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

Table of contents

§ 1 Allocation of the study programme

Pursuant to §54 par.1 Universities Act 2002, the Bachelor's Programme in Chemistry is grouped among the natural sciences study programmes.

§ 2 Admission

Admission to the programme is granted by the Rectorate in accordance with the provisions of the Universities Act 2002 (UG) on admission to bachelor's programmes.

§ 3 Qualification profile

(1) Subject-specific skills

- The study programme imparts basic and advanced professional competences for scientific work in the field of chemistry.
- Graduates possess the necessary knowledge and critical understanding of theories and principles of chemistry and related fields of science.
- They are able to identify, analyse and solve complex chemical problems and apply theoretical concepts to practical situations.
- They understand chemical systems at the molecular level and are able to conduct scientific experiments and research projects.
- They can analyse, interpret and present data and results.
- They are able to elaborate, assess and apply further scientific developments in the field of chemistry.

(2) General skills

- In addition to subject-specific skills, students also acquire general key competences, including the ability to work in a team, oral and written communication skills, interdisciplinary problem solving and time management.
- They acquire a sense of responsibility for the benefits and risks of scientific research and its application.

(3) Professional skills

- The Bachelor's Programme in Chemistry aims to prepare students for a professional career as chemists.
- Graduates are qualified to work in university and non-university (research) institutions in the field of chemistry.
- The bachelor's programme is the basis for further professional development in research, technology, industry, the environment and chemical-relevant official fields of activity.
- Graduates of the study programme are able to apply these acquired competences across disciplines.
- The programme is designed according to current academic standards and offers a competitive professional qualification.

(4) The Bachelor's Programme in Chemistry is the basis for a subsequent Master's Programme in Chemistry or related master's degree programmes.

§ 4 Scope and duration

The Bachelor's Programme in Chemistry covers 180 ECTS-Credits. This corresponds to a duration of the study programme of six semesters. One semester covers a workload of 25 hours.

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

(1) Courses without continuous performance evaluation:

Lectures (VO) are courses held in lecture format. They introduce the research areas, methods and schools of thought for a given subject. Maximum number of students per course: none

(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 students per course:10
2. Seminars (SE) provide in-depth treatment of scientific topics through students' presentations and discussion thereof. Maximum number of students per course: 120
3. Tutorials (UE) focus on the practical treatment of specific tasks in a specialist area and on practicing specific skills. Maximum number of students per course: 10

   For the tutorial (UE) Mathematics I for Chemists and the UE Mathematics II for Chemists the maximum number of students per course is 60.
4. 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 students: 120

§ 6 Procedure for the allocation of places in courses with a limited number of participants

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

1. Students of the studies for which the course is compulsory and who were not able to participate in the course due to a previous selection procedure.
2. Students of studies for which the course is compulsory.
3. If the criteria in no. 1 and 2 do not suffice to regulate the admission to a course, then the time of the achievement of the prerequisites for the course will be a selection criterium.
4. If the criteria in no. 1, 2 and 3 do not suffice to regulate the admission to a course, the arithmetic mean of the grades of the prerequisite examinations will be used for registration.
5. If the criteria from no. 1 to no. 4 do not suffice to regulate the admission to the course, then the admission will be decided by lot.

(2) If necessary, parallel courses shall also be provided, if need be, during the usually lecture-free period.

§ 7 Studies Induction and Orientation Stage

(1) Within the scope of the Studies Induction and Orientation Stage, which takes place in the first semester, the following courses are to be passed:

1. Experimental Lecture General Chemistry (CM 3a/VO 5/5.5 ECTS-Credits),
2. Analytical Chemistry I (CM 4a/VO 3/3.5 ECTS-Credits),
3. Chemical Calculations (CM 3d/VO 2/3 ECTS-Credits).

(2) Positive evaluation of all exams of the Studies Induction and Orientation Stage entitles to passing all further lectures and exams as well as to writing the Bachelor’s Thesis.

(3) Before completing the Studies and Induction and Orientation Stage, lectures (VO) and lecture tutorials (VU) covering up to 18 ECTS-Credits may be taken. The prerequisites specified by the curriculum are to be met.

§ 8 Compulsory and elective modules

(1) The following compulsory modules covering altogether 155 ECTS-Credits are to be passed:

1.	Compulsory Module: Physics	h	ECTS-Credits
a.	**VO Physics for Chemists Part I** Force and moment of force, kinematics, dynamics of a mass point, work, energy, dynamics of mass point systems, dynamics of rigid bodies, mechanics of deformable media, mechanical oscillations and waves, molecular physics, hydrostatics, hydrodynamics	3	3
b.	**VO Physics for Chemists Part II** Optics, nuclear physics, particle physics, electrostatics, stationary currents, magnetism, electrodynamics, atomic physics	2	2
	Total	**5**	**5**
	Learning Outcomes: The students are able to ad a.: understand and apply the fundamentals of mechanics and the motion of mass points and rigid bodies, including the calculation of forces, torques, velocities, accelerations and work, apply the laws of mechanics to complex systems and deformable media, understand and apply oscillations and waves as well as hydrostatic and hydrodynamic phenomena, including the calculation of frequencies, wavelengths and flow velocities. ad b.: to understand and apply concepts of optics, nuclear and particle physics, and atomic physics, the laws of electrostatics, magnetostatics and electrodynamics, including the calculation of electric and magnetic fields, voltages, currents and forces, as well as to understand and explain the physical concepts of nuclear fission, nuclear fusion and particle detection.		
	Prerequisite/s: none		

2.	Compulsory Module: Mathematics	h	ECTS-Credits
a.	**VO Mathematics for Chemists I** Basic arithmetic, propositional logic, set theory, complex numbers, introduction to linear algebra, in particular clarification of the terms group, vector space, generating system, basis, linear mapping, matrix, linear equation system, orthogonal projection, orthonormal basis, linear mapping, norm, scalar product, cross product, determinant, eigenvalue, eigenvector, coordinate transformation, orthogonal mapping	2	2.5
b.	**UE Mathematics for Chemists I** Discussion, in-depth study and exercising of the contents dealt with in the lecture Mathematics for Chemists Part I for chemical and physical tasks, practice of scientific argumentation and presentation	1	1
c.	**VO Mathematics for Chemists II** Introduction to one- and multidimensional real analysis, in particular clarification of the concepts of sequence, limit, Banach space, Hilbert space, derivative, directional derivative, partial derivative, total differential, two-term, three-term, implicit differentiation, one- and multidimensional primitive function, series, power series, radius of convergence, one- and multidimensional Taylor series, definite integral, improper integral, approximation, Fourier series, area integral, curve integral of the first and second kind, introduction to the theory of ordinary and partial differential equations	2	2.5
d.	**UE Mathematics for Chemists II** Discussion, in-depth study and exercising of the contents dealt with in the	1	1

	lecture Mathematics for Chemists II for chemical and physical tasks, practice of scientific argumentation and presentation of mathematical content		
	Total	**6**	**7**
	Learning Outcomes: The students are able to, ad a.: understand and apply propositional logic, set theory and complex numbers, understand and apply linear algebra, including groups, vector spaces, generating systems, bases, linear mappings, matrices, linear equation systems, orthogonal projection, orthonormal bases, norm, scalar and cross product, determinant, eigenvalue and eigenvector, coordinate transformation and orthogonal mappings. ad b.: use linear algebra to solve problems in chemistry and physics, discuss, deepen and present mathematical content, master scientific argumentation in connection with mathematical content, and understand and apply the connection between mathematics and chemistry. ad c.: understand one- and multidimensional real analysis, including sequences, limits, Banach and Hilbert spaces, derivatives, partial derivatives, total differential, two- and three-term series, implicit differentiation, one- and multidimensional primitive functions, series, power series, radius of convergence, one- and multi-dimensional Taylor series, definite and improper integrals, approximations, Fourier series, area and curve integrals, and the theory of ordinary and partial differential equations. ad d.: apply analysis to solve problems in chemistry and physics, relate mathematical concepts to real phenomena and processes, and apply mathematical concepts to real chemical and physical phenomena and processes.		
	Prerequisite/s: none		

3.	**Compulsory Module: General Chemistry**	**h**	**ECTS-Credits**
a.	**VO Experimental Lecture General Chemistry** Atomic theory, chemical formulae and reaction equations, energy conversion in chemical reactions, electron structure and properties of atoms, ionic and covalent bonding, molecular structure, molecular orbitals, basic principles of chemical thermodynamics, gases, liquids, solids, solutions, reactions in aqueous solution, reaction kinetics, chemical equilibrium, acids and bases, acid-base equilibria, solubility product and complex equilibria, electrochemistry, material chemistry	5	5.5
b.	**VO Chemistry in Aqueous Solution** Preparation for the practical course on chemistry in aqueous solution: reactions of salts and metals with water, acids, alkalis and molten salts; group and identification reactions of ions; simultaneous equilibria; ions in water: origin and removal; important naturally occurring and technically important inorganic reactions in aqueous solution.	1	1.5
c.	**VO Laboratory Safety** Rules of conduct for working in a chemical laboratory, safety and hazardous material labelling, hazardous work, personal safety equipment, hazardous materials, fire prevention, first aid	1	1
d.	**VO Chemical Calculations** Significance of the place value, empirical formula, mole, percentage composition of compounds, chemical reaction equations, redox equations, limiting reactants, yield in chemical reactions, concentration of solutions, two- and three-component mixtures, gas equilibria, pH value, weak acids/bases, multiprotonic acids, salts of weak acids/bases, buffer solutions, solubility product, precipitation reactions, coordination compounds and complex formation	2	3

	constants		
	Total	**9**	**11**
	Learning Outcomes: The students are able to ad a.: understand and apply concepts of atomic theory, chemical formulas and reaction equations, electron structure and properties of atoms, ionic and covalent bonding, molecular structure, molecular orbitals and chemical thermodynamics, as well as reaction kinetics, chemical equilibrium, acids and bases, acid-base equilibria, solubility product and complex equilibria, electrochemistry and material chemistry, including important naturally occurring and technically important inorganic reactions in aqueous solution. ad b.: understand and apply experimental methods for investigating gases, liquids, solids and solutions, reactions of salts and metals with water, acids, alkalis and molten salts, as well as simultaneous equilibria, understand and apply group and identification reactions for the analysis of ions and the separation and removal of ions in water, and understand and apply technically important inorganic reactions in aqueous solution. ad c.: understand, comply with and apply rules of conduct for working in a chemical laboratory as well as health and safety labelling, recognise, understand and apply hazardous work, personal protective equipment, hazardous substances, fire protection and first aid, and work safely in a chemical laboratory. ad d.: perform chemical calculations, including determining amounts of substances, the percentage compositions of compounds and concentrations of solutions, understand, calculate and apply chemical reaction equations, redox equations and yields in chemical reactions, as well as to understand and apply pH values, weak acids/bases, polyprotic acids, salts of weak acids/bases, buffer solutions, solubility products, precipitation reactions, coordination compounds and complex formation constants.		
	Prerequisite/s: none		

4.	**Compulsory Module: Analytical Chemistry A**	**h**	**ECTS-Credits**
a.	**VO Analytical Chemistry A** Basics (chemical equilibria, concentration measures), analytical instruments (balances, volumetric instruments), sample preparation and digestion, gravimetry, dimensional analysis, optical analysis methods, separation operations (precipitation, distribution, ion exchange, chromatography, electrophoresis)	3	3.5
b.	**VO Data Analysis and Chemometrics** Basics of univariate statistics and data analysis, error propagation, hypothesis testing, outlier tests, comparison of measurement series, variance analysis, regression, comparison with limit values, statistical experimental design, basics of chemometric methods	1	1.5
c.	**VO Analytical Chemistry II** Extraction and solid phase extraction, analytical calibration techniques, electro-analytical methods, gas chromatography, liquid chromatography, basics of mass spectrometry, analytical coupling methods	1	1.5
	Total	**5**	**6.5**
	Learning Outcomes: The students are able to ad a.: understand and apply the fundamentals of analytical chemistry, including chemical equilibria and measures of concentration, including the use of analytical instruments and the performance of sample preparation and digestion procedures, as well as understand and apply various analytical separation methods and procedures, including gravimetry, dimensional analysis,		

	optical analysis methods, and separation methods such as precipitation, distribution, ion exchange, chromatography, and electrophoresis. ad b.: Students are able to understand, interpret and apply statistical univariate and bivariate methods for data analysis, including error propagation, hypothesis testing, outlier testing, comparison of measurement series, analysis of variance and regression, understand and apply the fundamentals of chemometric methods, including the fundamentals of statistical experimental design and multivariate data analysis, and understand the importance of chemometric methods for the analysis and interpretation of analytical data. ad c.: understand and apply specific analytical techniques such as extraction, solid phase extraction, calibration techniques, electroanalytical methods, gas chromatography, liquid chromatography, mass spectrometry and analytical coupling methods, understand the role of analytical chemistry in the analysis of environmental samples and biomolecules, and understand the importance of analytical chemistry to other areas of chemistry and related disciplines.
	Prerequisite/s: none

5.	**Compulsory Module: Inorganic Chemistry A**	**h**	**ECTS-Credits**
a.	**VO Experimental Lecture Main-Group Element Chemistry** Introduction to main group chemistry (groups 1-2 and 13-18); description, properties and reactivities of s-block and p-block elements; importance of main group chemistry with regard to fundamental research and industrial processes based on critical discussions of ecological and toxicological connections	2	2.5
b.	**VO Experimental Lecture Subgroup-Element Chemistry** Chemistry of the subgroup elements with emphasis on d-block elements: general properties; fundamentals, binding models, reactivity of co- ordination compounds; occurrence, extraction, properties of d-metals; important compound classes; technically important processes; bioinorganic aspects, chemistry of lanthanides and actinides	2	2.5
	Total	**4**	**5**
	Learning Outcomes: The students are able to ad a.: understand and apply the chemistry of the main group elements, including their representation, properties and reactivities, to understand and critically discuss the importance of main group chemistry in basic research and in industrial processes, taking into account ecological and toxicological contexts, and to understand and apply experimental methods for investigating the chemistry of the main group elements. ad b.: understand and apply the chemistry of the secondary group elements, in particular the d-block elements including basic bonding models and reactivities of coordination compounds, know, understand and apply the properties, occurrence and extraction of d-metals, know and describe important compound classes and technically important processes as well as understand and discuss bioinorganic aspects and the chemistry of lanthanides and actinides.		
	Prerequisite/s: none		

6.	Compulsory Module: Inorganic Chemistry B	h	ECTS-Credits
	PR Chemistry in Aqueous Solution Dissolution and precipitation reactions, acid-base reactions, redox reactions and complexation reactions in aqueous solution; identification of salts, metals, acids or bases with the help of these reactions, based on their properties and other experimental findings	7	5
	Total	**7**	**5**
	Learning Outcomes: Students are able to understand, describe, and perform basic chemical reactions in aqueous solution, including dissolution and precipitation reactions, acid-base reactions, redox reactions, and complexation reactions; experimentally identify the properties of salts, metals, acids, and bases based on analytical observations and findings; and perform experiments, collect, analyse, and interpret data to draw scientific conclusions and communicate results in written and oral form.		
	Prerequisite/s: successful completion of compulsory module 3		

7.	Compulsory Module: Physical Chemistry A	h	ECTS-Credits
	VU Thermodynamics Introduction to chemical thermodynamics, equations of state of the ideal and real gas, 1st-3rd law, enthalpy, cyclic processes, entropy, free energy and free enthalpy, chemical potential, law of mass action, phase equilibria, colligative properties	4	5
	Total	**4**	**5**
	Learning Outcomes: Students are able to understand and apply thermodynamic concepts and methods to analyse and describe chemical systems, to formulate and apply equations of state of gases to understand and describe the behaviour of gases, to define and use the terms enthalpy, entropy, free energy and free enthalpy to describe chemical reactions and processes and to understand and apply the meaning of phase equilibria and colligative properties to describe the physical properties of solutions.		
	Prerequisite/s: none		

8.	Compulsory Module: Organic Chemistry A	h	ECTS-Credits
a.	**VO Organic Chemistry I** Chemical bonds in hydrocarbons; structure and basic aspects of the nomenclature of organic compounds; stereochemistry and conformation theory; material science (preparation & reactions of alkanes, alkyl halides, alcohols, ethers, amines, alkenes, alkynes, allenes & aromatics, carbonyl compounds, carboxylic acids & carboxylic acid derivatives); reaction mechanisms; chemical equilibrium; reaction theory (nucleophilic substitution, elimination reactions, addition reactions); enols and enolates; conjugation and conjugated π-systems; basics of electrophilic aromatic substitution	4	5
b.	**VO Structural Elucidation I** Basics of identification, characterisation and structure elucidation of organic compounds by mass spectrometry: short outline of the history of mass spectrometry, from atomic models and channel beams to the exploration of space	2	2.5

	and biomolecules; natural isotopic abundances of the elements as a basis for determining the elemental composition of compounds; nominal and exact mass taking into account the mass defect due to binding energies; set-up of mass spectrometers with homogeneous and static fields; separation of gaseous ions according to mass-to-charge ratio (m/z) in electric and magnetic fields; ionisation of volatile organic compounds with Electron Impact Ionization (EI) or Chemical Ionization (CI) and of non-volatile (bio)molecules with Matrix-Assisted Laser Desorption/Ionization (MALDI) or Electrospray Ionization (ESI); radical-induced and charge-induced fragmentation mechanisms of simple organic compounds (σ-cleavage, α-cleavage, i-cleavage, McLafferty rearrangements, onium reactions); fragmentations of aliphatic and aromatic compounds and the effect of heteroatoms on stability and fragmentation pathways of molecular ions; programmes for calculating isotope profiles and databases for thermochemical, thermophysical and ionic energy data as well as EI mass spectra		
	Total	**6**	**7.5**
	Learning Outcomes: The students are able to ad a.: understand the chemical bonds in hydrocarbons and explain and apply the basic aspects of the nomenclature of organic compounds, describe the structure and stereochemistry of organic compounds and explain the preparation and reactions of various classes of organic compounds including alkanes, alkyl halides, alcohols, ethers, amines, alkenes, alkynes, allenes, aromatics, carbonyl compounds, carboxylic acids and carboxylic acid derivatives, amines, alkenes, alkynes, allenes, aromatics, carbonyl compounds, carboxylic acids and carboxylic acid derivatives, understand and explain reaction mechanisms including nucleophilic substitution, elimination reactions, addition reactions and electrophilic aromatic substitution, and understand and explain methods for structure elucidation and analysis of organic compounds. ad b.: understand the basics of mass spectrometry for the identification, characterisation and structural elucidation of organic compounds, including the natural isotopic abundances of the elements, explain the functioning of mass spectrometers with homogeneous and static fields and differentiate between the various methods for ionisation of volatile organic compounds and non-volatile (bio)molecules, describe radical-induced and charge-induced fragmentation mechanisms of organic compounds and apply their knowledge to calculate isotope profiles and use databases for thermochemical, thermophysical and internal energy data as well as EI mass spectra.		
	Prerequisite/s: none		

9.	**Compulsory Module: Analytical Chemistry B**	**h**	**ECTS-Credits**
a.	**VO Analytical Chemistry III** Atomic spectroscopy, atomic absorption spectrometry, functioning of monochromators, detectors, interferences and their elimination, principle of FES, atomic fluorescence spectroscopy, plasma, spark, arc and laser emission spectroscopy	1	1,5
b.	**VO Analytical Chemistry IV** Types of decay, interaction of ionising radiation with matter, radioanalytics (alpha, beta and gamma spectroscopy, liquid scintillation) Radiation damage, technical application of X-rays, X-ray spectroscopy, electron spectroscopy	1	1,5
c.	**PR Analytical Chemistry – Basic Practical Course** Basic analytical operations (volume measurement, weighing, precipitation, filtration, digestion, annealing), safety and quality control in the analytical laboratory, filtration, gravimetric and volumetric determinations	4	4

	(neutralisation and redox measure analysis, complexometry), endpoint indication with colour indication and instrumental endpoint indication (photometry, pH electrode, conductivity measurement), statistical evaluation		
	Total	**6**	**7**
	Lernergebnisse: The students are able to ad a.: describe and compare different techniques of atomic spectroscopy, including their operation, detectors, monochromators, interferences and applications, explain and critically evaluate areas of application of atomic fluorescence spectroscopy and plasma, spark, arc and laser emission spectroscopy, as well as now methods to troubleshoot atomic spectroscopy and select appropriate analytical methods for specific samples. ad b.: understand, describe and distinguish the interaction of ionising radiation with matter and the different types of decay; explain different techniques of radioanalysis (alpha, beta and gamma spectroscopy, liquid scintillation) and evaluate their fields of application as well as know and describe technical applications of X-ray and electron spectroscopy and compare their advantages and disadvantages; ad c.: perform basic analytical techniques such as volume measurement, weighing, precipitation, filtration, digestion and annealing and know and apply appropriate safety and quality control measures, carry out gravimetric and volumetric determinations including neutralisation and redimension analysis as well as complexometry and calculate, document and critically evaluate the results as well as pply instrumental analysis techniques such as photometry, pH measurement and conductivity measurement and evaluate the results statistically.		
	Anmeldungsvoraussetzung/en: positive Beurteilung von Pflichtmodul 4 und 6		

10.	**Compulsory Module: Inorganic Chemistry C**	**h**	**ECTS-Credits**
	PR Inorganic Synthesis Synthesis of inorganic compounds of main group and subgroup elements in aqueous solutions as well as by means of solid-state chemical methods; application of basic preparative working techniques	5	5
	Total	**5**	**5**
	Lernergebnisse: The students are able synthesise inorganic compounds of the main group and subgroup group elements, applying various preparative working techniques; make a choice of suitable selected synthesis methods and reaction conditions, handle laboratory glassware and chemicals correctly; filtration, distillation, extraction and drying processes; carry out the synthesis of inorganic compounds by solid-state chemical methods, including the selection of suitable synthesis methods and conditions, the handling of apparatus for solid-state reaction, the performance of crystallisation and drying procedures, and the characterisation and identification of the compounds obtained by suitable analytical method.		
	Anmeldungsvoraussetzung/en: positive Beurteilung von Pflichtmodul 4 und 6		

11.	Compulsory Module: Physical Chemistry B	h	ECTS-Credits
	PR Lab-Course in Physical Chemistry I Fundamentals of physical-chemical measurement technology: mass, temperature and pressure measurement technology, vacuum generation, evaluation of measurement data and measurement uncertainty, curve fitting; e.g. measurement of reaction heats, electrolytic conductivity and molar masses; phase equilibria solid-fluid and liquid-gaseous	5	5
	Total	**5**	**5**
	Learning Outcomes: Students are able to understand, interpret and apply the basics of physico-chemical measurement technology, including mass, temperature and pressure measurement, vacuum generation, evaluation of measurement data and measurement uncertainty as well as curve fitting, to carry out and evaluate measurements of physico-chemical quantities and to understand and conceptually apply phase equilibria, including the interpretation of phase diagrams and the prediction of phase transitions.		
	Prerequisite/s: successful completion of compulsory module 1, 2 and 7		

12.	Compulsory Module: Physical Chemistry C	h	ECTS-Credits
a.	**VO Introduction to Quantum Chemistry** Collapse of the classical world view, double-slit experiment, uncertainty principle, Schrödinger equation, formal foundations of quantum mechanics, special solutions of the Schrödinger equation, operator formalism, angular momentum, spin, atomic spectra and fine structure, term symbols, helium atom, exchange interaction, Pauli principle, quantum mechanical principles of the structure of the periodic table	3	3
b.	**VO Physical Electrochemistry** Physical-chemical fundamentals of electrochemistry, electrochemical equilibria and cells, measurement technology, structure of the phase boundary, ionic conductivity, interionic interactions and the Debye-Hückel model, electrode kinetics, fundamentals of passivation and corrosion	2	25
	Total	**5**	**5.5**
	Learning Outcomes: The students are able to ad a.: discuss the limitations of classical mechanics in describing certain physical phenomena and apply the quantum mechanical principles of the structure of the periodic table to selected systems, understand, explain and use the Schrödinger equation to describe the configuration of the helium atom, describe the physical origin of the Pauli principle in the context of the concept of exchange interaction, and explain the concept of spin and describe its application to selected systems. ad b.: understand the physico-chemical fundamentals of electrochemistry, including electrochemical equilibria and cells, measurement techniques and the structure of the phase boundary, interionic interactions and the Debye-Hückel model and explain its application to interionic interactions as well as understand electrode kinetics and diffusion processes and know and explain the fundamentals of passivation and corrosion.		
	Prerequisite/s: none		

13.	Compulsory Module: Organic Chemistry B	h	ECTS-Credits
a.	**VO Organic Chemistry II** Electrophilic aromatic substitution; conjugated addition and nucleophilic aromatic substitution; chemoselectivity and protecting groups; reduction methods; alkylation of enolates; reactions of enolates with carbonyl compounds; pericyclic reactions; rearrangements and fragmentations; radical reactions; sulphur, silicon and phosphorus compounds in organic chemistry; olefination methods; oxidation methods	2	3
b.	**VO Structural Elucidation II** Introduction to nuclear magnetic resonance spectroscopy; physical basics, equilibrium magnetisation and vector model; excitation and detection; precession, scalar coupling and relaxation; Fourier transform, sign differentiation and referencing; influence of symmetry and chirality; creation of tree diagrams; basics of multidimensional methods; conformation determination; measurement of time-dependent effects (line width and kinetics); examples of structural characterisation of organic compounds using 1-dimensional and 2-dimensional methods	2	2.5
c.	**VO Preparation Techniques in Organic Chemistry** Safety in the organic preparative laboratory (basic rules, deactivation and disposal of reactive chemicals, general rules of conduct); materials for laboratory materials, glassware and set-up of standard reaction apparatus, ground and screw connections; characterisation of organic compounds by means of melting point, boiling point, refractive index and specific rotation value; basic techniques for the purification of organic compounds (distillation under various pressure conditions, filtration, recrystallisation, precipitation, sublimation); extraction with work-up to acidic, basic and neutral compounds; drying of solids, solutions and solvents; special cleaning operations for absolute solvents; working with gases (reactive gases, absorption of gases produced, protective gases); cleaning of laboratory equipment; stoichiometric calculation of organic-chemical reactions and use of chemistry-specific drawing programs, chemistry databases; selected application examples.	2	2.5
	Total	**6**	**8**
	Learning Outcomes: The students are able to ad a.: understand and explain the reaction mechanisms of electrophilic and nucleophilic aromatic substitution, conjugated addition, alkylation of enolates, and the reactions of enolates with carbonyl compounds, to understand and explain reduction methods, oxidation methods, and olefinisation methods, to understand the concepts of chemoselectivity and protective group chemistry and describe their applications in the synthesis of organic compounds, and to understand pericyclic reactions, rearrangements and fragmentations, radical reactions, and the reactions of sulphur, silicon, and phosphorus compounds in organic chemistry, and to describe their applications in the synthesis of organic compounds. ad b.: understand the fundamentals of nuclear magnetic resonance spectroscopy, including the physical principles, excitation and detection, precession and relaxation, apply multidimensional methods for conformational determination, and perform structural characterisation of organic compounds using 1-dimensional and 2-dimensional methods, as well as measure and interpret time-dependent effects such as line widths and kinetics in order to characterise the structure of organic compounds. ad c.: understand and apply the basic rules for occupational safety in organic preparative laboratories, master various techniques for purifying organic compounds, including distillation, filtration, recrystallisation, precipitation, sublimation and extraction with processing of acidic, basic and neutral compounds, as well as performing stoichiometric calculations for organic		

	chemical reactions and using chemistry databases and formula symbol programmes for support.
	Prerequisite/s: none

14.	**Compulsory Module: Biochemistry A**	**h**	**ECTS-Credits**
	VO Biochemistry I Basic knowledge of cell biology, biochemistry and metabolism; structure of cells and biomolecules (amino acids, peptides, proteins, nucleic acids, lipids, carbohydrates); structure/function of DNA, RNA, proteins, enzymes, membranes; strategies of metabolism; metabolic pathways of energy metabolism (glycolysis, gluconeogenesis, citrate cycle, oxidative phosphorylation).	3	5
	Total	**3**	**5**
	Learning Outcomes: Students are able to understand and discuss the fundamentals of cell biology, biochemistry and metabolism, including the importance of biomolecules such as amino acids, peptides, proteins, nucleic acids, lipids and carbohydrates, the structure and function of DNA, RNA, proteins, enzymes and membranes, and to understand the metabolic pathways of energy metabolism such as glycolysis, gluconeogenesis, the citric acid cycle and oxidative phosphorylation, and explain their importance for energy production.		
	Prerequisite/s: none		

15.	**Compulsory Module: Theoretical Chemistry A**	**h**	**ECTS-Credits**
a.	**VO Theoretical Chemistry I** Atom types, bond forces, bond angles, torsions, electrostatic interactions, van der Waals interactions, hydrogen bonds, hydrophobic interactions, simplified force fields, parameterisation of force fields, applications of force fields, minimisation methods, computer simulations, prediction of statistical thermodynamic properties in the liquid phase, connection with NMR spectroscopy	2	2.5
b.	**VO Theoretical Chemistry II** Hamiltonian operator for molecular multi-electron systems, Born-Oppenheimer approximation, method for solving the Kernschrödinger equation, harmonic approximation, connection with vibrational spectroscopy and statistical thermodynamics in the gas phase, method for solving the electronic Schrödinger equation, consequences of the Pauli principle for the multi-electron wave function, atomic orbitals, molecular orbitals, determinant basis in multi-electron Hilbert space, variational principle, full CI, Gaussian functions as a single-electron basis, Hartree-Fock, Roothaan-Hall equation, electron correlation, perturbation theory, density functional theory.	2	2.5
	Total	**4**	**5**
	Learning Outcomes: The students are able to ad a.: explain the fundamentals of describing chemical systems in the context of theoretical chemistry, as well as understand the quantum mechanical description of multi-electron systems and the implications of abstracting this description through inter- and intramolecular forces within the framework of molecular mechanics. ad b.: to compare various quantum mechanical methods and force fields in molecular mechanics in terms of their fundamentals and applications, as well as contrast their advantages, disadvantages and limitations of the various methods, to identify applications of the various methods,		

	such as the calculation of molecular vibrations or statistical-thermodynamic properties of the structural ensemble, and to argue for the choice of a suitable method for their calculation, as well as to establish the relationship between theoretical chemical calculations and experiments from the various chemical disciplines and to understand and discuss connections and differences.
	Prerequisite/s: none

16.	Compulsory Module: Biochemistry D	h	ECTS-Credits
a.	**VO Kinetics** Kinetic gas theory, transport processes, reaction rate, reaction order, reaction molecularity, counter reactions, parallel reactions, subsequent reactions, reactions with upstream equilibrium, stationary states, chain reactions, autocatalytic reactions, pandemic models	2	2.5
b.	**VO Microscopic Thermodynamics** Calculation of macroscopic quantities from microscopic properties, ensemble term, entropy and Boltzmann equation, state sums (translation, rotation, oscillation, electronic) and corresponding spectroscopic experiments, Maxwell-Boltzmann distribution, chemical equilibrium, quantum statistics, regular mixtures, mixture entropy, activity coefficients, chemical potentials.	2	2.5
	Total	**4**	**5**
	Learning Outcomes: The students are able to ad a.: understand the kinetic theory of ideal gases on a microscopic mechanical basis, to justify and derive the vectorial and scalar Maxwell-Boltzmann velocity and energy distribution functions, to understand the microscopic statistics of gas particles and to apply them to the quantitative description of transport properties (heat conduction, viscosity, diffusion), calculate and explain the empirical rate laws of chemical reactions, taking into account the reaction order and molecularity, distinguish and describe different types of reactions mechanistically, including chain reactions, autocatalytic reactions and reactions with upstream equilibrium, derive empirical rate laws based on the steady-state approximation, and apply the kinetic laws for autocatalytic reactions to empirical pandemic models. ad b.: understand and apply the calculation of macroscopic quantities from microscopic properties, e.g. equilibrium constants, the Boltzmann distribution, the Fermi-Dirac distribution and their application to chemical systems, as well as to calculate and apply chemical equilibria and activity coefficients, including quantum statistics, regular mixtures, mixing entropy, activity coefficients and chemical potentials.		
	Prerequisite/s: none		

17.	Compulsory Module: Physical Chemistry E	h	ECTS-Credits
	PR Lab Course in Physical Chemistry II Measurement methods for determining the kinetics of reactions, reaction and adsorption equilibria, macroscopic and microscopic material properties, e.g. measurement of viscosity, reaction kinetics, adsorption, surface determination of finely dispersed powders, thermodynamic and kinetic principles of gas chromatography, spectroscopy, dipole moment and dielectric constant.	4	5
	Total	**4**	**5**

	Learning Outcomes: The students are able to interpret and present experimental physical-chemical results, including the ability to determine kinetic process parameters and properties of functional materials, understand and apply fundamental thermodynamic and kinetic principles of physical-chemical processes, including the ability to interpret measurement results and make quantitative statements, as well as derive and explain relationships between physical quantities and chemical processes, for example in relation to reaction kinetics and adsorption, including the ability to make theoretical predictions and evaluate experimental results.
	Prerequisite/s: successful completion of compulsory module 11

18.	**Compulsory Module: Biochemistry B**	**h**	**ECTS-Credits**
a.	**VO Biochemistry II** Basics of the metabolic pathways of energy metabolism (pentose phosphate pathway, glycogen metabolism, lipid metabolism, amino acid metabolism, nucleotide metabolism); regulation and coordination of energy metabolism; basic principles of synthesis and regulation of biomolecules (DNA, RNA	3	3
b.	**VO Biochemical Methods** Basics of biochemical methods, nucleic acids (analysis, cloning, synthesis, sequencing), proteins (expression, purification, sequencing, structures), molecular interactions (identification, quantification, localisation, functional analyses of protein:RNA:ligands), chromatography, mass spectrometry, systems biology (genomics, proteomics, metabolomics), model organisms, model systems for physiological and pathological signal transduction cascades, biotechnology	2	2
c.	**UE Biochemical Methods** Use of bioinformatics and statistical methods for the evaluation of OMICs data sets; graphical data processing and visualisation, use of systems biology analysis methods	1	1
	Total	**6**	**6**
	Learning Outcomes: The students are able to ad a.: understand and explain basic concepts of energy metabolism pathways, including the pentose phosphate pathway, glycogen metabolism, lipid metabolism, amino acid metabolism, and nucleotide metabolism; describe the mechanisms of regulation and coordination of energy metabolism; and understand and explain the basic principles of the synthesis and regulation of biomolecules (DNA, RNA, proteins) as well as gene expression, transcription, RNA processing, and signal transduction. ad b.: understand and apply basic biochemical methods and techniques, including analysis, cloning, synthesis, and sequencing of nucleic acids; expression, purification, sequencing, and structure of proteins; identification, quantification, localization, and functional analysis of protein:RNA: ligand interactions, to understand and apply basic methods of chromatography and mass spectrometry, as well as the application of systems biology (genomics, proteomics, metabolomics), and to understand and apply the use of model organisms and model systems for physiological and pathological signal transduction cascades and biotechnology. ad c.: apply bioinformatic and statistical methods for the evaluation of OMICs data sets, apply and visualize methods of exploratory data processing, and apply systems biology analysis methods in order to understand and describe complex biological relationships.		
	Prerequisite/s: successful completion of compulsory module 14		

19.	Compulsory Module: Inorganic and Macromolecular Chemistry	h	ECTS-Credits
a.	**VO Environmental Chemistry** The atmosphere of the earth, natural and anthropogenic greenhouse effect, formation and degradation of ozone in the stratosphere, ozone hole, ground-near ozone, DDT, aerosols, emissions of combustion engines	1	1.5
b.	**VO Solid State Chemistry** Solid state reactions, thermodynamics, kinetics, diffusion, phase transformations, phase diagrams, methods of crystal growth, solid state synthesis from the gas phase, high-pressure/high-temperature syntheses, solid state structures, applications of solids (superhard materials, superconductors, organic phosphors, NLO materials, micro- and nanoporous materials)	2	2.5
c.	**VO Macromolecular Chemistry** Definitions of terms, classifications, nomenclature, molar mass and molar mass distribution, molecular weight, degree of polymerisation, stereoregularity, tacticity, isomerism, reaction, mechanism and kinetics of polymerisation, copolymers, multicomponent systems, industrially important polymers, polymers from renewable raw materials, structure-property relationships, thermal and mechanical properties, use and processing, biocompatible and medical special polymers, plasticiser and stabiliser chemistry, ecological aspects	2	2.5
	Total	**5**	**6.5**
	Learning Outcomes: The students are able to ad a.: understand and discuss the connections between anthropogenic emissions and environmental pollution, describe the chemical mechanisms of the greenhouse effect and ozone depletion in the atmosphere, and evaluate strategies for reducing environmental pollution through chemical processes and technologies, including regulations and standards. ad b.: understand and explain fundamental concepts of solid-state chemistry, including thermodynamics, kinetics, and structure of solids, describe methods for producing and characterising solids, including crystal growth, gas phase synthesis, and high-pressure/high-temperature synthesis, as well as applications of solids, including superhard materials, superconductors, inorganic phosphors, and micro- and nanoporous materials. ad c.: understand fundamental concepts of macromolecular chemistry, including degree of polymerisation, stereoregularity and reaction kinetics, describe the most important industrially relevant polymers, including their structure-property relationships, use and processing, and evaluate the environmental aspects of the production and use of polymers, including biocompatible and special medical polymers and their stabiliser chemistry.		
	Prerequisite/s: none		

20.	Compulsory Module: Organic Chemistry C	h	ECTS-Credits
a.	**PR Basic Organic Chemical Operations** Construction of chemical synthesis apparatus; extraction; distillation; recrystallisation; separation of substance mixtures via physical and chemical properties; simple organic syntheses	6	5
b.	**VO Organic Synthesis** Organic chemical synthesis as an approach to organic compounds such as natural products, active substances, catalysts and theoretically interesting compounds; pericyclic reactions in drug synthesis; selected chemistry of carbonyl compounds; transition metal-mediated reactions for synthesis	2	2.5

	chemistry; modern synthesis strategies for the conversion of functional groups; asymmetric synthesis; current concepts and examples for the (total) synthesis of organic compounds as well as natural and active substances		
c.	**VO Chemical Biology** Fundamentals of chemical biology; solid phase synthesis of peptides and nucleic acids; protein catalysis; nucleic acid catalysis; fundamentals of cofactors and their involvement in simple regulatory mechanisms; bioorthogonal chemistry.	1	1.5
	Total	**9**	**9**
	Learning Outcomes: The students are able to ad a.: select, set up and operate chemical synthesis equipment, including extraction and distillation equipment, isolate and characterise organic compounds through extraction, distillation, recrystallisation and separation of mixtures of substances, including simple syntheses, and to take appropriate safety measures when conducting chemical experiments, including the handling of chemicals and the use of protective equipment. ad b.: understand and apply organic synthesis as a means of accessing various types of organic compounds and active ingredients, including the synthesis of natural products and selected compounds, understand and explain the principles and mechanisms of pericyclic reactions, carbonyl chemistry, transition metal-mediated reactions and asymmetric synthesis, including selected reactions of carbonyl compounds, as well as modern synthesis strategies for the conversion of functional groups, including current concepts and examples for the (total) synthesis of organic compounds, natural products and active ingredients. ad c.: understand and apply the fundamentals of chemical biology, including solid-phase synthesis of peptides and nucleic acids, explain the principles of protein catalysis and nucleic acid catalysis, including the role of cofactors in the regulation of biological systems, and understand and apply the importance of bioorthogonal chemistry, including the integration of cofactors into simple regulatory mechanisms.		
	Prerequisite/s: successful completion of compulsory modules 3, 8 and 13		

21.	**Compulsory Module: Organic Chemistry D**	**h**	**ECTS-Credits**
	PR Organic Chemical Operations on a Laboratory Scale In-depth organic-chemical working techniques based on the practical training course "Basic Organic Chemical Operations "; thin-layer chromatographic reaction control; column chromatographic product purification; mass spectrometric and NMR spectroscopic product characterisation; esterification, hydrolysis, condensation, electrophilic substitution on the aromatic, oxidation and reduction reactions are carried out in experiments lasting several days.	6	6
	Total	**6**	**6**
	Learning Outcomes: The students are able to master organic-chemical work on a laboratory scale, including the application of advanced organic-chemical working techniques based on the practical course “Basic Organic Chemical Operations”, to carry out esterifications, hydrolysis, condensations, electrophilic substitutions on aromatics as well as oxidation and reduction reactions, to carry out thin-layer chromatographic reaction control and column chromatographic product purification and to control products by means of mass spectrometric and NMR spectroscopic product characterisation.		
	Prerequisite/s: successful completion of compulsory module 20		

22.	Compulsory Module: Biochemistry C	h	ECTS-Credits
	PR Laboratory Course in Basic Biochemistry DNA sequence analysis; RNA preparation and separation; DNA synthesis and DNA modification; nucleic acid hybridisation; protein-DNA interactions; protein expression and purification; function of proteins; molecular cloning; preparation of high molecular weight DNA	5	5
	Total	**5**	**5**
	Learning Outcomes: Students are able to apply various methods of DNA and RNA analysis, including DNA sequencing, RNA preparation and separation, and nucleic acid hybridisation, to analyse and characterise proteins, including protein-DNA interactions, protein expression and purification, and enzyme kinetics experiments, to understand and apply molecular cloning, including DNA synthesis, modification and isolation, and plasmid transformation experiments, to understand and apply the concept of protein function, including analysis of protein structure and function, and application of enzyme kinetics experiments, understand and apply the concept of protein function, including the analysis of protein structure and function and the application of enzyme kinetics experiments and apply various methods of DNA preparation and isolation, including the preparation of high molecular weight DNA and the application of centrifugation and precipitation techniques.		
	Prerequisite/s: successful completion of compulsory module 18		

23.	Compulsory Module: Theoretical Chemistry B	h	ECTS-Credits
	PR Theoretical Chemistry Laboratory Basics of Unix systems and high-performance computers, theoretical chemistry software packages for describing chemistry within the framework of quantum mechanics and classical mechanics; application of theoretical-chemical methods to problems in inorganic and organic chemistry as well as biochemistry, molecular structure and visualisation of small molecules and biomolecular systems; prediction of structures and spectroscopic properties using quantum mechanical methods; prediction of state sums and static-thermodynamic properties in the gas phase using quantum mechanical methods; prediction of conformational ensembles and statistical thermodynamic properties in the liquid phase using computer simulations	4	5
	Total	**4**	**5**
	Learning Outcomes: Students are able to apply basic working techniques of theoretical chemistry to interdisciplinary problems from the various other fields of chemistry and to contrast the advantages and disadvantages of different methods for the given problem, to know and professionally apply various theoretical-chemical software packages for the description of quantum mechanics and classical mechanics, to calculate and interpret the structural and thermodynamic properties of small molecules in the gas phase using quantum-mechanical methods, to predict and evaluate conformational ensembles and statistical thermodynamic properties in the liquid phase using molecular dynamics simulations, understand the atomic structure of small molecules and biomolecular systems, visualise these correctly and interpret structural relationships, validate theoretically calculated results using experimental data and argue the reasons for any deviations, successfully present the results of their theoretical-chemical calculations to a specialist audience and master the basics of text-based work on UNIX operating systems, including automation with scripting languages.		
	Prerequisite/s: successful completion of compulsory module 15		

24.	Compulsory Module: Bachelor's Thesis	h	ECTS-Credits
	SE Bachelor's Thesis Independent work in a chemical subject of free choice under the supervision of instructors with a doctorate in the subject. Presentation of own Bachelor's Thesis, professional discussion of the Bachelor Theses presented by other students.	1	1+14
	Total	**1**	**15**
	Learning Outcomes: Students are able to independently carry out practical-experimental work on a topic from chemistry, to present and discuss the results of practical-experimental work in the form of a scientific lecture and to apply interdisciplinary key competences in oral and written communication skills, presentation techniques and time and project management.		
	Prerequisite/s: successful completion of the compulsory modules 1 to 23		

(2) Elective modules covering a total of 15 ECTS-Credits are to be passed:

1.	Elective Module: Inorganic Chemistry	h	ECTS-Credits
a.	**PR Advanced Inorganic Synthesis** Research-oriented practical training in modern methods of preparative organometallic chemistry and solid-state chemistry; concrete application of advanced inert gas techniques and synthesis methods as well as analysis of substances with spectroscopic and diffraction methods.	5	5
b.	**VO Organometallic Chemistry** Classification, preparation, structure, stability, reactivity and applications of organometallic compounds in research and industrially relevant processes as well as current developments and challenges in organometallic chemistry.	2	2.5
	Total	**7**	**7.5**
	Learning Outcomes: The students are able to ad a.: understand and explain the basic concepts of preparative organometallic chemistry and solid state chemistry, including the use of inert gases and advanced synthesis methods, to classify, prepare and characterise organometallic compounds, to apply advanced spectroscopic and diffractometric methods for the analysis of organometallic substances as well as to know, evaluate and compare preparative methods, structure, stability, binding ratios and reactivity of organometallic compounds, including their applications in research and industrially relevant processes. ad b.: establish and understand relationships between the structure and properties of organometallic compounds, discuss current developments and challenges in organometallic chemistry and evaluate their impact on future research and applications.		
	Prerequisite/s: successful completion of compulsory module 5 and 10		

2.	Elective Module: Organic Chemistry	h	ECTS-Credits
a.	**PR Organic Chemical Synthesis** In experiments lasting several days, multi-step syntheses are carried out starting from self-produced reactants, with oxidation and reduction reactions as well as diazotisation and anhydrous work, e.g. Grignard reactions and reactions with metallic sodium that significantly increase synthesis competence. Working with reactive gases and working under inert gas, characterisation of organic compounds by means of spectrometric and spectroscopic methods	5	6
b.	**VO Structural Elucidation III** Structural determination of organic compounds; interaction with other analytical methods; structural characterisation of organic compounds by applying classical methods, such as IR and UV/visible spectroscopy; starting from simple hydrocarbons up to the complete analysis of multi-functionalised organic compounds, concrete ways of solving problems are worked out by means of consistent assignment of group vibrations on the basis of numerous examples	1	1.5
	Total	**6**	**7.5**
	Learning Outcomes: The students are able to ad a.: plan and carry out complex organic syntheses on a small scale, including the application of advanced oxidation and reduction reactions, diazotisation and anhydrous work as well as Grignard reactions and reactions with metallic sodium, to handle reactive gases, taking into account safety and protective measures, and to characterise organic compounds using spectrometric and spectroscopic methods, including the application of IR and UV/Vis spectroscopy. ad b.: structurally characterise and analyse complex organic compounds, including the application of classical methods such as IR and UV/Vis spectroscopy, to identify and assign group vibrations of functionalised organic compounds and to work out concrete ways to solve problems as well as to understand and apply the interaction with other analytical methods in order to achieve a comprehensive structural characterisation.		
	Prerequisite/s: successful completion of compulsory modules 20 and 21		

3.	Elective Module: Analytical Chemistry	h	ECTS-Credits
a.	**PR Basic Practical Course in Instrumental Analysis** Imparting knowledge of sample preparation and instrumental analysis, pH value and buffers (calculation and preparation), application of liquid chromatography, gas chromatography, extraction methods, UV/VIS spectroscopy, atomic spectroscopy, various calibration techniques for the analysis of real samples.	4	5
b.	**VO Gas Analysis** Air pollutants (origin, limit values, health hazards), sampling techniques, sample preparation, sample enrichment in classical gas analysis, gas chromatography, detection methods, on-line/off-line analysis, mass spectrometry, ion-molecule reaction in the gas phase, ion mobility spectrometry, gas sensors, applications (flue gas analysis, respiratory gas analysis, food industry, workplace monitoring, toxic gases, explosives, metabolomics)	2	2.5
	Total	**6**	**7.5**

	Learning Outcomes: The students are able to ad a.: plan and master sample preparation and instrumental analysis, including the application of liquid chromatography, gas chromatography, extraction methods, UV/VIS spectroscopy and atomic spectroscopy, applying various calibration techniques to analyse real samples, understanding and explaining pH values, and performing buffer calculations and production. ad b.: assess and describe limit values and health hazards of air pollutants, perform sampling techniques and sample preparation for gas analysis, including sample enrichment and various detection methods such as mass spectrometry, ion mobility spectrometry and ion-molecule reaction in the gas phase, including the application of gas sensors for flue gas analysis, breath gas analysis, the food industry, workplace monitoring, toxic gases, explosives and metabolomics.
	Prerequisite/s: successful completion of compulsory module 9

(3) Elective modules covering a total of 10 ECTS-Credits are to be passed:

4.	**Elective Module: Technical Chemistry**	**h**	**ECTS-Credits**
a.	**VO Technical Chemistry** Introduction to the special features of technical chemistry, selected (large) chemical reactors (e.g. stirred tank, cascade, tubular reactor) as well as selected basic operations (e.g. rectification, heat transfer, pump technology)	2	3.5
b.	**PR Technical Chemistry** Practical execution of experiments on process engineering plants from the fields of reaction engineering and thermal process engineering	1	1.5
	Total	**3**	**5**
	Learning Outcomes: The students are able to ad a.: understand and apply the special features of technical chemistry, including the differences to laboratory scale and the role of mass and energy balances, selected (large) chemical reactors such as stirred tanks, agitated tank cascades and flow tube reactors, including the description of residence time behaviour and the selection of optimal operating conditions and scaling, as well as selected basic operations such as rectification, heat transfer and pump technology, including the selection of optimal plant specifications and operating conditions. ad b.: design practical experiments on process engineering equipment in the fields of reaction engineering and thermal process engineering, including the preparation, follow-up and implementation of experiments and the evaluation and interpretation of results, to take safety and environmental aspects into account when conducting process engineering experiments, including compliance with regulations and the use of protective equipment, and to collect, evaluate and interpret experimental data, including plausibility checks and the creation of diagrams and tables, as well as the presentation of results.		
	Prerequisite/s: none		

5.	**Elective Module: Physical Chemistry**	**h**	**ECTS-Credits**
a.	**VO Advanced Thermodynamics** In-depth consideration and application of real gases, phase diagrams of single-substance systems, binary and ternary mixtures, thermodynamics and phase diagrams of real mixtures (fugacity concept, partial molar quantities, excess quantities), thermodynamics of surfaces: surface tension, wetting phenomena; elements of non-equilibrium thermodynamics, concept of thermodynamic potentials	2	2

b.	**PR Laboratory Course in Physical Chemistry III** Research-related work and application of modern concepts and equipment in physical chemistry	3	3
	Total	**5**	**5**
	Learning Outcomes: The students are able to ad a.: describe and calculate the thermodynamics of real gases using equations of state, including consideration of deviations from ideal gas behaviour, interpret phase diagrams of single-component systems, binary and ternary mixtures, and explain them on the basis of thermodynamics, including the concept of fugacity, partial molar quantities and excess quantities, describe and apply the thermodynamics of surfaces, including the description of surface tension and wetting phenomena, as well as the fundamentals of non-equilibrium thermodynamics, and describe the concept of thermodynamic potentials and apply it to questions. ad b.: conduct basic research in physical chemistry, including the application of modern concepts and equipment, plan, conduct, analyse and interpret experiments, identify and minimise sources of error, and present and critically discuss experimental results in a precise and comprehensible manner, both in writing and orally.		
	Prerequisite/s: successful completion of compulsory module 17		

6.	**Elective Module: Biochemistry**	**h**	**ECTS-Credits**
	VO Biochemistry III Research-oriented in-depth study of biochemical basics and principles in the field of metabolism, signal transduction and transcription regulation	2	2.5
	Total	**2**	**2.5**
	Learning Outcomes: Students are able to describe and explain the biochemical fundamentals and principles in the field of metabolism, signal transduction and transcription regulation, including the central metabolic pathways and their regulation as well as the most important signalling molecules and signal transduction pathways. plan and carry out biochemical experiments to answer research questions in the field of metabolism, signal transduction and transcription regulation, including the application of modern biochemical methods, and read and understand scientific publications in the field of biochemistry, including the critical evaluation of experiments, the interpretation of results and the derivation of conclusions.		
	Prerequisite/s: successful completion of compulsory module 18		

7.	**Elective Module: Interdisciplinary Skills**	**h**	**ECTS-Credits**
	Courses covering 2.5 ECTS-Credits are to be selected from the curricula of the bachelor’s or diploma programmes offered at the University of Innsbruck or from the field of “Equality and Gender Studies” at the University of Innsbruck.	2	2.5
	Total	**2**	**2.5**
	Learning Outcomes: Students have additional and in-depth knowledge, skills or qualifications and can make connections to their own subject knowledge.		
	Prerequisite/s: The prerequisites specified by the respective curricula are to be met.		

§ 9 Bachelor’s Thesis

(1) The topic of the Bachelor's Thesis can be chosen from the fields that are offered in the bachelor’s programme: analytical chemistry, inorganic chemistry, biochemistry, organic chemistry, physical chemistry, theoretical chemistry, macromolecular chemistry or technical chemistry.

(2) With the consent of the responsible instructor of the seminar “Bachelor’s Thesis”, the joint work on a topic by several students is permissible, provided the performance of the individual students can be assessed separately.

(3) With the consent of the course instructor of the seminar “Bachelor’s Thesis”, the practical work on a topic may be carried out at non-university institutions. In any case, the assessment is carried out by the course instructor of the seminar “Bachelor’s Thesis”.

(4) The complete Bachelor’s Thesis is to be submitted to the Director of Studies in electronic form. It is to be accompanied by an affidavit confirming that the rules of good scientific practice have been followed. At the request of the assessors, the Bachelor’s Thesis must also be submitted in written form in addition to the electronic form.

§ 10 Examination regulations

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

(2) The performance evaluation of the courses of the modules is based on the course examinations. Course examinations serve to proof knowledge and skills that have been acquired in the courses, whereby

1. the evaluation of courses without continuous performance assessment is based on a single oral or written examination at the end of the course.
2. the evaluation of courses with continuous performance assessment is based on at least two written, oral and/or practical contributions of the students.

(3) The course instructor has to announce the examination method before the start of the semester.

(4) For modules and courses selected from other study programmes, the examination regulations of the curriculum they have been taken from apply.

§ 11 Academic degree

Graduate of the Bachelor’s Programme in Chemistry are awarded the academic degree “Bachelor of Science”, abbreviated as “BSc”.

§ 12 Coming into force

This curriculum comes into force on 1 October 2025 and is to be applied to all students.

§ 13 Transitional provisions

Regular degree students, who have started the Bachelor’s Programme in Chemistry, as published in the University of Innsbruck Bulletin of 21 April 2008, Issue 28, No. 257, at the University of Innsbruck before 1 October 2023, are entitled from this point in time to complete this study programme within a maximum of eight semesters. If the bachelor’s programme is not completed in time, the students are subject to the new curriculum for the Bachelor’s Programme in Chemistry. In any case, students are entitled to submit to the new curriculum for the Bachelor’s Programme in Chemistry on a voluntary basis any time.