquium	Lecturers of chemistry	---	Ab	30	780 h / 120 h
				Total:	30	780 h / 120 h

Re. no. 1:

18a. Recomm. requirements	Admission in accordance with § 16 of the Regulatory statutes for the Master program Chemistry (AFB Master Chemistry).

19a. Contents	Thesis answering a scientific question from the research fields of the chemical institutes. Upon consultation, the thesis can be completed with external partners (industry, non-university research institutes).
20a. Type of media	---
21a. Literature	---
22a. Other	---

Study/examination achievements

23. no.	24. Assigned lecture	25. Exam type	26. CP	27. Grading	28. Share of the overall module grade
1	Master Thesis + Colloquium	Ab	30	ben.	100 %

29. Exam form / requirements for achieving CP	The scientific work is presented in a colloquium with subsequent discussion and submitted as a written Master thesis. The written Master thesis is evaluated by two examiners (90% of the final grade). Details are given in the *General Examination Regulations of Clausthal University of Technology* and the *Regulatory statutes for the Master program Chemistry*. The colloquium makes up 10% of the final grade. The colloquium takes place soon before or after the submission of the written thesis in front of a larger audience (e.g. Institute seminar).
30. Examiner in charge	Lecturers of chemistry
31. Mandatory exam prerequisites	none

1a. Module title (German)	1b. Module title (English)
Computational Chemistry	**Computational Chemistry**

2. Usability of the module in study programs

M.Sc. Chemistry (Mandatory Elective "Cross-Cutting Topics of Modern Chemistry")

3. Responsible for module		4. Responsible faculty	5. Module number
Prof. Dr. D. Johannsmann		Faculty of Natural and Materials Science	
6. Language	**7. CP**	**8. Duration**	**9. Offered**
English	6	[ ] 1 semester [X] 2 semesters	[ ] every semester [X] every year of study [ ] irregularly

10. Learning / qualification objectives of the module

Chemical Bond:

Students understand the concepts of orbitals and their energy levels.
They know the LCAO-MO Theory, the Valence Bond Theory, the VSEPR Theory and the Hückel Theory. Based on the Schrödinger equation, students can determine orbitals and energies for simple homonuclear and heteronuclear molecules; they have reflected upon the necessary approximations. The starting points for computer-aided calculation methods (e.g. the Hartree-Fock method) are also covered in this course.

Computational Quantum Chemistry:

By using modern quantum chemical software, students are able to calculate the properties of simple molecules. For this, students apply different approximations yielding different grades of accuracy. They have an overview of current calculation methods, their strengths, limitations and practical advantage. They also know how to interpret the results.

Computational Molecular Modeling:

Students understand the atomistic fundamentals of Molecular Modeling: Structure generation and visualization of molecules, force fields, molecular mechanics calculation methods and optimization algorithms. Students are able to apply their knowledge using available computer programs.
They can explain and compare interatomic interactions in metals, ceramics and biomolecules. They are able to show the connection of thermodynamic properties (temperature, pressure) and molecular dynamics; they can derive essential material properties from simulations.

In this module, students develop technical and methodological competences.

Lectures

11. No.	12. Title of the lecture	13. Lecturer	14. L no.	15. L Type	16. SWS	17. Workload Studies on campus/self-studies
1	Chemical Bond	Prof. Dr. J. Adams	W 3227	V	1	14 h / 46 h
2	Computer-Aided Quantum Chemistry	Prof. Dr. E. Hübner	W/S 3180	V/Ü	1	14 h / 46 h
3	Computer-Aided Molecular Modeling	Prof. Dr. D. Johannsmann Dr. Marco Drache Prof. Dr. Nina Gunkelmann	W 3228	V/Ü	2	28 h / 32 h
				Total:	4	56 h / 124 h

Re. no. 1:	
18a. Recomm. requirements	---
19a. Contents	• Hydrogen molecule cation • Molecular orbitals • LCAO-MO • H_2 molecule • Valence Bond Theory • Solutions of the Schrödinger equation for polyelectronic systems • Molecular orbital energy diagrams • Heteronuclear molecules • Polyatomic molecules • VSEPR Theory • Hybridization • Hückel Theory • Computational chemistry • Hartree-Fock Method, etc.
20a. Type of media	Board, PowerPoint, computer animations
21a. Literature	Th. Engel, P. Reid: "Physikalischen Chemie", Pearson, Munich, 2006 Additional literature will be announce with the commencement of the lectures.
22a. Other	---
Re. no. 2:	
18b. Recomm. requirements	---

19b. Contents	Students learn to independently use the quantum chemical calculation software, from creating the structure over selecting options of quantum chemical calculations to the evaluation of results. Students recognize and compare advantages and limitations of quantum chemical methods by calculating simple exemplary molecules (i.a. HF-calculation and DFT-calculation, calculation of excited states, second derivative to test the optimized structures, allocation of IR-oscillations). In addition, students can perform individual calculations in connection with the current (synthetic or analytic) research on site. In a project, students also recognize the use of quantum chemical calculations of applied chemistry.
20b. Type of media	Board, slides, PowerPoint, computer presentations, computer exercises
21b. Literature	T. Klapötke, A. Schulz, „Quantenmechanische Methoden in der Hauptgruppenchemie“, Spektrum, Heidelberg 1996
22b. Other	---
Re. no. 3:	
18c. Recomm. requirements	---
19c. Contents	Model representations of molecule mechanics calculation methods, representation of molecular structures, molecular graphs, visualization of molecules, analysis of molecular geometry, applicability of different force fields, typification of atoms, potential functions, calculation of partial atomic charges, conformity analyses
20c. Type of media	Board, slides, PowerPoint, computer presentations, computer exercises
21c. Literature	R. Hentschke, E.M. Aydt, B. Fodi, E. Stöckelmann „Einführung in die Theorie und Praxis der Computersimulation molekularer Systeme“, Book as PDF-file J. Gasteiger, T. Engel, Chemoinformatics, WILEY-VCH, Weinheim 2003
22c. Other	---

Study/examination achievements

23. no.	24. Assigned lecture	25. Exam type	26. CP	27. Grading	28. Share of the overall module grade
1	Chemical Bond	LN	2	ben.	0 %
2	Computer-Aided Quantum Chemistry	LN	2	ben.	0%
3	Computer-Aided Molecular Modeling	LN	2	ben.	0%
Re. no. 1:					

29a. Exam form / requirements for achieving CP	Theoretical assignment (ThA)
30a. Examiner in charge	Prof. Dr. J. Adams
31a. Mandatory exam prerequisites	None
Re. no. 2:	
29b. Exam form / requirements for achieving CP	Theoretical assignment (ThA)
30b. Examiner in charge	Prof. Dr. E. Hübner
31b. Mandatory exam prerequisites	None
Re. no. 3:	
29c. Exam form / requirements for achieving CP	Theoretical assignment (ThA)
30c. Examiner in charge	Prof. Dr. D. Johannsmann
31c. Mandatory exam prerequisites	None

1a. Module title (German)	1b. Module title (English)
Chemie im globalen Umfeld	**Chemistry in the global environment**

2. Usability of the module in study programs

M.Sc. Chemistry (Mandatory Elective "Cross-Cutting Topics of Modern Chemistry")

3. Responsible for module		4. Responsible faculty	5. Module number
Academic dean		Faculty of Natural and Materials Science	
6. Language	**7. CP**	**8. Duration**	**9. Offered**
German and English	6	[ ] 1 semester [X] 2 semesters	[ ] every semester [X] every year of study [ ] irregularly

10. Learning / qualification objectives of the module

Energy Flows, Material Cycles and Global Development:

Students know global energy flows and material cycles as well as changes caused by anthropogenic activities as seen by engineers and scientists. They know limitations of industrial energy and material flows and resulting consequences for future developments.

Safety and Reliability in Chemistry:

Students are familiar with technical, organizational and legal framework conditions for safe chemical work. They know exemplary basic elements of quality assurance in chemistry. They can apply their knowledge to relevant tasks from the professional field.

Business Chemistry

In this course, students develop the ability to link chemical questions to economic perspectives and to connect the challenges of industrial, technical and economical problems. Fundamental principles of industrial chemistry foster a deeper understanding of the fourth-largest industry sector with a turnover of about 10 billion euro, an export rate of more than 60 % and over 24,000 employees in about 150 companies in Lower Saxony alone.

This course addresses technical and system competence.

Lectures						
11. No.	**12. Title of the lecture**	**13. Lecturer**	**14. L no.**	**15. L Type**	**16. SWS**	**17. Workload Studies on campus/self-studies**
1	Energieflüsse, Stoffkreisläufe und globale Entwicklung (Energy Flows, Material Cycles and Global Development)	Prof. Dr. T. Turek	S 8413	V	2	28 h / 32 h
2	Sicherheit und Zuverlässigkeit in der Chemie (Safety and Reliability in Chemistry)	Dr. K. Hecht	S 3225	V	1	14 h / 46 h
3	Chemiewirtschaft (Chemical Industry)	Prof. Dr. W. Meier	W 3179	V	2	28 h / 32 h
				Total:	5	70 h / 110 h

Re. no. 1:	
18a. Recomm. requirements	---
19a. Contents	- Introduction and fundamentals (systems and system balance, thermodynamics and different energy forms) - Bio-geosphere (historical and modern development) - The earth's energy balance (radiation, greenhouse effect, photosynthesis, climate models) - Global materials cycles (i.a. carbon, oxygen, water, nitrogen) - Anthropogenic material and energy flows and their limitations - Scenarios for global development
20a. Type of media	Board, slides, PowerPoint
21a. Literature	• Georg Schaub, Thomas Turek, Energy Flows "Material Cycles and Global Development", Springer, Berlin 2011
22a. Other	---
Re. no. 2:	
18b. Recomm. requirements	---

19b. Contents	1. Introduction Framework conditions, structures, basic concepts (risk, threat, etc.) 2. Handling of hazardous substances, chemicals-related regulations Legal bases, hazardous properties, limits 3. Chemical safety technology Methods and procedures, plant safety 4. Quality assurance in analytical chemistry and test technology Chemical metrology; validation of processes, quality management, GLP, accreditation of laboratories, certification, conformity assessment
20b. Type of media	Board, slides, PowerPoint
21b. Literature	• H. Pohle, „Chemische Industrie Umweltschutz, Arbeitsschutz, Anlagensicherheit; Rechtliche und Technische Normen; Umsetzung in die Praxis.“ Wiley-VCH, Weinheim, 1991 • H. Bender, „Sicherer Umgang mit Gefahrstoffen, Sachkunde für Naturwissenschaftler“, Wiley-VCH, Weinheim 1995 • J. Steinbach, „Chemische Sicherheitstechnik“ , Wiley-VCH, Weinheim 1995 • H. Schäfer, C. Jochum, „Sicherheit in der Chemie, Ein Leitfaden für die Praxis“, Carl Hanser Verlag, Munich Vienna 1997 • H. Günzler (Hrsg.), „Akkreditierung und Qualitätssicherung in der Analytischen Chemie“, Springer Verlag Berlin, 1994 • C.R. Sunstein, „Gesetze der Angst“, Suhrkamp Verlag, Frankfurt (Main) 2007
22b. Other	---
Re. no. 3:	
18c. Recomm. requirements	---
19c. Contents	• Chapter 1: Current situation of chemists • Promotions, new hires, retention in a position, statistics • Chapter 2: Market • Chemical industry, locations, branches of industry • Chapter 3: Companies • Constellation, comparisons of global companies, middle class, private equity, organizational structures and management information • Chapter 4: Products • Definitions, individual reviews, product group consideration.
20c. Type of media	Board, PowerPoint
21c. Literature	Recent publications in business journals
22c. Other	---

Study/examination achievements					
23. no.	**24. Assigned lecture**	**25. Exam type**	**26. CP**	**27. Grading**	**28. Share of the overall module grade**
1	Energieflüsse, Stoffkreisläufe und globale Entwicklung	LN	2	ben.	0 %
2	Safety and Reliability in Chemistry	LN	2	ben.	0%
3	Chemiewirtschaft	LN	2	ben.	0%

Re. no. 1:	
29a. Exam form / requirements for achieving CP	Written exam (K, 60 min) or oral exam (M, 30 min)
30a. Examiner in charge	Prof. Dr. T. Turek
31a. Mandatory exam prerequisites	None
Re. no. 2:	
29b. Exam form / requirements for achieving CP	Theoretical assignment (ThA)
30b. Examiner in charge	Dr. K. Hecht
31b. Mandatory exam prerequisites	None
Re. no. 3:	
29c. Exam form / requirements for achieving CP	Theoretical assignment (ThA)
30c. Examiner in charge	Prof. Dr. W. Meier
31c. Mandatory exam prerequisites	None

1a. Module title (German)	1b. Module title (English)
Personal und Projektmanagement	**Staff Management and Project Management**

2. Usability of the module in study programs

M.Sc. Chemistry (Mandatory Elective "Cross-Cutting Topics of Modern Chemistry")

3. Responsible for module		4. Responsible faculty	5. Module number
Prof. Dr. D. Meiners		Faculty of Natural and Materials Science	
6. Language	**7. CP**	**8. Duration**	**9. Offered**
German	6	[ ] 1 semester [X] 2 semesters	[ ] every semester [X] every year of study [ ] irregularly

10. Learning / qualification objectives of the module

Students know the different organizational forms and their basic principles and can classify them. They understand principles of HR management, know career paths and can develop their own ideas.

They are familiar with current topics of corporate management and know methods of project handling and management. They are able to estimate the state, range and diversity of projects, and to conduct project-related analyses of value chains.

In this module, students develop technical and methodological competences as well as social competence (communication skills and managerial competence).

Lectures

11. No.	12. Title of the lecture	13. Lecturer	14. L no.	15. L Type	16. SWS	17. Workload Studies on campus/self-studies
1	Personal- und Unternehmensführung für Naturwissenschaftler und Ingenieure (Human Resources and Management Organization)	Prof. Dr. D. Meiners	W 7950	V/S	2	28 h / 62 h

2	Unternehmensstrukturen, Projektentscheidungen und Projektmanagement in der Praxis (Company structures, project decisions and project management in practice)	Dr. O. Gedrat	S 7941	V/Ü	2	28 h / 62 h
				Total:	5	70 h / 110 h

Re. no. 1:	
18a. Recomm. requirements	---
19a. Contents	- Principles of HR management (Disciplinary and technical leadership) - Instruments of HR management (Family and work, flexible work time models, performance reviews, employee survey, etc.) - Co-determination in the company (From the employer's and the unionist's perspective) - Successful HR management (From superior to boss) - Career planning (Career, yes or no?) - Application, job interview, hiring contract - From Me Incorporated to a corporation - Corporate planning (Strategic planning, budgeting) - Organizational structures of companies (Proprietor, manager, advisory board) - Corporate financing Private Equity (Chances and risks) - Corporate compliance requirements - Corporate management structures (Centralized/decentralized organizations) - Operative organizational structures in companies (Line/matrix organization)
20a. Type of media	Presentations, group work, presentations by external lecturers, presentations and role plays, if applicable
21a. Literature	Handed out at the event.
22a. Other	---
Re. no. 2:	
18b. Recomm. requirements	---

19b. Contents	- Product development process (PDP) - Market research and concept validation methods - Team behavior and Simultaneous Engineering (SET-structures) - Milestones in project execution - Methods of product development (FMEA, Rapid Prototyping, innovation workshop, cost calculation, innovation workshop) - Role of suppliers and procurement tasks - Cost optimization methods - Testing, quality and approval processes - Damage analysis and field observation - Product liability in practice and obligations of product recalls - Production preparation - Production optimization - Life cycle management - Requirements of global market presence - Moreover: - Structures and division of labor in companies - Organizational structures, operative functions and supervisory functions - Lawful conduct and compliance regulations - Decision boards and product decision calculations - Involving employees in decision processes by different leadership styles - Reporting and information channels - Risk evaluations - Responsibilities of managerial levels and management / delegation principles
20b. Type of media	Presentations, group works, presentations by external lecturers; role plays and project examples
21b. Literature	Handed out at the event.
22b. Other	---

Study/examination achievements

23. no.	24. Assigned lecture	25. Exam type	26. CP	27. Grading	28. Share of the overall module grade
1	Personal- und Unternehmensführung für Naturwissenschaftler und Ingenieure	LN	3	ben.	50%

2	Unternehmensstrukturen, Projektentscheidungen und Projektmanagement in der Praxis	LN	3	ben.	50%

Re. no. 1:	
29a. Exam form / requirements for achieving CP	Proof of performance / qualified participation (SL, attended > 66% of courses)
30a. Examiner in charge	Prof. Dr. D. Meiners
31a. Mandatory exam prerequisites	None
Re. no. 2:	
29b. Exam form / requirements for achieving CP	Proof of performance / qualified participation (SL, attended > 66% of courses)
30b. Examiner in charge	Prof. Dr. H. Ludanek
31b. Mandatory exam prerequisites	None

1a. Module title (German)	1b. Module title (English)
Wahlpflichtpraktikum I	**Mandatory Practical Course I**

2. Usability of the module in study programs

M.Sc. Chemistry (Mandatory Module "SR Applied Chemistry")

3. Responsible for module	4. Responsible faculty	5. Module number
Lecturers of chemistry	Faculty of Natural and Materials Science	

6. Language	7. CP	8. Duration	9. Offered
English	5	[X] 1st semester [ ] 2nd semester	[X] every semester [ ] every year of study [ ] irregularly

10. Learning / qualification objectives of the module

Through their practical and research-oriented participation in work groups, students know about current topics of their selected field (1 or 2). Students are able to work on and solve scientific questions according to their state of knowledge. They know experimental and theoretical methods and models and are able to apply them.

This module promotes technical and methodological competences, and social competence through the participation in a work group.

Lectures

11. No.	12. Title of the lecture	13. Lecturer	14. L no.	15. L Type	16. SWS	17. Workload Studies on campus/self-studies
1	Wahlpflichtpraktikum I (Mandatory Practical Course I)	Lecturers of chemistry		P	5	100 h / 50 h
				Total:	5	100 h / 50 h

18. Recomm. requirements	The contents of the lectures of the respective field (1 or 2) are prerequisites.
19. Contents	Research-oriented practical course on a current topic of field 1 or 2.
20. Type of media	---
21. Literature	The choice of literature depends upon the individual research topic. Choosing literature is part of the practical course.
22. Other	---

Study/examination achievements					
23. no.	**24. Assigned lecture**	**25. Exam type**	**26. CP**	**27. Grading**	**28. Share of the overall module grade**
1	Mandatory Practical Course I	MP	5	ben.	100 %
29. Exam form / requirements for achieving CP	Practical assignment (PrA), Conducting of the practical work, preparing a work report				
30. Examiner in charge	Lecturers of chemistry				
31. Mandatory exam prerequisites	none				

1a. Module title (German)	1b. Module title (English)
Wahlpflichtpraktikum II	**Mandatory Practical Course II**

2. Usability of the module in study programs			
M.Sc. Chemistry (Mandatory Module "SR Applied Chemistry")			
3. Responsible for module Lecturers of chemistry		**4. Responsible faculty** Faculty of Natural and Materials Science	**5. Module number**
6. Language English	**7. CP** 10	**8. Duration** [X] 1st semester [ ] 2nd semester	**9. Offered** [X] every semester [ ] every year of study [ ] irregularly

10. Learning / qualification objectives of the module

Through their practical and research-oriented participation in work groups, students know about current topics of their selected field (1 or 2). Students are able to work on and solve scientific questions according to their state of knowledge. They know experimental and theoretical methods and models and are able to apply them.

This module promotes technical and methodological competences, and social competence through the participation in a work group.

Lectures

11. No.	12. Title of the lecture	13. Lecturer	14. L no.	15. L Type	16. SWS	17. Workload Studies on campus/self-studies
1	Wahlpflichtpraktikum II (Mandatory Practical Course II)	Lecturers of chemistry		P	12	240 h / 60 h
				Total:	12	240 h / 60 h

18. Recomm. requirements	The contents of the lectures of the respective field (1 or 2) are prerequisites.
19. Contents	Research-oriented practical course on a current topic of field 1 or 2.
20. Type of media	---
21. Literature	The choice of literature depends upon the individual research topic. Choosing literature is part of the practical course.
22. Other	---

Study/examination achievements					
23. no.	**24. Assigned lecture**	**25. Exam type**	**26. CP**	**27. Grading**	**28. Share of the overall module grade**
1	Mandatory Practical Course II	MP	10	ben.	100 %

29. Exam form / requirements for achieving CP	Practical assignment (PrA), conducting of the practical course, presentation in the respective work group
30. Examiner in charge	Lecturers of chemistry
31. Mandatory exam prerequisites	none

1a. Module title (German)	1b. Module title (English)
Chemie des festen Zustands	**Chemistry of Solid State**

2. Usability of the module in study programs

M.Sc. Chemistry (Mandatory elective "Specialist field 1")

3. Responsible for module		4. Responsible faculty	5. Module number
Prof. Dr. A. Adam		Faculty of Natural and Materials Science	
6. Language	**7. CP**	**8. Duration**	**9. Offered**
English	11	[ ] 1 semester [X] 2 semesters	[ ] every semester [X] every year of study [ ] irregularly

10. Learning / qualification objectives of the module

Students develop specific knowledge of inorganic synthesis chemistry and inorganic materials. Students especially understand the structural chemistry of inorganic bonds, and the determination of solid state structures by using suitable program packages and databases.

Students are able to actively participate in seminars on current problems of inorganic solid state and material chemistry by giving presentations and joining critical discussions.

In this module, students develop not only technical and methodological competences (analytical capability and rhetoric) but also social competence (esp. communication skills) and self-competence (esp. dedication and time management).

Lectures

11. No.	12. Title of the lecture	13. Lecturer	14. L no.	15. L Type	16. SWS	17. Workload Studies on campus/self-studies
1	Inorganic Synthesis Chemistry III	Prof. Dr. A. Adam	S 3036	V	1	14 h / 46 h
2	Modern Inorganic Chemistry	Prof. Dr. A. Adam adjunct Prof. Dr. M. Gjikaj	W 3037	V	1	14 h / 16 h
3	Chemistry of the Solar System	Prof. Dr. A. Adam	W 3041	V	1	14 h / 16 h
4	X-ray Crystallography	Dr. N.-P. Pook Prof. Dr. A. Adam	W/S 3040	V/Ü	4	56 h / 94 h
5	Seminar on Solid State and Coordination Chemistry	Prof. Dr. A. Adam adjunct Prof. Dr. M. Gjikaj	W/S 3048	S	2	28 h / 32 h
				Total:	9	126 h / 204 h

Re. no. 1:	
18a. Recomm. requirements	---
19a. Contents	Hydro and ammonothermal synthesis, salt melt
20a. Type of media	Board, overhead projector, PowerPoint presentations, lecture notes
21a. Literature	• K. Th. Wilke, J. Bohm: Kristallzüchtung, J. A. Barth, Leipzig (1993) • H.-J. Meyer (Hrsg.): Riedel Moderne Anorganische Chemie, 5th ed., deGruyter, (2018)
22a. Other	---
Re. no. 2:	
18b. Recomm. requirements	---
19b. Contents	Selected topics of modern solid state and coordination chemistry, like e.g. amorphous solids, intercalation, gas phase transport reactions, salt melts, ionic liquids, etc.
20b. Type of media	PowerPoint presentations, board, overhead projector, handouts
21b. Literature	Handouts, current papers
22b. Other	
Re. no. 3:	
18c. Recomm. requirements	---
19c. Contents	Analytical methods of geochemistry on earth and on interplanetary space missions, and resulting findings on the development of the solar system and the planet by the aid of selected examples.
20c. Type of media	Board, overhead projector, PowerPoint presentations, lecture notes
21c. Literature	• B. Mason, C. B. Moore: Grundzüge der Geochemie, Enke Verlag (1985)
22c. Other	---
Re. no. 4:	
18d. Recomm. requirements	Lectures on Inorganic Structural Chemistry
19d. Contents	Computer-aided structure solutions and visualizations by intranet-aided exercises. Usage of programs and softwares for X-ray structure analysis.
20d. Type of media	PC/Laptop, PowerPoint presentations, lecture notes, board, overhead projector
21d. Literature	• W. Massa, Kristallstrukturbestimmung, 8th ed., Springer-Vieweg (2015) • G. M. Sheldrick, SHELXS-2017, University Göttingen (2017) • C. K. Johnson, Ortep 3 for Windows, L. J. Farrugia, J. Appl. Cryst. (2012),45, 849-854. • K. Brandenburg, DIAMOND, Version 4.5, Crystal Impact GbR, Bonn (2018). • POV-Ray, Version 3.7, Persistence of Vision Raytracer Pty. Ltd (2003–2008)

22d. Other	---
Re. no. 5:	
18e. Recomm. requirements	---
19e. Contents	Research-related topics from solid state and coordination chemistry
20e. Type of media	PowerPoint presentations, overhead projector, board
21e. Literature	Handouts, current research topics
22e. Other	---

Study/examination achievements

23. no.	24. Assigned lecture	25. Exam type	26. CP	27. Grading	28. Share of the overall module grade
1	Inorganic Synthesis Chemistry III, Modern Inorganic Chemistry, Chemistry of the Solar System, X-ray crystallography	MP	9	ben.	100 %
2	Seminar zur Festkörper- und Koordinationschemie	LN	2	unben.	0 %

Re. no. 1:	
29a. Exam form / requirements for achieving CP	Oral examination (M, 45 minutes)
30a. Examiner in charge	Prof. Dr. A. Adam, adj. Prof. Dr. M. Gjikaj
31a. Mandatory exam prerequisites	Participation in the lectures of this module
Re. no. 2:	
29b. Exam form / requirements for achieving CP	Proof of performance (attendance and presentations, SL)
30b. Examiner in charge	Prof. Dr. A. Adam, adj. Prof. Dr. M. Gjikaj
31b. Mandatory exam prerequisites	None

1a. Module title (German)	1b. Module title (English)
Mikroanalytik und Materialanalytik	**Micro Analysis and Material Analysis**

2. Usability of the module in study programs

M.Sc. Chemistry (Mandatory elective "Specialist field 1")

3. Responsible for module	4. Responsible faculty	5. Module number
Prof. Dr. U. E. A. Fittschen	Faculty of Natural and Materials Science	

6. Language	7. CP	8. Duration	9. Offered
English	11	[ ] 1 semester [X] 2 semesters	[ ] every semester [X] every year of study [ ] irregularly

10. Learning / qualification objectives of the module

Students develop specific knowledge of analytic chemistry, especially of chemical analyses of trace elements, micro analysis and material analysis with X-rays of matter containing little or no crystalline matter. They significantly deepen their theoretical and practical competence to characterize and analyze materials, functional materials in particular and such characterized by heterogeneous composition of aggregate phases. They understand elemental specification, separation processes and data evaluation. They gain insights in the challenges of developing new methods in analytical chemistry.

Students are able to actively participate in seminars on current problems of analytical chemistry by giving presentations and joining critical discussions.

In this module, students develop not only technical and methodological competence (analytical capability and rhetoric) but also social competence (esp. communication skills) and self-competence (esp. dedication and time management).

Lectures

11. no.	12. Title of the lecture	13. Lecturer	14. L no.	15. L Type	16. SWS	17. Workload Studies on campus/self-studies
1	Instrumental Analysis II	Prof. Dr. U. Fittschen	W 3055	V/Ü	3	42 h / 48 h
2	X-ray based material and micro analysis	Prof. Dr. U. Fittschen	S 3052	V/Ü	2	28 h / 62 h
3	Characterization of Nano Materials	Prof. Dr. J. Kolny-Olesiak	S 3053	V/Ü	2	28 h / 32 h
4	Working methods of applied and technical mineralogy	Dr. T. Schirmer	W 3059	V	2	28 h / 32 h

5	Seminar Analytical Chemistry	Prof. Dr. U. Fittschen	S 3063	S	1	14 h / 16 h
				Total:	10	128 h / 202 h

Re. no. 1:	
18a. Recomm. requirements	---
19a. Contents	In these lectures the focus is placed on theoretical fundamental methods of trace analysis like chromatography, electrophoresis, atomic emission spectroscopy, atomic absorption spectroscopy, and electrochemical methods. Micro analysis and material analysis are covered as well. These include the comparison of material analytical methods. The analysis results are evaluated regarding quality assurance in analytical chemistry. The theoretical lectures are complemented by instrumental exercises and data collections.
20a. Type of media	Board, overhead projector, PowerPoint presentations
21a. Literature	• D. Harris, Lehrbuch der Quantitativen Analyse, Springer (2014) • G. Schwedt: Analytische Chemie, Thieme Verlag (1995) • M. Otto: Analytische Chemie, 2nd ed., Wiley - VCH (2000) • R. Kellner, J.M. Mermet, M. Otto, H.M. Widmer: Analytical Chemistry, 2nd Ed., Wiley - VCH (2004)
22a. Other	---
Re. no. 2:	
18b. Recomm. requirements	---
19b. Contents	Building on the lecture on instrumental analysis, the possibilities and realization of methods of micro and microscopic analysis of solid and liquid phases are scrutinized (analysis of complex structured systems, boards, sediments, energy storage materials). Methods enabling element analysis of non-crystallized matter, e.g. solids, are the key topic of the course. These are, in particular, X-ray based methods, like micro-RFA and X-ray spectroscopy (XANES) and electron probes (SEM-EDX). Students develop deeper knowledge of physical fundamentals of X-ray spectrometry (interaction with matter, absorption, ionization, fluorescence, diffraction and refraction. Special importance is placed on the particular requirements of species (oxidation state, counterions, ligands) and the determination of elements across phase boundaries. The theoretical lectures are complemented by instrumental exercises and data collections.
20b. Type of media	Board, overhead projector, PowerPoint presentations
21b. Literature	• Van Grieken Handbook of X-Ray Spectrometry, Marcel Dekker 2001 • Klockenkämper and von Bohlen, TXRF, Wiley, 2015

22b. Other	---
Re. no. 3:	
18c. Recomm. requirements	---
19c. Contents	This lecture gives an overview of the special properties of nanocrystals and the methods of characterization of nanostructured materials in terms of their size, shape, composition, surface properties and crystallographic structure. The following methods will be presented in the lecture and discussed with respect to the possibilities of characterization of nanomaterials: Transmission electron microscopy (TEM), energy dispersive X-ray spectrometry (EDX), powder X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), UV-Vis absorption and emission spectroscopy. The theoretical teaching units are accompanied by exercises.
20c. Type of media	Board, overhead projector, PowerPoint presentations
21c. Literature	• Williams, Carter, Transmission Electron Microscopy: A Textbook for Materials Science; Springer 2009 • Fultz, Howe Transmission Electron Microscopy and Diffractometry of Materials, Springer 2013 • Suga, Sekiyama, Photoelectron Spectroscopy Bulk and Surface Electronic Structures, Springer 2014 • Review articles from the current literature (e.g. in Chem Soc Rev, Chem Rev, Adv Mater)
22c. Other	---
Re. no. 4:	
18d. Recomm. requirements	---
19d. Contents	Based on the existing knowledge of instrumental analysis, typical instrumental methods used in mineralogical characterization will be deepened (ICP-MS, XRF, RDA, ESMA) and others will be introduced (XPS, APT). Furthermore, basics of mineralogy are taught (crystallography, model systems, crystallization from the melt). Furthermore, the module contains an introduction to special mineralogy as well as basics of petrology and deposit science. The various properties and technical applications of mineral (crystalline) compounds and raw materials (ceramics, cement, natural building materials) are presented. Another topic is mineral residues (mining residues, tailings) and the targeted modification of slags for the enrichment of environmentally relevant or technologically interesting elements.
20d. Type of media	---

21d. Literature	Okrusch, S., Matthes, S., (2014): Mineralogie: Eine Einführung in die spezielle Mineralogie, Petrologie und Lagerstättenkunde, Springer, Kristallographie (2002), Springer Götze, M., Göbbels, M., (2017): Einführung in die Angewandte Mineralogie Springer Telle, R., Keramik (2007), Springer Bock, R. (2005): Handbuch der analytisch-chemischen Aufschlussmethoden, Springer Ritgen, U., (2019/2020): Analytische Chemie I u. II, Springer Pecharsky, V.K., Zavalij, P.Y. (2003): Fundamentals of Powder Diffraction and Structural Characterization Of Materials, Springer Beckhoff, B. et al (2006): Handbook of Practical X-Ray Fluorescence, Springer GoldsteinJ.I., et al (2018) Scanning Electron Microscopy and X-Ray Microanalysis, Springer
22d. Other	---
Re. no. 5:	
18e. Recomm. requirements	---
19e. Contents	Current topics of analytical chemistry, which students present and discuss in a scientific talk.
20e. Type of media	Board, overhead projector, PowerPoint presentations
21e. Literature	Van Grieken Handbook of X-Ray Spectrometry, Marcel Dekker 2001 Klockenkämper and von Bohlen, TXRF, Wiley, 2015 • D. Harris, Lehrbuch der Quantitativen Analyse, Springer (2014) • G. Schwedt: Analytische Chemie, Thieme Verlag (1995) • M. Otto: Analytische Chemie, 2nd ed., Wiley - VCH (2000) • R. Kellner, J.M. Mermet, M. Otto, H.M. Widmer: Analytical Chemistry, 2nd Ed., Wiley - VCH (2004)
22e. Other	---

Study/examination achievements

23. no.	24. Assigned lecture	25. Exam type	26. CP	27. Grading	28. Share of the overall module grade
1	Instrumental Analysis II, Material and Microanalysis, Characterization of Nano Materials, Working Methods in applied and technical Mineralogy	MP	10	ben.	100 %
2	Seminar Analytical Chemistry	LN	1	unben.	0 %

Re. no. 1:	
29a. Exam form / requirements for achieving CP	Oral examination (M45 minutes)
30a. Examiner in charge	Prof. Dr. U. E. A. Fittschen

31a. Mandatory exam prerequisites	None
Re. no. 2:	
29b. Exam form / requirements for achieving CP	Seminar work (SL)
30b. Examiner in charge	Prof. Dr. U. E. A. Fittschen
31b. Mandatory exam prerequisites	None

1a. Module title (German)	1b. Module title (English)
Organische Materialchemie	**Organic Materials**

2. Usability of the module in study programs

M.Sc. Chemistry (Mandatory elective "Specialist field 1")

3. Responsible for module	4. Responsible faculty	5. Module number
Prof. Dr. R. Wilhelm	Faculty of Natural and Materials Science	

6. Language	7. CP	8. Duration	9. Offered
English	11	[ ] 1 semester	[ ] every semester
		[X] 2 semesters	[X] every year of study
			[ ] irregularly

10. Learning / qualification objectives of the module

After completing this module, students will have a deeper knowledge and understanding of the organic chemistry of the preparation, modification, applications and recycling of organic materials and organic biomaterials. They will understand the molecular basis of material properties and their underlying intermolecular interactions. They have knowledge of modern spectroscopic and spectrometric methods of molecular and material analysis as well as their range and limits of application.

They are able to communicate current developments in the field of organic and bioorganic materials chemistry in seminar lectures, are able to independently identify the literature required for this purpose, can evaluate it in the specific context and use it.

In addition to technical competence, the module also imparts methodological and systems competence.

Lectures						
11. No.	**12. Title of the lecture**	**13. Lecturer**	**14. L no.**	**15. L Type**	**16. SWS**	**17. Workload Studies on campus/self-studies**
1	Organic Materials	Prof. Dr. R. Wilhelm	S 3136	V	2	28 h / 62 h
2	Advanced NMR-Methods	Dr. Namyslo	W 3135	V/Ü	3	42 h / 48 h
3	Organic Biomaterials	Prof. Dr. R. Wilhelm	W 3127	V	2	28 h / 62 h
4	Seminar for Organic Materials	Prof. Dr. R. Wilhelm	S 3142	S	2	28 h / 32 h
				Total:	11	126 h / 204 h

Re. no. 1:	
18a. Recomm. requirements	---
19a. Contents	The characteristic and applications of organic materials will be discussed: Natural products; ionic liquids; molecular rods, rotators and machinery; organic sensors and electric conductors; fullerenes; carbon nanomaterials; nano-reactors; organic photovoltaic cells
20a. Type of media	Board, slides, PowerPoint
21a. Literature	Current reviews from research journals
22a. Other	---
Re. no. 2:	
18b. Recomm. requirements	---
19b. Contents	Development of FT-NMR, equipment, fields of application; advanced physical fundamentals, detection method; NMR-parameters in practice, independence of the chemical shift from the structure; homo- and heteronuclear spin-spin-coupling, decoupling methods: relaxation phenomena; Nuclear Overhauser Effect (NOE); polarization transfer experiments; 2D-methods, homo- and heteronuclear shift correlation in NMR spectroscopy, inverse detection, gradients in NMR spectroscopy, molecular dynamics in NMR, determination of activation parameters. Heteronuclear NMR of organic chemically relevant cores (e.g. ^{15}N, ^{19}F, ^{11}B, ^{29}Si, ^{31}P); an overview of additional NMR methods (solid-state NMR, imaging methods, medical applications); increment systems, computer-aided NMR prediction.
20b. Type of media	Board, slides, PowerPoint

21b. Literature	• H. Friebolin, Basic One- and Two-Dimensional NMR Spectroscopy, Wiley-VCH, 2013. • S. Bienz, L. Bigler: Hesse/Meier/Zeeh, Spektroskopische Methoden in der Organischen Chemie, 9th edition, Thieme, 2016 • J. K. M. Sanders, B. K. Hunter, Modern NMR Spectroscopy, A Guide for Chemists, 2nd edition, Oxford University Press, 1993. • R. S. Macomber, A Complete Introduction to Modern NMR Spectroscopy, Wiley, 1998. • S. Berger, S. Braun, 200 and More NMR Experiments: A Practical Course, Wiley-VCH, 2004. • E. Breitmaier, Structure Elucidation by NMR in Organic Chemistry: A Practical Guide, Wiley, 2002.
22b. Other	---
Re. no. 3:	
18c. Recomm. requirements	---
19c. Contents	The purpose of this lecture is to provide for students an overview dealing with (bio)organic materials from natural sources, their chemical modifications and applications, as the field of biomaterials has grown considerably during the last decades. Seemingly, the term "biomaterials" is not well-defined. On the one hand, experiences gained in clinical uses of materials, the replacement of diseased or missing body parts by man-made materials, and tissue-engineering, on the other hand structure-properties relationships and degradation of materials are portions of that field. We, however, put a strong emphasis on the organic and biochemical aspects to understand the fundamentals of biomaterials and biopolymer research. Chapter I deals with peptide- and protein-based materials including peptide-nanomaterials, stimulus-responsive peptide-based materials, coiled coils, synthetic collagen mimics, and spider silk related materials. Chapters II to IV cover portions of carbohydrate-based materials (cellulose, starch, functional polymers from sugars, glyconanomaterials), polyketide-based materials, and modified nucleic acids, respectively.
20c. Type of media	Board, slides, PowerPoint
21c. Literature	• Current reviews from research journals • J. Park, R. S. Lakes, Biomaterials, An Introduction, 3. edition, 2010, Springer. • B. D. Ratner, A. S. Hoffman, F. J. Schoen, J. E. Lemons, Biomaterials Science, 2. edition, 2004, Elsevier Academic Press.
22c. Other	---
Re. no. 4:	
18d. Recomm. requirements	---
19d. Contents	In the seminar, students give literature presentations on current topics in organic materials chemistry.
20d. Type of media	Board, slides, PowerPoint
21d. Literature	• Current reviews from research journals

22d. Other	---

Study/examination achievements

23. no.	24. Assigned lecture	25. Exam type	26. CP	27. Grading	28. Share of the overall module grade
1	Organic Materials, Advanced NMR-Methods, Organic Biomaterials	MP	9	ben.	100 %
2	Seminar for New Synthesis Methods	LN	2	unben.	0 %

Re. no. 1:	
29a. Exam form / requirements for achieving CP	Oral examination (45 minutes)
30a. Examiner in charge	Prof. Dr. R. Wilhelm
31a. Mandatory exam prerequisites	None
Re. no. 2:	
29b. Exam form / requirements for achieving CP	Seminar assignment
30b. Examiner in charge	Prof. Dr. R. Wilhelm
31b. Mandatory exam prerequisites	None

1a. Module title (German)	1b. Module title (English)
Syntheses and Mechanisms	**Syntheses and Mechanisms**

2. Usability of the module in study programs

M.Sc. Chemistry (Mandatory elective "Specialist field 1")

3. Responsible for module		4. Responsible faculty	5. Module number
Prof. Dr. A. Schmidt		Faculty of Natural and Materials Science	
6. Language	**7. CP**	**8. Duration**	**9. Offered**
English	11	[ ] 1 semester [X] 2 semesters	[ ] every semester [X] every year of study [ ] irregularly

10. Learning / qualification objectives of the module

In the lecture "Named Reactions" students develop deepened knowledge of synthesis methods and mechanisms which enables them to deepen their understanding of structure elucidation based on selected named reactions of organic chemistry. The interconnectedness of individual topics is shown and retrosynthetic approaches are discussed. Students are thus enabled to apply mechanistic basic principles also to unknown examples and to plan specific synthesis routes, to scrutinize mechanisms and to apply them to their own scientific questions. The course "Total Syntheses of Selected Target Molecules" is based on inductive learning methods and thus students are assigned to small groups. The groups conduct research on a given synthesis problem from the latest primary literature in a certain period of time while also applying all available media (library, databases: SciFinder, CrossFire and Web of Science; internet, online journals). Students will then present their didactically prepared results on the board in front of the other groups. This seminar is based on students' presentations on the latest developments in the fields of their research topics and synthesis problems. This module conveys mostly technical competence. Due to the research assignments, which include information procurement, structuring, evaluation and interpretation following the given task as well as the didactic presentation, this seminar also conveys methodological competence to a high degree. Training students to understand complex synthesis problems in model reactions and to draw conclusions from them, also supports their system competence. Working in teams helps students develop their social competence and fosters the integration of international and new students at TU Clausthal. All courses will be held either in German or English, as decided by students' vote.

Lectures						
11. No.	**12. Title of the lecture**	**13. Lecturer**	**14. L no.**	**15. L Type**	**16. SWS**	**17. Workload Studies on campus/self-studies**
1	Ausgewählte Totalsynthesen (Total Syntheses of Selected Target Molecules)	Prof. Dr. A. Schmidt	S 3199	V	2	28 h / 62 h
2	Advanced NMR-Methods	Dr. Namyslo	W 3135	V/Ü	3	42 h / 48 h
3	Named Reactions	Prof. Dr. A. Schmidt	W 3120	V	2	28 h / 62 h
4	Seminar for New Synthesis Methods	Prof. Dr. A. Schmidt	W 3171	S	2	28 h / 32 h
				Total:	11	126 h / 204 h

Re. no. 1:	
18a. Recomm. requirements	---
19a. Contents	Based on methods of inductive learning, students work out the latest total syntheses from the primary literature in small group. For this, students each receive synthesis problems as a cloze, in which either reagents or reaction products are to be added. Thus, the seminar is concerned with synthesis methods, reagents, mechanisms, side reactions, spectroscopic processes, application of models and theories (Zimmermann-Traxler, Cram, Felkin-Anh, Bürgi-Dunitz, Fukui-Concept, substitution effect etc.) as sort of a summary of the previously acquired knowledge.
20a. Type of media	Board, slides, PowerPoint
21a. Literature	• Databases • Internet • Online journals • Textbooks from the Library of the Institute of Organic Chemistry
22a. Other	---
Re. no. 2:	
18b. Recomm. requirements	---

19b. Contents	Development of FT-NMR, equipment, fields of application; advanced physical fundamentals, detection method; NMR-parameters in practice, independence of the chemical shift from the structure; homo- and heteronuclear spin-spin-coupling, decoupling methods: relaxation phenomena; Nuclear Overhauser Effect (NOE); polarization transfer experiments; 2D-methods, homo- and heteronuclear shift correlation in NMR spectroscopy, inverse detection, gradients in NMR spectroscopy, molecular dynamics in NMR, determination of activation parameters. Heteronuclear NMR of organic chemically relevant cores (e.g. ^{15}N, ^{19}F, ^{11}B, ^{29}Si, ^{31}P); an overview of additional NMR methods (solid-state NMR, imaging methods, medical applications); increment systems, computer-aided NMR prediction.
20b. Type of media	Board, slides, PowerPoint
21b. Literature	• H. Friebolin, Basic One- and Two-Dimensional NMR Spectroscopy, Wiley-VCH, 2013. • S. Bienz, L. Bigler: Hesse/Meier/Zeeh, Spektroskopische Methoden in der Organischen Chemie, 9th edition, Thieme, 2016 • J. K. M. Sanders, B. K. Hunter, Modern NMR Spectroscopy, A Guide for Chemists, 2nd edition, Oxford University Press, 1993. • R. S. Macomber, A Complete Introduction to Modern NMR Spectroscopy, Wiley, 1998. • S. Berger, S. Braun, 200 and More NMR Experiments: A Practical Course, Wiley-VCH, 2004. • E. Breitmaier, Structure Elucidation by NMR in Organic Chemistry: A Practical Guide, Wiley, 2002.
22b. Other	---
Re. no. 3:	
18c. Recomm. requirements	---

19c. Contents	*CC single bond formations* - Stork enamine alkylation and variations: Imine variant of the Stork reaction, proline as organocatalyst, SAMP/RAMP, asymmetric induction - Aldol addition and related (Boroenolate, stereo chemistry, regio selectivity; Claisen-Schmidt, directed aldol addition, Mukaiyama Reaction, Iwanow Reaction, Myers Reaction, Eder-Sauer-Wiechert-Hajos-Parrish Reaction, Fujimoto-Belleau Reaction, Baylis-Hillman Reaction, Henry Reaction) - Non-aldol-type conversion of carbonyls - Normant Reagents, Stetter Reaction, Sakurai Allylation, Trost Allylation, Paternò-Büchi Reaction, de Mayo Reaction, Roush Coupling, Prins Reaction, Nazarov Cyclization, Pauson-Khand, Passerini, Ugi, Barbier) -Synthesis of and with amino acids (Dakin-West, Schöllkopf) *C=C double bond formations* -C=C double bond formations via phosphorous compounds (Wittig, Wittig-Schlosser, Still-Gennari, Cory-Winter, Barton-Kellog) -C=C double bond formations via silicon compounds (Peterson) -C=C double bond formations via sulfuric compounds (Julia-Lythgoe, Ramberg-Bäcklund) -C=C double bond formations via boric compounds (Bor-Wittig v., Zweifel Olefination) -C=C double bond formations via nitrogen compounds (Bamford-Stevens, Shapiro) -Olefin-Metathesis -Tebbe Reaction -Bergman and Myers Cyclization *Reactions of non-activated CH-compounds* -Hoffmann-Loeffler-Freytag Reaction -Barton Nitrite Photolysis *Defunctionalization* -Barton-McCombie vs. Chatgilialoglus Reagent *Oxidations* -DMP, Pfitzner-Moffat, Cory-Kim, Riley, Jones, Collins, Sarett) *Epoxidations*

	-Jacobson-Katsuki, Shi, Rubottom *Reductions* *Activation of carboxylic acid* -Staab, Mukaiyamas Reagent, Yamaguchi, Cory-Nicolaou, Masamune Cyclization *Cross coupling* -Heck, Sonmogashira, Stille, Kumada, Suzuki-Miyaura, Negishi
20c. Type of media	Board, slides, PowerPoint
21c. Literature	• L. Kürti, B. Czakó, *Strategic Applications of Named Reactions in Organic Synthesis*, Elsevier Academic Press, 2005. • F.A. Carey, R.J. Sundberg, *Organische Chemie*, VCH, Weinheim 2007. • R. Brückner, *Reaktionsmechanismen: Organische Reaktionen, Stereochemie, Moderne Synthesemethoden*, Elsevier / Spektrum akademischer Verlag, 3rd corr. edition, 2009. • Houben-Weyl: *Methoden der organischen Chemie*,Thieme (Zusammenstellung von Namensreaktionen, see volume 16/2, pp. 1179 et seq.) • Current reviews from research journals
22c. Other	---
Re. no. 4:	
18d. Recomm. requirements	---
19d. Contents	In this seminar, students give presentations on current developments in the field of their research work or present solution strategies of synthesis problems.
20d. Type of media	Board, slides, PowerPoint
21d. Literature	• Current reviews from research journals
22d. Other	---

Study/examination achievements

23. no.	24. Assigned lecture	25. Exam type	26. CP	27. Grading	28. Share of the overall module grade
1	Total Syntheses of Selected Target Molecules, Named Reactions, Advanced NMR-Methods	MP	9	ben.	100 %
2	Seminar for New Synthesis Methods	LN	2	unben.	0 %
Re. no. 1:					
29a. Exam form / requirements for achieving CP	Oral examination (45 minutes)				

30a. Examiner in charge	Prof. Dr. A. Schmidt
31a. Mandatory exam prerequisites	None
Re. no. 2:	
29b. Exam form / requirements for achieving CP	Seminar assignment
30b. Examiner in charge	Prof. Dr. A. Schmidt
31b. Mandatory exam prerequisites	None

1a. Module title (German)	1b. Module title (English)
Spezielle Physikalische Chemie	**Special Topics in Physical Chemistry**

2. Usability of the module in study programs

M.Sc. Chemistry (Mandatory elective "Specialist field 1")

3. Responsible for module	4. Responsible faculty	5. Module number
Prof. Dr. D. Johannsmann	Faculty of Natural and Materials Science	

6. Language	7. CP	8. Duration	9. Offered
English	11	[ ] 1 semester [X] 2 semesters	[ ] every semester [X] every year of study [ ] irregularly

10. Learning / qualification objectives of the module

Students develop deeper knowledge of physical chemistry and current physicochemical topics, some with direct connection to the Institutes research areas.

In this course, students develop the following competences:

Technical competence: 70%, methodological competence: 10%, professional competences: 10%, social competence: 10%

Lectures

11. No.	12. Title of the lecture	13. Lecturer	14. L no.	15. L Type	16. SWS	17. Workload Studies on campus/self-studies
1	Statistical Thermodynamics	Prof. Dr. J. Adams	W 3208	V	1	14 h / 46 h
2	Biophysical Chemistry	Prof. Dr. D. Johannsmann	W 3216	V	2	28 h / 62 h
3	Modern Spectroscopic Methods	Prof. Dr. J. Adams	S 3219	V	2	28 h / 62 h
4	Chemical Sensors	Prof. Dr. D. Johannsmann	S 3224	V	2	28 h / 62 h
				Total:	7	98 h / 232 h

Re. no. 1:	
18a. Recomm. requirements	---

19a. Contents	• Mathematical fundamentals of statistics
	• Distributions
	  o Boltzmann
	  o Bose-Einstein
	  o Fermi-Dirac
	• Partition function and its application
	• Systems of independent particles
	• Thermodynamic functions
	  o of ideal gases
	  o of diatomic gases
	  o of solids

20a. Type of media	Board, PowerPoint
21a. Literature	• G. Wedler: Lehrbuch der Physikalischen Chemie (5th edition), Wiley-VCH, Weinheim, 2004
22a. Other	---
Re. no. 2:	
18b. Recomm. requirements	---
19b. Contents	• The concept of life • Vital molecules (concentrated electrolytes, polysaccharides, DNA, proteins, lipids,...) • Forms of energy storage • The biomembrane • Complexity of enzyme kinetics • Single bio materials • Bioanalysis: HPLC and electrophoresis • Nerve conduction, information processing in the brain
20b. Type of media	Board, slides
21b. Literature	B. Alberts et al.: Essential Cell Biology
22b. Other	---
Re. no. 3:	
18c. Recomm. requirements	---

19c. Contents	• Interaction of electromagnetic radiation and matter
	• Methodological and instrumental fundamentals of
	  o IR
	  o NMR
	  o UV-Vis
	  o Fluorescence
	• Single-molecule spectroscopy
	• Fluorescence spectroscopy
	  o Depolarization measurement
	  o Quenching
	  o Excimer and exciplex dynamics

	○ Förster resonance energy transfer • Structure determination of complex molecular superstructures • Methods and application of ultrafast spectroscopy
20c. Type of media	Board, slides, PowerPoint
21c. Literature	Various textbooks and monographies of physical chemistry
22c. Other	---
Re. no. 4:	
18d. Recomm. requirements	---
19d. Contents	• Sensor features • The dynamic area, strategies for extension • Thermal, acoustic, conductometric, potentiometric, amperometric and optical sensors
20d. Type of media	Board, slides
21d. Literature	P. Gründler: Chemische Sensoren, Springer, 2004
22d. Other	---

Study/examination achievements

23. no.	24. Assigned lecture	25. Exam type	26. CP	27. Grading	28. Share of the overall module grade
1	Statistical thermodynamics, biophysical chemistry, modern spectroscopic methods, chemical sensors	MP	11	ben.	100 %

29. Exam form / requirements for achieving CP	Oral examination (M, 45 minutes)
30. Examiner in charge	Prof. Dr. D. Johannsmann
31. Mandatory exam prerequisites	None

1a. Module title (German)	1b. Module title (English)
Spezielle Technische Chemie	**Special Aspects of Technical Chemistry**

2. Usability of the module in study programs

M.Sc. Chemistry (Mandatory elective "Specialist field 1")

3. Responsible for module		4. Responsible faculty	5. Module number
Prof. Dr. S. Beuermann		Faculty of Natural and Materials Science	
6. Language	**7. CP**	**8. Duration**	**9. Offered**
English	11	[ ] 1 semester [X] 2 semesters	[ ] every semester [X] every year of study [ ] irregularly

10. Learning / qualification objectives of the module

Lecture 'Modeling of Chemical Processes':

In the lecture 'Modeling of Chemical Processes', students learn to apply the knowledge from 'Chemical Reaction Engineering' to the modeling of chemical/biochemical processes. They can link kinetic models for composite complex reactions in homogeneous phase to material transport processes. Students understand the impact of reaction control and temperature by evaluating computer-aided concrete reaction processes. These kinetic models are theoretically covered by deterministic and stochastic simulations.

Lecture 'Process Intensification in Chemistry':

Students know the essential principles of process optimization and experiment design. They are able to apply these principles to current examples. They know possibilities to establish sustainable processes (e.g. innovative reaction media, reactor design, microreaction technology, etc.)

Practical course:

Students develop deep knowledge of technical chemistry by working on a current topic of the field 'Special aspects of technical chemistry'). Students apply their English skills by reading English technical literature. Students gain insight in ways of working and thinking in research by completing an experimental seminar paper (with subsequent presentation) on a current research topic of the Institute. By drafting an extensive protocol, students deepen their knowledge of scientific representation and discussion of results. In the presentation, students practice presentation techniques and multimedia competence.

The module focuses on technical and methodological competences. Students are able to fundamentally discuss current issues regarding the development of sustainable processes.

Lectures						
11. No.	**12. Title of the lecture**	**13. Lecturer**	**14. L no.**	**15. L Type**	**16. SWS**	**17. Workload Studies on campus/self-studies**
1	Modeling of Chemical Processes	Dr. M. Drache	W 3303	V/Ü	2	28 h / 47 h
2	Process Intensification	Prof. Dr. S. Beuermann, Dr. M. Drache	S 3327	V	2	28 h / 47 h
3	Practical Course on 'Special Aspects of Technical Chemistry'	Prof. Dr. S. Beuermann	W/S 3361	P	4	70 h / 50 h
4	Seminar on the 'Practical Course on Special Aspects of Technical Chemistry'	Prof. Dr. S. Beuermann	W/S 3374	S	1	14 h / 46 h
				Total:	9	140 h / 190 h

Re. no. 1:	
18a. Recomm. requirements	Fundamentals of Technical Chemistry
19a. Contents	– Reaction technology and modeling with deterministic and stochastic processes – Impact of the chemical reactor, idealized reactor types: Residence time distribution of chemical reactors, behavior of chemical reactors, reaction control, heat balance of chemical reactors, reactor stability – Simulation of polymerization reactions, product properties
20a. Type of media	Board, PowerPoint (presentations are made available on Stud.IP)
21a. Literature	• L. Boodhoo, A. Harvey, Process Intensification for Green Chemistry, Wiley-VCH • M. Baerns, A. Behr, A. Brehm, J. Gmehling, H. Hofmann, U. Onken, A. Renken, Technische Chemie, Viley-VCH • O. Levenspiel: Chemical Reaction Engineering, Wiley & Sons, New York • R. W. Missen, C. A. Mims, B. A. Saville: Intruduction to Chemical Reaction Engineering and Kinetics, Wiley & Sons, New York • Wissenschaftliche Übersichtsartikel zu einzelnen Themen
22a. Other	---

Re. no. 2:	
18b. Recomm. requirements	Fundamentals of Technical Chemistry
19b. Contents	– Principles of process intensification – Alternative reaction media – Alternative methods of energy input (e.g. microwave or ultrasound radiation) – Microreaction technology – Membrane process – Integral processes: e.g. reactive distillation, reactive extraction, heat coupling – Statistical experiment design
20b. Type of media	Board, PowerPoint (presentations are made available on Stud.IP)
21b. Literature	• L. Boodhoo, A. Harvey, Process Intensification for Green Chemistry, Wiley-VCH • M. Baerns, A. Behr, A. Brehm, J. Gmehling, H. Hofmann, U. Onken, A. Renken, Technische Chemie, Viley-VCH • O. Levenspiel: Chemical Reaction Engineering, Wiley & Sons, New York • R. W. Missen, C. A. Mims, B. A. Saville: Intruduction to Chemical Reaction Engineering and Kinetics, Wiley & Sons, New York • Wissenschaftliche Übersichtsartikel zu einzelnen Themen
22b. Other	---
Re. no. 3:	
18c. Recomm. requirements	Fundamentals of Technical Chemistry
19c. Contents	Working on a current research topic of the Institute
20c. Type of media	---
21c. Literature	• L. Boodhoo, A. Harvey, Process Intensification for Green Chemistry, Wiley-VCH • M. Baerns, A. Behr, A. Brehm, J. Gmehling, H. Hofmann, U. Onken, A. Renken, Technische Chemie, Viley-VCH • O. Levenspiel: Chemical Reaction Engineering, Wiley & Sons, New York • R. W. Missen, C. A. Mims, B. A. Saville: Intruduction to Chemical Reaction Engineering and Kinetics, Wiley & Sons, New York • Scientific literature on process intensification and the topic of the practical work
22c. Other	---
Re. no. 4:	
18c. Recomm. requirements	Fundamentals of Technical Chemistry
19c. Contents	The findings of the research will be presented and subsequently discussed.
20c. Type of media	Students' PowerPoint presentations

21c. Literature	• L. Boodhoo, A. Harvey, Process Intensification for Green Chemistry, Wiley-VCH • M. Baerns, A. Behr, A. Brehm, J. Gmehling, H. Hofmann, U. Onken, A. Renken, Technische Chemie, Viley-VCH • O. Levenspiel: Chemical Reaction Engineering, Wiley & Sons, New York • R. W. Missen, C. A. Mims, B. A. Saville: Intruduction to Chemical Reaction Engineering and Kinetics, Wiley & Sons, New York • Scientific literature on process intensification and the topic of the practical work
22c. Other	---

Study/examination achievements

23. no.	24. Assigned lecture	25. Exam type	26. CP	27. Grading	28. Share of the overall module grade
1	Modeling of chemical processes, process intensification	MP	5	graded	100 %
2	Practical Course Specific Technical Chemistry	LN	4	ungraded	0%
3	Seminar on the Practical Course Specific Technical Chemistry	LN	2	ungraded	0%

Re. no. 1:	
29a. Exam form / requirements for achieving CP	Oral examination (M, 45 minutes)
30a. Examiner in charge	Prof. Dr. S. Beuermann
31a. Mandatory exam prerequisites	None
Re. no. 2:	
29b. Exam form / requirements for achieving CP	Practical assignment (PrA)
30b. Examiner in charge	Prof. Dr. S. Beuermann
31b. Mandatory exam prerequisites	None
Re. no. 3:	
29c. Exam form / requirements for achieving CP	Seminar performance (SL)
30c. Examiner in charge	Prof. Dr. S. Beuermann

31c. Mandatory exam prerequisites	None

1a. Module title (German)	1b. Module title (English)
Moderne Umweltchemie	**Modern Environmental Chemistry**

2. Usability of the module in study programs

M.Sc. Chemistry (Mandatory elective "Specialist field 2")

3. Responsible for module		4. Responsible faculty	5. Module number
Academic dean		Faculty of Natural and Materials Science	
6. Language	**7. CP**	**8. Duration**	**9. Offered**
German	11	[ ] 1 semester [X] 2 semesters	[ ] every semester [X] every year of study [ ] irregularly

10. Learning / qualification objectives of the module

Students develop deepened knowledge and deeper understanding of the different processes in environmental chemistry and recycling, chemical and physical analytical measurement methods, agent usage, aerosols, legal bases, mechanisms of degradation and recycling of the essential metals.

They are able to evaluate current questions of environmental chemistry in a technically correct manner, to critically question processes and applications, to develop solutions and, if applicable, apply them to their own work.

Students can describe ways of polymer recycling and explain the individual machines. They are also able to identify current topics of the complex "recycling", to prepare them scientifically and present them to the other participants.

In this module, students develop technical and methodological competences and some social competences.

Lectures

11. No.	12. Title of the lecture	13. Lecturer	14. L no.	15. L Type	16. SWS	17. Workload Studies on campus/self-studies
1	Recycling von Metallen (Recycling of Metals)	Dr. J. Wendelstorf	S 7904	V/Ü	3	42 h / 48 h
2	Umweltanalytik I - Einführung in die Umweltchemie (Environmental Analysis I - Introduction to Environmental Chemistry)	Dr. A. Fischer	S 3050	V/S	2	28 h / 47 h

3	Umweltanalytik II - Chemische Umweltanalytik (Environmental Analysis II - Chemical Environmental Analysis)	Dr. A. Fischer	W 3051	V/S	2	28 h / 47 h
4	Recycling von Kunststoffen (Recycling of Polymers)	Prof. Dr. D. Meiners	W 7919	V/S	3	42 h / 48 h
				Total:	10	140 h / 190 h

Re. no. 1:	
18a. Recomm. requirements	---
19a. Contents	1. Introduction 2. Iron and steel recycling 3. Copper recycling 4. Zinc recycling 5. Lead recycling 6. Aluminum recycling 7. Magnesium recycling 8. Comparison of extractive metallurgy processes
20a. Type of media	PowerPoint, Films
21a. Literature	H. Martens und D. Goldmann: Recyclingtechnik. Fachbuch für Lehre und Praxis. Springer Verlag (2016). ISBN 978-3-658-02786-5
22a. Other	---
Re. no. 2:	
18b. Recomm. requirements	---
19b. Contents	- Substances in the environment - Environmental law - Transport phenomena - Media-related concepts - Eco-toxicology - Case studies (ozone, carbon dioxide, cadmium, phthalates, pentachlorophenol, dibenzofurans, volatile organic compounds)
20b. Type of media	Board, slides, PowerPoint
21b. Literature	• Lecture notes • R. A. Hites, J. D. Raff, P. Wiesen, Umweltchemie, Wiley-VCH, 2017 • C. Bliefert, Umweltchemie, Wiley-VCH, 2010
22b. Other	---
Re. no. 3:	

18c. Recomm. requirements	---
19c. Contents	*Environment and material cycles:* - Definitions - Environmental fields - Material cycles (geological cycle, mineralization and biosynthesis, nitrogen cycle, sulfur cycle, phosphor cycle, global anthropogenic cycle *Analytical chemistry* - History - Tasks and problems - Classification of analysis methods - Basic steps and work areas - Error analysis, calibration curves *Mobile environmental analysis:* - Basics, classification - Test sticks and test papers - Colorimetric tests - Titration methods - Gas detection tubes - Examination of soil air with gas detection tubes - Air-water extraction procedures with gas detection tubes - Analysis sets and compact carrying case - Electrometrical measurement methods (conductivity, pH-value, redox potential, electrochemical sensors, voltammetry) - Photometric processes (cuvette tests, reflectometry) - Gas sensors (UV- and IR-absorption, interferometry, thermal conductivity measurement, potentiometric and amperometric sensors, susceptibility measurements, chemiluminescence-sensors, multi gas detectors, portable hydrocarbon analyzers - Oil-in-water analyses with NDIR - Multifunction meters in water analysis - Multifunction meters in air analysis - Fields of application of mobile gas chromatographs - Fields of application of mobile liquid chromatographs - Mobile mass spectrometers - Ion mobility sensor - Biological and biochemical test methods *Surveillance of air pollution control* - Federal Immission Control Act - Regulations, definitions, emissions- immissions - Measurement strategies (heated or cooled probe, isokinetic extraction, measuring gas treatment, measuring arrangement for inorganic gases, dust substances, metals and metalloids, PAK, dioxins and furans - Sampling and suction errors - Sampling and measurement with the FID *Waters testing*: - Ground water, surface water, drinking water, drinking water ordinance - Waste water and its examination parameters - Landfill leachates, analysis of key parameters - Chemical oxygen demand COD - Biochemical oxygen demand BOD - Sum parameters TC, TIC, TOC, DOC and POC - Sum parameters AOX, EOX , POX as well as phenolindex - DIN- and EN-standards

	- Ion chromatography - Element analyses with the ICP-OES *Solids testing:* - Sampling (total sample, tapering, partial sample) - Sampling soils - Breakdown of solid samples - Testing of PCB-contaminated soils - Processes for KW, PAK and pesticides in soils - Heavy metals in soils and solids - Mobilization of heavy metals, extraction results - Parameters of waste analysis, disposal channel incineration - Parameter of waste analysis, disposal channel landfills
20c. Type of media	Board, slides, PowerPoint
21c. Literature	• C. Bliefert: Umweltchemie, 3rd ed. (2002), VCH Verlag, Weinheim • G. Schwedt: Taschenatlas der Umweltchemie, Wiley VCH (1996)
22c. Other	---
Re. no. 4:	
18d. Recomm. requirements	---
19d. Contents	• Economic data on polymers • Thermal recycling • Mechanical recycling • Materials recycling • Examples of recycling • Application of recyclates • Legal bases • Designing for recyclability
20d. Type of media	Board, slides, PowerPoint presentations, films
21d. Literature	• G. Menges: Recycling von Kunststoffen, Carl Hanser Verlag, ISBN 978-3-4461-6437-6 • N. Rudolph: Understanding Plastics Recycling, Carl Hanser Verlag, ISBN 978-1-5699-0676-7
22d. Other	---

Study/examination achievements

23. no.	24. Assigned lecture	25. Exam type	26. CP	27. Grading	28. Share of the overall module grade
1	Recycling of Metals, Chemical Environmental Analysis I and II, Recycling of Polymers	MP	11	graded	100 %

29. Exam form / requirements for achieving CP	Oral examination (M, 45 minutes)
30. Examiner in charge	Dr. J. Wendelstorf, Dr. A. Fischer, Prof. Dr. D. Meiners
31. Mandatory exam prerequisites	None

1a. Module title (German)	1b. Module title (English)
Einführung in die Chemie des Brauwesens	**Introduction into the chemistry of Brewing**

2. Usability of the module in study programs

M.Sc. Chemistry (Mandatory elective "Specialist field 2")

3. Responsible for module	4. Responsible faculty	5. Module number
Prof. Dr. F. Endres	Faculty of Natural and Materials Science	

6. Language	7. CP	8. Duration	9. Offered
German/ English	11	[ ] 1st semester [X] 2nd semester	[ ] every semester [X] every year of study [ ] irregularly

10. Learning / qualification objectives of the module

The students know and explain the significance of the chemical and processes in the production of beer. They describe and evaluate the production and characterization of beers from the basic ingredients to the finished product. Students will understand basic physical and chemical properties of beers and possess in-depth knowledge of processes for their production and characterization. They outline their own recipes and carry out the brewing process in all stages up to the to the analysis of the finished product.

They transfer and verify the gained knowledge practically on the basis of current research topics. Students work up their scientific results and discuss them critically.

The module imparts technical, social and methodological competence.

Lectures

11. No.	12. Title of the lecture	13. Lecturer	14. L no.	15. L Type	16. SWS	17. Workload Studies on campus/self-studies
1	Theorie und Praxis der Bierbrauerei (Theory and practice of brewing)	Prof. Dr. F. Endres	S 8036	V	2	28 h / 62 h
2	Bieranalytik (Beer analytics)	Prof. Dr. F. Endres	W 8056	V/Ü	2	28 h / 62 h
3	Praktikum in der TU Clausthal Brauerei (Practical course in the TU Clausthal Brewery)	Prof. Dr. F. Endres	S 8056	P	3	48 h / 42 h

4	Exkursion und Blockvorlesung zu kommerziellen Aspekten des Brauwesens (Excursion and block lecture on commercial aspects of brewing)	Prof. Dr. F. Endres Dr. M. Zarnkow	W 8090	E/L	2	30 h / 30 h
				Total:	9	134 h / 196 h

Re. no. 1:	
18a. Recomm. requirements	Basic knowledge of physics and chemistry is required, such as those taught in the bachelor's degree program in chemistry at the TU Clausthal
19a. Contents	- History - The Purity Law of April 23, 1516 - The provisional beer law of 1993 - Fiscal aspects - The "craft beer" era - Classification of beers - Beer categories - Types of beer - Overview of the brewing process - Overview of malt production and malt varieties - Brewing water - Hops - Alcoholic fermentation and brewing yeasts - The technology of wort preparation (equipment, malt selection, - malting, mashing) - Isothermal mashing at temperatures > 70 °C
20a. Type of media	Board, slides, lecture notes, exercise block
21a. Literature	1. „Bier – Eine Geschichte von der Steinzeit bis heute“, G. Hirschfelder und M. Trummer, Theiss Verlag 2016 2. „Abriss der Bierbrauerei“, L. Narziß, W. Back, M. Gastl, M. Zarnkow“, Wiley-VCH 2017 3. „Die Bierbrauerei, Band 1: Die Technologie der Malzbereitung“, L. Narziß und W. Back, Wiley-VCH 2012 4. „Die Bierbrauerei, Band 2: Die Technologie der Würzebereitung“, L. Narziß und W. Back, Wiley-VCH 2009 5. „Ausgewählte Kapitel der Brauereitechnologie“, W. Back, Fachverlag Hans Carl 2008 6. „Gutes Bier selbst brauen: Schritt für Schritt - mit Rezepten“ (BLV) Taschenbuch – 9. März 2016, Hubert Hanghofer 7. „Bier selbst gebraut“, K. Kling, Verlag die Werkstatt GmbH, 4. Auflage 2015
22a. Other	---
Re. no. 2:	

18b. Recomm. requirements	Basic knowledge of physics and chemistry is required, such as those taught in the bachelor's degree program in chemistry at the TU Clausthal
19b. Contents	- Original gravity of unfermented wort by refractometry and - Bending oscillator - Determination of sugar distribution (enzymatic, HPLC) - Determination of amino acids (ninhydrin method, HPLC) - Determination of original gravity and alcohol content of finished beers by means of bending oscillator and NIR spectrometry - Determination of color and bitterness by UV/Vis-spectrometry - Determination of lactic acid content - Identification of lactic acid bacteria contamination - by means of the polymer cascade reaction
20b. Type of media	Board, slides, lecture notes, exercise block
21b. Literature	Mitteleuropäische Brauanalysekommission (MEBAK), Würze, Bier, Biermischgetränke (WBBM). Selbstverlag der MEBAK, 2012, ISBN 978-3-9805814-6-2
22b. Other	---
Re. no. 3:	
18c. Recomm. requirements	Basic knowledge of physics and chemistry is required, such as those taught in the bachelor's degree program in chemistry at the TU Clausthal
19c. Contents	- Calculation of different brews - Brewing of 3 beers in the research brewery (bottom-fermented, - top-fermented, non-alcoholic beer) - In situ monitoring of brewing parameters - Fermentation in cylindrical-conical fermentation tanks - Bottling under Counter-pressure - Beer analysis - HACCP - Hazard Analysis and Critical Control Points
20c. Type of media	Internship guidance, recent scientific publications
21c. Literature	---
22c. Other	---
Re. no. 44:	
18d. Recomm. requirements	Basic knowledge of physics and chemistry is required, such as those taught in the bachelor's degree program in chemistry at the TU Clausthal

19d. Contents	- Excursion to a brewery, familiarization with commercial brewing processes - brewing processes, accompanying lecture (by Dr. Zarnkow): - Malting - only an energetic paradox? - Mashing - from poorly soluble to liquid - Fermentation - almost inexhaustible variety - Foam - the characteristic of beer - Stability - the crux of globalization - Brewing history - beer as a driving force for sedentism?
20d. Type of media	---
21d. Literature	Bier – Eine Geschichte von Hopfen und Malz. Meusdoerffer, F., Zarnkow, M., CH Beck Verlag, München, 2016
22d. Other	---

Study/examination achievements

23. no.	24. Assigned lecture	25. Exam type	26. CP	27. Grading	28. Share of the overall module grade
1	Theory and practice of brewing, Beer analytics, Practical course on brewing	MP	9	ben.	100 %
2	Excursion brewing	LN	2	unben.	0 %

Re. no. 1:	
29a. Exam form / requirements for achieving CP	Oral examination (M, 45 minutes)
30a. Examiner in charge	Prof. Dr. F. Endres
31a. Mandatory exam prerequisites	None
Re. no. 2:	
29b. Exam form / requirements for achieving CP	Exc
30b. Examiner in charge	Prof. Dr. F. Endres
31b. Mandatory exam prerequisites	None

1a. Module title (German)	1b. Module title (English)
Energie und Materialphysik	**Energy and Materials Physics**

2. Usability of the module in study programs

M.Sc. Chemistry (Mandatory elective "Specialist field 2")

3. Responsible for module	4. Responsible faculty	5. Module number
Prof. Dr. D.M. Schaadt	Faculty of Natural and Materials Science	

6. Language	7. CP	8. Duration	9. Offered
German	11	[ ] 1st semester [X] 2nd semester	[ ] every semester [X] every year of study [ ] irregularly

10. Learning / qualification objectives of the module

Surface analytics:

Students know essential properties of monocrystalline solid surfaces and thin layers as well as processes for their manufacturing and characterization. This course includes laboratory tutorials, teaching students essential surface analytical procedures and the determination of suitable analysis methods for different surfaces and surface chemistries. Furthermore, students gain insights in the modern ultra-high vacuum technology.

Functional materials:

Students know the different materials in batteries, fuel cells and sensors. They are familiar with the basic physical processes of the functional units and know their similarities. Students recognize the connection between function and material and are able to identify application-relevant material systems.

Solar Energy Conversion:

Students know basic physical processes of solar energy conversion. They are able to thermodynamically describe solar energy conversion processes and to decide which processes are optimal for certain applications.

The module focuses on technical and methodological competences.

Lectures

11. No.	12. Title of the lecture	13. Lecturer	14. L no.	15. L Type	16. SWS	17. Workload Studies on campus/self-studies
1	Oberflächenphysik – Oberflächenanalytik (Physics of Surfaces - Surface Analysis)	Dr. K. Stahlberg	W 2319	V/Ü	4	56 h / 64 h
2	Funktionsmaterialien (Functional Materials)	Prof. Dr. H. Fritze	S 2340	V	4	56 h / 64 h
3	Solare Energieumwandlung (Solar Energy Conversion)	Prof. Dr. D.M. Schaadt	W 2330	V	2	28 h / 62 h
				Total:	10	140 h / 190 h

Re. no. 1:

18a. Recomm. requirements	None
19a. Contents	1.Two-dimensional X-ray structure analysis - invariance of crystals and their surfaces with symmetry operations 2.Defined surfaces and sample environment 3.Determination of geometrical surface structures: Diffraction experiments 4.States and electron transfer at solid surfaces (valence band and conduction band states) 5.Surface imaging on an atomic scale: Scanning probe microscopy 6.Interactions of electrons and matter 7.Auger electron spectroscopy 8.Photo emission spectroscopy 9.Electron microscopy to depict surfaces: Setup and contrast emergence 10.Analytical electron microscopy: EDS, WDS, SAM 11.Ion-assisted methods of solid state analysis: SIMS and RBS 12.Adsorption, diffusion and desorption 13.Surface defects – equilibrium forms of crystals 14.Growth and manufacture of thin layers
20a. Type of media	Board, retrievable presentations, practical exercises on modern analysis tools

21a. Literature	• H. Lüth: "Solid Surfaces, Interfaces and Thin Films", 4th Edition, Springer, 2001 • H. Ibach: "Physics of Surfaces and Interfaces", Springer 2006 • K. Oura et al.: Surface Science, Springer 2003 • M. Henzler: "Oberflächenphysik des Festkörpers", Teubner 1991
22a. Other	---
Re. no. 2:	
18b. Recomm. requirements	none
19b. Contents	• Energy resources and savings potentials • Anodes and cathodes materials for batteries • Materials for (high temperature) fuel cells • Sensor materials
20b. Type of media	Board, PowerPoint, electronically retrievable lecture notes and presentations
21b. Literature	Announced by the commencement of lectures
22b. Other	---
Re. no. 3:	
18c. Recomm. requirements	none
19c. Contents	Energy and energy sources - thermodynamics - solar thermal energy - photovoltaics
20c. Type of media	Board, PowerPoint, electronically retrievable lecture notes and presentations
21c. Literature	Würfel: Physik der Solarzellen, Hochschultaschenbuch, Spektrum Verlag
22c. Other	---

Study/examination achievements

23. no.	24. Assigned lecture	25. Exam type	26. CP	27. Grading	28. Share of the overall module grade
1	Surface analytics	MTP	5	ben.	33 %
2	Functional materials for batteries, fuel cells and sensors	MTP	3	ben.	33 %
3	Solar energy conversion	MTP	3	ben.	33 %
Re. no. 1:					

29a. Exam form / requirements for achieving CP	Oral examination (M, 30 minutes)
30a. Examiner in charge	Dr. K. Stahlberg
31a. Mandatory exam prerequisites	None
Re. no. 2:	
29b. Exam form / requirements for achieving CP	Oral examination (M, 30 minutes)
30b. Examiner in charge	Prof. Dr. H. Fritze
31b. Mandatory exam prerequisites	None
Re. no. 3:	
29c. Exam form / requirements for achieving CP	Oral examination (M, 30 minutes)
30c. Examiner in charge	Prof. Dr. D.M. Schaadt
31c. Mandatory exam prerequisites	None

1a. Module title (German)	1b. Module title (English)
Makromolekulare Chemie und Prozesse	**Macromolecular Chemistry and Processes**

2. Usability of the module in study programs

M.Sc. Chemistry (mandatory module "SR Polymer Chemistry")

3. Responsible for module	4. Responsible faculty	5. Module number
Prof. Dr. S. Beuermann	Faculty of Natural and Materials Science	

6. Language	7. CP	8. Duration	9. Offered
English	8	[ ] 1st semester [X] 2nd semester	[ ] every semester [X] every year of study [ ] irregularly

10. Learning / qualification objectives of the module

In the lecture 'Macromolecular kinetics and reaction technology', students develop deeper knowledge of polymerization kinetics and technology. Students dive into current methods to determine kinetic coefficients for elementary reactions. Due to their detailed understanding of elementary reactions, students are able to understand and explain the coupling of kinetics, reaction control and polymer architecture. Based on this knowledge, students can make suggestions for the synthesis of custom polymers. Students know examples of sustainable developments in polymer chemistry.

In the lecture 'Current Aspects of Polymer Chemistry', students become familiar with current developments and work in the field of polymer chemistry, especially the synthesis of polymers with custom properties and the coupling of synthetic polymers and biomacromolecules. They have deepened knowledge of different possibilities for the targeted synthesis of polymer architectures. Students can suggest synthesis strategies for complex polymer molecules.

In the course 'Modeling of Polymerization Processes', students learn about the modeling of polymerization processes and the resulting product properties. Based on the theoretical foundations, students can use computers to conduct parameter studies, extrapolations and optimization of polymerization processes and polymer properties.

The module focuses on technical and methodological competences. Students are able to have well-informed discussions about sustainability aspects of polymer chemistry.

Lectures						
11. No.	**12. Title of the lecture**	**13. Lecturer**	**14. L no.**	**15. L type**	**16. SWS**	**17. Workload** **Studies on campus/self-studies**
1	Macromolecular Kinetics and Polymer Reaction Engineering	Prof. Dr. S. Beuermann	S 3324	V/Ü	3	42 h / 48 h
2	Modern Aspects of Polymer Chemistry	Prof. Dr. S. Beuermann	W 3334	V	2	28 h / 62 h
3	Modeling and Simulation in Polymer Reaction Engineering	Dr. M. Drache	S 3326	V/Ü	2	28 h / 32 h
				Total:	7	98 h / 142 h

Re. no. 1:	
18a. Recomm. requirements	The fundamentals of macromolecular chemistry as well as the fundamentals of organic chemistry, technical chemistry and physical chemistry as taught in the Bachelor program Chemistry.
19a. Contents	- Molar mass distribution - Coupling polymerization kinetics - molar mass distribution - Modern methods for determination of kinetic coefficients for elementary reactions - Targeted synthesis of polymer structures based on kinetics and modeling - Catalytic polymerizations - Reaction control influence - Sustainable developments in polymer chemistry
20a. Type of media	Board, PowerPoint (presentations are made available on Stud.IP)
21a. Literature	• G. Moad, D. H. Solomon „The Chemistry of Radical Polymerization", Elsevier, 2. fully revised edition, 2006 • G. Odian "Principles of Polymerization", Wiley, 4th edition, 2004 • M.D. Lechner, K. Gerke, E.H. Nordmeier: Makromolekulare Chemie, Birkhäuser Verlag, Berlin • Echte: Handbuch der Technischen Polymerchemie, Wiley-VCH • Current scientific publications
22a. Other	---
Re. no. 2:	
18b. Recomm. requirements	The fundamentals of macromolecular chemistry as well as the fundamentals of organic chemistry, technical chemistry and physical chemistry as taught in the Bachelor program Chemistry.

19b. Contents	- Custom-made polymers - Controlled radical polymerization - Click chemistry - Enzymatic polymerizations - Bioconjugates - Block copolymers - Polyolefines: Metallocene-catalyzed reactions
20b. Type of media	Board, PowerPoint (presentations are made available on Stud.IP)
21b. Literature	• G. Moad, D. H. Solomon „The Chemistry of Radical Polymerization", Elsevier, 2. fully revised edition, 2006 • G. Odian "Principles of Polymerization", Wiley, 4th edition, 2004 • „Macromolecular Engineering" (4 volumes), K. Matyjaszewski, Y. Gnanou, L. Leibler, Wiley-VCH 2007 • Current scientific publications
22b. Other	---
Re. no. 3:	
18c. Recomm. requirements	Lecture / Exercise Macromolecular Kinetics and Reaction Technology
19c. Contents	- Modeling of polymerization processes with deterministic and stochastic simulation processes - Parameter studies – extrapolation – validation - Optimization of polymer properties
20c. Type of media	Board, PowerPoint (presentations are made available on Stud.IP)
21c. Literature	• G. Moad, D. H. Solomon „The Chemistry of Radical Polymerization", Elsevier, 2. fully revised edition, 2006 • G. Odian "Principles of Polymerization", Wiley, 4th edition, 2004 • M.D. Lechner, K. Gerke, E.H. Nordmeier: Makromolekulare Chemie, Birkhäuser Verlag, Berlin • Echte: Handbuch der Technischen Polymerchemie, Wiley-VCH • K.-D. Hungenberg, M. Wulkow „Modeling and Simulation in Polymer Reaction Engineering“, Wiley-VCH • Current scientific publications
22c. Other	---

Study/examination achievements					
23. no.	**24. Assigned lecture**	**25. Exam type**	**26. CP**	**27. Grading**	**28. Share of the overall module grade**
1	Macromolecular Kinetics and Reaction Technology, Modern Aspects of Polymer Chemistry, Modeling of Polymerization Processes	MP	8	ben.	100 %

29. Exam form / requirements for achieving CP	Oral examination (M, 45 minutes)
30. Examiner in charge	Prof. Dr. S. Beuermann
31. Mandatory exam prerequisites	None

1a. Module title (German)	1b. Module title (English)
Physikalisch-Chemische Aspekte der Polymere	**Physicochemical Aspects of Polymers**

2. Usability of the module in study programs

M.Sc. Chemistry (mandatory module "SR Polymer Chemistry")

3. Responsible for module	4. Responsible faculty	5. Module number
Prof. Dr. D. Johannsmann	Faculty of Natural and Materials Science	

6. Language	7. CP	8. Duration	9. Offered
English	8	[ ] 1st semester [X] 2nd semester	[ ] every semester [X] every year of study [ ] irregularly

10. Learning / qualification objectives of the module

The students have deepened knowledge on the structure of macromolecules, characterization methods for polymers, their physical forms, phase behavior and interface characteristics. They know different traditional and modern methods of polymer analysis and have partly applied them in practice. They can apply their knowledge on issues of modern, polymer materials.

The module focuses on technical and methodological competences, and social and system competences by the practical course.

Lectures

11. No.	12. Title of the lecture	13. Lecturer	14. L no.	15. L Type	16. SWS	17. Workload Studies on campus/self-studies
1	Physical Chemistry of Polymers	Prof. Dr. J. Adams	W 3217	V	3	42 h / 78 h
2	Modern Polymer Materials	Prof. Dr. D. Johannsmann, Prof. Dr. J. Adams	S 3220	V	1	14 h / 16 h
3	Polymers at Interfaces	Prof. Dr. D. Johannsmann	S 3226	V	1	14 h / 46 h
4	Practical Course on 'Physical Chemistry of Polymers'	Prof. Dr. J. Adams	W 3226	P	1	20 h / 10 h
				Total:	6	90 h / 150 h

Re. no. 1:

18a. Recomm. requirements	The fundamentals of macromolecular chemistry, physical chemistry, organic chemistry and technical chemistry are required.
19a. Contents	- Structure of macromolecules: ideal and real x, evaluated in different models. - Characterization of polymers: Separation of polymers, determination of molar mass distribution and average molar mass Determination of thermodynamic parameters, structure and size of polymer coils - Polymers in solids: Flory-Huggins theory, diluted, semiconcentrated and concentrated polymer solutions, diffusion in solutions. - Physical state of pure polymers: Polymer melt, flow processes in polymer melt, glassy state, crystalline state, thermal transitions - Mechanical analysis of pure polymers: dynamic mechanical thermal analysis, tensile strain test. - Rubber elasticity.
20a. Type of media	Board, slides, PowerPoint
21a. Literature	• H.-G. Elias: Makromoleküle, Band 2, Physikalische Strukturen und Eigenschaften, Wiley-VCH, 6th edition, 2001 • M. D. Lechner, K. Gehrke, E. H. Nordmeier: Makromolekulare Chemie, Birkhäuser Verlag, 2010 • M. Rubinstein: R. H. Colby, Polymer Physics, Oxford University Press, 2003
22a. Other	---
Re. no. 2:	
18b. Recomm. requirements	The fundamentals of macromolecular chemistry, physical chemistry, organic chemistry and technical chemistry are required.
19b. Contents	Current topics of polymer research are presented, which are intensively worked on in industry or science. The selection of topics has not been determined. Possible topics are: • Electrically conductive polymers • Polymer OLED • Polymer gels • Liquid crystalline polymers • Polyurethanes
20b. Type of media	Board, slides, PowerPoint, computer presentations
21b. Literature	Lecture notes, original literature from journals and monographs
22b. Other	---
Re. no. 3:	

18c. Recomm. requirements	The fundamentals of macromolecular chemistry, physical chemistry, organic chemistry and technical chemistry are required.
19c. Contents	• Interface abnormalities • Thin films • Polymer adsorbates in liquid phases • Polymer brushes • Interfaces between polymer melts • The extracellular matrix
20c. Type of media	Board, slides, PowerPoint, computer presentations
21c. Literature	• H.-G. Elias: Makromoleküle, Band 2, Physikalische Strukturen und Eigenschaften, Wiley-VCH, 6th edition, 2001 • M. D. Lechner, K. Gehrke, E. H. Nordmeier: Makromolekulare Chemie, Birkhäuser Verlag, 2010 • M. Rubinstein: R. H. Colby, Polymer Physics, Oxford University Press, 2003 • L.H. Sperling: Introduction to Physical Polymer Science, Wiley, 1992 • I.S. Sanchez: Physics of Polymer Surfaces and Interfaces, Butterworth-Heinemann, 1992 • G.J. Fleer et al.: Polymers at Interfaces, Chapman & Hall, 1993
22c. Other	---
Re. no. 4:	
18d. Recomm. requirements	Contents of the lecture "Physical Chemistry of Polymers"
19d. Contents	• Accompanying the lecture 'Physical Chemistry of Polymers', the practical course aims to enhance the students' practical knowledge. • Experiments on the following topics will be conducted by students: • Solution and precipitation of polymers. • Membrane osmosis to determine molar masses and thermodynamic parameters. • Static light scattering at polymer solutions • Dynamic mechanical thermo analysis to determine the glass temperature and the complex Shear modulus • Stress-strain-experiments with elastomers
20d. Type of media	Practical course notes
21d. Literature	See lecture "Physical Chemistry of Polymers"
22d. Other	---

Study/examination achievements					
23. no.	**24. Assigned lecture**	**25. Exam type**	**26. CP**	**27. Grading**	**28. Share of the overall module grade**
1	Physical Chemistry of Polymers, Modern Polymeric Materials, Polymers at Interfaces	MP	7	ben.	100 %
2	Practical Course Physical Chemistry of Polymers	LN	1	unben.	0 %

Re. no. 1:	
29a. Exam form / requirements for achieving CP	Oral examination (M, 45 minutes)
30a. Examiner in charge	Prof. Dr. D. Johannsmann
31a. Mandatory exam prerequisites	None
Re. no. 2:	
29b. Exam form / requirements for achieving CP	Practical assignment (PrA) Conducting of the experiments in groups
30b. Examiner in charge	Prof. Dr. J. Adams
31b. Mandatory exam prerequisites	None

1a. Module title (German)	1b. Module title (English)
Kunststoffverarbeitung	**Plastics Processing**

2. Usability of the module in study programs

M.Sc. Chemistry (mandatory module "SR Polymer Chemistry"), B.Sc. Material Science and Technology [mandatory elective of SR material technology]

3. Responsible for module	4. Responsible faculty	5. Module number
Prof. Dr. D. Meiners	Faculty of Natural and Materials Science	

6. Language	7. CP	8. Duration	9. Offered
English	6	[ ] 1st semester [X] 2nd semester	[ ] every semester [X] every year of study [ ] irregularly

10. Learning / qualification objectives of the module

Students are able to describe and explain the processing machines and the process. They can also name specific features of the individual processing steps and describe and classify their material-specific characteristics.

The module focuses on technical and methodological competences.

Lectures

11. No.	12. Title of the lecture	13. Lecturer	14. L no.	15. L Type	16. SWS	17. Workload Studies on campus/self-studies
1	Kunststoffverarbeitung I (Plastics Processing I)	Prof. Dr. D. Meiners	W 7903	V/Ü	3	42 h / 48 h
2	Kunststoffverarbeitung II (Plastics Processing II)	Prof. Dr. D. Meiners	S 7901	V/Ü	3	42 h / 48 h
				Total:	6	84 h / 96 h

Re. no. 1:

18a. Recomm. requirements	---

19a. Contents	• Plastics processing • Processing behavior fundamentals • Extrusion technology • Injection molding technology • Press / transfer molding technology
20a. Type of media	PowerPoint presentations, videos, machine / process demonstrations
21a. Literature	• W. Michaeli: Einführung in die Kunststoffverarbeitung, Carl Hanser Verlag, ISBN 978-3-446-42488-3 • W. Michaeli: Technologie der Kunststoffe, Carl Hanser Verlag, ISBN 978-3-446-41514-0
22a. Other	---
Re. no. 2:	
18b. Recomm. requirements	

19b. Contents	• Fiber composite technology
	  ○ Prepreg, winding process, pressing technique, RTM-processes
	• Foaming
	  ○ Foam formation process, integral foam technology
	• Joining technologies
	• Interface phenomena
	  ○ Adhesion, cohesion, interdiffusion
	• Adhesive technologies
	• Welding processes

20b. Type of media	PowerPoint presentations, videos, machine / process demonstrations
21b. Literature	• G. W. Ehrenstein: Faserverbund-Kunststoffe, Carl Hanser Verlag, ISBN 978-3-446-22716-3 • M. Flemming, G. Ziegmann, S. Roth: Faserverbundbauweisen, Springer Verlag, ISBN 978-3-540-60616-1
22b. Other	---

Study/examination achievements					
23. no.	**24. Assigned lecture**	**25. Exam type**	**26. CP**	**27. Grading**	**28. Share of the overall module grade**
1	Plastics processing I, plastics processing II	MP	6	ben.	100 %

29. Exam form / requirements for achieving CP	Written examination (K, 60 minutes)
30. Examiner in charge	Prof. Dr. D. Meiners
31. Mandatory exam prerequisites	None

1a. Module title (German)	1b. Module title (English)
Polymerpraktikum I	**Practical Course on Polymers I**

2. Usability of the module in study programs

M.Sc. Chemistry (mandatory module "SR Polymer Chemistry")

3. Responsible for module	4. Responsible faculty	5. Module number
Prof. Dr. S. Beuermann Prof. Dr. D. Johannsmann	Faculty of Natural and Materials Science	

6. Language	7. CP	8. Duration	9. Offered
English	5	[X] 1st semester [ ] 2nd semester	[X] every semester [ ] every year of study [ ] irregularly

10. Learning / qualification objectives of the module

By active and research oriented participation in work groups, students know current topics of their selected field, either 'Macromolecular Chemistry and Processes' or 'Physico-chemical Aspects of Polymers'. Students are able to work on and answer scientific questions based on their state of knowledge. They know experimental and theoretical methods and models and are able to apply them.

This module promotes technical and methodological competences, and social competence through the participation in a work group.

Lectures

11. No.	12. Title of the lecture	13. Lecturer	14. L no.	15. L Type	16. SWS	17. Workload Studies on campus/self-studies
1	Polymerpraktikum I (Practical Course on Polymers I)	Prof. Dr. S. Beuermann Prof. Dr. D. Johannsmann		P	5	100 h / 50 h
				Total:	5	100 h / 50 h

18. Recomm. requirements	The contents of the lectures of the respective field "Macromolecular Chemistry and Processes" or "Physico-Chemical Aspects of Polymers" are required.
19. Contents	Research-oriented practical course concerned with a current topic of the fields "Macromolecular Chemistry and Processes" or "Physico-Chemical Aspects of Polymers".
20. Type of media	---

21. Literature	The choice of literature depends upon the individual research topic. Choosing literature is part of the practical course.
22. Other	---

Study/examination achievements

23. no.	24. Assigned lecture	25. Exam type	26. CP	27. Grading	28. Share of the overall module grade
1	Practical Course Polymers I	MP	5	ben.	100 %

29. Exam form / requirements for achieving CP	Practical assignment (PrA) Conducting of the practical work, preparing a work report
30. Examiner in charge	Prof. Dr. S. Beuermann, Prof. Dr. D. Johannsmann
31. Mandatory exam prerequisites	none

1a. Module title (German)	1b. Module title (English)
Polymerpraktikum II	**Practical Course on Polymers II**

2. Usability of the module in study programs			
M.Sc. Chemistry (mandatory module "SR Polymer Chemistry")			
3. Responsible for module Prof. Dr. S. Beuermann Prof. Dr. D. Johannsmann		**4. Responsible faculty** Faculty of Natural and Materials Science	**5. Module number**
6. Language English	**7. CP** 10	**8. Duration** [X] 1st semester [ ] 2nd semester	**9. Offered** [X] every semester [ ] every year of study [ ] irregularly

10. Learning / qualification objectives of the module

Through their practical and research-oriented participation in work groups, students know about current topics of their selected field, either "Macromolecular Chemistry and Processes" or ""Physico-chemical Aspects of Polymers". Students are able to work on and solve scientific questions according to their state of knowledge. They know experimental and theoretical methods and models and are able to apply them.

This module promotes technical and methodological competences, and social competence through the participation in a work group.

Lectures

11. No.	12. Title of the lecture	13. Lecturer	14. L no.	15. L Type	16. SWS	17. Workload Studies on campus/self-studies
1	Polymerpraktikum II (Practical Course on Polymers II)	Prof. Dr. S. Beuermann Prof. Dr. D. Johannsmann		P	12	240 h / 60 h
				Total:	12	240 h / 60 h

18. Recomm. requirements	The contents of the lectures of the respective field "Macromolecular Chemistry and Processes" or "Physico-Chemical Aspects of Polymers" are required.
19. Contents	Research-oriented practical course concerned with a current topic of the fields "Macromolecular Chemistry and Processes" or "Physico-Chemical Aspects of Polymers".
20. Type of media	---

21. Literature	The choice of literature depends upon the individual research topic. Choosing literature is part of the practical course.
22. Other	---

Study/examination achievements

23. no.	24. Assigned lecture	25. Exam type	26. CP	27. Grading	28. Share of the overall module grade
1	Practical Course Polymers II	MP	10	ben.	100 %

29. Exam form / requirements for achieving CP	Practical assignment (PrA), conducting of the practical course, presentation in the respective work group
30. Examiner in charge	Prof. Dr. S. Beuermann, Prof. Dr. D. Johannsmann
31. Mandatory exam prerequisites	none

List of abbreviations

Explanatory Notes:

(1) Type of Course:

E	Excursion [Exkursion]
P	Practical Course [Praktikum]
S	Seminar [Seminar]
T	Tutorial Lecture [Tutorium]
V	Lecture [Vorlesung]
Ü	Exercise [Übung]

(2) Examination Form:

K	Written Exam [Klausur]
M	Oral examination
SL	Seminar performance [Seminarleistung]
PrA	Practical Work [Praktische Arbeit]
ThA	Theoretical Work [Theoretische Arbeit]
Ex	Excursion [Exkursion]
Ab	Final Thesis [Abschlussarbeit]

(3) Type of Examination:

LN	Certificate of performance [Leistungsnachweis]
MP	Module exam [Modulprüfung]
MTP	Module-part exam [Modulteilprüfung]
PV	Prerequisite [Prüfungsvorleistung]

(4) Further Abbreviations:

ben.	Graded performance [benotet Leistung]
unben.	Ungraded performance [unbenotet Leistung]
od.	or [oder]
LV	Course [Lehrveranstaltung]
Prüf.	Examination [Prüfung]
CP	Credit points
SWS	Semester hours per week [Semesterwochenstunden]