BERGISCHE
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WUPPERTAL

Module Handbook

for the examination regulations

Sustainable Chemistry Degree Program with a Bachelor of Science Degree

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SCBA	Thesis	PF/WP PF	Weight 12	Workload 12 CP	Workload 360 h

Qualification objectives:

The students can work on a chemical problem independently and scientifically within a given time limit and to present the result in writing in a technically and linguistically appropriate manner.

Duration: 1	Offer frequency: each semester	Recommended FS: 6

Proof	Form	Duration	Repeatability	CP
Final module examination ID: 80677	**Final Work (Thesis)**	3 Months	1	12

Introduction and basics

SCENG	English for Scientists	PF/WP PF	Weight 0	Workload 3 CP	Workload 90 h

Qualification objectives:

Students can understand and present chemical-scientific content and use argumentation strategies. Learners can follow media reports and extract key information from them. They can use a wide range of linguistic resources appropriately to actively participate in a range of conversation contexts without preparation, to keep the conversation going and to end it. They are also able to pass on, check and confirm technical information, discuss, and clarify problems, and exchange opinions and ideas on more complex topics with ease. Learners can understand key information in general and technical texts from books or magazines with relative certainty.

General remarks:

Solid knowledge of English at level B1 according to the Common European Framework of Reference for Languages is expected.

Duration: 1 Semester	**Offer frequency:** each semester	**Recommended FS:** 1

Proof	Form	Duration	Repeatability	CP
Ungraded coursework ID: 81182	Form according to explanation	90 min	unlimited	3

Explanation:

Written performance query

Component(s)		PF/WP	Teaching method	SWS	Time expenditure
BChENG-a	**English for Chemistry Students**	PF	Seminar/ Exercise	3	90 h

Remarks:

It is strongly recommended to take the component in the 1st or 2nd semester.

Solid English skills at level B1 according to the Common European Framework of Reference for Languages are expected.

Contents:

The course prepares chemistry students for professional and scientific situations and tasks.

The language course focuses on the following, among others:
• Effective presentation and argumentation
• Describing reactions, processes, procedures, etc.
• Describing diagrams, graphics, and tables
• Standard and safety requirements
• Exchange and effective communication about technical content
• Reading and understanding technical texts
• Repeating grammar, if necessary

SCMAT	Mathematics	PF/WP PF	Weight 5	Workload 5 CP	Time expenditure 150 h

Qualification objectives:

The students understand the following mathematical operations and can apply them themselves:

- Mathematical operations in linear algebra and differential equations
- Mathematical prerequisites for the formulation of chemical and physical applications
- Error calculation
- Elementary vector calculus
- Real functions of one and several variables
- Differential calculus
- Integral calculus
- Complex numbers
- Linear systems of equations
- Matrix calculus
- Differential equations

General remarks:

Content requirements: School knowledge of mathematics

Duration: 1	**Offer frequency:** every 2nd semester	**Recommended FS:** 1

Proof	Form	Duration	Repeatability	CP

Final module examination ID: 80681	**Written examination (exam)**	180 min	unlimited	5

Component(s)		PF/WP	Teaching method	SWS	Time expenditure
SCMAT-a	**Mathematics exercise for chemists**	PF	Lecture	3	120 h

Contents:

Learning and deepening basic mathematical operations that are used in chemical and physical applications; building up basic knowledge that can later be deepened in specific areas. Elementary vector calculus: Linear vector space, scalar product, cross product, Gram-Schmidt orthogonalization Elementary theory of real functions of one and several variables: Homogeneous polynomials,
exponential functions, power functions, trigonometric functions, composite functions, inverse functions
Error calculation: Statistical and systematic errors, normal distribution, arithmetic means, standard deviation, Student-t distribution, error propagation, linear regression
Differential calculus: Derivation of elementary functions, differentiation rules, partial derivatives, total differential.
Integral calculus: Integration of elementary functions, integration methods.

SCMAT-b	**Mathematics exercise for chemists**	PF	Exercises	1	30 h

Contents:

The topics discussed in the lecture are deepened and practiced using example tasks.

SCBC	Basics of Chemistry	PF/WP PF	Weight 12	Workload 12 CP	Time expenditure 360 h

Qualification objectives:

The students have basic knowledge of general chemistry. They are familiar with models of atomic and molecular structure and know chemical bonds as well as the systematics and behavior of substances.
They know the basic statements of the 12 basic principles of green chemistry according to Anastas and Warner.
The students can work safely in the laboratory and handle harmful chemicals and hazardous substances.
They know the basic material properties and recognize physical and chemical relationships. They can apply basic working techniques and measuring methods and know how to use measuring devices.

Duration: 2	**Offer frequency:** each semester	**Recommended FS:** 1

Proof	Form	Duration	Repeatability	CP

Composition of the module completion:

The content, deadline, and form of the individual achievements in the portfolio will be announced by the examination board at the beginning of the semester.

Final module examination ID: 80680	Collection folder with assessment		unlimited	12

Component(s)		PF/WP	Teaching method	SWS	Time expenditure
SCBC-a	**Basics of Chemistry - Lecture**	PF	Lecture	2	60 h

Remarks:

Content requirements: School knowledge of chemistry

Contents:

Development of an understanding of the basic laws of chemical reactions: derivation of element properties from the position in the periodic table; introduction to the various bonding forms; qualitative and quantitative relationships in chemical reactions. Atomic and molecular structure: element and compound symbols, historical development, substances and their characterization, substance classification, elements and compounds, subatomic particles, radioactivity. Abundance of elements in the earth's crust and in space and their formation, abundance of nuclides, isotopes and isotope effects, molecular and structural formulas, atomic associations, atomic mass unit, mass defect, amount of substance and mole, Bohr's atomic model, quantum numbers, quantum mechanics, Pauli principle, Hund's rule, structure of the periodic table, construction principle, orbitals. Chemical bond: strong and weak bonds, treatment of the three idealized strong bond types: ionic bonds,
covalent bonds and metallic bonds. Noble gas configuration, octet rule, ionization potential, electron affinity, ionic crystals, radius ratio, coordination number, packing, simple lattice types, Lewi’s valence bond formulas, VB theory hybridization, VSEPR theory. Introduction to the basics of MO theory, electronegativity, valence theory terms, electrical conductivity, metals, semiconductors and non-conductors, band model, alloys, phase diagrams, magnetism, bonding parameters, mass, and energy balance, setting up reaction equations, reversible reactions, chemical equilibrium, basic kinetic terms, characterization of solutions, electrolytes, conductivity, pH value, acids and bases, titration, indicators, buffer systems, solubility product

SCBC-b	**Basics of Chemistry - Exercise**	PF	Exercise	1	30 h
Contents: Structured treatment of fundamental chemical questions. Knowledge is deepened and practice questions are modelled for professional exam preparation.					
SCBC-c	**Introduction to Physical Chemistry - Lecture**	PF	Lecture	2	60 h
Remarks: Content requirements: School knowledge of chemistry					
Contents: • Dealing with physical units • Introduction to physical chemistry: books, basic quantities, derived quantities, decimal multiples of units, physical constants, conversion factors for the various energy units, aggregate states, phases, definition of systems, measurement of the variables V, p, T • The ideal gas: Boyle-Mariotte law, Gay-Lussac law, Avogadro hypothesis, law of the ideal gas, concept of the state function, Dalton's partial pressure law • Kinetic gas theory: derivation of pressure, average kinetic energy of a gas, uniform distribution theorem, degrees of freedom, speed of molecules (Maxwell-Boltzmann), collision numbers, mean free path, effusion, transport processes (viscosity, thermal conductivity), distribution) • The real gas: the ideal gas compared to reality, virial equation, van der Waals equation, critical data of a gas, theorem of corresponding states					
SCBC-d	**Fundamentals of Chemistry (SCBC) - Practical**	PF	Practical	6	180 h
Remarks: Content requirements: School knowledge of chemistry					
Contents:					

Component(s)		PF/WP	Teaching method	SWS	Time expenditure
Inorganic chemistry: • Proper and safe work in the laboratory: handling harmful chemicals and hazardous substances. • Knowledge of basic material properties, deepening of the lecture material through practical application and examples in the chemical laboratory. • Basic working techniques and measuring methods, introduction to basic measuring instruments. • Handling scales and measuring instruments - gravimetric methods; separation of precipitates (fractional crystallization, filtration, centrifugation); • Titration of strong and weak acids; determination of pKa values; conductometry. • Determination of solubility products; - redox reactions. • Selected detection reactions and characteristic reactions of individual elements. Physical chemistry: Recognizing physical-chemical relationships. • Basic working techniques and measuring methods, getting to know measuring instruments. • Temperature measurement, thermocouples, evaluation of calorific measurements, heat capacity, cold mixtures, Dulong-Petit's rule of the heat of chemical reactions. • Application of the ideal gas laws, volume and pressure measurement, use of the gas burette, determination of equivalent and molar mass. • Real behavior of gases, saturated vapor, evaporation enthalpy, vapor pressure curves, dynamic equilibrium, phase diagram of water, substance-specific temperatures, supercooling, Clausius-Clapeyron equation. • Kinetic gas theory, velocity distribution, number of collisions, mean free path, dynamic viscosity, Hagen-Poiseuille law, laminar flow. • Spectroscopic properties of light sources, atomic and molecular spectra, emission, absorption, fluorescence, line spectra, spectral series, Rydberg constant of hydrogen.					
SCBC-e	**Basics of Chemistry (Seminar)**	PF	Seminar	1	30 h
Contents: Preliminary and follow-up discussions of the experiments carried out during the practical.					

SCPHY	Physics for chemists	PF/WP PF	Weight 4	Workload 4 CP	Time expenditure 120 h

Qualification objectives:

The students know the basic physical phenomena and can describe them mathematically using models. This includes the topics of mechanics, optics, and electricity.

Duration: 1	**Offer frequency:** every 2nd semester	**Recommended FS:** 2

Proof	Form	Duration	Repeatability	CP
Final module examination ID: 80682	**Written examination (examination)**	120 min	unlimited	4

Component(s)		PF/WP	Teaching method	SWS	Time expenditure
SCPHY-a	**Basics of physics**	PF	Lecture	3	90 h

Remarks:

Content requirements: High school mathematics

Contents:

• Knowledge of basic physical phenomena through observation and visualization (physical demonstration experiments) as well as their mathematical description within the framework of models.
• Using examples, the relationships inherent in the various natural phenomena are to be made visible and understanding is to be deepened.
• Measurement of physical quantities, measurement errors, measurement accuracy
• Kinematics of the point, kinematic equations for uniformly accelerated motion • Newton's axioms
• Momentum, momentum conservation law, work, forms of energy, energy conservation law
• Basic concepts of electricity, charges, electric field and its force effects, capacitor
• Moving charges, magnetic field, induction, self-induction
• Electromagnetic oscillations and waves
• Geometric optics, wave optics, quantum optics

SCPHY -b	**Exercise on basic physics**	PF	Exercise	1	30 h

Contents:

The topics discussed in the lecture are deepened and practiced using example tasks.

SCICS	Introduction to Computer Science	PF/WP PF	Weight 4	Workload 4 CP	Time expenditure 120 h
Qualification objectives: The students have mastered the basics of computer science with a particular focus on computer-aided chemistry. The students know both the formal aspects of computer science and the functionality of algorithms in connection with their implementation in modern programming languages. This also includes the use of word processing, spreadsheet and drawing programs for chemical formulas.					
Duration: 1	**Offer frequency:** every 2nd semester		**Recommended FS:** 1		

Proof	Form	Duration	Repeatability	CP
Final module examination ID: 80685	**Written exam (exam)**	90 min	unlimited	4
Final module examination ID: 81428	**Electronic exam**	90 min	unlimited	4

Component(s)		PF/WP	Teaching method	SWS	Time expenditure
SCICS-a	**Introduction to Computer Science**	PF	Lecture	3	90 h
Contents: The students are taught the following topics: • Introduction to computer science, what is computer science? • Representation and processing of information, • Logical circuits, • Computer systems, processor, RAM, operating system, • Algorithms and programs, • Current programming languages, • Object orientation, attributes, object methods, • Inheritance, constructors, classes • Programming with Visual Basic, • Basic language elements, • Imperative control structures, • Data types, • Functions, • Modeling of problems, • Documentation and testing, • Development tools.					
SCICS-b	**Using MS Office and VBA**	PF	Exercise	1	30 h
Contents: The students learn the following skills: • Using a word processing program (MS Word) • Using a spreadsheet program (MS Excel) • Using a presentation program (MS PowerPoint) • Using a drawing program for chemical structural formulas (ADC/ChemSketch) • Programming simple tasks using Visual Basics and integrating the algorithms into Applications (VBA)					

Instrumental Analysis and Inorganic Chemistry

SCANME	Analytical methods	PF/WP PF	Weight 8	Workload 8 CP	Time expenditure 240 h
Qualification objectives: The students know elementary physics and the interaction of light and matter, as well as the electromagnetic spectrum. The students understand the basic principle of the analysis methods presented and can apply the acquired knowledge to new spectroscopic problems.					
Duration: 1	**Offer frequency:** every 2nd semester			**Recommended FS:** 5	

Proof	Form	Duration	Repeatability	CP
Final module examination ID: 80695	**Collection folder with assessment**		unlimited	8
Explanation of the final module examination: The folder consists of the internship work, a seminar presentation, and a technical discussion on the lecture.				

Component(s)		PF/WP	Teaching method	SWS	Time expenditure
SCANME-a	**Introduction to analytical methods and spectroscopy**	PF	Lecture	4	120 h

Contents:

The students receive a theoretical overview of the most important methods for characterizing chemical compounds and materials, understand the basics of spectroscopic methods and possible applications:

Infrared and Raman spectroscopy
• Basics of infrared absorption and Raman scattering
• Selection rules
• Characteristic vibrations and vibration spectra
Nuclear magnetic resonance spectroscopy
• Basics of NMR spectroscopy
• 1H and 13C NMR spectroscopy
• 2D methods
UV/VIS spectroscopy
• Lambert-Beer's law
• Basics of UV excitation
• Selection rules
X-ray diffraction methods
• Basics of X-rays and interaction with matter
• X-ray diffraction methods Basics of mass spectrometry
• Various ionization methods
• Interpretation of mass spectra
• Coupled methods

SCANME-b	**Exercises on advanced spectroscopic methods**	PF	Seminar/ Exercise	2	60 h

Remarks:

This seminar deepens the knowledge acquired in the lecture "Introduction to analytical methods and spectroscopy" through exercises on the spectroscopic methods presented.

Important contents are:
• Brief overview of analytical methods
• Exercises on IR, NMR, UV/VIS spectroscopy, X-ray diffraction methods and mass spectrometry
• Presentations by students on various topics of analytical methods

Contents:
The students complete application-oriented exercises on the spectroscopic methods mentioned above.
• Problems, example applications and special measurement methods are presented by the students in PowerPoint presentations. After completing the course, it is expected that the students will be able to solve basic problems in each of the spectroscopic methods discussed.

SCANME-c	**Analytical methods**	PF	Practical	2	60 h

Component(s)	**PF/WP**	**Teaching method**	**SWS**	**Time expenditure**
Remarks: Contents of the courses “Introduction to analytical methods and spectroscopy” and “Exercises in advanced spectroscopic methods” (SCANME-a and -b) are required. The students gain practical experience with each device and learn how to operate it. A report is written on what has been learned and the measurement results, which represents the examination performance for this part of the module.				
Contents: Introduction to the handling of each spectrometer presented in the SCANME-a and -b module parts in the laboratory and detailed explanation of the functional principle. Independent operation of the spectrometers and measurement of the first samples in the laboratory to gain practical experience in the spectroscopic methods mentioned above.				

SCQA	Quantitative analysis	PF/WP PF	Weight 10	Workload 10 CP	Time expenditure 300 h
Qualification objectives: The students understand the important principles of quantitative analysis and can apply the theoretical knowledge to the implementation and evaluation of the various wet chemical analysis methods.					
General remarks: Prerequisites for participation: Completed module Fundamentals of Chemistry (SCBC)					
Duration: 1	**Offer frequency:** every 2nd semester		**Recommended FS:** 2		

Proof	Form	Duration	Repeatability	CP
Final module examination ID: 80693	**Written examination (exam)**		unlimited	10
Explanation of the final module examination: The prerequisite for participation in the MAP is previous regular participation in the SCQAc laboratory internships in accordance with the guideline for dealing with attendance requirements dated October 16, 2019 (Official Gazette 67/19 amended on March 15, 2023 Official Gazette 08/23).				

Component(s)		PF/WP	Teaching method	SWS	Time expenditure
SCQA-a	**Instrumental Analysis**	PF	Lecture	3	90 h

Remarks:

Prerequisites: Basic knowledge of chemistry and mathematics

Contents:

The students learn the classic volumetric and gravimetric analysis methods; understanding important principles of quantitative analysis with derivation and discussion of the relevant titration curves and diagrams; getting to know the basics of potentiometric and spectrometric methods.

Basic terms: amount of substance, molar mass, equivalent amount of substance, concentration, ionic strength, activity, and activity coefficient.

Chemical equilibrium: equilibrium constant; equilibrium and thermodynamics; dissociation of weak acids, complex formation, solubility product and precipitation of precipitates, effect of additives with the same and foreign ions; influence of pH on solubility; activity coefficients
Acid-base equilibria: acid-base theories; pH value of strong and weak acids and bases; dissociation of polyprotic acids; buffers and buffer capacity.
Acid-base titrations: titration curves, calculation, and experimental determination; titration of strong acids with strong bases and strong bases with strong acids, titration of weak acids with strong bases, titration of weak bases with strong acids, titration of a mixture of two acids or bases of different strengths, titration of polyprotic acids; acid-base indicators; applications of acid-base titrations; Hägg diagrams, mathematical derivation, and geometric construction.
Precipitation titrations: potentiometric titrations with silver (I); titration of chloride according to Mohr, titration according to Volhard, titration of halides or sulfate using adsorption indicators.
Complexometric titrations: metal chelate complexes; ethylenediaminetetraacetic acid (EDTA); influence of pH and auxiliary complexing agents on the titration curve; metal indicators; titration methods with EDTA, determination of water hardness.
Redox reactions and redox titrations: Redox reactions, electrode potentials, dependence of the electrode potential on the concentration, redox reactions by combining half reactions, potentiometric titration, shape of the redox titration curve, redox indicators, speed, and mechanism of redox reactions.
Electrodes and potentiometry: Indicator electrodes, reference electrodes, ion-selective electrodes, liquid membrane electrodes, solid membrane electrodes, application of ion-selective electrodes, pH measurement with the glass electrode, fluoride determination.
Gravimetry: precipitation mechanism, conditions for analytical precipitation, precipitation from homogeneous solution, impurities in precipitates, filtering and washing precipitates, heating the precipitate, calculation of results, examples of gravimetric determinations.
SpectraCPhotometry: Absorption of radiant energy, Lambert-Beer law, measurement of the absorption of radiation, spectraCPhotometric determinations in the visible range and in the UV range.

SCQA-b	**Quantitative analysis**	PF	Exercise	2	60 h

Contents:

The students understand the following questions:
Which separation technique (LC, GC, CE) can be used for which scientific question? How do you vary/select the most important parameters to develop a functional method?

The students develop strategies to develop these methods more in the direction of “green analytical chemistry” to reduce material, solvent, and energy consumption.

Component(s)		**PF/WP**	**Teaching method**	**SWS**	**Time expenditure**
SCQA-c	**Quantitative Analysis – Practical**	PF	Practical	5	150 h

Contents:

The students can work safely and methodically and qualitatively in the laboratory and are able to handle chemicals safely. They can apply theoretical knowledge in the laboratory and develop appropriate task plans. This enables them to solve analytical questions of sustainable chemistry, e.g. the environmental chemical analysis of water and soil samples in the laboratory and to quantitatively determine the amount of various elements. The experiments include:

- Acid-base titrations
- Precipitation titrations
- Titration of halides
- Complexometric titrations
- Redox titrations
- Potentiometry
- Gravimetry
- SpectraCPhotometry (UV-vis photometry):

SCIA	Instrumental analysis	PF/WP PF	Weight 10	Workload 10 CP	Time expenditure 300 h

Qualification objectives:

The students are familiar with the available instrumental analytical methods for the qualitative and quantitative analysis of (environmental) samples. They have a basic understanding of how these can be used to analyse the environmental behavior of compounds. This module thus forms a bridge between the sustainable production of compounds and environmental toxicology. The students have basic knowledge of the theory and application of all relevant modern analytical methods with advanced knowledge of chromatography and elemental analysis. The focus of the module is that the students learn method development and application and can characterize the performance of the developed methods in their practical application.

General remarks:

Participation requirements:
Completed Quantitative Analysis (SCQA) module

Duration: 1	**Offer frequency:** every 2nd semester	**Recommended FS:** 3

Proof	Form	Duration	Repeatability	CP
Final module examination ID: 80696	**Written examination (exam)**		unlimited	10

Explanation of the final module examination:

The prerequisite for participation in the MAP is previous regular participation in the SCIAd laboratory internships in accordance with the guideline for dealing with attendance requirements dated October 16, 2019 (Official Gazette 67/19 amended on March 15, 2023 Official Gazette 08/23).

Component(s)		PF/WP	Teaching method	SWS	Time expenditure
SCIA-a	**Instrumental analysis**	PF	Lecture	4	120 h

Contents:

The students understand the following methods:
• Atomic spectroscopy (flames, ovens, plasmas (ICP-OES), ICP-MS)
• Separation techniques
• Thin layer chromatography, with applications
• Liquid chromatography (LC) (stationary/mobile phases, device technology, detectors)
• Gas chromatography (stationary/mobile phases, device technology, detectors)
• Electrophoresis (CE, PAGE)
• Mass spectrometry coupled to chromatography (sources, analysers, and their functional and application modes)
And learn how to develop these and use them for sustainable chemistry. This includes knowledge of sample preparation procedures (e.g. extraction, LLE, SPE, QUECHERS, microwave digestions).
The students can describe the performance of analytical methods and thus understand the basics of method validation and quality assurance. This includes basic knowledge of statistical data analysis (measurement errors, statistically significant differences (t-test, ANOVA)).

SCIA-b	**Seminar - separation techniques**	PF	Seminar	2	60 h

Contents:

The students understand the following questions:
Which separation technique (LC, GC, CE) can be used for which scientific question? How do you vary/select the most important parameters to develop a functional method?

The students develop strategies to develop these methods more in the direction of “green analytical chemistry” to reduce material, solvent, and energy consumption.

SCIA-c	**Seminar - Mass Spectrometry**	PF	Seminar	1	30 h

Contents:
The students understand the following topics:
How are ions formed and moved in the mass spectrometer?
Important parameters for the application and optimization of common ion sources
Selection of a suitable mass analyser for research questions and its application modes Interpretation of GC-MS and LC-MS spectra
Quantitative analysis using GC-MS and LC-MS(/MS)

SCIA-d	**Laboratory practical - GC and LC**	PF	Practical	3	90 h

Contents:

The students know the most important steps in setting up GC and LC methods. They gain experience in the selection of mobile and stationary phases and the settings of instrument parameters, such as flow rate, detector selection and settings. This deepens their knowledge of the chemical and physical properties of molecules and elements as well as the separation techniques.
The experiments include:
• Characterization and optimization of chromatographic separations (N, k, aCPha).
• Qualitative analysis and interpretation of chromatograms.
• Quantitative analysis and interpretation of the data.

Component(s)	PF/WP	Teaching method	SWS	Time expenditure
• Handling the instruments and dangerous chemicals.				

SCIC1	Inorganic Chemistry	PF/WP PF	Weight 6	Workload 6 CP	Time expenditure 180 h

Qualification objectives:

The students understand the basic concepts and models of general and inorganic chemistry. This includes understanding the:
• properties of main group and transition metals based on their position in the periodic table
• structure-property relationships of inorganic compounds and understanding of basic chemical processes

Duration: 2	**Offer frequency:** every 2nd semester	**Recommended FS:** 2

Proof	Form	Duration	Repeatability	CP
Final module examination ID: 80683	**Written examination (exam)**	180 min	2	6

Component(s)		PF/WP	Teaching method	SWS	Time expenditure
SCIC1-a	**Chemistry of main group elements (lecture)**	PF	Lecture	2	60 h
Contents: The course provides basic knowledge of inorganic chemistry and includes the following components: • Trends in selected element properties (ionization energy, electron affinity, electronegativity, covalent and ionic radii) in the periodic table of elements. • Chemical nomenclature • Relationships between structure, chemical bonding, and properties • Classify chemical reactions according to acid/base or redox reactions and discuss them from a thermodynamic and kinetic perspective. • Models and concepts (e.g. VSEPR, acid-base concepts). • Occurrence, extraction, properties and technical significance of the main group elements and their most important binary hydrides, oxides, and halides: • Hydrogen: isotopes, fuel cells, hydrides (ionic, covalent, metallic), water and aqueous solutions, acids and bases, hydrogen bonds • Alkali metals: flame coloration, salts of oxoacids, chlor-alkali electrolysis, alkalis, ionic lattices • Alkaline earth metals: water hardness, complexometry, sulfates, and carbonates, building materials such as gypsum and cement • Boron group: borax, aluminum, multi-center bonds, Lewis's acid/base reactions, isoelectronic BN and C compounds, hard materials, inert electron pairs, ampholytes • Carbon group: allotropes of carbon, carbides, CFCs, semiconductor materials, silicon dioxide and silicates, aluminosilicates, glasses, Sn and Pb compared to the lighter elements, Pb battery • Nitrogen group: Haber-Bosch and Ostwald processes, allotropes, fertilizers, Linde process • Chalcogens: structure of the atmosphere, allotropes of the elements, Claus process, contact processes, oxoacids, H_2S precipitation • Halogens: elements, hydrides, halogen oxides and oxoacids • Discovery of noble gas chemistry					
SCIC1-b	**Exercise on the chemistry of main group elements**	PF	Exercise	1	30 h
Contents: The topics covered in the SCIC1-a course are deepened and practiced using sample tasks.					
SCIC1-c	**Chemistry of transition metals**	PF	Lecture	2	60 h

Contents: The course is a continuation of the Inorganic Chemistry I module and covers other important aspects of inorganic compounds and concepts of inorganic chemistry: • Understanding the properties and chemistry of subgroup elements based on their position in the periodic table and their electronic structure • Occurrence, extraction and properties of the transition metals, lanthanides, and actinides • Chemistry of the d- and f-block elements. Occurrence, extraction, properties, and reactivity. • Overview of some important industrial processes for the extraction of metals • Basics of coordination chemistry • Crystal field and ligand field theory • Color, magnetism, kinetic and thermodynamic stability • Biological aspects of subgroup metals • Basics of nuclear chemistry					
SCIC1-d	**Exercise on the chemistry of transition metals**	PF	Exercise	1	30 h
Contents:					

Component(s)	**PF/WP**	**Teaching method**	**SWS**	**Time expenditure**
The topics covered in the SCIC1-c course are deepened and practiced using example tasks.				

SCIC2	Experimental Inorganic Chemistry	PF/WP PF	Weight 8	Workload 8 CP	Time expenditure 240 h

Qualification objectives:

The students have basic knowledge of handling chemicals and hazardous substances by independently carrying out analyses and preparations. The qualification objective is the independent planning of simple experiments, the recording of observations and the interpretation of the results.

General remarks:

Prerequisites for participation: Completed module Fundamentals of Chemistry (SCBC)

Duration: 1	**Offer frequency:** each semester	**Recommended FS:** 2

Proof	Form	Duration	Repeatability	CP
Final module examination ID: 80686	**Written examination (exam)**	90 min	unlimited	8

Component(s)		PF/WP	Teaching method	SWS	Time expenditure
SCIC2-a	**Inorganic Chemistry II (Practical)**	PF	Practical	11	210 h

Contents:

• Independent planning of laboratory work
• Acquisition of knowledge about inorganic substances by independently carrying out qualitative analyses. This includes: qualitative analysis of inorganic samples, introduction to analytical methodology, critical evaluation of experimental observations, separation processes, specific reactions of inorganic ions, reducing and oxidizing anions, development of experimental methods and material knowledge, creation of test protocols - production of simple inorganic compounds: metals from their oxides, formation of simple compounds of metals and non-metals, application of reductive and oxidative coupling reactions, synthesis of classic inorganic complexes, synthesis of transition metal complexes with multidentate ligands.

SCIC2-b	**Seminar on the Practical Course in Inorganic Chemistry II**	PF	Seminar	1	30 h

Contents:

Comprehensive discussion of the theoretical background for analytical and preparative experiments in the laboratory course SCIC2-a.

Organic Chemistry

SCOC1	Introduction to Organic Chemistry	PF/WP PF	Weight 10	Workload 10 CP	Time expenditure 300 h

Qualification objectives:

The students understand the basic topics of organic chemistry and their importance. The students master the relationships between organic chemistry, biochemistry, materials chemistry, and the contents of general chemistry. This includes the structure of an organic molecule and its function, various functional groups, and the basics of systematic organic compounds.

General remarks:

Prerequisites for participation: Completed module Fundamentals of Chemistry (SCBC)

Duration: 1	**Offer frequency:** every 2nd semester	**Recommended FS:** 3

Proof	Form	Duration	Repeatability	CP
Final module examination ID: 80684	**Written examination (exam)**	90 min	unlimited	10
Final module examination ID: 81413	**Electronic examination**	90 min	unlimited	10

Component(s)		PF/WP	Teaching method	SWS	Time expenditure
SCOC1-a	**Fundamentals of Organic Chemistry**	PF	Lecture	3	135 h

Contents:

- Polar covalent bonds; acids and bases; nonpolar molecules; structure and bonding.
- Overview of organic reactions.
- Reactions of alkanes: bond-dissociation energies, radical halogenation, and relative reactivity.
- Properties and reactions of haloalkanes: nucleophilic substitutions and eliminations.
- Functional group transformations. Alcohols: properties, preparation, and strategy of synthesis. Ethers.
- Systematic nomenclature of organic compounds.
- Unsaturated hydrocarbons. Alkenes and alkynes: properties and addition reactions.
- Benzene and aromaticity: aromatic substitution reactions.
- Aldehydes and ketones: nucleophilic addition reactions.
- Enols, enolates and the aldol condensation: unsaturated aldehydes and ketones
- Carboxylic acid derivatives: nucleophilic acyl substitution reactions.
- Ester enolates and the Claisen condensation: synthesis of dicarbonyl compounds; acyl anion equivalents.
- Amines and their derivatives: functional groups containing nitrogen.
- Heterocycles: heteroatoms in cyclic organic compounds.

SCOC1-b	**Organic Stereochemistry**	PF	Seminar	1	45 h

Contents: Conformations of organic molecules. Conformation of cycloalkanes. Stereochemistry of alkenes: E/Z isomerism. Enantiomers and the tetrahedral carbon atom. Diastereomers and meso compounds. Chirality in nature and other chiral environments.					
SCOC1-c	**Working methods in organic chemistry**	PF	Practical	4	90 h
Contents: The students know the most important basic working techniques and standard equipment for the synthesis, separation, purification, and characterization of organic compounds. They gain initial experience in the proper handling of substances and equipment, considering safety, disposal and environmental aspects, and deepen their understanding of the chemical and physical properties of the most important substance classes. • Standard reaction apparatus and methods of preparative organic chemistry. • Organic-chemical separation and purification processes (e.g. extraction, distillation, sublimation, recrystallization, chromatography). • Classic characterization and identification methods. • Proper handling of hazardous substances.					
SCOC1-d	**Seminar on working methods in organic chemistry**	PF	Seminar	1	30 h
Contents: The experiments to be carried out in the internship are prepared and followed up.					

SCOC2	Reaction mechanisms	PF/WP PF	Weight 10	Workload 10 CP	Time expenditure 300 h
Qualification objectives: Students will master the physical-organic perspective on a wide range of chemical processes. Students will be able to illustrate reaction mechanisms in detail while discussing the electronic and structural principles that influence reactivity and selectivity.					
General remarks: Prerequisites for participation: Completed module Introduction to Organic Chemistry (SCOC1)					
Duration: 1	**Offer frequency:** every 2nd semester			**Recommended FS:** 4	

Proof	Form	Duration	Repeatability	CP
Final module examination ID: 80687	**Written examination (exam)**		unlimited	10

Component(s)		PF/WP	Teaching method	SWS	Time expenditure
SCOC2-a	**Reaction mechanisms**	PF	Lecture	3	120 h
Contents: Students will understand the following topics: • Chemistry of enols, enamines. Mukaiyama aldol reaction. • Chemistry of alkaline earth metal enolates: Zimmerman-Traxler model. Stereoselective aldol reactions. Enolate alkylations. • Conversion of phosphorus- or sulfur-stabilized carbon nucleophiles with carbonyl groups. • Rearrangements: Cationic rearrangements. Sigmatropic rearrangements. Miscellaneous rearrangements. • Thermal cycloadditions: Diels-Alder reactions. [2+3] cycloadditions. Click chemistry. • Oxidations and reductions in organic chemistry.					
SCOC2-b	**Exercise - reaction mechanisms**	PF	Exercise	1	30 h
Contents: Structured treatment of mechanistic questions. Knowledge is deepened and practice questions are modelled for professional exam preparation.					
SCOC2-c	**Basic Organic Chemistry - Practical Course**	PF	Practical	8	120 h

Contents: The students deepen their knowledge of the synthesis, separation, purification, and characterization of organic compounds. They can carry out, record, and evaluate experiments independently and gain a deeper understanding of the lecture material through preparative work. • Organic-chemical separation and purification processes (e.g. extraction, distillation, sublimation, recrystallization, chromatography). • Classic and modern characterization and identification methods. • Preparation classes: nucleophilic substitution on the saturated carbon atom, elimination reactions, additions to double bonds, aromatic substitution reactions, oxidation and reduction reactions, reactions of carbonyl compounds. • Planning of syntheses. • Proper handling of hazardous substances					
SCOC2-d	**Seminar on the basic organic chemistry course**	PF	Seminar	1	30 h
Contents: The experiments to be carried out in the internship are prepared and followed up.					

SCOC3	Homogeneous catalysis	PF/WP PF	Weight 10	Workload 10 CP	Time expenditure 300 h

Qualification objectives:

The students understand the basic principles of homogeneous catalysis and the associated industrial catalytic processes. The students master the design of transition metal catalysts and organocatalysts, as well as the advantages resulting from catalytic processes in terms of ecological and economic aspects.

General remarks:

Participation requirements: Completed Reaction Mechanisms module (SCOC2)

Duration: 1	**Offer frequency:** every 2nd semester	**Recommended FS:** 5

Proof	Form	Duration	Repeatability	CP
Final module examination ID: 80688	**Oral Exam**	60 min	unlimited	10

Component(s)		PF/WP	Teaching method	SWS	Time expenditure
SCOC3-a	**Homogeneous catalysis**	PF	Lecture	2	60 h

Contents:

Students will understand the following topics:
• Fundamentals of catalytic processes: Environmental aspects. Economic aspects. The catalytic cycle. TONTOF. Heterogeneous and homogeneous catalysis.
• Organocatalysis: Nature's playbook. History of organocatalysis. Enamine catalysis. Diels-Alder reactions. Catalysis of acids. CBS reduction.
• Lewis acid catalyzed processes: Diels-Alder reactions. Aldol reactions.
• Transition metal catalyzed hydrogenations: Alkene reductions. Wilkinson catalyst. Carbonyl reductions. Stereochemistry of hydrogenations. Noyori catalysts.
• Transition metal catalyzed oxidations: Alcohol oxidations. Alkene epoxidations and dihydroxylations. Stereochemistry of epoxidations. Sharpless, Jacobsen and Shi epoxidations. Wacker oxidation.
• Reactions to form carbon-carbon bonds: palladium catalysis. Heck reaction.
Cross-couplings (Suzuki, Stille, Negishi reactions).
• Catalytic processes in industry: hydroformylations. Oxidations.

SCOC3-b	**The development of organic synthesis**	PF	Seminar	1	30 h

Contents:

The development of catalytic processes is placed in a historical context. It is shown how certain transformations were made possible by multi-stage processes and stoichiometric reagents. These processes are directly compared with modern catalytic processes, which lead to shortened overall processes and offer economic and ecological advantages.

SCOC3-c	**Exercise on homogeneous catalysis.**	PF	Exercise	1	30 h

Contents: Structured treatment of mechanistic questions. Knowledge is deepened and practice questions are modelled for professional exam preparation.					
SCOC3-d	**Organic Synthetic Chemistry - Practical**	PF	Practical	6	150 h
Contents: The students know special working techniques and methods of modern synthetic chemistry, carry out literature research independently and evaluate it critically. They can plan multi-stage syntheses, create experimental procedures, characterize reaction products, and understand how to handle dangerous and air-sensitive chemicals. In addition, they use spectroscopic methods for characterization and interpret the spectra. They can evaluate experimental observations and critically question them. They also have experience in presenting and discussing selected topics. • Special working techniques such as working under protective gas, low-temperature techniques. • Synthesis methods for organic and organometallic compounds. • Selected classes of substances in organic and organometallic chemistry. • Characterization of substances using IR and NMR spectroscopy, mass spectrometry. • Modern chromatographic separation and analysis methods. • Literature research.					
SCOC3-e	**Seminar on the practical course in organic synthetic chemistry**	PF	Seminar	1	30 h
Contents: The experiments carried out in the internship are prepared and followed up. A seminar presentation must be given.					

Sustainability and Green Chemistry

SCGC	***Green Chemistry***	PF/WP **PF**	Weight **10**	Workload **10 CP**	Time expenditure **300 h**

Qualification objectives:

The students are familiar with the available instrumental analytical methods for the qualitative and quantitative analysis of (environmental) samples. They have a basic understanding of how these can be used to analyse the environmental behavior of compounds. This module thus forms a bridge between the sustainable production of compounds and environmental toxicology. The students have basic knowledge of the theory and application of all relevant modern analytical methods with advanced knowledge of chromatography and elemental analysis. The focus of the module is that the students learn method development and application and can characterize the performance of the developed methods in their practical application.

General remarks:

Prerequisites for participation: Completed module Fundamentals of Chemistry (SCBC)

Duration: 2	**Offer frequency:** every 2nd semester	**Recommended FS:** 3

Proof	Form	Duration	Repeatability	CP
Final module examination ID: 80697	**Oral Exam**	90 min	unlimited	10

Component(s)		PF/WP	Teaching method	SWS	Time expenditure
SCGC-a	***Green Chemistry***	PF	Lecture	4	120 h

Contents:

Students will learn the basic principles of green chemistry and its applications:
• Green Chemistry – A Design Framework for Sustainability
• History and Background of Green Chemistry: Societal Challenges, Unintended Consequences of Chemistry
• Principles of Green Chemistry and Green Engineering
• Chemical Exposure and Dosing
• Green Chemical Process Improvements: Catalysis
• Green Chemical Process Improvements: Solvents
• Renewable Resources
• Green Chemistry and Energy I
• Green Chemistry and Energy II
• Green Product Improvements: Design for Recycling and Degradation; Reuse, Recycle, Reuse
• Case Studies: Green Industrial Process Improvements
• Case Studies: Green Materials Improvements for Energy and the Environment
• Case Studies: Green Consumer Product Improvements

SCGC-b	***Green Chemistry* - Exercise**	PF	Exercise	1	30 h

Contents: Analysis and applications of the principles of green chemistry in selected case studies: • Identification of a concrete case study for the application of the principles of green chemistry in an industrial process or the design of a consumer product • Critical evaluation of the case study in scientific written and oral form					
SCGC-c	**Practical in Green Chemistry**	PF	Practical	4	120 h
Contents: The students learn the working techniques in the chemical laboratory with a focus on sustainable modern processes and methods. This includes: • Synthesis of biodiesel • Electrocatalytic water splitting • Photocatalytic removal of organic dyes from water • Synthesis of TiO_2 photocatalysts and semiconductor electrodes • Production of bio-based membranes					
SCGC-d	**Green Chemistry Practical (Seminar)**	PF	Seminar	1	30 h
Remarks: Pre- and post-discussion of the experiments carried out during the practical course.					

SCIND	Paths to sustainability in industry	PF/WP PF	Weight 3	Workload 3 CP	Time expenditure 90 h

Qualification objectives:

The students understand critical and necessary aspects when integrating the principles of green chemistry in chemical process control and development. The students can analyse case studies from the chemical industry using the 12 principles of green chemistry and develop proposed solutions.

Duration: 1	**Offer frequency:** every 2nd semester	**Recommended FS:** 1

Proof	Form	Duration	Repeatability	CP
Final module examination ID: 80698	**Oral exam**	30 min	unlimited	3

Component(s)		PF/WP	Teaching method	SWS	Time expenditure
SCIND-a	**Paths to sustainability in industry (seminar)**	PF	Seminar	3	90 h

Contents:

• Using case studies, students learn about the processes in the chemical industry and how to integrate the principles of green chemistry into existing chemical processes
• Showing the different production techniques in the chemical industry
• Getting to know the most important equipment
• Getting to know the most important processes in mechanical and thermal process engineering

SCSSC	Material Chemistry	PF/WP PF	Weight 5	Workload 5 CP	Time expenditure 150 h

Qualification objectives:

The students understand the basic models and concepts of inorganic solid-state chemistry and can apply them. The students learn the theoretical basis for the synthesis of materials and understand the basic structure-property relationships.

General remarks:

Prerequisites for participation: Completed module Fundamentals of Chemistry (SCBC)

Duration: 1	Offer frequency: every 2nd semester	Recommended FS: 5

Proof	Form	Duration	Repeatability	CP
Final module examination ID: 80692	**Oral exam**	45 min	unlimited	5

Component(s)		PF/WP	Teaching method	SWS	Time expenditure
SCSSC-a	**Material Chemistry**	PF	Lecture	3	90 h

Contents:

The lecture covers the basics of solid-state chemistry, material properties and their applications:
• Electronic band structures of solids
• Structure-property relationships
• Chemical bonds in solids
• Description of simple crystal structures (sphere-C packings, gap occupation, unit cell, translation symmetry)
• Simple structural types of binary and ternary compounds
• Molecular and crystal symmetry - point and space groups
• State diagrams, phases, polymorphism
• Methods of synthesizing materials
• Real crystals and defect structures (point and surface defects)
• Ionic conduction
• Metals/semiconductors/insulators
• Cooperative electrical and magnetic properties and their applications
• Zintl phases and intermetallic compounds
• Nanoscopic materials

SCSSC-b	**Material Chemistry - Exercise**	PF	Exercise	2	60 h

Contents:

The knowledge acquired in the lecture is deepened through exercises based on practice tasks.

SCRM	Renewable materials	PF/WP PF	Weight 5	Workload 5 CP	Time expenditure 150 h

Qualification objectives:

Students have a broad understanding of renewable materials, including their sources, structure, reactivity, physical-chemical properties, processing, synthesis, and applications. By addressing physical-chemical properties of renewable resources, students can assess the suitability of these materials for practical applications.

General remarks:

Prerequisites for participation: Completed module Fundamentals of Chemistry (SCBC)

Duration: 1	**Offer frequency:** every 2nd semester	**Recommended FS:** 6

Proof	Form	Duration	Repeatability	CP
Final module examination ID: 80699	**Oral Exam**	45 min	unlimited	5

Component(s)		PF/WP	Teaching method	SWS	Time expenditure
SCRM-a	**Renewable materials**	PF	Lecture	3	90 h

Contents:

The students learn to critically evaluate the source of biomass, availability and suitability of the compounds contained therein for the synthesis of renewable materials. The lecture includes the description of the molecular structure and functional groups, structure formation, hydration, and water solubility of natural polymers:
• Introduction to natural polymers and renewable materials
• Materials based on lignocellulose
• Cellulose and nanocellulose
• Other polysaccharides
• Lignin
• Lipids and proteins
• Composites and hybrid materials
• Biomineralization
• Renewable nanomaterials
• Degradability
• Characterization of renewable materials

SCRM-b	**Renewable materials (Seminar)**	PF	Seminar	2	60 h

Contents:

Using selected examples, the students learn the advantages and disadvantages of renewable materials compared to fossil-based materials over their product life cycle.

SCSPC	Introduction to sustainable polymer chemistry	PF/WP PF	Weight 9	Workload 9 CP	Time expenditure 270 h

Qualification objectives:

The students know the chemistry of natural and artificial macromolecules and have competence regarding the basic principles for the formation reactions of macromolecular substances and the consequences for their classification, their properties, and their characterization, especially in comparison to low molecular weight substances. Based on the i) competences described above and the ii) principles of green chemistry, the students are able to prepare macromolecules and biopolymers using sustainable synthesis routes.

Duration: 1	**Offer frequency:** every 2nd semester	**Recommended FS:** 5

Proof	Form	Duration	Repeatability	CP
Final module examination ID: 80700	**Oral exam**	45 min	unlimited	9

Component(s)		PF/WP	Teaching method	SWS	Time expenditure
SCSPC-a	**Introduction to sustainable polymer chemistry**	PF	Lecture	2	60 h

Contents:

• Overview of macromolecular chemistry and polymer science
• Main polymerization mechanisms (step growth – condensation, addition – and chain growth) • Kinetics and thermodynamics
• Molar mass distribution, dispersity, and control of the degree of polymerization
• Synthesis methods (substance, solution, emulsion/dispersion)
• Copolymerization
• Polymer structure and morphology
• Important polymer classes
• Physical properties of polymers (chain conformation, solubility, miscibility, crystallinity) • Basic methods for characterization
• Sustainability (environmental impact, bio-based monomers, sustainable polymer synthesis and processing, recyclable polymers)

SCSPC-b	**Introduction to Sustainable Polymer Chemistry - Exercise**	PF	Exercise	1	30 h

Remarks:

The topics discussed in the lecture are deepened and practiced using example tasks.

SCSPC-c	**Introduction to Sustainable Polymer Chemistry - Practical**	PF	Practical	6	180 h

Contents:

Through 9 selected experiments, students will
• gain an in-depth understanding of the lecture material through preparative work, such as

chain transfer polymerization, emulsion polymerization, polymerization with reversible deactivation, ring-opening metathesis polymerization and cationic ring-opening polymerization.
• master standard reaction apparatus and methods of preparative polymer chemistry, such as polymer separation and purification methods (e.g. precipitation, dialysis, Soxhlet extraction) as well as classic and modern

characterization and identification techniques (e.g. NMR spectroscopy, IR and UV-Vis spectroscopy, SEC, DLS, DSC);

• master the correct handling of (dangerous) substances and equipment, considering safety, disposal, and environmental aspects.

• independent experiment planning, execution, and reports.

Physical chemistry

SCCKD	Chemical kinetics and dynamics	PF/WP PF	Weight 6	Workload 6 CP	Time expenditure 180 h

Qualification objectives:

The students understand the kinetic relationships at the microscopic and macroscopic level. They can search databases for kinetic data and their relevance in more complex chemical reaction systems. The students can calculate kinetic courses using numerical differential equation solvers, carry out kinetic experiments in practice and evaluate kinetic experiments regarding the relevant parameters.

Duration: 1	**Offer frequency:** every 2nd semester	**Recommended FS:** 4

Proof	Form	Duration	Repeatability	CP
Final module examination ID: 80691	**Oral exam**	30 min	unlimited	6

Component(s)		PF/WP	Teaching method	SWS	Time expenditure
SCCKD-a	**Chemical kinetics and dynamics**	PF	Lecture	2	90 h
Contents: Formal kinetics • Definitions: order, molecularity, rate and time law, rate constant • Rate laws and their analytical solutions • Setting up complex systems and solving them using differential equation solvers • Concept of the rate-determining step and quasi-stationarity • Determining reaction types from concentration/time profiles (parallel, subsequent reactions, reversible reactions) • Experimental and formal kinetic methods in the gas phase and in condensed matter • Description of chain reactions, explosions, detonations Molecular reaction dynamics • Physical derivation of a rate constant from a gas kinetic perspective (ideal gas concept, collision cross section, mean free path, collision number, Maxwell-Boltzmann velocity distribution) • Extension of the “potential curves” to the concept of “hyperpotential surfaces” • Consideration of simple reactions on hyperpotential curves • Concept of the reaction coordinate • Differentiation from Thermodynamics • Concept of catalysis • Concept of Marcus theory (electron transfer in solution)					
SCCKD-b	**Practical course in chemical kinetics and dynamics**	PF	Practical	2	90 h
Contents: Experiments on chemical kinetics and molecular dynamics that convey the following aspects through practical experience: Tracking reaction rates in the condensed phase and gas phase, time laws, quasi-stationarity, empirical determination of reaction orders, rate-determining step, reaction mechanisms with parallel and subsequent reactions, catalysis, experimental investigation of fast reactions, gas dynamics, transport phenomena in the gas phase, kinetic gas theory, elementary collision theory, cyclic voltammetry, kinetics of electrode processes, electrochemical reversibility, electrochemical reaction mechanisms, ion mobility, ion-molecule reactions, numerical modelling of reaction dynamics.					

SCMMM	Modelling of molecules and materials	PF/WP PF	Weight 8	Workload 8 CP	Time expenditure 240 h
Qualification objectives: The students know the basics of the structure of matter on the microscopic to the macroscopic scale. The students can apply the fundamental concepts of quantum mechanics and thermodynamics and have essential knowledge of quantum chemistry and statistical thermodynamics					
Duration: 1	**Offer frequency:** every 2nd semester			**Recommended FS:** 4	

Proof	Form	Duration	Repeatability	CP
Final module examination ID: 80694	**Oral Exam**	30 min	unlimited	8

Component(s)		PF/WP	Teaching method	SWS	Time expenditure
SCMMM-a	**Structure of atoms and molecules**	PF	Lecture	2	100 h
Contents: Basic quantum mechanics: wave functions, operators, expectation values; Time-independent Schrödinger equation; Particle in a box, harmonic quantum oscillator, hydrogen atom Variation principle; Born-Oppenheimer approximation; Chemical bond: valence bond and molecular orbital theory The Hückel approximation.					
SCMMM-b	**Macroscopic material properties**	PF	Lecture	2	100 h
Contents: The three laws of thermodynamics; Temperature, entropy, and thermodynamic potentials; Applications of thermodynamics: phase transitions, van der Waals equations, osmotic pressure Kinetic theory; The Gibbs ensemble and Liouville's theorem; The Maxwell-Boltzmann distribution; Microcanonical, canonical and grand canonical ensembles.					
SCMMM-c	**Exercises in quantum chemistry and thermodynamics**	PF	Exercise	1	40 h
Contents: The basic concepts of quantum chemistry, as well as classical and statistical thermodynamics from the components SCMMM-a and SCMMM-b are deepened and applied in dedicated exercises.					

SCTEC	Thermodynamics and electrochemistry	PF/WP PF	Weight 8	Workload 8 CP	Time expenditure 240 h

Qualification objectives:

The students have a fundamental understanding of the concept of “energy” and its essential importance for considering all states and processes in the universe. The students can apply the basic thermodynamic concepts to (electro-)chemical systems.

Duration: 2	**Offer frequency:** every 2nd semester	**Recommended FS:** 2

Proof	Form	Duration	Repeatability	CP

Prerequisite for the final module examination:

Passed pre-tests, completion of the practical experiments, submission of the experiment protocols and a passed seminar presentation.
[Please consult: are these UBL - if so, how many and for which component - otherwise possibly a folder?]

Final module examination ID: 80690	**Collection folder with assessment**	30 min	unlimited	8

Explanation of the final module examination:

The folder consists of the pre-assessed internship achievements, the pre-assessed seminar presentation, and the written performance assessment (90 min) for the SCTEC-a component.

Component(s)		PF/WP	Teaching method	SWS	Time expenditure
SCTEC-a	**Thermodynamics & electrochemistry**	PF	Lecture	3	90 h

Contents:

- Basics and relevance of the energy concept
- Fundamental energy storage systems
- Interactions between systems for the exchange of energy
- Introduction of thermodynamic quantities: internal energy, enthalpy, entropy, free enthalpy
- Laws of thermodynamics
- Concept of machines for gradient reduction and associated work performance
- Introduction of the (electro-)chemical potential
- Nernst equation and application for quantitative electrochemistry
- Redox reactions and electrochemical voltage series

SCTEC-b	**Practical course in thermodynamics and electrochemistry**	PF	Practicum	3	120 h

Contents:

Fundamentals of experimental methods in physical chemistry, data evaluation and documentation, practical handling of experimental quantities subject to uncertainty.

Experiments in thermodynamics and basic electrochemistry that convey the following aspects through practical experience:
Reaction enthalpies / calorimetry, heat engines / heat pumps, conservation of energy, entropy,

Energy balances and efficiencies, adsorption isotherms, equilibrium thermodynamics, non-ideal behavior of real solutions, thermodynamics of phase transition, colligative properties, coulometry / Faraday's law, solvation phenomena, electrode potentials, potentiometry, electrolysis reactions, numerical modelling of equilibrium phenomena.

SCTEC-c	**Seminar on the practical course in thermodynamics and electrochemistry**	PF	Seminar	1	30 h

Contents:

Deepening and presentation of specific module-relevant aspects through student presentations:
Alternative experimental procedures and concepts, current developments, industrial and social relevance of the topics covered in the internship, further application of experimental procedures, simulation and modelling procedures, research in scientific primary literature and databases, presentation techniques, suitable topic definition and preparation.

Participants must give their own presentation.

Toxicology

SCTOX	Toxicology	PF/WP PF	Weight 4	Workload 4 CP	Time expenditure 120 h
Qualification objectives: Students know the principles of toxicology and understand the hazards/risks that toxic compounds in the environment pose to the ecosystem and human health. Students have knowledge of the toxicological aspects of chemicals.					
Duration: 1	**Offer frequency:** every 2nd semester			**Recommended FS:** 1	

Proof	Form	Duration	Repeatability	CP
Final module examination ID: 80689	**Written examination (exam)**	90 min	unlimited	4

Component(s)		PF/WP	Teaching method	SWS	Time expenditure
SCTOX-a	**Lecture - Biology / Biochemistry**	PF	Lecture	1	30 h
Contents: Lecture Biology / Biochemistry: The lecture covers important topics in anatomy, physiology, biomolecules, and biochemistry (structure of biomolecules, carbohydrates, lipids, and proteins) as well as the basics of molecular cell biology.					
SCTOX-b	**Lecture - Fundamentals of Toxicology**	PF	Lecture	2	60 h
Contents: Fundamentals of toxicology: toxicokinetic (ADME), toxicodynamic (dose-response, acute/chronic effects), receptor-, ion channel- and enzyme-mediated effects, target organ toxicity, genotoxicity, mutagenicity, carcinogenicity, toxicity of specific toxins. Environmental toxicology: fate in the environment, persistence, and biodegradation; environmental toxicology; ecotoxicology. Test strategies and risk assessment: The course gives an overview of experimental methods and toxicological tests. The course gives an overview of the concept of risk assessment with concrete examples (Understanding Hazard and Risk), REACH and other guidelines for toxicity testing (ICH, OECD).					
SCTOX-c	**Seminar - Toxicology**	PF	Seminar	1	30 h
Content: Students assess the toxicity of compounds based on documents and evaluate "safer" alternatives for the compounds					

Industrial internship

SCINTERN	Industrial internship	PF/WP PF	Weight 0	Workload 10 CP	Time expenditure 300 h
Qualification objectives: The students strengthen their key professional competencies outside of the area-specific specialist expertise and learn the basics of the tasks in the everyday working life of chemists in companies or businesses.					
Duration: 1	**Offer frequency:** each semester			**Recommended FS:** 6	

Proof	Form	Duration	Repeatability	CP
Final module examination ID: 80701	**Written homework**		unlimited	10
Explanation of the final module examination: The term paper consists of the internship report: 10 pages (Arial 11, line spacing 1.2) Duration: 4 weeks				

Component(s)		PF/WP	Teaching method	SWS	Time expenditure
SCINTERN-a	**Industrial internship**	PF	Practicum	10	300 h
Contents: Practical work in a private company.					

Captions

PF	Compulsory subject
WP	Optional Compulsory Subject
FS	Semester
CP	Credit points
MAP	Final module examination
UBL	Ungraded academic performance
SWS	Semester hours per week