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Curriculum for the
Master's Programme in Chemistry
at the Faculty for Chemistry and Pharmacy at the University of Innsbruck

(New-release 2024)

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§ 1 Allocation of the study programme

According to § 54 para. 1 Universities Act, the Master’s Programme in Chemistry is grouped among the natural science programmes.

§ 2 Admission

(1) The admission to the Master’s Programme in Chemistry requires the completion of a subject-specific bachelor’s programme or a subject-relevant bachelor’s programme passed completed at a university of applied sciences or another equivalent degree programme passed at obtained from a recognised post-secondary educational institution, either domestically home or abroad.

(2) The completion of the Bachelor’s Programme at the University of Innsbruck is in any case a relevant study programme. The Rectorate decides on the existence of another subject-relevant study programme and on the equivalence of a study programme passed at a post-secondary educational institution home or abroad based on the regulations of the Universities Act.

(3) If equivalence is given in principle with only a few supplements missing for full equivalence, additional courses and examinations corresponding to a maximum of 30 ECTS-Credits may be prescribed for full equivalence, which must be taken by the end of the second semester of the master’s programme.

§ 3 Qualification profile

(1) Subject-specific qualifications:

- The Master's Programme in Chemistry teaches the specialist skills and methods for chemical-scientific research.
- The programme is designed with a focus on current fields of research, combining in close combination with theoretical training and with experimental/practical experimental and practical skills.
- It offers a comprehensive education in chemistry and, by selecting suitable content, enables students to specialise or deepen their knowledge of the subject in accordance with their inclinations and interests.
- It allows the acquisition of advanced knowledge in the sub-disciplines of chemistry according to the current state of knowledge and expertise in chemistry.

(2) General qualifications:

- Graduates of the Master's Programme in Chemistry are able to carry out scientific research in the subjects of chemistry independently and significantly.
- Key interdisciplinary skills are imparted during the programme.
- It promotes a sense of responsibility for the benefits and risks of scientific research and application.

(3) Professional qualifications:

- The aim of the master's programme is to qualify students for a career in chemistry and to prepare them comprehensively for their future roles in this field.
- The master's degree programme provides the qualifying prerequisites for entry into the profession of a chemist in research, technology, industry, the environment and chemistry-related official fields of activity.

(4) The Master's Programme in Chemistry qualifies students for admission to an advanced Doctoral Programme in Chemistry or related fields.

§ 4 Scope and duration

The Master’s Programme in Chemistry covers 120 ECTS-Credits. This corresponds to a duration of the study programme of four semesters. One ECTS-Credit corresponds to a workload of 25 hours.

§ 5 Language

The Master's Programme in Chemistry is offered in English.

§ 6 Types of courses and maximum number of students per course

(1) Courses without continuous performance assessment:

1. **Lectures** (VO) are courses held in lecture format. They introduce the research areas, methods and schools of thought for a given subject.

(2) Courses with continuous performance evaluation:

1. **Practical courses (PR)** provide practical experience with concrete scientific tasks, complementing occupational and academic training. Maximum number of participants: 10
2. **Seminars (SE)** provide in-depth treatment of scientific topics through students' presentations and discussion thereof. Maximum number of participants: 120
3. **Lecture-tutorials (VU)** focus on the practical treatment of concrete scientific tasks that are discussed during the lecture parts of the course. Maximum number of participants: 120

§ 7 Allocation of places in courses with a limited number of participants

(1) Students are selected according to the following priorities:

1. Students of programmes for which the course is compulsory and who were unable to attend the course due to an earlier selection procedure.
2. Students of the degree programmes for which the course is compulsory.
3. If the criteria in no. 1 and 2 are not sufficient to regulate admission to a course, the date of acquisition of the prerequisites for the registration shall be used.
4. If the criteria in no. 1, no. 2 and no. 3 are not sufficient to regulate admission to a course, the arithmetic mean of the grades of the prerequisite examinations will be used.
5. If the criteria in no. 1 to no. 4 are not sufficient to regulate admission to a course, the places for participating will be raffled.

(2) If necessary, parallel courses should also be organised, possibly during the time when there are no other courses.

§ 8 Structure of the study programme

(1) The Master's Programme in Chemistry is divided into the following groups of modules:

1. The Compulsory Module "Preparation for the Master's Thesis" (7,5 ECTS-Credits) and the Compulsory Module "Master's Thesis Defense" (2,5 ECTS-Credits).
2. Elective modules from six subdisciplines in chemistry - Analytical Chemistry, Inorganic Chemistry, Biochemistry, Organic Chemistry, Physical Chemistry and Theoretical Chemistry. From these elective modules, modules covering altogether a total of 62,5 ECTS-Credits are to be must be selected from five sub-disciplines in chemistry.
3. Elective modules for advanced study of the subdisciplines in chemistry:Analytical Chemistry, Inorganic Chemistry, Biochemistry, Organic Chemistry, Physical Chemistry, Theoretical Chemistry, Material and Nano Sciences and Chemical Engineering. Modules covering a total of 15 ECTS-Credits are to be passed from these elective modules.
4. Electives modules in general skills. From these elective modules, modules covering a total of 10 ECTS-Credits are to be passed.

§ 9 Compulsory and elective modules

(1) Compulsory modules covering altogether 10 ECTS-Credits are to be passed.

(2) Elective modules covering altogether 87,5 ECTS-Credits are to be passed. From no. 1 to 9 (chemical subdisciplines), modules covering 62,5 ECTS-Credits, from no. 10 to 27 (advanced study), modules covering altogether 15 ECTS-Credits and from no. 28 to 35 (general qualifications), modules covering altogether 10 ECTS-Credits are to be selected.

The compulsory modules are:

Compulsory Modules	h	ECTS-Credits
1. Compulsory Module: Preparation of the Master's Thesis		7,5
2. Compulsory Module: Master's Thesis Defense		2,5

The elective modules are:

Elective Modules	h	ECTS-Credits
1. Elective Module: Analytical Chemistry A	6	7,5
2. Elective Module: Analytical Chemistry B	5	5
3. Elective Module: Inorganic Chemistry A	5	7,5
4. Elective Module: Inorganic Chemistry B	5	5
5. Elective Module: Biochemistry	10	12,5
6. Elective Module: Organic Chemistry A	5	7,5
7. Elective Module: Organic Chemistry B	5	5
8. Elective Module: Physical Chemistry	10	12,5
9. Elective Module: Theoretical Chemistry	10	12,5
10. Elective Module: Advanced Study or Analytical Chemistry A	2	2,5
11. Elective Module: Advanced Study or Analytical Chemistry B	3	5
12. Elective Module: Advanced Study of Analytical Chemistry C	3	5
13. Elective Module: Advanced Study of Inorganic Chemistry A	3	5
14. Elective Module: Advanced Study of Inorganic Chemistry B	3	5
15. Elective Module: Advanced Study of Inorganic Chemistry C	3	2,5
16. Elective Module: Advanced Study of Biochemistry A	3	5
17. Elective Module: Advanced Study of Biochemistry B	4	5
18. Elective Module: Advanced Study of Organic Chemistry A	3	5
19. Elective Module: Advanced Study of Organic Chemistry B	5	5
20. Elective Module: Advanced Study of Organic Chemistry C	2	2,5
21. Elective Module: Advanced Study of Physical Chemistry A	5	5
22. Elective Module: Advanced Study of Physical Chemistry B	2	2,5
23. Elective Module: Advanced Study of Physical Chemistry C	5	5
24. Elective Module: Advanced Study of Theoretical Chemistry A	4	5
25. Elective Module: Advanced Study of Theoretical Chemistry B	4	5

26. Elective Module: Advanced Study of Material Sciences and Chemical Engineering		5
27. Elective Module: Practice		5
28. Elective Module: Intellectual Property Rights and Legal Framework of Chemistry	2	2,5
29. Elective Module: Science Management	2	2,5
30. Elective Module: Lecture Series - GÖCh/CMBI/Material and Nano Science	2	2,5
31. Elective Module: Interdisciplinary Skills		5
32. Elective Module: Computer-Aided Database Research	2	2,5
33. Elective Module: Measurement Technology and Computer-Assisted Control of Experiments	3	2,5
34. Elective Module: Metal and Ceramics Processing for Laboratory Use	5	5
35. Elective Module: Glass Processing for Laboratory Use	5	5

(3) Compulsory Modules:

1.	**Compulsory Module: Preparation of the Master's Thesis**	**h**	**ECTS-Credits**
	Agreement on the topic, scope and form of the Master's Thesis on the basis of a brief description of the content (synopsis) as well as agreement on the work processes and the progress of the study programme; planning of a corresponding time frame for the completion of the Master's Thesis.	-	7,5
	Total	**-**	**7,5**
	Learning Outcomes: Students • can write a brief description of the content of the planned Master's Thesis (synopsis); • can correctly apply the conventions of the subject area in terms of presentation, stylistic devices, structure and content and use high-quality, credible and relevant sources to present their ideas; • can present the core concept of the planned Master's Thesis, define the scope and outline a timeline; • are thus in a position to conclude a written Master's Thesis Agreement; • can apply the principles of good scientific practice; • are able to design a detailed laboratory work scheme that includes the specific methods and techniques required to carry out their Master's Thesis; • can take into account relevant safety protocols and ethical guidelines to ensure that all experimental work meets the standards of good laboratory practice.		
	Prerequisite/s: none		

2.	Compulsory Module: Master's Thesis Defense	h	ECTS-Credits
	Presentation and final oral defense (defensio) of the independently written Master's Thesis in a 20-minute academic presentation followed by an academic discussion and questioning by an examination board	-	2,5
	Total	-	**2,5**
	Learning Outcomes: Students • have highly specialised knowledge which, at least in the area of their Master's Thesis, is based on the latest scientific findings, • are able to make appropriate reference to information and analyses that support their own results, • can explain the methodological principles and central results of their Master's Thesis in a comprehensible manner and communicate them convincingly.		
	Prerequisite/s: positive evaluation of all prescribed modules and the Master's Thesis		

(4) Elective modules

Elective modules from the six sub-disciplines of chemistry:

1.	Elective Module: Analytical Chemistry A	h	ECTS-Credits
a.	**VO Advanced Analytical Separation Methods I** Liquid-liquid extraction, multiplicative distribution coefficients, kinetic theory, separation model, dynamic theories, chromatographic parameters, liquid chromatography, HPLC, UHPLC, instrumentation, HPLC low and high pressure gradient, reversed phase chromatography, ion pair reversed phase chromatography, hydrophilic HILIC interaction chromatography, partition chromatography, ion chromatography, size exclusion chromatography, affinity chromatography, supercritical fluid chromatography, method transfer, solid phase extraction, sample preparation, stationary phases, molecularly imprinted polymers, gas chromatography, retention index, detectors, couplings to mass spectrometry, capillary electrophoresis, isotacho-phoresis, isoelectric focussing, zone electrophoresis, 2D gel electrophoresis	2	2
b.	**VO Advanced Analytical Separation Methods II** Stationary phases for liquid chromatography (synthesis, characterisation, selection and method optimisation), special detection methods; miniaturisation of separation processes, e.g. chip technologies for electrophoresis and chromatography	1	1
c.	**VO Bioanalysis** Properties of biomolecules, separation methods for biomolecules, diagnostic tests, DNA purification and determination, bioanalysis in the life sciences, protein extraction, protein precipitation, protein quantification with using protein assays, Biuret test, Lowry test, Bradford test, immunoassays, Micro-HPLC in bioanalysis, size exclusion chromatography, coupling methods for mass spectrometry, applications of LC-MS in bioanalysis, applications of MALDI-TOF MS in bioanalysis, top-down MS, bottom-up MS, structural elucidation of biomolecules, gel electrophoresis	1	1,5
d.	**VO Advanced Spectroscopic Methods** Theory and applications of UV, MIR, NIR and Raman spectroscopy, current applications from industry and research	1	1,5

e.	**VO Modern Applications of Analytical Chemistry** Problems and applications of selected analytical techniques (separation processes, spectroscopy, spectrometry, etc.) in research and industrial practice	1	1,5
	Total	**6**	**7,5**
	Learning Outcomes: Students are able to: • understand, evaluate and apply complex relationships and theories of analytical separation techniques, including liquid-liquid extraction, kinetic theory, chromatographic characteristics and instrumentation of various forms of chromatography such as HPLC, UHPLC and gas chromatography, • gain detailed knowledge of the synthesis, characterisation and optimisation of stationary phases for liquid chromatography, including low-pressure and high-pressure gradient HPLC, various forms of reversed-phase chromatography and innovative approaches such as supercritical fluid chromatography and molecularly imprinted polymers, • evaluate innovative techniques and miniaturisation of separation processes, including advances in capillary electrophoresis, isotachophoresis and isoel-electric focusing, • differentiate and optimise advanced bioanalytical methods for the separation and structural elucidation of biomolecules, including biomolecule properties, diagnostic tests, DNA purification and determination, and special methods such as gel electrophoresis and top-down or bottom-up MS, • critically reflect on the theories and applications of spectroscopic methods, including UV, MIR, NIR and Raman spectroscopy as well as current applications from industry and research, • critically evaluate the use and relevance of modern analytical techniques in industrial practice, including selected problems and applications, • generate an in-depth knowledge of current and future challenges in analytical chemistry, including new techniques, methods and applications, • critically engage with the latest advances in analytical chemistry and recognise their relevance to different application areas, including medicine and environmental protection.		
	Prerequisite/s: none		

2.	**Elective Module: Analytical Chemistry B**	**h**	**ECTS-Credits**
	PR Advanced Practical Training Course on Instrumental Analysis Selected practical examples from the fields of environmental, food, bio, polymer and industrial analysis using electrophoretic, chromatographic, electrochemical, spectroscopic, mass spectrometric and coupled analysis methods, processing and sample preparation of real samples, data evaluation and method comparison.	5	5
	Total	**5**	**5**
	Learning Outcomes: Students are able to: • independently and critically assess and apply advanced analytical techniques in instrumental analysis, including electrophoretic, chromatographic, electrochemical, atomic spectroscopic, molecular spectroscopic and mass spectrometric or coupled methods, • design, optimise and evaluate sample preparation and work-up techniques for real samples, including sample preparation for environmental, food, bio, polymer and industrial analysis, • systematically and critically analyse data, compare methods and interpret the results in scientific and practical contexts, including the application of analysis methods, data evaluation tools and method comparisons.		

	Prerequisite/s: none

3.	Elective Module: Inorganic Chemistry A	h	ECTS-Credits
a.	**VO Solid-State Chemistry II** “Inorganic functional materials” relevant to materials science: structure-property relationships in various substance classes (hard materials and highly efficient inorganic phosphors for high-performance applications), their synthesis and technically relevant electronic, optical and magnetic properties	2	3
b.	**VO Homogeneous Organometallic Catalysis** Elementary reactions of organometallic compounds, heterogeneous versus homogeneous catalysis, mechanisms and applications of homogeneous catalytic processes on both on a technical and laboratory scales, current developments and challenges in homogeneous catalysis, aspects of sustainability	1	1,5
c.	**VO Responsive Functional Materials** Responsive functional materials and their characterisation using diffractometric and spectroscopic methods, properties and applications of hybrid materials made of porous host lattices and chromophoric molecules, fundamentals of photochemistry	2	3
	Students	**5**	**7,5**
	Learning Outcomes: Students are able to: • apply knowledge and understanding of materials science relevant inorganic functional materials and their structure-property relationships, including hard materials, high efficiency inorganic phosphors and technically relevant electronic, optical and magnetic properties, • critically evaluate and draw conclusions regarding the structure-property relationships of different classes of substances in inorganic chemistry, including technically relevant materials, inorganic phosphors and their applications in high performance applications, • acquire comprehensive knowledge of the principles of organometallic complex catalysis and understand and interpret reaction mechanisms and selectivity principles with regard to method development and the optimisation of catalysts, • analyse current developments and problems in homogeneous catalysis, including the differences between heterogeneous and homogeneous catalysis, the challenges in homogeneous catalysis and sustainability aspects, • generate an in-depth knowledge of responsive functional materials and describe and apply their characterisation using specific methods, including diffractometric and spectroscopic methods, hybrid materials with porous host lattices and chromophoric molecules, and fundamentals of photochemistry, • reflect an in-depth understanding of the properties and applications of hybrid materials, including their composition, structure, and their response to external stimuli, • critically analyse and interpret current scientific literature to gain a deeper insight into the topics of the module, including the latest developments in solid state chemistry, homogeneous catalysis and responsive functional materials, • independently generate and apply knowledge to develop solutions to complex problems in inorganic chemistry, including the synthesis of functional materials, characterisation using modern methods and the application of catalysis processes.		
	Prerequisite/s: none		

4.	Elective Module: Inorganic Chemistry B	h	ECTS-Credits
	PR Laboratory Course in Advanced Inorganic Chemistry Independent experimental work on current research topics in an inorganic chemistry working group; concrete application of advanced synthesis methods and spectroscopic and diffractometric substance characterisation: optional focus on organometallic chemistry and catalysis, coordination chemistry, photochemistry, materials science or solid-state chemistry	5	5
	Total	**5**	**5**
	Learning Outcomes: The students are able to: • apply complex synthesis methods independently in inorganic research, including advanced synthesis methodology and spectroscopic and diffraction characterisation, • work on current research topics in inorganic chemistry and independently plan and carry out scientific experiments, including the selection of suitable topics such as organometallic chemistry, coordination chemistry and solid-state chemistry, • use advanced analytical methods in materials characterisation and interpret their results in a broader scientific context, including photochemistry, materials science and solid-state chemistry.		
	Prerequisite/s: none		

5.	Elective Module: Biochemistry	h	ECTS-Credits
a.	**VO Advanced Biochemistry I** Proteins - from structure to function: in-depth study of the structure and function of proteins, in particular: chemistry of amino acid building blocks, peptide binding, protein analysis, conformation, folding, degradation and dynamic function of proteins, allosteric proteins, mechanisms of enzymatic catalysis, protein sequence motifs (bioinformatics)	2	3
b.	**VO Advanced Biochemistry II** Metabolic networks: in-depth study of biochemical regulation and signal transduction pathways processes, in particular: amino acid metabolism, cholesterol metabolism, steroid hormones, isoprenoid compounds, chemical attributes of DNA, gene-protein relationship, gene regulation, protein targeting, mitogenic signal transduction, molecular basis of tumour development.	2	3
c.	**VO Introduction to the Laboratory Course in Advanced Biochemistry** Theoretical principles of modern biochemical and genetic engineering methods, possible applications in basic biochemical research and in medical and pharmacological issues	1	1,5
d.	**PR Laboratory Course in Advanced Biochemistry** Research-orientated practical training in modern biochemical, genetic engineering and OMICs methods, in particular: recombinant protein expression, protein purification, protein-DNA interactions, analysis of gene expression, gene transfer, cell transformation	5	5
	Total	**10**	**12,5**
	Learning Outcomes: Students are able to: • generate an in-depth understanding of the structure and function of proteins, including the chemistry of amino acid building blocks, peptide binding and protein conformation and folding,		

	• evaluate and explain advanced aspects of biochemical regulation and signalling processes, including amino acid metabolism, cholesterol metabolism and gene-protein relationships, • critically reflect on theoretical concepts of modern biochemical and genetic engineering methods, including applications in basic biochemical research, gene regulation and protein targeting, • demonstrate practical skills in the application of modern biochemical, genetic engineering and OMICs methods, including recombinant protein expression, protein-DNA interactions and gene transfer, • independently develop and implement in-depth experimental strategies in the field of biochemistry and genetics, including analysing gene expression, cell transformation and protein purification, • critically analyse and interpret scientific results from biochemical investigations, particularly with regard to the molecular basis of tumour development, steroid hormones and isoprenoid compounds, • identify innovation potentials and research gaps in the field of biochemistry and genetics and develop solutions, including mitogenic signal transduction, chemical attributes of DNA and protein sequence motifs (bioinformatics), • classify biochemical data and findings ethically, professionally and socially and discuss their relevance and implications for medical and pharmacological issues, including gene-protein relationships, gene regulation and the molecular basis of tumour development.
	Prerequisite/s: none

6.	Elective Module: Organic Chemistry A	h	ECTS-Credits
a.	**VO Advanced Organic Synthesis** Modern concepts in the field of heterocyclic chemistry, nomenclature of heterocycles, synthesis strategies, properties and reactivity of heterocycles, synthesis of active ingredients and natural products, e-electrophilic, nucleophilic and radical substitution, stereoselective synthesis, synthesis methods, synthesis with organometallic complexes, protecting groups, industrial applications	2	3
b.	**VO Bioorganic Chemistry** Fundamentals of bioorganic chemistry, organic-chemical synthesis as access to natural product analogues, which leads to the targeted manipulation of properties of biological systems, structural basis of biocatalysis and special stereochemical aspects	2	3
c.	**SE Seminar Biological Organic Chemistry** Working on and presenting current topics in organic chemistry with a focus on ‘structure, reactivity & synthesis’ as well as chemical-biological approaches, lecture and discussion training in symposium format	1	1,5
	Total	**5**	**7,5**
	Learning Outcomes: Students are able to: • understand and reproduce modern concepts of heterocyclic chemistry, nomenclature of heterocycles and synthesis strategies, • develop and identify strategies for the synthesis of organometallic complexes, protecting groups and heterocycles, including electrophilic, nucleophilic and radical substitution as well as stereoselective synthesis, • identify and analyse complex properties and reactivities of heterocycles, including applications in drug and natural product synthesis and industrial applications,		

	• understand advanced concepts of bioorganic chemistry, in particular the structural basis of biocatalysis and stereochemical aspects; synthesise natural product analogues and understand their effects on biological systems, • work on and present current topics in organic chemistry, in particular with regard to structure, reactivity and synthesis, • formulate and present advanced chemical-biological approaches in current scientific discussions, • apply effective presentation techniques and lead discussions in a symposium format.
	Prerequisite/s: none

7.	Elective Module: Organic Chemistry B	h	ECTS-Credits
	PR Laboratory Course in Advanced Organic Chemistry Practical implementation of organic chemical synthesis steps using modern strategies and methods for carrying out selective material conversions. Organisation: rotation principle, which leads through the current research topics of organic chemistry; concrete application of advanced synthesis methodology and spectro-analytical substance characterisation	5	5
	Total	**5**	**5**
	Learning Outcomes: Students are able to: • independently plan, select and execute complex organic chemical synthesis strategies, including the selection of modern synthesis methods, the application of selective material conversions and the use of advanced spectroanalytical characterisation methods, • analyse and critically reflect on research-based questions and problems within organic chemistry, including the recognition of connections between different research topics, the analysis of synthesis routes and the evaluation of spectroanalytical data, • generate and perfect advanced practical skills in organic chemistry, including the rotational principle for exploring current research topics, implementing advanced synthesis methods and performing spectroanalytical substance characterisation.		
	Prerequisite/s: none		

8.	Elective Module: Physical Chemistry	h	ECTS-Credits
a.	**VU Properties of Solid-State Materials** Structure, lattice vibrations, electronic properties, transport properties, metals, insulators, semiconductors	2	2
b.	**VO Kinetics and Catalysis** Complex reaction kinetics, non-linear and oscillating systems, microscopic fundamentals of kinetics, fundamentals of heterogeneous catalysis	2	3
c.	**SE Seminar Current Topics in Materials Science and Physical Chemistry** Analytical methods for material and process characterisation, physico-chemical systems for energy conversion	2	2,5
d.	**VO Atmospheric Chemistry** Fundamentals of atmospheric chemistry, layered structure stratification of the atmosphere, chemistry of the troposphere (hydrological cycle, clouds, pollutant balance, smog, degradation mechanisms, half-lives), chemistry of the ozone layer (stratosphere), chemistry of higher atmospheric layers and	1	1,5

	in interstellar space, history (and future) of the atmosphere, extra-terrestrial atmospheres, greenhouse effect, ‘indoor chemistry’, pressure and temperature profile; Earth's radiation balance; optical phenomena (auroras, halos, rainbows, blue/red sky)		
e.	**PR Practical Training Course in Applied Physical Chemistry** Fuel cell, electrolysis cell, mass spectrometry, quantitative gas analysis	2	2,5
f.	**PR Practical Training Course in Production and Characterisation of Thin Films** Synthesis and characterisation of functional thin-film systems	1	1
	Total	**10**	**12,5**
	Learning Outcomes: Students are able to: • understand and critically interpret the properties of solids, including structure, lattice vibrations, electronic properties, transport properties and differentiation between metals, insulators and semiconductors, • discuss and explain advanced mechanisms of reaction kinetics and catalysis, including non-linear and oscillatory systems and the microscopic basis of kinetics, • apply current analytical methods in materials science and evaluate physico-chemical systems for energy conversion, • understand and explain the main concepts of atmospheric chemistry, including the layered structure of the atmosphere, the chemistry of the troposphere and stratosphere, and optical phenomena such as auroras and halos, • demonstrate practical skills in the application and interpretation of experiments in applied physical chemistry, including fuel cells, electrolytic cells and mass spectrometry, • master thin film technology and gas phase deposition techniques and synthesise and characterise functional thin film systems, • apply knowledge from their studies to analyse real problems, drawing on their knowledge and skills from the various courses, • reflect critically and independently on advanced chemical concepts in order to develop solutions for new and unknown challenges in physical chemistry.		
	Prerequisite/s: none		

9.	**Elective Module: Theoretical Chemistry**	**h**	**ECTS-Credits**
a.	**VO Advanced Quantum Chemistry** Ab initio quantum chemistry, Hartree-Fock methods, post-Hartree-Fock methods, density functional theory, perturbation theory, energy hypersurfaces, application examples	2	3
b.	**VO Simulation Methods** Molecular dynamics simulations, quantum mechanical-molecular mechanical hybrid methods, free energy calculations, Monte Carlo simulations	2	3
c.	**VO Theoretical Treatment of Biomolecules** Bioinformatics, biomolecular databases, sequence analysis, prediction of RNA/DNA structures; prediction of protein folding and protein structures, DNA, RNA and protein dynamics	2	3

d.	**PR Practical Training Course in Advanced Theoretical Chemistry and Computer Chemistry** Practical applications of the calculation methods from the master's programme	4	3,5
	Total	**10**	**12,5**
	Learning Outcomes: Students are able to: • analyse, evaluate and interpret advanced theoretical concepts and methods of quantum chemistry, including ab initio quantum chemistry, Hartree-Fock methods and post-Hartree-Fock methods, • critically reflect on and evaluate theoretical approaches in chemistry, including density functional theory, perturbation theory and energy hypersurfaces, • recognise and evaluate complex simulation methods in chemistry, including molecular dynamics simulations, quantum mechanical-molecular mechanical hybrid methods and free energy calculations, • identify and analyse complex problems in the field of theoretical chemistry and develop independent solution strategies, including Monte Carlo simulations and other advanced computational methods, • synthesise and evaluate biomolecular data and structures based on theoretical approaches, including bioinformatics, sequence analysis and prediction of RNA/DNA structures, • analyse and apply advanced methods for the prediction of biomolecular structures and dynamics, including the prediction of protein folding and protein structures as well as DNA, RNA and protein dynamics, • independently plan and carry out advanced practical applications in the field of theoretical chemistry, including the use of calculation methods from the master's programme, • integrate both theoretical knowledge and practical skills in the field of theoretical chemistry and apply them in new, unpredictable contexts, including the integration of knowledge from the various courses of this module.		
	Prerequisite/s: none		

10.	**Elective Module: Advanced Study of Analytical Chemistry A**	**h**	**ECTS-Credits**
a.	**VO Material Analysis** Traditional and new material analysis methods and procedures: mercury porosimetry, BET, XRF, infrared and Raman spectroscopy	1	1,5
b.	**VO Chemical and Biological Sensors** Design, measuring principle and function of various sensor types; applications of electrochemical and optical sensors, semiconductor gas sensors, biosensors; modern developments and miniaturisation based on field-effect transistors and sensor arrays	1	1
	Total	**2**	**2,5**
	Learning Outcomes: Students are able to: • critically evaluate subject-specific findings and principles of material analysis methods and procedures, including traditional and newer methods such as mercury porosimetry, BET, XRF and infrared and Raman spectroscopy, • to reflect current research and trends in the field of material analytical chemistry, especially in the context of spectroscopic methods, • recognise the limits and areas of application of various analytical methods in the context of materials science issues,		

	• interpret advanced knowledge of the design, measurement principle and operation of different types of sensors, including electrochemical, optical sensors, semiconductor gas sensors and biosensors, • to analyse complex relationships and developments in sensor technology, in particular modern developments and miniaturisation based on field-effect transistors and sensor arrays, • make decisions on the selection of appropriate analytical methods depending on the material being analysed and the purpose of the investigation, including consideration of sensor characteristics, detection limits and specific requirements of the investigation context.
	Prerequisite/s: none

11.	**Elective Module: Advanced Study of Analytical Chemistry B**	**h**	**ECTS-Credits**
a.	**VO Food Analysis** Tasks of food analysis, legal regulations (EU, Austria), sampling and sample preparation, analytical methods for food, determination of food components, analysis of harmful substances, contaminants, residues and food allergens, proof of food authenticity	1	1,5
b.	**VO Diagnostic Laboratory Analysis** Sampling, analysis and diagnostics of biological samples (blood, urine, cerebrospinal fluid), molecular biological analysis methods (PCR diagnostics, mutation diagnostics, ELISA procedures), immunological procedures (enzyme immunoassays - EIA), biomarker analysis (MALDI, SELDI, MELDI) in the field of genomics, proteomics and metabolomics	1	1,5
c.	**VO Drug and Active Substance Analysis** Sample preparation (extraction, solid phase extraction), enzymatic and non-enzymatic analyses, colour reactions, chromatographic analysis methods, analysis of psychoactive herbal drugs and doping analysis	1	2
	Total	**3**	**5**
	Learning Outcomes: Students are able to: • understand and evaluate advanced aspects of food analysis, including national and international legal regulations, sampling, sample preparation, food analysis methods, determination of the main components of food, analysis of pollutants, contaminants, residues, food allergens and proof of food authenticity, • explain advanced laboratory diagnostic analysis techniques of biological samples and discuss their clinical relevance, including sampling, PCR diagnostics and immunological procedures such as enzyme immunoassays, • interpret modern molecular biological analysis methods and their applications in the fields of genomics, proteomics and metabolomics, including mutation diagnostics, ELISA methods and biomarker analysis using MALDI, SELDI and MELDI, • describe current methods of natural product extraction and their technical features, including microwave extraction, PLE and SFE, • critically reflect on innovative sample purification techniques and discuss their advantages and limitations compared to conventional methods, including solid phase extraction and LLE, • explain the principles and applications of separation techniques for natural products, with particular emphasis on coupling with mass spectrometry, • assess the chemical-analytical challenges in the analysis of complex matrices such as food, biological samples and drugs and recommend suitable strategies for analysis, • assess current trends and developments in analytical chemistry and anticipate their potential impact on future research directions and applications.		

	Prerequisite/s: none

12.	Elective Module: Advanced Study of Analytical Chemistry C	h	ECTS-Credits
a.	**VO Chemometric Methods in Analytical Chemistry** Analysis of variance, multivariate data analysis (principal component analysis, cluster analysis), multivariate regression methods (MLR, PCR, PLS), statistical experimental design (screening designs, optimisation designs, mixture designs)	2	3,5
b.	**VO Quality Assurance in Analytical Chemistry** Solving analytical problems in industry, requirements for analytical methods, process steps from new analytical methods to routine analysis, establishment requirements, evaluation and validation of analytical methods, measurement system analysis (MSA), quality management tools	1	1,5
	Total	**3**	**5**
	Learning Outcomes: The students are able to: • understand advanced statistical methods and algorithms, including analysis of variance, multivariate data analysis (principal component analysis, cluster analysis) and multivariate regression methods (MLR, PCR, PLS), • assess and apply principles and techniques of statistical design of experiments, including screening designs, optimisation designs and mixture designs, • critically reflect on quality assurance techniques in analytical chemistry, including the solution of analytical problems in industry, requirements for analytical procedures and process steps from new analytical procedures to routine analysis, • critically analyse the principles of evaluation and validation of analytical methods, including establishment requirements and measurement system analysis (MSA), • evaluate and differentiate quality management tools in analytical chemistry, including their application and relevance in industrial and academic contexts, • integrate the acquired knowledge of analytical chemistry into basic and advanced discussions and considerations, with a focus on current and future trends and developments in analytical chemistry.		
	Prerequisite/s: none		

13.	Elective Module: Advanced Study of Inorganic Chemistry A	h	ECTS-Credits
a.	**VO Advanced Solid-State Chemistry** In-depth study of solid-state chemistry with special consideration of modern synthesis strategies such as high-temperature and high-pressure syntheses; insight into modern solid-state-specific characterisation methods and introduction to current research fields and applications of solid-state chemistry	1	2
b.	**PR Practical Training Course in Applied High-Pressure Solid-State Chemistry** Experimental realisation of modern high-pressure syntheses (multi-anvil technique) with a focus on current issues in the synthesis of new functional materials	2	3
	Total	**3**	**5**

	Learning Outcomes: Students are able to: • apply knowledge and understanding of advanced concepts and theories of solid-state chemistry, including modern synthesis strategies such as high temperature and high pressure syntheses, solid state specific characterisation methods and current research fields and applications, • apply integrated knowledge and problem-solving skills in solid-state chemistry, including the interpretation of experimental results, the analysis of functional materials and the application of solid-state specific characterisation methods, • demonstrate critical judgement in the evaluation and application of high-pressure solid-state chemistry methods and techniques, including multianvil techniques, synthesis of new functional materials and current issues, • perform independent experiments using modern high-pressure synthesis techniques, including planning, selection of appropriate synthesis parameters and safe laboratory practices, • communicate results and findings in solid state chemistry both orally and in writing in a clear and professional manner, including discussion of research results, presentation of syntheses and interpretation of data, • act independently and ethically responsible in the scientific research and application of solid-state chemistry, including consideration of safety regulations, ethical considerations and scientific integrity.
	Prerequisite/s: none

14.	**Elective Module: Advanced Study of Inorganic Chemistry B**	**h**	**ECTS-Credits**
a.	**VO Reactive Main Group Compounds** Design, function and current applications of molecular main group compounds for bond activation and as catalysts, principles of reactivity of the heavy elements of the p-block, main group element multiple bonds, compounds with low and high coordination numbers, superbases, superacids, ambiphiles	1	2
b.	**VO Chemistry of f-Elements** General properties of the f-elements, generation of artificial elements, radioactivity, recycling processes, molecular magnetism, (classical) coordination chemistry of the f-elements divided into ligand classes (cyclopentadienyls, alkoxides, thiols and phenols, amides, phosphines, phosphides and N-heterocyclic carbenes), reactivity of metal-ligand multiple bonds, selected reactivity differences to d- and p-block elements	1	1,5
c.	**VO Heteronuclear Magnetic Resonance Spectroscopy** Fundamental relationships between nuclear spin, magnetic dipole moment, Larmor frequency and Zeeman energy, estimation of signal intensity, referencing of spectra, effect of indirect spin-spin coupling, modern 2D methods, hyperpolarisation effects, solid-state NMR spectroscopy, nuclear Overhauser effect	1	1,5
	Total	**3**	**5**
	Learning Outcomes: The students are able to: • explain modern principles of reactivity of main group molecular compounds, including their design and functions for bond activation and as catalysts, • analyse and interpret principles of reactivity of f-elements, including differences to d- and p-block elements. Understand the general properties, creation of artificial elements, radioactivity,		

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- describe the principles of heteronuclear NMR spectroscopy, including the relationships between nuclear spin, magnetic dipole moment, Larmor frequency and Zeeman energy, and the estimation of signal intensity,
- demonstrate detailed knowledge of the (classical) coordination chemistry of the f-elements using different classes of ligands, including cyclopentadienyls, alkoxides, thiols and phenols, amides, phosphines, phosphides and N-heterocyclic carbenes,
- interpret advanced methods of NMR spectroscopy, including modern 2D methods, hyperpolarisation effects and solid-state NMR spectroscopy,
- analyse the effects and mechanisms of indirect spin-spin coupling in NMR spectroscopy,
- analyse reactivity principles using main group element multiple bonds, compounds with different coordination numbers as well as superbases, superacids and ambiphilic compounds,
- explain the principles and mechanisms of the nuclear Overhauser effect in NMR spectroscopy.

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<tr><td></td><td>Prerequisite/s: none</td></tr>
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<table>
<tr><th>15.</th><th>Elective Module: Advanced Study of Inorganic Chemistry C</th><th>h</th><th>ECTS-Credits</th></tr>
<tr><td>a.</td><td>VO X-Ray Diffractometry on Single Crystals
Principles, methods, characteristics and state of the art of X-ray structure analysis on single crystals</td><td>1</td><td>1</td></tr>
<tr><td>b.</td><td>PR Practical Training Course - Diffraction Methods
Methods of single-crystal X-ray structure analysis, independent performance of single-crystal structure analyses on selected complex compounds, organometallic compounds and solids, interpretation and computer-aided evaluation as well as visualisation of the data, structural characterisation of inorganic materials in solids</td><td>2</td><td>1,5</td></tr>
<tr><td></td><td>Total</td><td>3</td><td>2,5</td></tr>
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Learning Outcomes:
Students are able to:

- explain basic and advanced principles of X-ray diffraction on single crystals, including methods, characteristics and the current state of the art,
- describe and differentiate between the various methods of single crystal X-ray structure analysis, including their applications, advantages and limitations,
- carry out independent single-crystal structure analyses on selected complex compounds, organometallic compounds and solids, including the selection of suitable methods, practical implementation and interpretation of the results,
- perform computer-aided evaluation and visualisation of data from single crystal structure analyses, including the selection and application of suitable software tools, data interpretation and presentation of results,
- to carry out the structural characterisation of inorganic materials in the solid state, including the interpretation of structural data, the determination of material properties and the application in research and development,
- perform critical analyses and evaluations of research results in the field of X-ray diffraction on single crystals, including the identification of strengths and weaknesses, the application of best practices and the derivation of conclusions and recommendations.

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<tr><td></td><td colspan="3">Prerequisite/s: none</td></tr>
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16.	Elective Module: Advanced Study in Biochemistry A	h	ECTS-AP
a.	**VO Advanced Biochemistry III** Biochemical design - protein engineering: regulation of gene expression, gene silencing, gene mutation, DNA microarray technology, gene isolation, gene transfer, gene therapy, proteomics, metabolomics	1	1
b.	**PR Advanced Laboratory Course in Biochemistry** Modern biochemical, bioanalytical, molecular biological and genetic engineering methods for the isolation, structural characterisation and functional analysis of specific target genes and their protein products as well as quantitative proteomics and metabolomics	1	1
	Total	**5**	**5**
	Learning Outcomes: Students are able to: • critically reflect on and evaluate complex concepts and methods of biochemistry, including regulation of gene expression, gene silencing and DNA microarray technology, • independently develop and implement innovative strategies in gene and protein engineering technology, including gene mutations, gene isolation and gene transfer, • independently analyse and critically discuss scientific results and developments in the field of biochemistry, including gene therapy, proteomics and metabolomics, • apply modern biochemical and molecular biological methods and interpret their results, including isolation, structural characterisation and functional analysis of specific target genes, • advance skills in bioanalytical and genetic engineering methods and apply them in practice, including work with protein products, quantitative proteomics and metabolomics, • demonstrate and perfect practical problem-solving skills in biochemical laboratory situations, including the use of modern bioanalytical, molecular biological and genetic engineering techniques.		
	Prerequisite/s: none		

17.	Elective Module: Advanced Study in Biochemistry B	h	ECTS-Credits
a.	**VO Advanced Biochemistry IV** Mass spectrometric proteomics - principles and application in basic research and industry: mass spectrometric proteomics, quantitative analysis of complex proteome mixtures and post-translational modifications in the context of systems biology and basic research, application of mass spectrometry in industry for the analysis of active substances and proteins, mass spectrometric bio- and proteome analysis in basic research and industrial research	2	2,5
b.	**VO Advanced Biochemistry V** Signalling cascades and metabolism - regulation and therapy: tumour research with a focus on biochemical approaches and technologies, methodological challenges of various disciplines (oncogenic signalling, tumour metabolism, tumour transcriptomics, systems oncology and bioengineering)	2	2,5
	Total	**4**	**5**
	Learning Outcomes: Students are able to: • demonstrate an in-depth understanding of the principles and techniques of mass spectrometric proteomics, including quantitative analysis of complex proteome mixtures, post-translational modifications and applications in systems biology and basic research,		

	• perform critical and systematic assessments of the application of mass spectrometry in industry, including the investigation of active ingredients, proteins and their relevance in mass spectrometric bio- and proteome analysis, • understand advanced biochemical approaches and technologies in tumour research, including oncogenic signalling, tumour metabolism and tumour transcriptomics, • develop an in-depth understanding of signal transduction cascades and metabolism in the context of tumour research, including regulation, therapy and methodological challenges of different disciplines, • critically evaluate and summarise knowledge from various biochemical disciplines including systems oncology, bioengineering and the application of mass spectrometry techniques in research, • develop advanced knowledge and skills to critically analyse and evaluate current challenges and developments in biochemistry, including the integration of knowledge from mass spectrometry proteomics, signal transduction cascades and metabolism in therapeutic approaches.
	Prerequisite/s: none

18.	Elective Module: Advanced Study in Organic Chemistry A	h	ECTS-Credits
a.	**VO Catalysis of Organic Reactions** Introduction to the catalysis of organic reactions; fundamental principles of energetics basics; acid-base catalysis versus transition metal catalysis versus biocatalysis; heterogeneous versus homogeneous catalysis with reference to solid phase synthesis of organic compounds; catalysis by proteins and nucleic acids, current problems	1	1,5
b.	**VO Mechanisms of Organic Reactions** Mechanistic principles and methods (isotope effects, labelling, NMR, etc.), eliminations, substitutions, pericyclic reactions, photochemistry, transition metal catalysis, rearrangements and fragmentations, application in complex molecule synthesis, current examples and problems	1	1,5
c.	**VO Stereochemistry & Supramolecular Chemistry** Systematics of stereochemistry, symmetry and symmetry elements in (larger) organic compounds, organisational principles and functions of supramolecules, use of supramolecular compounds in chemical-biological synthesis using current examples	1	2
	Total	**3**	**5**
	Learning Outcomes: Students are able to: • make critical judgments about the different types of catalysts in organic chemistry, including their energetic basis, differences between acid-base catalysis and transition metal catalysis, and application in the solid-phase synthesis of organic compounds, • to discuss innovative approaches and concepts in the field of biocatalysis, including catalysis by proteins and nucleic acids as well as current problems contemporary challenges, • demonstrate a comprehensive knowledge of the mechanisms of organic reactions, including methodological approaches such as isotope effects and NMR and the distinction between eliminations, substitutions and pericyclic reactions, • critically analyse current and advanced examples of organic reaction mechanisms, including photochemistry, transition metal catalysis and complex molecular synthesis, • understand changes and rearrangements of organic molecules in terms of fragmentation, including application in complex molecule synthesis and current problems,		

	• explain complex relationships and processes in stereochemistry and supramolecular chemistry, including the systematics of stereochemistry, the significance of symmetry elements in organic compounds and the organisational principles of supramolecules, • demonstrate extensive knowledge of supramolecular compounds in chemical-biological synthesis, including the use and functionality of supramolecular systems using current examples, • utilise knowledge in the field of organic chemistry to solve current and complex problems, including the challenges and opportunities in research and development.
	Prerequisite/s: none

19.	Elective Module: Advanced Study of Organic Chemistry B	h	ECTS-Credits
a.	**VO Structural Organic Chemistry I** Spectroscopic characterisation of organic compounds, nano-materials and biomolecules using NMR spectroscopy	1	1,5
b.	**VO Structural Organic Chemistry II** Spectrometric characterisation of organic compounds, nano-materials and biomolecules using modern mass spectrometric methods	1	1,5
c.	**PR Laboratory Course in Structural Organic Chemistry** Characterisation of a synthesis product or a natural substance using (heteronuclear) NMR spectroscopy, mass spectrometry, UV-VIS, CD, IR and fluorescence spectroscopy	3	2
	Total	**5**	**5**
	Learning Outcomes: Students are able to: • understand and describe advanced NMR spectroscopy techniques for spectroscopic characterisation of organic compounds, nanomaterials and biomolecules, including resonances, spin interactions and spectroscopic signatures, • identify and explain state-of-the-art mass spectrometric methods for the spectrometric characterisation of organic compounds, nanomaterials and biomolecules, including ionisation methods, mass analysis and detection, • independently characterise synthetic products or natural products using various spectroscopic techniques, including (heteronuclear) NMR spectroscopy, mass spectrometry, UV-VIS, CD, IR and fluorescence spectroscopy, • efficiently interpret data from (heteronuclear) NMR spectroscopy and mass spectrometry to perform clear and accurate structure elucidation of organic molecules, nanomaterials and biomolecules, • apply and interpret methods of UV-VIS, CD, IR and fluorescence spectroscopy to obtain additional information on the structure and dynamics of molecules, • recognise the experimental challenges and limitations of the various spectroscopic techniques and identify suitable solution strategies or alternative techniques for the characterisation of compounds, • efficiently integrate spectroscopic data from different sources to perform a comprehensive and accurate characterisation of complex organic compounds, nano-materials or biomolecules, • consider the safety and ethical considerations of using these spectroscopic techniques in a laboratory environment, including the proper handling of samples, instruments and data.		
	Prerequisite/s: none		

20.	Elective Module: Advanced Study of Organic Chemistry C	h	ECTS-Credits
	PR Practical Training Course in Solid Phase Synthesis and Natural Product Isolation Independent experimental work on current research topics in an organic chemistry working group; practical implementation of an automated solid-phase synthesis, the isolation of a natural substance or a targeted natural substance transformation or synthesis	2	2,5
	Total	**2**	**2,5**
	Learning Outcomes: Students are able to: • critically apply and extend complex and specialised knowledge and methods in the field of organic chemistry, including automated solid-phase synthesis, isolation of natural products and targeted natural product transformations or syntheses, • work independently in a working group within organic chemistry and work on current research topics experimentally, including the planning, realisation and interpretation of the results, • develop and implement innovative approaches to solving scientific problems in organic chemistry, including the application of modern synthesis methods, techniques for isolating and analysing natural products and the use of appropriate instruments and equipment.		
	Prerequisite/s: none		

21.	Elective Module: Advanced Study in Physical Chemistry A	h	ECTS-Credits
a.	**VU Kinetics and Dynamics of Surface Processes** Mechanisms of molecular and dissociative adsorption, potential energy surfaces, activated adsorption, atomic and molecular bonding on surfaces. Modern techniques for observing surface processes (‘high-speed’ atomic force microscopy and time-resolved X-ray spectroscopy)	1	1
b.	**VU Energy Engineering and Catalysis** Electronic and structural principles of heterogeneous catalysis, physico-chemical properties of nanostructured catalytic materials, environmental catalysis, exhaust gas purification, processes for chemical energy storage and conversion, CO_2 storage and utilisation	1	1
c.	**VU Electrochemistry with Applications in Energy Research** In-depth consideration of electrochemical phenomena and electrocatalysis in the basis and application in fuel and electrolysis cells. Theoretical concepts (e.g. d-band model) to explain catalytic reactivity	1	1
d.	**PR Practical Course “Current Research in Physical Chemistry”** Work in current research in a research group chosen by the student Physical Chemistry working group, e.g. characterisation and structural investigation of surface and adsorbate systems (LEED, STM), catalytic CO_2 activation and conversion to energy carriers, reforming of energy carriers for hydrogen production, product analysis (MS, GC), electrocatalytic characterisation of SOFC-relevant materials, electrocatalysis and battery research, photoelectrochemistry, spectroscopy (IR, Raman and UV-VIS), calorimetry and X-ray diffraction of cryomaterials, space chemistry and cryochemistry, high-pressure moulding of aqueous phases (ice polymorphism and clathrate hydrates)	2	2
	Total	**5**	**5**

	Learning Outcomes: Students are able to: • generate and apply in-depth knowledge of the mechanisms of surface processes, including mechanisms of molecular and dissociative adsorption, Kisliuk isotherms and potential energy surfaces, • understand and critically evaluate electronic and structural principles of heterogeneous catalysis, including physicochemical properties of nanostructured catalytic materials, exhaust gas purification and CO_2 storage, • analyse advanced electrochemical phenomena and applications in energy research, including in-depth studies of electrocatalysis, fuel and electrolysis cells and theoretical concepts to explain catalytic reactivity, • work independently in current research areas of physical chemistry and interpret results, including characterisation of surfaces and adsorbate systems, electro-catalytic characterisation and spectroscopy methods such as IR, Raman and UV-VIS.
	Prerequisite/s: none

22.	**Elective Module: Advanced Study in Physical Chemistry B**	**h**	**ECTS-Credits**
a.	**VU Materials under Cyro-Circumstances** Fundamentals cryochemistry, especially of aqueous solutions and volatile components; freezing and thawing behaviour; freezing concentration; vitrification, cold crystallisation; applications in astronomy (formation of planets, stars, galaxies from interstellar dust; chemistry of comets), atmospheric chemistry (ice clouds), glaciology (glaciers and ice sheets), biology (cryomicroscopy) and medicine (cryonics) as well as technology (de-icing processes, technical snow) and the food industry (freeze-drying).	1	1,5
b.	**PR Laboratory Course Materials under Kyro-Circumstances** Work with current research methods, e.g. production and analysis of aqueous solutions under cryogenic conditions, analysis in particular using cryomicroscopy, cryo-XRD and cryo-calorimetry; production by vitrification, vapour deposition or high-pressure cryosynthesis	1	1
	Total	**2**	**2,5**
	Learning Outcomes: Students are able to: • understand and explain basic and advanced concepts of cryochemistry, especially of aqueous solutions or volatile components, including freezing and thawing behaviour, freezing concentration, vitrification and cold crystallisation phenomena, • place the acquired knowledge in the context of various scientific and technical applications, including their importance in astronomy (e.g. imaging of planets, stars and galaxies), glaciology (e.g. glaciers and ice sheets) and the food industry (e.g. freeze-drying); • work with current research methods in the field of cryochemistry, including the preparation and analysis of aqueous solutions under cryogenic conditions, • apply and interpret advanced analytical techniques, in particular methods such as cryomicroscopy, cryo-XRD and cryo-calorimetry, • utilise and evaluate different methods of manufacturing materials under cryogenic conditions, including vitrification, vapour deposition and high pressure cryosynthesis.		
	Prerequisite/s: none		

23.	Elective Module: Advanced Study in Physical Chemistry C	h	ECTS-Credits
a.	**VO Interface and Material Analysis** structure and chemical composition of surfaces and interfaces: scanning tunnelling microscopy (STM), X-ray photoelectron spectroscopy (XPS), depth profile analysis and adsorption spectroscopy	1	1,5
b.	**PR Laboratory Course in Interface and Material Analysis** Practical training course for VO Interface and Material Analysis; experimental work with (electrochemical) STM, surface and depth profile analysis with X-ray photoelectron spectroscopy (XPS)	1	1
c.	**VO Scanning Probe and Electron Microscopy** Principles and operation of scanning probe microscopy, atomic force microscopy, surface potential microscopy, electric force microscopy, friction microscopy and transmission electron microscopy	1	1,5
d.	**PR Practical Training Course in Scanning Proble and Electron Microscopy** Characterisation of surfaces in the nanoscopic range and with atomic resolution using scanning probe methods, investigation of nanoparticles and layered materials with electron microscopy	2	1
	Total	**5**	**5**
	Learning Outcomes: Students are able to: • understand and explain methods for determining the morphology, structure and chemical composition of surfaces and interfaces, including scanning tunnelling microscopy, X-ray photoelectron spectroscopy, depth profile analysis and adsorption spectroscopy, • carry out and analyse experimental work in the field of interface and material analysis, including the use of (electrochemical) STM and depth profile analysis with X-ray photoelectron spectroscopy, • understand and describe the principles and applications of scanning probe microscopy, atomic force microscopy and other microscopic techniques, including surface potential microscopy, electric force microscopy, friction microscopy and transmission electron microscopy, • to characterise surfaces in the nanoscopic range and with atomic resolution, including the use of scanning probe methods, and to carry out investigations of nanoparticles and layered materials with electron microscopy.		
	Prerequisite/s: none		

24.	Elective Module: Advanced Study in Theoretical Chemistry A	h	ECTS-Credits
a.	**VO Molecular Modelling** Chemoinformatics, molecular descriptors, chemical similarity, virtual screening, structure-based design, chemical databases, machine learning, artificial intelligence	2	2,5
b.	**PR Practical Training Course in Molecular Modelling** Application of methods for the characterisation of active ingredient molecules and their interactions	2	2,5
	Total	**4**	**5**

	Learning Outcomes: Students are able to: • understand advanced concepts of chemoinformatics, including aspects of molecular descriptors, chemical similarity and virtual screening, • to explore methods and techniques of structure-based design and to understand the relevance and application of chemical databases in theoretical chemistry, • recognise technologies and methodologies in the field of machine learning and artificial intelligence in the context of chemistry and understand their applications in the field of molecular modelling, • develop practical skills to characterise active agent molecules and to analyse and interpret their interactions by applying molecular modelling methods.
	Prerequisite/s: none

25.	Elective Module: Advanced Study in Theoretical Chemistry B	h	ECTS-Credits
a.	**VO Introduction to Computer-Based Materials Science** Polarisation capability and many-body effects, reactive force fields, periodic approaches in quantum mechanics, density functional theory, application examples	2	2,5
b.	**PR Practical Training Course Numerical Methods - Computer Methods for Determining Physico-Chemical Properties** Dealing with various codes for the numerical calculation of material properties	2	2,5
	Total	**4**	**5**
	Learning Outcomes: Students are able to: • critically analyse and evaluate complex concepts of polarisation capability and many-body effects, including the basic theories, application of reactive force fields and periodic approaches in quantum mechanics, • synthesise and interpret the principles and methods of density functional theory at an advanced level, including its applications, limitations and relevance in materials science, • professionally handle numerical codes and computer applications to predict and calculate physico-chemical properties of materials, including selecting appropriate methods, analysing results and applying them in real-life scenarios, • demonstrate and perfect practical skills in the use of software and numerical tools to determine material properties, including the ability to identify problems, optimise solutions and interpret data.		
	Prerequisite/s: none		

26.	Elective Module: Advanced Study of Material Sciences and Chemical Engineering	h	ECTS-Credits
	Further courses from the Master's Programme in Material and Nano Sciences or the Master's Programme in Chemical Engineering at the University of Innsbruck covering 5 ECTS-Credits are to be selected.		5
	Total		**5**
	Learning Outcomes: Students • have additional and in-depth competences, skills and additional qualifications, • can make connections to their own specialist knowledge and are able to individualise and deepen their profile by acquiring additional qualifications, • have a comprehensive understanding of the fundamental principles of materials science and chemical engineering, including the interactions between chemical structures and material properties, • can apply this knowledge to develop innovative materials that address specific chemical or physical challenges, • have advanced analytical and experimental skills that enable them to investigate and optimise complex chemical processes and material behaviour, • can use these skills to find efficient, sustainable and economical solutions to problems in materials science and chemical engineering.		
	Prerequisite/s: The prerequisites specified in the respective curricula must be met.		

27.	Elective Module: Practice	h	ECTS-Credits
	In order to test and apply the knowledge and skills acquired and to gain an orientation on the conditions of professional practice and the acquisition of additional qualifications, students must complete a Practice totalling 5 ECTS-Credits (or 120 hours). The work placement must be completed in industrial companies or official institutions active in the field of materials science. Approval must be obtained from the Director of Studies before commencing the internship. A certificate from the institution must be submitted stating the duration, scope and content of the work completed; a report must also be drawn up.	-	5
	Total	**-**	**5**
	Learning Outcomes: Students • can apply the knowledge and skills they have acquired in their chemistry programme in a professional environment, such as in the chemical industry or at official institutions. They identify chemical problems, develop practicable solutions based on their specialist knowledge and carry out appropriate experiments and analyses to overcome these challenges, • are able to understand the conditions and requirements of professional practice in the field of chemistry and find their way around. They recognise the importance of interdisciplinary thinking and action and can link their chemical knowledge with other specialist areas in order to develop holistic solutions, • can critically reflect on the experiences and results of their practical work and relate them to their theoretical knowledge. They are able to recognise the relevance of their work for the scientific community and society and can communicate these connections precisely and comprehensibly in a written report, • understand how their learning and skills have changed and expanded as a result of practical experience. They can self-critically evaluate their personal and professional development		

	and name specific examples of how they have successfully applied their knowledge and skills in a complex, professional context.
	Prerequisite/s: study achievements from this curriculum covering 30 ECTS-Credits

(6) Elective modules in general skills

28.	Elective Module: Intellectual Property Rights and Legal Framework of Chemistry	h	ECTS-Credits
	VO Intellectual Property Rights and Legal Framework of Chemistry: Patent and Chemicals Law Patent law, copyright law, trademark law, European chemicals law, handling and authorisation of chemicals and pharmaceuticals	2	2,5
	Total	**2**	**2,5**
	Learning Outcomes: Students are able to: • demonstrate a critical understanding of key concepts and practices in the field of intellectual property, particularly in the context of chemistry, including patent law, copyright and trade mark law; • demonstrate comprehensive knowledge of European chemicals legislation and its implications for the handling and authorisation of chemicals and pharmaceuticals, including handling, authorisation processes and safety standards; • critically analyse and evaluate the current state of practice in intellectual property and regulatory frameworks in chemistry, including ongoing developments and challenges in this area.		
	Prerequisite/s: none		

29.	Elective Module: Science Management	h	ECTS-Credits
	VU Science and Innovation Management Systematic planning, management, organisation and control of innovation processes in companies or organisations, types of innovation, evaluation of ideas, success factors for innovations, stage-gate process, innovation team, product development, FMEA, strategic innovation management, project definition, tools for planning, organisation, implementation and control of projects, process optimisation, workflow control of processes, case studies from the research and industrial environment	2	2,5
	Total	**2**	**2,5**
	Learning Outcomes: Students are able to: • critically analyse and evaluate innovation processes, including systemic planning, management and control, the evaluation of innovation ideas and the identification of success factors, • initiate, plan and successfully implement scientific projects, including the clear definition of projects, the use of suitable tools for planning, organisation and control and the integration of stage-gate processes, • to carry out process optimisation in scientific and industrial contexts including workflow control, the application of FMEA for product development and the analysis of case studies from the research and industrial environment.		
	Prerequisite/s: none		

30.	Elective Module: Lecture Series - GÖCh/CMBI/Material and Nano Science	h	ECTS-Credits
	SE Lecture Series - GÖCh/CMBI/Material and Nano Science Participation in lectures by invited guests as part of the series of the 'Austrian Chemical Society' (GÖCh) and/or the 'Centre for Molecular Biosciences Innsbruck' (CMBI) and/or the focus on materials and nanosciences	2	2,5
	Total	**2**	**2,5**
	Learning Outcomes: Students • are familiarised with current research topics by external experts through participation in the lectures, • acquire an in-depth understanding of these topics and are able to assess their relevance for the further development of materials science and nanoscience as well as for related subject areas, • learn how current topics are presented and discussed at a scientific level, • have the ability to critically analyse the quality and scope of scientific presentations and to interpret the key messages for their own subject area, • get to know the scientific community through contact with the invited professors, • can build effective networks and use them to promote their academic and professional development.		
	Prerequisite/s: none		

31.	Elective Module: Interdisciplinary Skills	h	ECTS-Credits
	Provided that places are available, courses amounting to 5 ECTS-Credits can be freely selected from the curricula of the master's and/or diploma programmes offered at the University of Innsbruck. It is particularly recommended that students attend a course that deals with gender aspects including the specialised results of women's and gender studies.	-	5
	Total:	**-**	**5**
	Learning Outcomes: Students • have additional and in-depth competences, skills and additional qualifications that they have acquired through the selection of courses from various disciplines, • are able to combine the interdisciplinary approaches and perspectives they have learnt with their specialist knowledge of chemistry. This enables them to analyse complex issues using various scientific methods and theories and to develop innovative solutions, • choose courses according to their own interests, needs and inclinations and can thus individualise and deepen their profile in a targeted manner. This flexibly organised education enables them to think beyond the boundaries of chemistry and promotes the development of key qualifications such as critical thinking, creativity and the ability to communicate across disciplines, • depending on the course chosen, pay particular attention to courses that focus on gender aspects and the results of women's and gender studies, • gain an awareness of the importance of diversity and gender equality in science and are able to integrate these perspectives into their professional work and research. In this way, they contribute to an inclusive and fairer organisation of academic discourse and practice.		
	Prerequisite/s: The prerequisites specified in the respective curricula are to be met.		

32.	Elective Module: Computer-Aided Database Research	h	ECTS-Credits
	VU Computer-Aided Database Research Structuring and information content of chemical-scientific databases (SciFinder, Beilstein Reaxys, Science of Synthesis - Houben Weyl, esp@cenet, Cambridge Crystallographic Data Centre etc.); literature search strategies, search algorithms and search profiles, data management	2	2,5
	Total	**2**	**2,5**
	Learning Outcomes: Students are able to: • critically and comprehensively evaluate and reflect on key theories and methods of computerised database searching, including: the structuring of chemical science databases, the key features of databases such as SciFinder, Beilstein Reaxys, and Cambridge Crystallographic Data Centre, and the general structure and information content of these databases, • develop, interpret and adapt advanced and detailed strategies for searching literature in scientific databases, including: using different search algorithms, creating effective search profiles and applying specific search techniques in specialised databases such as Science of Synthesis - Houben Weyl and esp@cenet, • systematically analyse, manage and critically interpret complex data from chemical science databases, including: assessing the relevance and quality of data, applying data management principles and techniques, and using information resources to solve chemical science problems.		
	Prerequisite/s: none		

33.	Elective Module: Measurement Technology and Computer-Assisted Control of Experiments	h	ECTS-Credits
	PR Practical Training Course Measurement Technology and Computer-Assisted Control of Experiments Measurement technology, e.g. basic components of analogue/digital (A/D) and digital/analogue (D/A) conversion, programming in LABVIEW	3	2,5
	Total	**3**	**2,5**
	Learning Outcomes: Students are able to: • independently analyse and evaluate measurement techniques, including the identification of basic components of A/D and D/A conversion, the differentiation of various conversion mechanisms and the recognition of signal interference, • design and implement advanced computerised systems for experiment control, including the development of programs in LABVIEW, the optimisation of data acquisition systems and the integration of software and hardware components, • critically reflect on the applicability and limitations of modern measurement techniques and computerised experiment control in real chemical experimental environments, including the evaluation of data quality, the assessment of system latencies and the analysis of potential sources of error.		
	Prerequisite/s: none		

34.	Elective Module: Metal and Ceramics Processing for Laboratory Use	h	ECTS-Credits
	PR Practical Training Course - Metal and Ceramics Processing for Laboratory Use Independent work in the precision engineering workshop	5	5
	Total	**5**	**5**
	Learning Outcomes: Students are able to: • to independently deepen specific knowledge and understanding of metal and ceramic processing, including knowledge of processes, techniques and tools of the precision engineering workshop, • identify and analyse problems in the precision engineering workshop using analytical skills and methods of scientific work and independently develop solutions, including the selection of suitable tools, materials and techniques for specific applications, • apply practical skills in the precision engineering workshop both independently and as part of a team in a safe, efficient and ethical manner, including the fabrication, machining and modification of metallic and ceramic components for laboratory applications.		
	Prerequisite/s: none		

35.	Elective Module: Glass Processing for Laboratory Use	h	ECTS-Credits
	PR Practical Training Course – Glass Processing for Laboratory Use Independent exercises in glass blowing and the production of glass apparatus required in the laboratory	5	5
	Total	**5**	**5**
	Learning Outcomes: Students are able to: • apply glass blowing techniques, including recognising different types of glass, selecting appropriate techniques for specific requirements and considering safety issues when working with glass, • independently design and manufacture glass apparatus for laboratory applications, including the realisation of specific laboratory configurations, the application of joining techniques and compliance with standards for laboratory apparatus, • develop and implement solutions to glass-related problems in the laboratory environment, including dealing with unforeseen challenges during glassblowing, adapting techniques to specific requirements and integrating glass apparatus into multidisciplinary laboratory projects.		
	Prerequisite/s: none		

§ 10 Master’s Thesis

(1) A Master's Thesis covering 22,5 ECTS-Credits must be completed as part of the master's programme. The Master's Thesis is a piece of academic work which serves to demonstrate the ability to work independently on an academic topic in terms of content and methodology.

(2) The topic of the Master's Thesis can be chosen from the fields of Analytical Chemistry, Inorganic Chemistry, Biochemistry, Organic Chemistry, Physical Chemistry or Theoretical Chemistry. The prerequisite for the announcement of the topic of the Master’s Thesis is proof of at least 60 ECTS-Credits from the elective modules.

(3) The completed Master's Thesis must be submitted to the Director of Studies in electronic form. It must be accompanied by an affidavit confirming that the rules of good scientific practice have been followed.

(4) In order to enable students to complete the task of the Master's Thesis in accordance with § 81 (2) Universities Act within six months (equivalent to 30 ECTS-Credits), the academic work (amounting to 22,5 ECTS-Credits) is in any case preceded by the ‘Preparation of the Master's Thesis’ (amounting to 7,5 ECTS-Credits). The degree programme is completed with the ‘Master’s Thesis Defense’ (2,5 ECTS-Credits).

§ 11 Examination regulations

(1) A module is completed by the positive evaluation of its courses.

(2) The performance of the courses of the modules is evaluated by course examinations. Course examinations serve to proof the knowledge and skills imparted in an individual course, whereby

1. in the case of courses without continuous performance evaluation, the evaluation is based on a single examination at the end of the course.
2. in the case of courses with continuous performance evaluation, the evaluation is based on at least two written, oral and/or practical contributions of the participants.
3. The course instructor fixes the examination method for course examinations (written/oral/practical work) before the start of the semester.
4. The performance in the Module “Practice” is evaluated by the Director of Studies based on the written report on the Practice. Positive evaluation reads “participated with success”, negative evaluation “participated without success”.
5. The performance in the Module “Preparation of the Master’s Thesis” is evaluated by the supervisor based on a synopsis. Positive evaluation reads “participated with success”, negative evaluation “participated without success”.
6. The performance evaluation of the Module “Master’s Thesis Defense” is evaluated by an oral examination before an examination board consisting of three examiners.

(3) Modules and courses from other study programmes are subject to the examination regulations of the curricula they have been taken from.

§ 12 Academic degree

Graduates of the Master’s Programme in Chemistry are awarded with the academic degree “Master of Science”, abbreviated as “MSc”.

§ 13 Coming into force

This curriculum comes into force on 1 October 2024.

§ 14 Transitional provisions

(1) This curriculum applies to all students commencing the Master's Programme in Chemistry as of the 2024/25 winter semester.

(2) Regular degree students who have started the Master's Programme in Chemistry, published in the University of Innsbruck Bulletin of 25 November 2008, Issue 12, No. 80, last changed on 28 June 2019, Issue 66, No. 878, before 1 October 2024, are entitled to finish this study programme within six semesters from this moment in time. If the Master's Programme in Chemistry is not finished in time, the students will be subjected to this curriculum.

(3) Furthermore, students are entitled to voluntarily subject themselves to this curriculum at any time.