Content overview of lectures and lab courses from master's program Chemistry and Molecular Sciences (90 ECTS)

CURRENTLY OFFERED LECTURES

Advanced Medicinal Chemistry
1.5 ECTS, 1V
This lecture series illustrates the modern drug discovery process from target identification to the selection of drug candidates for clinical testing. While the course reiterates key concepts and methodologies of traditional medicinal chemistry and pharmacology, several practical examples serve to highlight the advantages of a target-centric approach with a particular emphasis on 3D structural information.

Advanced NMR I
2 ECTS, 1V+0.5Ü
This lecture includes several independent chapters and exercises. The topics discussed include: strengths and weaknesses of NMR, second order effects, the vector model of NMR, 2D NMR Spectroscopy, NOE effect, Acquisition&Processing of NMR data. Some more specialized themes, such as basic principles of Solid State NMR & HRMAS NMR, Chiral reagents, dynamic NMR, principles of diffusion NMR measurements, NMR of heteronuclei are provided as supplementary material. The exercises (structure & stereochemistry verification) should help the students to independently analyze complex 1D and 2D NMR spectra. During the exercises, the strengths&weaknesses of the different NMR methods are discussed and highlighted.

Advanced NMR II
2 ECTS, 1V+0.5Ü
The advanced NMR II course is conceived for students who are already familiar with using NMR on a day-to-day basis, but who wish to deepen their understanding of how NMR experiments work and the theory behind them. As such, this course is only intended to students with a strong interest and a solid NMR background. A strong interest for the mathematical and physical aspects of NMR spectroscopy is absolutely required. The course is divided in chapters, each chapter being associated with exercises, if needed. After a short introduction showing the limits of the vector model, chapter I will cover the quantum mechanics for NMR Spectroscopy, chapter II will introduce the notion of product operators, which represents the core of the lecture. In chapter III, some 2D NMR experiments will be discussed. In chapter IV, the concept of gradients and phase cycling will be discussed.

Advanced Solid State Chemistry and Spectroscopy
1.5 ECTS, 1V
The development of a chemical compound towards an optimized material is discussed, mainly on examples of solid state, light emitting materials. Beginning at the synthesis (e.g., starting materials, reaction conditions, purity) the process involves many more steps of optimization (e.g., doping, length scale (nm powder to cm sized crystal) and combination with other materials) towards a real (commercial) product. The chemical aspects are combined with optical spectroscopy and other

methods of characterization.
In the basic course the principles of e.g., light absorption, emission, energy migration, broad band and line emitters, f-f, f-d, d-d transitions are discussed.
The advanced course includes more detailed discussions of e.g., scintillators, persistent phosphors, upconversion phosphors, and LEDs.

Advanced Spectroscopy – non-linear properties, lasers, time-resolved spectroscopy
3 ECTS, 2V
This lecture is about the concepts of modern laser spectroscopy. An introduction to lasers, in particular those generating ultra-short optical pulses, is given. We then discuss nonlinear optical phenomena that can be observed thanks to the high peak intensities of short laser pulses, as well as their applications. This leads to the description of various time-resolved spectroscopic techniques, including pump-probe transient absorption spectroscopy, time-resolved fluorescence techniques (single-photon counting, fluorescence up-conversion), terahertz spectroscopy, and an introduction to coherent spectroscopies, which will be illustrated with case studies. After having followed this lecture, the students will be able to: • - appreciate the functioning of pulsed laser systems. • - predict non-linear effects in various media • - understand various time-resolved spectroscopy techniques • - interpret experimental data obtained with those techniques

Applied Electrochemistry I
3 ECTS, 2V

• Basic electrochemical thermodynamics
  o One electrode systems: derivation of the Nernst equation
  o Two electrode systems: definition of measurable quantities
  o Electrodes of the first kind
  o Electrodes of the second kind
• Basic electrochemical kinetics
• Electrochemical methods
• Electrochemistry and technology of electroplating
• Electrochemistry and technology of fuel cells and batteries (energy conversion)
• Organic electrochemistry (synthesis)

Applied Mass Spectrometry
1.5 ECTS, 1V
Mass spectrometry Demonstration of non-classical instrumentation and applications of modern mass spectrometry: • Stepping out of the lab: Miniature and portable mass spectrometry. • Ambient ionization techniques. • Mass spectrometry in the clinical and forensic sciences: Analysis of drugs, their metabolites, and illicit substances. • Mass spectrometry in arts and archeology. • Extreme mass spectrometry: Exploring the current of an analytical technique.

Applied Optical Spectroscopy in Chemical Biology
1.5 ECTS, 1V
• Introduction to chromophores and principles of photophysics • UV-vis absorption spectroscopy • Fluorescence spectroscopy • Circular dichroism (CD) spectroscopy • Linear dichroism (LD) spectroscopy • Practical demonstration of spectroscopic instruments

Atmospheric and Aerosol Chemistry
3 ECTS, 2V
• Why Atmos. Chemistry • A flavor about the main problems • General circulation, transport in the atmosphere • Spectroscopy, Photochemistry • Kinetics • Introduction Waste incineration (KVA), Introduction to aerosols • Excursion: Visit of KVA • Aerosols • Aerosol dynamics, Organic aerosols, Cloud droplets • Student presentations about current topics in Atmospheric Chemistry • 11. Clouds and aqueous chemistry

Basic Medicinal Chemistry
1.5 ECTS, 1V
What is medicinal chemistry? • The drug discovery process • Drug-Target interactions • Enzyme inhibitors • Drugs interacting with DNA • Drug metabolism • The prodrug concept

Basic Solid State Chemistry and Spectroscopy
1.5 ECTS, 1V
The development of a chemical compound towards an optimized material is discussed, mainly on examples of solid state, light emitting materials. Beginning at the synthesis (e.g., starting materials, reaction conditions, purity) the process involves many more steps of optimization (e.g., doping, length scale (nm powder to cm sized crystal) and combination with other materials) towards a real (commercial) product. The chemical aspects are combined with optical spectroscopy and other methods of characterization. **In the basic course** the principles of e.g., light absorption, emission, energy migration, broad band and line emitters, f-f, f-d, d-d transitions are discussed. The advanced course includes more detailed discussions of e.g., scintillators, persistent phosphors, upconversion phosphors, and LEDs.

Chemical Biology I (until FS2019 this lecture was called Therapeutic Proteins and Peptides)
3 EC TS, 2V
Proteins and peptides are used as drugs to treat a wide range of conditions and diseases, and comprise historical drugs such as insulin to treat diabetes and cyclosporin as an immunosuppresive agent to recent development such as Fuzeon as an HIV inhibitor and various antibody –drug conjugates to treat cancer. The course takes a look at primary and secondary literature on the topic addressing important issues ranging from clinical studies, adminstration routes and efficacy studies, and basic research and development studies. Each student is asked to analyze and present two selected publications during the course of the semester. Prerequisite for the course is basic knowledge on the peptide and protein structure, chemical and bio-synthesis, and biology (courses in biochemistry and organic chemistry).

Chemical Biology II
3 EC TS, 2V
Chemical biology is the application of chemical synthesis to the study of biological problems, and conversely the application of biological tools to chemical problems. The course takes a look at recent primary literature in chemical biology from selected authors covering topics such as activity-based protein profiling, DNA-encoded chemistry, articifial protein design, drug-target interactions, synthetic glycoproteins, and more. Each student is asked to analyze and present two selected publications during the course of the semester. Prerequisite for the course is basic knowledge in cell biology (cellular structures and mechanisms), biochemistry (structure and analysis of proteins and nucleic acids) and organic chemistry (structure and reactivity of organic molecules).

Chemical Crystallography
3 ECTS, 2V
The course provides the basic crystallographic information to understand crystal structure determination from X-ray diffraction, including an overview of microscopic techniques. Students will be able to understand the main structural features of molecular crystals, the details of experiments and of structure solution methods. A background knowledge about mathematics and physics, in particular quantum mechanics and chemical bonding is advantageous. Textbooks: 1. Massa, Kristallstrukturbestimmung; 2. Luger, Modern X-ray analysis on single crystals; 3. Giacovazzo, Fundamentals of Crystallography

Clinical Chemistry and Laboratory Medicine – An Introduction
1.5 ECTS, 1V
• Laboratory medicine and clinical chemistry (next to haematology, immunology, microbiology and medical genetics) • Career opportunities in laboratory medicine? • Knowledge and understanding of clinical chemistry in the areas of laboratory investigation of medical conditions • Understanding of pre-analytical, analytical and post-analytical issues • Critically discuss the interpretation of the laboratory results. • Topics: Analytical Techniques, Inflammation, Anemia, Therapeutic Drug Monitoring (TDM), Liver, Kidneys, Cardiac Markers, Newborn-Screening

Computational Chemistry (previously called Ab-initio Computational Chemistry)
3 ECTS, 2V
This lecture provides an introduction to various computational methods applied in molecular and solid-state chemistry and includes 8 hours of practical computational work using these methods. • Quantumchemical basis sets • Wave-function based Hartree-Fock and Post Hartree-Fock methods • Density functional theory • Structural relaxation, vibrations, reaction pathways • Molecular dynamics

Environmental Radionuclides and Nuclear Dating
1.5 ECTS, 1V
• Introduction/Basics • Cosmogenic radionuclides I • Cosmogenic radionuclides II • Natural decay chains I • Natural decay chains II • Nuclear energy • Nuclear accidents • Nuclear weapons • Radiation exposure • Biological radiation effects • Dating I • Dating II • Exercises

Forensic Chemistry and Toxicology
3 ECTS, 2V
• Fundamentals in Forensic Toxicology, Pharmacologic Concepts • Criminal and Accidental Poisoning (Medico-Legal Cases) • Hemp Production, Cannabinoids, Analyses and Pharmacology • Cocaine, Pharmacology, Analyses and Toxicology • Amphetamine, Methamphetamine, Methylenedioxymethamphetamine (MDMA) and other Designer Drugs, Research Chemicals, Doping • Ethyl Alcohol, Gammabutyrolactone (GBL), Gamm hydroxybutyrate (GHB), Pharmacology, Effects on the Body • Opioids, Heroin, Methadone, Buprenorphine, Fentanyl… • Hallucinogens, LSD, Mescaline, Psilocybin… • Driving under the Influence of Ethyl Alcohol, Illicit and Therapeutic Drugs

Fragrance Chemistry
1.5 ECTS, 1V
The lecture provides a journey into the molecular world of scents from the chemical secrets behind Chanel N°5 to structure–odor relationships, industrial processes, and total synthesis of terpenoids. Each subunit is centered on one odorant family and highlights a certain class of chemical reactions, illustrated by prominent perfumery examples. • Historical Introduction (Perkin • Fischer • Fougère • vanillin • aromatic aldehydes) • Coco Chanel: Fatty Aldehydes and Raldeïnes (Darzens • aliphatic aldehydes • ionones • irone • maltol) • From Ionones to Iso E Super and back (Diels–Alder • Iso E Super • Georgywood • Wender • Corey)

- Muguet: Essential but Essenceless (hydroxycitronellal • Enders • Oppolzer • muguet rules • Cope)
- The Sense of Smell (Heck • code of olfaction • Amoore • Rupe • mercaptanes)
- Rose and Rose Ketones (citronellol • rose oxide • Schenk photooxygenation • damascones)
- Metallic-green Pineapples and Leafy Cassis (Dynascone • Sonogashira • undecatriene • theaspiranes)
- Monoterpenes: Isoprene from Head to Tail (terpineol • ketenes • Komppa • pyrolyses • Carroll • (–)-menthol)
- Sesquiterpenes: Cedar, Vetiver and Patchouli (cedrol • khusimone • patchoulol • spirovetivenones • ketols)
- Jasmine: Benzyl Acetate vs. Hedione (Benzyl derivatives • Hedione • jasmon(ate) • Paradisone • Boelens rule)
- Steroids and Sandalwood (Timberol • Suzuki • santalols • isocamphene • campholenal)
- Musks of Nature – Macrocycles (Ruzicka • Carothers • Wilke • Eschenmoser–Ohloff • Dale nomenclature)
- Nitro, Polycyclic and Linear Musks (Carpenter • Galaxolide • horseshoe folding • dienone musks)
- "Marines": Calone 1951, Ambergris and Ketals (Dieckmann • ambreine • Ambrox • Cetalox • amberketals)

Geochronology and Isotope Geochemistry
3 ECTS, 2V
Learning outcome: The students know the essential geochronological methods used to determine cosmo- and geological events ranging in age from the beginning of our solar system to sub-recent times. They are familiar with recent methodological advances and limitations. They have the skills to rigorously evaluate data quality including uncertainties. They also know the key diagrams of geochronological data representation and are able to use them to judge the significance of geochronological data or identify possible sources of inaccuracies. The students are able to asses and discuss the results of published geochronological studies.

Geological Disposal of Radioactive Waste
2.5 ECTS, 10 Tage à 3V
Characterisation of solid wastes, long-term geochemical behaviour in the environment, feasibility of recycling, disposal options, regulations. - Fundamental processes affecting different waste types in the subsurface - Investigation and remediation approaches of waste deposits and contaminated sites - Legislation for waste deposits and contaminated sites in Switzerland

Heterogeneous Catalysis and Sustainable Chemistry (previously called Applied Electrochemsitry II)
3 ECTS, 2V
The lecture course discusses the concepts and applications of heterogeneous catalysts. In particular the role of heterogeneous catalysts for sustainable chemistry and regenerative energy conversion is highlighted. In addition to the basic concepts the synthesis and characterization of (heterogeneous) catalysts is discussed highlighting the importance of in-situ characterization techniques. As applications for heterogenous catalysts, we introduce fuel cells and water electrolyzers as a means of a CO2 free energy cycle.

Homogeneous Catalysis
1.5 ECTS, 1V
Specific topics of modern catalysis including cataytic transfer hydrogenation, hydrogenation, and C–H bond activation (with a thorough introduction into cyclometalation). Upon completion of this course, students are expected to)i) understand and apply the basic concepts of heteroatom-assisted C–H bond activation to predict selectivity and reaction outcome, (ii) apply the mechanistic principles of transfer hydrogenation, and (iii) understand and explain homogeneously catalyzed alkane oxidation

Introduction to Radiopharmaceutical Chemistry
1.5 ECTS, 1V
The lecture will give an overview from radionuclide production to their application in patients. The production of medically relevant radionuclides in cyclotrons, nuclear reactors, and with radionuclide generator systems as well as the synthesis and the preclinical evaluation of newly designed radiopharmaceuticals will be discussed. Translational aspects like GMP (good manufacturing practice) or other pharmaceuticals requirements and the application of radiolabelled pharmaceuticals for diagnosis and therapy of patients will be a further topic of the lecture.

Introduction to the Physics & Chemistry of Surfaces
3 ECTS, 2V
This lecture aims at introducing students to the fundamentals of modern surface physics and chemistry, both emphasising the role surfaces play in the general context of solid state physics & chemistry and demonstrating the importance of surfaces and interfaces in modern nanometre scale science. • Basics of Surface Science • Structure of Solids and Surfaces • Surface Analysis: Experimental methods and examples • Surface Electronic Properties • Elementary Processes at Surfaces: Adsorption and Desorption • Central Concepts in Heterogenous Catalysis • On-surface synthesis

Metal Mediated Synthesis
1.5 ECTS, 1V
This course will discuss advanced topics in the coordination and organometallic chemistry of the d and f-block metals, including metal-metal bonding, cluster formation, ligand effects and small molecule activation, with particular reference to the 4d, 5d, 4f and 5f elements.

Nuclear- / Radiochemistry
3 ECTS, 2V
• Superheavy Elements: Chemistry and Physics - Stability & Production of Transactinides - Accelerators, Targets and Separators - Relativistic Effects - Experimental Methods to Investigate Transactinide Elements - Gas adsorption chromatography – Theory - Gas phase chemical properties of Transactinides

- Energy for the Future: the Nuclear Option
- CO_2, energy and our climate
- Nuclear energy: basics, reactor types, nuclear energy worldwide
- Concerns: the reactor accidents of Tschernobyl and Fukushima
- Concerns: nuclear waste

Nucleic Acid Analaogues
1.5 ECTS, 1V
General aspects of DNA synthesis • Solid phase DNA synthesis • Solid phase RNA synthesis • Nucleic acid structure • Modifications • Natural modifications in DNA and RNA • α-DNA and α-RNA • Hexose nucleic acids • Design Principles • HNA • Bicyclo DNA (bcDNA) • Molecular Beacons • Principles to inhibit protein function • siRNA, miRNA mechanisms • ODN analaogues • tcDNA • Applications with tcTNA • Functional nucleic acids • Properties of unmodified functional nucleic acids • Properties of modified functional nucleic acids • Nucleoside triphosphates

Principles of Nucleic Acids
1.5 ECTS, 1V
• The Chemical Structure of Nucleic Acids • The Double Helix • Alternative Secondary and Tertiary DNA and RNA Structures • Intercalation • Chemical Synthesis of Nucleic Acids • On-line Demo - how to find and visualize nucleic acids structures

Process Chemistry
1.5 ECTS, 1V
The Process Chemistry course will be divided in two main parts, to be delivered in parallel. The first part will introduce, in general terms, the specific considerations for the synthesis of fine chemicals / elaborated active ingredients (AI) on Scale. Dedicated chapters will be (i) Process Safety ; (ii) Selection of synthetic routes, reagents and solvents on scale ; (iii) Practical considerations for operating range, addition, mixing, quenching, extraction and purification. The second part, equal in weight with the first, will consist in real case studies from Pharmaceutical companies, where medicinal chemistry routes towards elaborated AI (marketed or abandoned candidates) were

transformed into manufacturing routes. Those examples were chosen from recent literature to exemplify best the principles taught in the general section. They may also consist of single reaction optimizations, solving specific issues observed during scale up.
During the whole course, emphasis will be put on the deep understanding of the mechanisms of organic reactions shown, allowing for information driven optimization. Else, when chemical hypotheses fail to deliver optimally safe, manufacturing processes, Optimal Design of Experiments and multivariate analysis will be shortly introduced.

Radicals in Organic Synthesis (former Advanced Synthesis)

3 ECTS, 2V

- Introduction
- Tin hydride
- Substitute to tin hydride
- Tin mediated allylation and vinylation
- Atom-transfers
- Barton-decarboxylation
- Deoxygenation
- Xanthates
- Cyclizations
- Rearrangements
- CH-activation
- Homolytic aromatic substitution
- Alkoxyl radicals
- S-Radicals
- Sulfonyl radicals
- Phosphorous radicals
- Boron
- Oxidative Non-chain
- Reductive Non-chain
- Diastereoselectivity
- Enantioselectivity
- Organocatalysis
- Photoredox cazalysis

Scientific Writing

2 ECTS, 1.5V

This is a writing course in academic English at B2/C1 level in the Common European Framework. It is designed to help bio/chemistry students to

- become more familiar with different kinds of writing and writing strategies;
- increase the scope and accuracy of their written English, so that they can write texts in English with reasonable self-confidence
- improve their knowledge of English grammar, vocabulary and style.

Classes are planned to consist of the following activities: text analysis, practice exercises, correction activities, and writing practice.

Specialist Course – Introduction to Medical Radiation Physics
4 ECTS, 3V
The purpose of this course is to provide the students with an introduction to ionizing radiation and its use in medicine and biology. Covered topics include production of radiation, interactions with matter, measurements, and biological effects. Some applications will also be discussed. By the end of the course, students will possess the following knowledge and understanding: • Scientific background related to the practice of medical radiological physics (types of radiation, atomic structure, interaction of radiation with matter, radiological quantities, etc.); • Scientific background related to particle accelerators and detectors in medical applications; • Explain the basis of the biological effects of ionizing radiation and the most relevant models of cellular inactivation; • Explain the basic physics principles of cancer radiotherapy, diagnosis and radiation-protection; • Explain the basic physics principles of medical imaging (CT, PET, SPECT, etc.); • Explain the principles of radiation dosimetry; • Choice of methods for detecting and measuring ionizing radiation exposure; • Explain the principles of therapeutic radiation physics using X-rays, electron and ion beams (hadrontherapy), sealed and unsealed radioactive sources; • Explain the principles and practice of radiation protection, dose limits, screening and protection mechanisms.

Summer Course at Paul Scherrer Institute
2 months (no ECTS anymore, only salary)
Individual projects

Supramolecular Chemistry and Applications of Lipids
1.5 ECTS, 1V
Amphiphile molecules, such as lipids, are chemicals that are both hydrophilic and hydrophobic. This dual nature leads to their self-assembly into various micro- and nanoaggregates in aqueous solutions or in solvent mixtures. Many types of natural molecules (from lipids to proteins) or man-made molecules (e.g., blockcopolymers) possess amphiphilic characteristics, and are therefore able to self-assemble. This property is being exploited in their everyday life applications (e.g., soaps and detergents, ice cream, mayonnaise, cremes, drug delivery systems). In this course, we will review the basic physico-chemical principles that govern lipid self-assembly, and the properties of the resulting aggregates. We will discuss their occurrence in the cellular context and, using selected examples, current and potential applications of amphiphile structures in man-made industrial products (e.g., drug delivery systems, heterogeneous catalysis, synthetic biology and chemistry).

Synthesis of Natural Products (former Biosynthesis and Synthesis of Natural Products)
3 ECTS, 2V
• Secondary Metabolites - The construction mechanisms • The Acetate Pathway • The Shikimate Pathway • The Mevalonate and Deoxyxylulose Phosphate Pathways: Terpenoids and Stereoids • Alkaloids

Legend:

V = Lecture
Ü = Exercises
P = Lab course hours
G = Lecture and exercises mixed
(e.g. 3V = 3 lecture hours per week)

1 ECTS credit point correponds to 25-30 working hours (lecture/lab course + homework).

LECTURES OFFERED IN PREVIOUS YEARS

Applied NMR Spectroscopy
1.5 ECTS, 1V
NMR Spectroscopy • Basic Principles • Two-dimensional NMR spectroscopy • The Nuclear Overhauser effect • Diffusion NMR experiments • Processing of NMR spectra • Description of NMR experiments: the vector model

Chemical Modifications of Proteins
1.5 ECTS, 1V
• Introduction • Classic mutagenesis/unnatural amino acid mutagenesis • Total/semisynthesis of proteins • Chemical modification of nucleophilic amino acids • SAM-mediated modifications • Protein tag-mediated modifications • Metabolic labelling • Click chemistry • Cu-free click chemistry • Staudinger ligations • Other bioorthogonal reactions • Photoaffinity probes • Multimodular probes • Catch & release affinity probes

Chromatographic Analysis
1.5 ECTS, 1V
• Trace Analysis • Qualitative Analysis • Quantitative Analysis • Integration • Sample Preparation

- Quality Management

Crystal Structure Determination (Lab course)
4 ECTS, 16P
This laboratory is a practical course on X-ray single crystal diffraction analysis and crystal structure determination. The labory is divided into experimental and computational parts: • Experimental part: o selection of crystals under polarized light microscope o mounting crystals for X-ray diffraction o data collection • Computational part: o determination of unit cell parameters from precession photographs o determination of Laue classes and space groups o crystal structure solution o crystal structure refinement o analysis of the molecular geometries and the crystal packing structure correlation analysis

Environmental Chemistry
3 ECTS, 2V
• Introduction/ Atmosphere 1 • Atmosphere 2: Stratospheric ozone • Atmosphere 3: Tropospheric ozone, aerosols • Lithosphere: rocks, soils, weathering • Hydrosphere: hydrological cycle, hydrochemistry, marine geochemistry • Natural cycles of nitrogen, phosphorus, sulfur, acid rain • Cycles of Si, Fe, Al, Ca/Mg, Na/K, heavy metals • Ecotoxicology: Emissions, damage of ecosystems, POPs, CFCs, Xenobiotics, waste • Water pollution • Green chemistry • Radionuclides in the environment: Radioactivity, tracing of environmental processes • Carbon cycle, energy and climate • Analytical instrumentation • Stable isotopes in the environment

Enzyme Mechanisms and Enzyme Models
3 ECTS, 2V
• Introduction • Chemical and enzymatic catalysis • Hydrolysis of amide bonds: Mechanism of Proteases • Enzymes for Carbon-Carbon bond formation • Triosephosphate isomerase (TIM) – enzyme perfection • Mechanism of enzymes requiring cofactors • Enzyme models 1 • Mechanism of enzymes in the Shikimic acid pathway • Radicals in enzyme catalysis • Enzyme models 2 • Halogenases and dehalogenases

- Reaction catalyzed by orotidine 5'-monophosphate decarboxylase

Heterocyclic Chemistry
3 ECTS, 2V
1. Starting with simple organic reactions and mechanisms, and comparing the carbocyclic (benzene and derivatives) chemistry, students will learn how to use that knowledge in heterocyclic compounds. 2. By understanding the mechanism of reactions, students will learn to synthesise tailor-made heterocyclic molecules. 3. Main topic is material science and surface chemistry. Students will get familiar with such applications. 4. Students will learn how to synthesize and the functionalisation of their desired molecules, 5-membered (pyrrol, furane, thiophene and related annulated compounds, e.g. indole) and 6-memebered (monoazines: pyridine, pyrimidine, pyridazine, pyrazine and the annulated ones such as quiinoline, isoquinoline, as well as multi-N-containing azines) aromatic heterocyles.

HPLC – From Theory to Instruments to Separations
1.5 ECTS, 1V
• **Theory**: Chromatography, resolution, peak capacity, reduced parameters • **Instrument**: Pumps, injectors, columns, detectors, capillaries, coupling with spectroscopy • **Phases**: Eluents (mobile phases), stationary phases • **Separation modes**: Adsorption, reversed-phase, bonded phases, ion exchange, size-exclusion chromatography, separation of enantiomers • **Separation strategies**: Isocratic vs. gradient

Laser Spectroscopy
3 ECTS, 2V
• Introduction: General principles (Basic principles of lasers, two-level and multilevel systems, three-level systems, four-level systems) • Optical resonators • Frequency selection and frequency tuning

Mass Spectrometry (Lab course)
4 ECTS, 16P
Hands-on training in an analytical laboratory. The course covers modern techniques for sequencing of biopolymers and quantification of small molecules: • High-resolution electrospray tandem mass spectrometry of oligonucleotides • Peptide sequencing by MALDI-TOF-MS/MS • Quantification of drugs by multiple reaction monitoring

Materials Characterization
1.5 ECTS, 1V
Materials science particularly aims at studying processing-structure-property relationships in materials, with a special attention to "microstructure," i.e., how materials are constructed on the microscopic and sub-microscopic (even nanometer) level, and how this affects their properties. This course aims at introducing the student to materials science and making him/her aware of the challenging opportunities this field offers to chemists. By a selection of case-studies, the student will become acquainted with synchrotron and imaging techniques, well-suited for the study of materials.

Particular emphasis will be given to concepts important (but not limited) to materials, such as ”multiscale” properties and material heterogeneity, non-destructive, non-invasive and in-situ analysis, as well as representativity of the analysis (appropriate measurement scale, adequate statistics, issues with beam-induced damages). The student is also expected to learn good practices in material analysis (and science in general), i.e. how to choose analytical techniques relevant to the scientific question, sample the material adequately, perform a minimally invasive measurement and assess the robustness of the analysis.

Materials for Future Energy Technologies
3 ECTS, 2V
A lecture/master course on the chemistry of materials for energy conversion technologies: Topics will include the development, synthesis and characterization of functional materials for the better utilisation of renewable energy sources by understanding structure-composition-property-relations, e.g. of materials applied in improved solar cells, geothermal heat converters, thermoelectric converters, as well as in energy storage materials such as battery materials or hydrogen storage materials.

Measurement Uncertainty in Chemical Analysis
1.5 ECTS, 1V
• Introduction • Uncertainty of volumetric operations • Uncertainty of weighing operations • Uncertainty of the purity of chemicals • Uncertainty of molecular weights • Uncertainty of recovery • Uncertainty of calibration functions • Useful tools • Detailed example: Uncertainty of an analytical method

Methods for Molecular Simulations
3 ECTS, 2V
The aim of this course is to present to students the state-of-the-art in molecular modeling research. Critical assessments of different methodologies, with direct comparisons, and description of their strengths and pitfalls are done. A pool of possible subjects is presented to students (i.e., from excited state calculations, to protein folding, enzyme reactions etc). According to the specific interest of the students, the subjects of the course are decided at its beginning. The number of frontal lectures is limited to the minimum necessary to introduce basic concepts. The rest of the course is based on reading, presenting and discussing selected research papers on the various subjects of interest by the students. The course is addressed also to non-specialist students, i.e., students with a strong experimental profile. Possible topics of the course are: • Excited states dynamics • Density Functional Theory for intermolecular forces • Enhanced sampling techniques for exploration of the conformational-space • Simulations of chemical reactions and activated processes • Enzymatic catalysis • Protein folding • Protein-ligand interactions

- Large-scale simulations

Modern Methods in Chemical Information
1.5 ECTS, 1V
• Introduction: Organization of Chemical Information • Planning the Course: Information Sources Case Studies: • Organic Compounds • Coordination Compounds • Inorganic Compounds • Substructure and Data Search • Preparation and Reactions This core program is modified/augmented according to the interests of the participants, with topics like Synthesis Planning, Patents, Topic (Keyword) Searching, Author Searching, Sequences of Biopolymers, Polymers, etc.

Neurochemistry
3 ECTS, 2V
• The cellular foundations of nervous system function • Synaptic transmission • Intracellular signaling • Acetylcholine – the transmitter which made history • Glutamate is exciting! • GABA – the brake in the brain • Modulating neurotransmitters • Atypical signaling in the nervous system • Food for thought (energy metabolism in the brain) • Long-term synaptic changes. The biochemistry of learning and memory • Neurodegenerative diseases (Parkinson's, Alzheimer's) • The biochemistry of schizophrenia • Pain and sensory perception

Nuclear and Radiochemistry (Lab course)
4 ECTS, 16P
• Thermochromatography (University of Bern) • Isotope exchange with radiotracers (University of Bern) • Neutron activation analysis (University of Basel) • Ion beam analysis (ETH) • Radiochemistry in atmospheric science (PSI)

Principles of Materials Science
3 ECTS, 2V
This master lecture presents an introduction to tensorial properties of materials, namely dielectrics. Theoretical models allowing a design of polar materials are discussed along with crystal growth methods.

Solid State Chemistry – Theoretical and Experimental Structural Investigations
3 ECTS, 2V
Part 1 • Thermodynamics in solids • Calorimetric techniques • Techniques to determine Solid state structures • Reaction in solid states • Optical / Electronic / Mechanical properties of materials Part 2 • DFT / Solids • Molecular Dynamics & Phase Transitions • Crystal Properties • Forces • Statistical Mechanics

Statistical Mechanics and Thermodynamic
3 ECTS, 2V
This lecture provides some bases on the theories linking microscopic to macroscopic description of matter. • Dynamical systems. • Microcanonical Ensemble • Canonical Ensemble • Grand-canonical Ensemble • Quantum-statistical mechanics • Molecular partition functions

Surface Electrochemistry
3 ECTS, 2V
The lecture course represents an introduction into basic concepts and applications of Surface Electrochemistry. We will discuss properties of electrolytes, electrodes and of the interface based on theoretical concepts and experimental investigations. Classical approaches will be combined with structure sensitive techniques, such as scanning tunneling microscopy, infrared and Raman spectroscopy as well as surface X-ray scattering. The in-class sessions will be accompanied by a lab-based tutorial on metal single crystal preparation and electrochemistry. • Introduction • Electrolytes (PCIV) • Electrochemical Double Layer • The Electrode Surface • (Single) Electrodes and Electrode Preparation • Cyclic Voltammetry – The „Spectroscopy“ of the Electrochemist • The Electrochemical Experiment (Lab Demonstration) • Concepts of Specific Adsorption • Specific Adsorption – Molecules • Scanning Tunneling Microscopy (STM) • Atomic Force Microscopy (AFM) • Vibrational Spectroscopy at Solid/Liquid Interfaces I (Infrared) • Vibrational Spectroscopy at Solid/Liquid Interfaces II (Raman)

- Surface X-ray Scattering
- Project Work (Blocks 8 to 14)

Transporter Biology + Chemistry
3 ECTS, 2V
• Introduction on membrane transport / TransCure + Human diseases caused by ion channel dysfunction - Channelopathies • Mechanisms of transmembrane ion transport • ATP-binding cassette (ABC) transporters: Physiological functions, structures, mechanisms • Structure and mechanisms of ligand and voltage sensing in potassium channels • Structure and function of amino acid transporters • ATP-binding cassette (ABC) transporters: clinical significance • Physiological role of sodium/proton exchangers • Transporters and cancer: it works both ways • Vesicular transporters as potential targets in brain pathologies • The Swiss Kidney Project on Genes in Hypertension (SKIPOGH) • Role of transporters in drug disposition • Drug discovery in the area of transporter modulators • Natural products as leads in drug discovery • Bioorthogonal chemistry and other chemical tools to study transmembrane proteins