Faculty of Chemical Technology and Biotechnology

IMPORTANT NOTES

If for one subject you can find several different types (lecture, practice, laboratory) of courses then please choose one and only one course from each type in order to be able to perform the subject's requirements successfully.Civil Engineering courses are on the website seperately. Courses chosen from the offer of Faculty of Civil Engineering will be checked and arranged individually by the departmental coordinator.

Subject code	Subject name	Requirement	ECTS credit
BMEVEBEA301	Biochemistry	Exam	4

Course type	**Course code**	**Course language**	**Timetable information**
Lecture	A10	English	MON:15:15-18:00(CH307)

The subject (biochemistry) does not aim at giving comprehensive biochemistry knowledge. Instead it would like to give a short overview of the biochemical pathways and their connections. The first part gives basic knowledge from the field of basic cell biology. The second part focuses to the basic principles of enzymology and bioenergetics. This part gives background to the metabolic processes discussed in the third block. The energy producing processes such as the oxidative phosphorylation and the photosynthesis is embedded into this metabolic part. This metabolic part is followed by the forth, last part which discuss the basics of molecular biology.#160;

Subject code	Subject name	Requirement	ECTS credit
BMEVEFAA306	Plastics	Mid-semester mark	5

Course type	**Course code**	**Course language**	**Timetable information**
Laboratory	lab-ENG	English	FRI:13:15-17:00(HF4)
Lecture	theory-ENG	English	MON:08:15-10:00(CH308)

Introduction. Position and development of the plastics industry, the role of plastics in the economy. Definition: macromolecule, polymer, plastic, additives, other ingredients. Types of plastics: linear and cross-linked polymers, elastomer, engineering plastics. Properties of polymers and their modification. Outline of the subject, key questions (chemistry, physics, processing, application, environmental issues).2.#160;#160; Polymerization. Radical polymerization. Basic reactions: initiation, chain propagation, chain transfer, termination. Polymerization technologies: gas phase, emulsion, suspension, bulk. Copolymerization, relative reactivity. Ionic polymerization. Stereospecific polymerization.3. Polycondensation, cross-linked polymers. Functionality, average functionality. Molecular mass and functionality, criterion of cross-linking and the production of cross-linked polymers. Materials, short introduction to the most frequently used polymers. Thermoplastics: PE, PP, PVC, PS and its copolymers. Engineering plastics: PC, PET, PA. Thermoset resins: pheno- and aminoplasts, epoxy resins, polyesters, polyurethanes. Elastomers and rubbers. 4#160;#160;#160; Polymer physics. Conformation, the freely-jointed chain model, factors hindering conformational changes. Radius of gyration, chain-end distance, entanglements. Polymer solutions, phase diagram, solubility. Several methods to determine molecular weight. The behavior of solid polymers, rubber elasticity.5.#160;#160; Deformation and fracture. Gas, liquid and solid state. Physical states. Crystalline and amorphous materials. Themomechanical traces, transitions. Melt rheology, flow, viscosity, shear dependence. Phenomenological models, viscoelastic deformation. Unidirectional deformation, stress vs. strain traces, necking. Fracture, brittle and plastic fracture, stiffness-impact resistance correlations.6.#160;#160; Correlation of structure and properties. Relationship of the molecular and macroscopic structure of plastics, characteristic temperatures, properties. Plasticization. Semi-crystalline polymers. Crystallization, melting, polymorphism. Nucleation. Correlation between crystalline structure and properties. Structure of amorphous polymers. 7.#160;#160; Modified polymers. Polymer blends, miscibility, compatibility. Particulate filled polymers, correlation between component characteristics and composite properties. Reinforcing with short and long fibers. Micromechanical deformation processes. Structure and properties. Influence of interfacial interactions.8.#160;#160; Processing of thermoplastics. Physical states and processing technologies. Melt processing, the role of viscoelasticity. Extrusion, injection molding, blow-molding, calendaring. Processing in the rubber elastic state: thermoforming. Machining.9.#160;#160; Other processing methods and products. Fiber spinning, foams, membrane technology. Reactive injection molding. Processing of cross-linkable resins. Molding epoxy resins, impregnation, polyester resins reinforced with glass fibers and mats. Phenoplast and aminoplast boards. Rubber technology, tires. Lacquers, adhesives.10. Application of plastics. Types of plastics used as packaging materials, the corresponding processing technologies, products. The most important characteristics of plastic packaging materials (mechanical properties, aesthetics, permeability, additives, lifetime, etc.). Aspects used in the selection of plastic packaging materials (properties, economy, regulations). Packaging of food and drugs. Legal aspects of using plastic packaging materials. Automotive industry. Body and body parts, bumpers. Suspension, vibration and sound insulation. Under hood parts. Lights and other electric parts. Instrument panel, seats, floor, trunk. Electronics, informatics. Insulators and conducting plastics. Non-linear optical plastics. Light sensitive, piezoelectric and liquid crystal polymers. Household equipment, bowls, plates, utensils. Chemical industry, pipes, pumps, heat exchangers. Agriculture: green houses, irrigation systems, artificial insemination, animal identification plates. Healthcare: disposable products, catheters, etc. Building industry: pipes, wall paper, profiles, electrical parts, etc. 11. Degradation, stabilization, additives. Reasons of degradation: heat, light, oxidation, irradiation. Mechanism of degradation, chain scission, elimination, depolymerization. Type of additives: additives maintaining (stabilizers, lubricants) or modifying properties (plasticizers, fillers, colorants, blowing agents, impact modifiers, etc.). Role and mechanism of additives.12. Plastics and the environment. Plastic waste. Life cycle analysis. Methods of waste disposal: incineration, chemical decomposition, reprocessing, dumping. Technical and financial questions of reprocessing. Natural polymers and components: starch, cellulose, wood flour. Biodegradable polymers: properties and economy. Legal issues related to the handling of plastic waste. #160;Laboratory practice1.#160;#160; Introduction. Presentation of the goals and method of lab practice. Instructions for the preparation of the reports and information about individual questions. Aspects of the evaluation of the work done in the lab and of the report. Information about the prevention of accidents and fire in the lab.2.#160;#160; Identification of plastics. Application of rapid methods for the identification of unknown plastics. Identification based on visual inspection and the burning test (way of burning, odor of burning material, pH, dripping). Identification of heteroatoms, solubility and density. 3.#160;#160; Thermal analysis of polymers. Application of differential scanning calorimetry (DSC), polarization optical microscopy, thermo-optical methods for the study of plastic products. Differences between crystalline and amorphous polymers, analysis of correlations between structure and application properties. 4.#160;#160; Mechanical properties of plastics. Tensile testing of amorphous and crystalline polymers and copolymers, evaluation and interpretation of tensile characteristics. Application of dynamic mechanical thermal analysis (DMTA) for the determination of the relaxation transition of polymers (demonstration). 5.#160;#160; Extrusion of thermoplastics. Introduction to the construction and operation of the extruder. Processes taking place in the extruder and the factors determining them. Similarities and differences in industrial and laboratory extrusion. Correlations between the technological parameters of the extrusion and the properties of the product. 6.#160;#160; Injection molding of thermoplastics. Parts, construction and operation of injection molding machines. Detailed presentation of processes taking place during injection molding. Structure and properties of injection molded parts. Effect of injection molding technology on the properties of injection molded parts.7.#160;#160; Plastic foams. Production of foams with physical and chemical blowing agents. Preparation of foamed polystyrene blocks. Production of soft and rigid polyurethane foams. Characterization of the structure of the foam. #160;

Subject code	Subject name	Requirement	ECTS credit
BMEVEFAA405	Physical Chemistry II	Exam	4

Course type	Course code	Course language	Timetable information
Lecture	A6-ER	English	TUE:08:15-11:00(CH307)
Practice	A7-ER	English	TUE:08:15-11:00(CH307)

Kinetics: rates of chemical reactions#160;#160; #160;–#160;#160; #160;Definitions: molecularity, order of reactions, rate of reaction. Zero-order reactions, first-order reactions, second-order reactions.–#160;#160; #160;Equilibrium reactions. Consecutive and parallel reactions.–#160;#160; #160;Homogeneous catalytic reactions, autocatalysis, enzyme kinetics, oscillating reaction.–#160;#160; #160;Temperature dependence, collision theory, transition-state theory.–#160;#160; #160;Determining the order and rate constant of a reaction.–#160;#160; #160;Kinetics of heterogeneous reactions.–#160;#160; #160;Kinetic salt effects.Electrochemistry#160;#160; #160;–#160;#160; #160;Chemical potentials and activities in electrolyte.–#160;#160; #160;The electrochemical potential.–#160;#160; #160;Electrochemical cells.–#160;#160; #160;Thermodynamics of Galvanic cells, the Nernst equation.–#160;#160; #160;Electrode potentials.–#160;#160; #160;Types of electrodes.–#160;#160; #160;Membrane potentials, glass electrodes.–#160;#160; #160;Conductivity of electrolytes.–#160;#160; #160;Electrode kinetics and polarization.–#160;#160; #160;Corrosion, Protecting against corrosion.Transport phenomena–#160;#160; #160;Definitions, thermodynamic driving forces.–#160;#160; #160;Laws of diffusion: Fick laws, statistical view, steady state diffusion.–#160;#160; #160;Heat conduction.–#160;#160; #160;Viscosity, newtonian and non-newtonian fluids.Physical Chemistry Calculations in kinetics and electrochemistry#160;

Subject code	Subject name	Requirement	ECTS credit
BMEVEFAA506	Physical Chemistry Laboratory Practice	Mid-semester mark	3

Course type	Course code	Course language	Timetable information
Laboratory	A0	English	THU:08:15-12:00(F11FK)

Introductory lecture: students are introduced with the basics of experimental procedures in determination of physicochemical properties of materials, types of experimental errors, calculation and characterization of errors and presentation of experimental results. Mathematical statistics (probability, deviation) will be discussed shortly.The practical part of the subject consists of 8-10 practices in small groups (6 students in one group) which will be chosen from the following practices at the beginning of each semester. Each practice aims to improve the skills of students in individual work, arranging of experimental setups and critical evaluation of results. The knowledge covers various fields in thermodynamic and kinetics as it follows.1. Determination of apparent heat of evaporation in a one-component system. Various organic solvents will be characterized by using the Clausius-Clapeyron-equation and several possible experimental errors will be considered during the measurement. The method of linear least squares regression is used for evaluation.2. Phase equilibrium in liquid-liquid two-component systems. Two-component systems displaying either LCST or UCST will be investigated and the composition-temperature phase diagram will be constructed. Component balance equation will be discussed and used to determine the volume ratio of phases.3. Adsorption. Two different experiments will be introduced: nitrogen gas adsorption and adsorption of diluted solutions on the carbon surfaces. Theoretical background and limits of the methods will be discussed and results of the methods will be compared with a critical viewpoint.4. Determination of the molecular weight of a linear macromolecule using viscosimetry. The terms dynamic, relative, specific and intrinsic viscosity will be introduced and discussed. The molecular weight of a chosen neutral polymer will be determined by the measurement of its relative viscosity by a capillary viscosimeter. Experimental error and its effect on the molecular weight will be characterized.5. Rheology.#160; Flow and viscosity curves will be discussed and classified. Newtonian and thixotropic fluids will be investigated by using an Ostwald and a rotational viscosimeter. 6. Calorimetry. Various calorimetric methods will be introduced. Heat of an acid-base reaction will be determined by an adiabatic calorimeter while specific heat capacity of an organic liquid will be determined by a heat transfer calorimeter. Experimental results will be compared with literature data. 7. Conductivity of electrolyte solutions. The basics of conductometry will be introduced and the terms conductivity, specific and molar conductivity will be discussed. The degree of dissociation of a chosen electrolyte will be determined by the measurement of conductivity and thermodynamic functions for the dissociation (enthalpy, Gibbs free energy and entropy) will be calculated.8. Rate constant of iodination of acetone. Basics of reaction kinetics (order, rate constants) will be discussed and the reaction rate constant of a simple chemical reaction will be determined by concentration measurements as a function of time with titration. The rate-limiting reaction step will be determined by linear plot.9. Order of a component in kinetics of decomposition of hydrogen peroxide.#160; Reaction rate of the peroxide will be calculated from the flow rate of the product (oxygen gas) in a continuous reactor. Order of the kinetics will be determined.#160; #160;10.Kinetics of reaction between ions. Basic of reaction kinetics and the effect of inert ions on reaction rate will be discussed. A simple ion reaction will be investigated and reaction time will be determined by using a colour indicator of reaction end. Reaction rate constant will be determined and the effect of experimental errors will be analysed. 11. Electrochemistry. Both electrochemical equilibrium and kinetics of an electrochemical reaction will be investigated. A simple galvanic cell will be constructed and the validity of the Nernst-equation will be analysed in a wide concentration range of components. Polarization of an other cell will be characterized by recording the polarization curve and the Tafel plot of an electrochemically active organic compound.#160;

Subject code	Subject name	Requirement	ECTS credit
BMEVEFAM201	Physical chemistry and structural chemistry	Exam	5

Course type	**Course code**	**Course language**	**Timetable information**
Lecture	A0-ER	English	WED:14:15-17:00; THU:11:15-13:00

The subject deals with the theoretical foundations of chemistry and the experimental and calculation methods that present information about the structure and properties of molecules and molecule ensembles.1.#160;#160;#160;#160; Interactions of atoms and molecules with particles and external fields#160;1.1.#160;#160; Research and its application#160;1.2.#160;#160; Interactions with particles#160;1.3.#160;#160; Interactions with electric field#160;1.4.#160;#160; Interactions with magnetic field#160;1.4.1. Elementary magnets#160;1.4.2. Diamagnetism#160;1.4.3#160; Precession#160; magnetic moment#160;1.4.4. Paramagnetism#160;1.5.#160;#160; Interactions with magnetic waves#160;1.6.#160;#160; The electromagnetic spectrum#160;#160;2.#160;Structure and properties of atoms#160;2.1.#160;#160; Introduction#160;2.2.#160;#160; The hydrogen atom#160;2.2.1. The structure of the hydrogen atom#160;2.2.2. Angular and magnetic moments of the hydrogen atom#160;2.2.3. Selection rules of the hydrogen atom#160;2.2.4. The electronic spectrum of the hydrogen atom#160;2.3.#160;#160; Many-electron atoms#160;2.3.1. Hydrogen-like atoms#160;2.3.2. Other many-electron atoms#160;2.3.3. Interaction with external magnetic field#160;2.3.4. Interaction with external electric field#160;2.3.5. Interpretation of the electronic spectra#160;2.3.6#160; The measurement of the atomic spectra#160;2.4.#160;#160; Ions#160;2.4.1. Ionization#160;2.4.2. Interactions of ions#160;#160;3.#160;Structure and properties of molecules#160;3.1.#160;#160; Molecular symmetry#160;3.1.1. Symmetry elements and symmetry operations#160;3.1.2. Point groups#160;3.1.3#160; Representations of point groups#160;3.2.#160;#160; The electronic structure of molecules#160;3.2.1. Construction of molecular orbitals#160;3.2.2. The symmetry of molecular orbitals#160;3.2.3. Localized molecular orbitals#160;3.3.#160;#160; The covalent bond#160;3.3.1. The characteristics of the covalent bond#160;3.3.2. The structure of two-atomic molecules#160;3.3.3. Hybridization#160;3.3.4. Delocalized systems#160;3.3.5. Complex compounds of the transition metals#160;3.4.#160;#160; The rotation of the molecules#160;3.4.1. Introduction#160;3.4.2. Rotational motion of diatomic molecules#160;3.4.3. The rotational spectra of the diatomic molecules#160;3.4.4#160; The rotational spectra of polyatomic molecules#160;3.5.#160;#160; The vibration of molecules#160;3.5.1. Vibrational motion of diatomic molecules#160;3.5.2. Vibrational spectra of diatomic molecules#160;3.5.3. Vibrations of polyatomic molecules#160;3.5.4. Vibrational spectra of polyatomic molecule#160;3.5.5. Non-linear spectroscopy#160;3.5.6. Other vibrational spectroscopic methods#160;3.5.7. Large amplitude motion#160;3.6.#160;#160; Electronic transitions in molecules#160;3.6.1. The excitation of the electrons#160;3.6.2. The types of electronic transitions#160;3.6.3. The excited state and its decay#160;3.6.4. The electron excitation spectrum and the substituent effect#160;3.6.5. Measurement and application of electron excitation spectra#160;3.6.6. Ultraviolet photoelectron spectroscopy (UPS)#160;3.7.#160;#160; The dispersion of light#160;3.7.1. The dispersion of the refractive index#160;3.7.2. Electron excitation with polarized light#160;3.8.#160;#160; Mass spectroscopy (MS)#160;3.8.1. The principle and instrumentation of mass spectroscopy#160;3.8.2. Applications of the mass spectroscopy#160;3.9.#160;#160; Paramagnetic properties of molecules#160;3.9.1. Paramagnetic molecules#160;3.9.2. Electron spin resonance#160;3.10. #160;Nuclear magnetic resonance (NMR)#160;3.10.1.#160;#160; The nuclear magnetic resonance#160;3.10.2.#160;#160;#160; Spin-spin interactions#160;3.10.3.#160;#160;#160; 13C-NMR spectroscopy#160;3.10.4.#160;#160;#160;#160;

Recording NMR spectra#160;3.10.5.#160;#160;#160;#160; The Overhauser effect (NOE) #160;3.10.6.#160;#160;#160;#160;#160; Relaxation processes#160;3.10.7.#160;#160;#160;#160;#160; Measurement of the relaxation processes#160;3.10.8.#160;#160;#160;#160;#160; Two-dimensional NMR spectroscopy#160;3.11.#160;#160;#160;#160;#160;#160;#160;#160; Diffraction methods in the molecular structure elucidation#160;3.11.1#160;#160;#160;#160;#160;#160; Introduction to the diffraction methods#160;3.11.2#160;#160;#160;#160;#160;#160; Scatterings on isolated molecules#160;3.11.3#160;#160;#160;#160;#160;#160; Electron diffraction in gas phase#160;3.11.4#160;#160;#160;#160;#160;#160; The character of the measured and calculated geometric parameters#160;#160;4.#160;The structure of atomic and moleclar ensembles#160;4.1.#160;#160; Intermolecular interactions#160;4.1.1.#160; The theoretical description of the intermolecular interactions#160;4.1.2#160; The types of intermolecular interactions#160;4.2.#160;#160;#160; The structure of molecular ensembles#160;4.2.1.#160; Liquid state models#160;4.2.2#160;#160; The structure of liquids#160;4.2.3.#160; The solid crystalline phase#160;4.2.4#160;#160; Conductors, semiconductors and insulators in solid state#160;4.3.#160;#160;#160;#160; Diffraction methods#160;4.3.1.#160; Diffraction methods in the structure investigation of ordered systems#160;4.3.2.#160;#160;#160; Methods of X-ray diffraction#160;4.3.3.#160;#160;#160; Methods of electron diffraction in solid state#160;4.4.#160;#160; Spectroscopic methods #160;4.4.1.#160;#160;#160;#160; X-ray photoelectron spectroscopy (XPS) #160;4.4.2.#160;#160;#160;#160; Auger-electron spectroscopy (AES)#160;4.4.3#160;#160;#160;#160;#160; Secondary ion emission mass spectrometry (SIMS)#160;4.4.4.#160;#160;#160;#160; Mössbauer spectroscopy#160;4.4.5.#160;#160;#160;#160; Vibrational spectroscopy in condensed phases#160;#160;

Subject code	Subject name	Requirement	ECTS credit
BMEVEFAM212	Biopolymers	Exam	4

Course type	Course code	Course language	Timetable information
Laboratory	lab-ENG	English	
Lecture	theory-ENG	English	TUE:14:15-16:00(HF2)

Biopolymers are polymers arising in living organisms (e.g. microorganisms or higher order plants and animals) or synthesized from bio-based building blocks (e.g. acids, amino acids, carbohydrates, natural triglycerides) in a chemical process. The course introduces the students to the most significant biopolymers, their chemical structure, properties and the most important applications. #160;

Subject code	Subject name	Requirement	ECTS credit
BMEVEFAM503	Nonconventional Materials	Mid-semester mark	3

Course type	Course code	Course language	Timetable information
Lecture	A0	English	THU:12:15-14:00(HF2)

In the modern materials science the main goal is designing materials to accomplish multiple properties in a single system. Usually these materials can respond to environmental stimuli by exhibiting particular changes in some of their properties. The aim of this course is to provide theoretical and practical knowledge in the chapters of modern materials science based on the colloids science (“the world of nano”), surface chemistry and physical chemistry of polymers. #160;1. Introduction:History and definitions.2. Nonconventional hard materials:Metal foams: preparation and application. Shape memory: shape memory alloys, shape memory polymers. Their response to the envi-ronmental stimuli. Structure-property correlations. Application.Special technical ceramics: Piezoelectric and magnetostrictive materials, structure-property correlations. Application.3. Complex fluids:Different types of magnetic behavior. Preparation, structure and properties of ferrofluids, magneto- and electrorheological fluids. Biomedical and industrial applications. 4. Soft materials, polymer gels:Classification, synthesis and characterization of polymer (hydro)gels. Tough hydrogels. Re-sponsive polymer gels. Applications of the responsive polymer gels, focused on the biomedical applications.5. Self-assemblySelf-assembly as a universal process. Molecules and particles capable of self-assembly. Clas-sification of self-assembly processes. Practical importance of self-assembly: Coatings and thin films made with self-assembly. LBL-techniques (layer-by-layer). Langmuir- and Langmuir-Blodgett thin films. 6. Nanoparticles, nanocoatingsFunctional nanoparticles and nanocoatings, their synthesis using wet colloid chemical meth-ods. Properties of nanoparticles, quantum size effects. Core-shell and hollow nanoparticles. Biomedical applications of nanoparticles. The sol-gel method. Characterization of nanocoat-ings – optical methods (optical spectroscopy, scanning angle reflectometry, ellipsometry.)7. Applications of nanocoatings Morphology and water-repellent properties: superhydrophobicity. Wetting models. Self-cleaning, self-healing coatings. Adhesive nanostructured coatings. Coatings and thin films in solar cells. Biomedical applications of nanocoatings.8. Porous nonconventional materials:Classification and characterization (rigid and flexible pores, independent pores vs. pore net-works, composites, possible applications). Brief description of characterization methods and their complementarity.9. Use of templates for porous materials:Soft and hard templates; synthesis, (MCM, zeolites, MIP): Synthesis; new properties related to porosity. 10. Nanotubes (carbon, boron, noble metal, etc); carbon allotropes:Synthesis, physical and chemical properties, present and perspective applications11. Organic and inorganic aerogels:Synthesis; new properties introduced by porosity (thermal and electric conductivity, etc.). 12. Metal organic frameworks (MOFs):3D self-assembly of multivalent metal ions and organic ligands; stiff and flexible porosity; their potential in gas storage, sensing, etc.#160;

Subject code	Subject name	Requirement	ECTS credit
BMEVEKFA513	Theory of Separation Processes and Reactors	Exam	4

Course type	Course code	Course language	Timetable information
Lecture	eng_th	English	THU:12:15-15:00(CH307)
Practice	eng	English	THU:12:15-15:00(CH307)

Characterization and calculation of liquid-liquid and gasliquid-liquid equilibria. Equilibrium ratio, vapor tension, Antoine equation, Raoult-Dalton equation, relative volatility, bubble-point calculations, phase distribution calculations.Use of binary phase plots and equlibrium plots, use of ternary phase plots. Single stage equilibrium distillation and flash. Simple distillation. Rayleigh equation, vapor consumption.Steam distillation. Continuous multistage distillation. Reflux ratio. MESH equations. CMO. Upper and lower operating lines. Q-line. Graphical determination of the theoretical number of stages. Graphical determination of the minimum numberof theoretical stages. Fenske equation. Minimum reflux#160; ratio, graphical construction. Relations between number of stages, reflux ratio, and product purity. Plates and packings. Stage efficiency, HTU, NTU, HETP. Column capacity. Batch rectification with constant reflux ratio and with constant purity. Azeotropic and extractive distillation methods. Pressure swing distillation. Absorption. Kremser-Souders-Brown equation.Liquid extraction. Equilibrium ratio, distribution ratio, and phase ratio. Simple extraction. Repeated extraction. Perkolation. Continuous countercurrent multistage extraction.Counter-solvent extraction. Devices. Computation with constant equilibrium ratio, graphical constraction with constant phase ratio and with non-constant phase ratio.#160;

Subject code	Subject name	Requirement	ECTS credit
BMEVEKFMBR1	Environmentally Benign and Catalytic Processes	Exam	4

Course type	Course code	Course language	Timetable information
Lecture	eng_ER	English	FRI:08:15-11:00

National and international activities with respect to environmental programs. "Clean" technologies. EU directives, tendencies, regulations. Clean air projects, activities, processes. Classification of air pollutants, intervention places, exhaust reduction. Water quality control, physico-chemical treatment of waste waters, WAO, stripping with air or steam. Clean technologies, supercritical solvents and processes. Membrane processes, case studies. Catalytic processes, working mode of catalysts, kinetics, catalyst preparation, testing, modification, catalyst poisons, catalytic reactors, economics of catalytic processes. Catalytic processes in environmental technologies, automotive catalysis, fuel-cells, hydrogen and methanol economy. #160;

Subject code	Subject name	Requirement	ECTS credit
BMEVEMBM501	Environmental toxicology	Mid-semester mark	3

Course type	Course code	Course language	Timetable information
Laboratory	A9	English	TUE:10:15-12:00
Lecture	A10	English	TUE:10:15-12:00

Environmental toxicology as part of the risk-based environmental management plays an increasingly important role. The main aim of the subject is to give an overview on the effect-based tools of the modern environmental risk management. The course covers both the theoretical background and the detailed practical aspects of environmental toxicology together with its applications in the risk assessment, risk management and in the environmental decision making. TheoryThe role of environmental toxicology, environmental toxicology in risk-based environmental management, the basics of environmental toxicology, the effects of toxic substances and the measurement of the effects.Classification of environmental toxicity methods: generally applicable methods to water, soil, sediment, methods suitable to pure chemical substances, test organisms, measurement and study endpoints for measurement of the effects and chemical substances and contaminated environmental elements.Studying of the interaction between chemical substances and the environment, measurement of the actual toxicity of chemical substances, selection of test methods suitable for the environmental problem, test battery for integrated monitoring. #160;Detailed description of ecotoxicity test methods applied to water, sediment and soil. Single species ecotoxicity tests with bacterial, plant, animal test organisms. Multispecies environmental toxicity methods: microcosm, mesocosm tests, field studies. Genotoxicity and mutagenicity studies. Innovative and alternative environmental toxicity test methods replacing animal testing.Evaluation, interpretation and utilisation of environmental toxicity results in the integrated assessment of contaminated sites, in integrated environmental monitoring, in the general risk assessment of chemical substances, in the derivation of environmental quality criteria and#160; limit values, in the local and site specific risk assessment of contaminated sites and generally in environmental management.The concept and methodology of environmental and human health risk assessment of chemical substances. Environmental risk assessment of contaminated sites: methods, examples, case studies. Laboratory practice The students will learn about five various topics within the laboratory practice of this main subject.1. Environmental toxicity test methods with aquatic test organisms. We may test the adverse effects of chemical substances on the water ecosystem with test organisms from various trophic levels. #160;The most common test methods include: alga test, single cell animal (pl. Tetrahymena pyriformis) test, plant test (ex. tiny duckweed), animal test (ex. fresh water shell-covered crustacean (Ostracoda), water flea).2. Respiration measurement of soil microflora in a dynamic and a static system. The activity of soil microflora can be studied by measurement of the amount of CO2 produced by soil microbes in a dynamic (ventilated) and static (closed bottle test) system. The methods are suitable for monitoring of bioremediation.3. Microbiological studies of soil hygiene. Soil microorganisms are involved in numerous essential processes. There are various techniques for their quantitative and qualitative study.#160;4.#160;#160;Aliivibrio fischeri bioluminescence inhibition test. Aliivibrio fischeri is a marine bacterium, which emits light under favourable conditions. Light emission is inhibited in the presence of toxic substances, which can be detected by luminometer5. Plant germination and Collembola mortality test. Terrestrial plants represent one of the most important trophic level, the producers. They can be used for ecotoxicity testing of both waters and soils polluted with toxic substances. Folsomia candia (Collembola), the ancient springtails insect can be used for testing of soils polluted with organic contaminants.#160;

Subject code	Subject name	Requirement	ECTS credit
BMEVESAA101	General Chemistry	Exam	5

Course type	**Course code**	**Course language**	**Timetable information**
Lecture	A22-ER	English	MON:12:15-14:00(CHA10); THU:10:15-12:00(CHA10)

The basics of chemistry. The structure of the materials. Mixtures and compounds. The concept of equilibra. Conservation principles. The concept of mol. Chemical changes and chemical equations. Stochiometry. Oxiadation and reduction, redox processes. The oxidation number, and its use in balancing chemical equations. #160;(6 hours) Characterization of the gasous states. Macroscopic description and microscopic understanding. Laws governing the gaseous state, boundary conditions, the ideal gas law. Characterization of the liquid and solid states. Lattice types. Phase diagram of pure materials. Laws for phase equlibra. Vapour tension. The phenomena of boiling and melting. Non-equlibrium processes. Laws of mixtures of materials. Mixtures of gases, liquids and solids. Phase diagrams of binary mixtures. Distillation, rectification, crystallization as purification processes. Freezing point depression, boiling point elevation, laws of the osmotic pressure. Determination of the molecular weigth. Limitations. #160;(6 hours)The basics of the thermodynamics:Extensive and intensive measures. The concept of energy. Chemical equlibra and its relation to the energy. Thermochemistry, Heat. Definitions: heat of formation, heat of combustion, reaction energy. Hess’s law. Chemical systems and chemical equlibria. Equlibrium constant. Gaseous equlibria, Equlibria in the liquid phase. Heterogenous equlibria. Equlibria of electrolytes. The concept of pH. pH equlibria. Weak acids and bases, acidity and basicity strength. Hydrolyzing salts of weak acids and bases. Water as a specific case. Buffer solutions. Titration of weak acids. Acid-base indicators. The Solubility product constant. Coupled equlibria. (16 hours)#160;Acid base theories. Acid-base theory of Arrhenius, wateric solutions. The Bronsted acid base theory. Acidity as a relative measure, weak and strong acids. The Lewis acid-base theory, relation to complex formation and to the Bronsted theory, superacids. (2 hours)Basics of electrochemistry. Electric energy: potential and charge. Faraday’s law, the conservation of the charge. Conductivity. The additivity of the specific conductivities in dilute solutions. The electrode potential, concept, measurement, the hydrogen electrode, relatio to pH. Nernst’s equation. The relation of the elecrode potential to the redox properties. Galvanic cells, batteries. #160; #160;(12 hours).The kinetics of chemical reactions. Definitions: reaction rate, rate constant, concentration dependence. Reaction order and molecularity. Reaction mechanisms. Activation barrier and the law of Arrhenius. The principle of catalysis. Remarks on the thermodynamics and kinetics.#160;(2 hours)The structure of matter.#160; #160;The experimental reasults leading to the quantum mechanics, quantized physical properties (atomic spectra, photoelectric effect, Rutherford’s experiment). The electronic structure of the hydrogen atom: orbitals, energies, electron density, (quantum numbers). Heavier atoms. The Aufbau principle, occupation rules (Hund’s rule, Pauli principle, electron spin). Realtion to the periodic system, ionization energy, electron affinity, electronegativity. The concept of the covalent bonding, qualitative understanding by quantum mechanics. Polarized covalent and ionic bonding, dative bond formation. Bonding and formation of hydrides, valence rules (octet rule) in the periodic table. Molecular structure and simple models (the concept of hybridization and the VSEPR model). Electronic structure of diatomic molecules, the case of oxygen. The concept of electron delocalization.(12 h)#160;

Subject code	Subject name	Requirement	ECTS credit
BMEVESAA104	General Chemistry Calculations for Chemical Engineers	Mid-semester mark	4

Course type	**Course code**	**Course language**	**Timetable information**
Practice	A11-ER	English	FRI:08:15-11:00

Expression for the composition of solutions and their applications. Operations with solutions, crystallization, recrystallization.Gases. Properties of gases. Equation of state for ideal gas, and its versions. Boyle’s law, Charles’ laws. Gay-Lussac’s law.Mixtures of gases, their compositions. Partial pressure, and volume. Dalton’s rule and Amagat’s rule. Vapor pressure.Colligative properties of dilute solutions. Vapor pressure lowering, boiling-point elevation, and freezing-point depression, osmosis.Balancing equations. Oxidation numbers, redox equations. Stoichiometry and its applications. Yield. Avogadro’s law. Calculation of titration.Basic terms in thermochemistry. Energy, heat and enthalpy. Heat capacity, molar heat capacity. The heat of reactions and Hess' law.General description of chemical equilibria. Various forms of equilibrium constants and their connections.#160;Application of LeChatelier's principle. The shift in the equilibrium composition by the change in the amount of reactants, in the pressure, and in the temperature. Heterogeneous equilibria.Acid-base equilibria, pH of solutions:-#160;#160; Strong acids and bases;-#160;#160; Weak acids and bases;-#160;#160;#160; Hydrolysis of salts;-#160;#160;#160; Buffers and buffer capacitiesSolubility equilibria: solubility product and its applications, common ion effect; speciation effect; temperature effect.Electrochemisty:-#160;#160;#160; Electrolyte solutions. Electrical resistance and conductivity of dilute solutions;-#160;#160;#160; Electrolysis;-#160;#160;#160; Electrode potentials: standard hydrogen electrode, simple metal electrodes, redox electrodes,#160; metal-insoluble salt electrodes, gas electrodes-#160;#160;

Composition dependence of electrode potentials in various electrode types: Nernst equation.-#160;#160; Electrochemical cells, cell diagrams, cell reactions, half-cell reactions. Electromotive force.-#160;#160;#160; Basic terms in electrochemistry, direction of electrochemical processes.#160;

Subject code	Subject name	Requirement	ECTS credit
BMEVESAA302	Analytical Chemistry I.	Mid-semester mark	5

Course type	Course code	Course language	Timetable information
Lecture	A10-ER	English	TUE:14:15-16:00; WED:14:15-16:00

To provide thorough understanding of the fundamental principles, main methods and applications of chemical analysis (volumetric, gravimetric and instrumental analysis), as well as their tools of trade. The subject aims to provide a sound bases for later subjects including the Analytical Chemistry Laboratory and other advanced analytical chemistry subjects within Analytical and Structural Chemistry Specialization. #160;

Subject code	Subject name	Requirement	ECTS credit
BMEVESAA512	Elucidation of Organic Structures	Mid-semester mark	3

Course type	Course code	Course language	Timetable information
Lecture	A05	English	MON:12:15-15:00(CH306)

IntroductionThe strategy of structure determination of the organic compounds. Basic conceptions of organic structures (configuration, conformation, isomerism, tautomerism, rate processes). Organic microanalysis. Methods to determine the carbon, hydrogen and nitrogen content of the samples. Determination of the sulphur and halogen content. Qualitative and quantitative analysis of some important functional groups.UV spectroscopyElectronic structure of the molecules, atomic and molecular orbitals, orbital symmetry, Electronic transitions, and selection rules. Band structures. Chromophores and auxochromic groups. Discussion of some simple chromophores. Conjugation, the Woodward-Fieser rules.Substituent, solvent and steric effects, Polyenes, aromatic and heteroaromatic structures.IR spectroscopyMolecular vibrations, the vibrational and vibrational-rotational spectrum. The two-atomic model, the harmonic and nonharmonic vibrations. Characteristic vibrational frequencies. The correlation between the IR and Raman spectroscopy. Stretching and bending frequencies.The impact of the structural effects modifying the vibrational frequencies: inductive and mesomeric effects, hyperconjugation, ring strain, steric and isotope effects. Characteristic frequencies of carbonyl compounds, alcohols, amines, nitro compounds, etc. The measurement of the infrared spectra. Sample preparation. The Fourier-transform infrared spectrophotometer.Mass spectroscopyThe mass spectrometer. Ionization methods (EI, CI, APCI, ESI, MALDI). Isotopes. Ion separation and detection methods. The coupling of the mass spectrometer (GC-MS, HPLC-MS, MS/MS). The importance of the molecule and base peak. Ion chemistry: fragmentation and rearrangement. The most important processes: alpha cleavage, onium reaction, allyl and benzyl-cleavage, McLafferty rearrangement, retro Diels-Alder reaction. Typical fragmentations and rearrangements of organic molecules. Application of isotope abundance determination: halogen compounds.Nuclear magnetic resonance (NMR) spectroscopyThe nuclear spin. Nuclear spins in magnetic field: the Bloch equations. The measurement of the NMR spectra: CW and PFT. Spectral aquisition. 1H and 13C-NMR spectroscopy. The basic NMR parameters: the chemical shift, the coupling constant. 1H-NMR: Multiplicity and intensity of the signals. The inductive effect, diamagnetic anisotropy, ring currents. Empirical calculation of the chemical shift. The Karplus-curve. 13C-NMR: broadband decoupling, gated decupling. Spectral editing methods: the DEPT and the APT experiments.#160;

Subject code	Subject name	Requirement	ECTS credit
BMEVESAM202	Material Science Analysis Methods	Mid-semester mark	4

Course type	Course code	Course language	Timetable information
Laboratory	AL7-ER	English	TUE:10:15-14:00(CHFAA)
Lecture	AE7-ER	English	THU:13:15-15:00

The course will give a broad overview on the measurement methods used in materials science involving nanotechnology, inorganic chemistry, polymers, biomaterials, organic materials. During the laboratory practices the students will get both theoretical knowledge and practical experience about a large number of analytical methods and instruments.Laboratory practices: 9x4 hours- XPS, SIMS (X-ray photoelectron spectroscopy, Secunder ion mass spectrometry)#160;#160;#160;#160;#160;#160;#160;#160; 4 h- FTIR (Infrared spectrocopy)
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
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#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; 4 h- Raman
spectroscopy#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#
160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#16
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160;#160;#160;#160;#160; 4 h- XRD (X-ray diffraction)
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1

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#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; 4 h- SEM-EDX (Scanning electron microscopy, Energy dispersive X-ray spectroscopy)#160;#160;#160;#160;#160;#160;#160; 4 h- AFM (Atomic force miscoscopy)
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
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#160;#160;#160; 4 h- High resolution optical microscopy
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
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4 h- Particle size analysis#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
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60;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; 4 h- Thermal analysis (TG/DTA-MS: Simultanous thermogravimetry and differential thermal analysis with on-line coupled mass spectrometry)
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
60;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; 4 hTest:1x2 h1. test: From the laboratory practice curriculum#160;

Subject code	Subject name	Requirement	ECTS credit
BMEVESZA301	Organic Chemistry I.	Exam	5

Course type	Course code	Course language	Timetable information
Lecture	A23-ER	English	MON:10:15-12:00; WED:10:15-12:00
Practice	A24-ER	English	MON:10:15-12:00; WED:10:15-12:00

Part I. Basic of organic chemistry, structure and chemistry of hydrocarbons6.1. Basics of organic chemistry, structures of carbon compoundsDevelopment of organic chemistry. Structure of molecules: theory of covalent bonding, rationalization of chemical bonds.#160; #160; #160; #160; #160; #160; #160; #160; #160; #160; #160; #160; #160;#160; #160;
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
60;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;
#160;#160;#160; 3 hClassification of organic compounds. Nomencalture of basic hydrocarbons. Nomenclature of aliphatic and aromatic hydrocarbons. #160;2 h6.2. Configuration,#160; stereochemistry, conformation Constitutional isomerisms. Stereoisomerism: E/Z isomerism, chirality, enantiomers and diastereomers. Inversion, retention and recemization. Conformation of aliphatic and alicyclic hydrocarbons.
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
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#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
60;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
60;#160;#160;#160;#160;#160;#160;#160;#160; 3 hSubstitutional and groupfunctional nomenclature. The main functional groups. #160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; 2 h6.3. Theory of reactions, theories of acid-base, HSAB and FMO theories Types of organic reactions: substitutions, additions, eliminations and rearrangements. Nature of the reactions: multistep and concerted, ionic and radical reactions. The energy profile of reactions: transition state, parameters for activation, intermediates, concept of#160; kinetic and thermodynamic control. Acid-base equilibria. The concept of electrophilicity and nucleophilicity.#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
60;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
60;#160;#160;#160;#160;
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
60;#160;#160; #160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; 3 hExercise for nomenclature of organic compounds. #160; 2 h6.4. Theory of redox and radical reactions, chemistry of paraffins Rationalizing the oxidation number. Preparation of paraffins and cycloparaffins by reduction, methods for forming carbon-carbon single bonds. Physical properties, radical reactions and oxidation of paraffins and cycloparaffins.
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
60;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;

#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
60;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;
#160;#160;#160;#160;#160; 3 hExercise for the CIP-system.#160;#160;#160;#160; 2 h6.5. Reactivity of olefines and acetylenes, electrophilic addition, oxidation and polymerization#160;Electrophilic addition and radical reactions of olefines. Reactions of 1,3-dienes. Electrophilic addition and radical reaction of acetylene derivatives. Substitution and adddition reactions of conjugate bases of acetylene
derivatives.#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
60;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;
#160;#160;#160;#160;#160;#160;#160;
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
60;#160;#160; #160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; 3 hPreparation of paraffins and cycloparaffins. Exercise for oxidation number. Reactions of paraffins. Conformation of paraffins and cycloparaffins.
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
60;#160;#160; 2 h6.6. Reactivity of monocyclic aromatic compounds, electrophilic substitutionThe structure of benzene, aromaticity and aromatic character. The mechanism of electrophilic substitution, halogenation, nitration and sulphonation, Friedel-Crafts alkylation and acylation. Orientation rules.#160;#160;#160;#160;#160;#160;
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
60;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
60;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; 3 hPreparation and reactions of olefines. E/Z nomenclature of olefines. Elimination reactions. Preaparation and reactions of
acetylenes.#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
60;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
60;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; 2 h Part II. Compound containing carbon-heteroatom single bonds8.7. The theory of substitution and eliminationThe mechanisms of aliphatic nucleophilic substitutions and eliminations, their regio- and stereochemistry. Factors influencing these reactions. Ambident nucleophiles. Aromatic nucleophilic substitution.#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
60;#160;#160;
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
60;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; 3 hTest 1.: Nomenclature. Preparation, reactions, conformation and configuration of aliphatic and cyclic paraffins. Preparation and reactions of olefines. Regio- and stereoselectivity. Preparation and reactions of acetylenes. #160;#160;#160;#160;
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
60;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
60;#160;#160;#160;#160;#160;#160;#160;#160; 2 h 8.8. The chemistry of halogen compounds, alcohols, phenols and ethers The physical properties of halogen compounds, alcohols, phenols and ethers. Acidity and basicity of these compounds. Reactions of halogen compounds with metals. Preparation and reactions of alcohols, phenols and ethers.#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#
160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#16
0;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#
160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#16
0; 3 hPreparation and reactions of aromatic compounds. Exercises for SEAr and SNAr reactions. #160;#160; 2 h8.9. The chemistry of nitro compounds and amines Preparation and reduction of nitro compounds. The structure, physical and basical properties of amines. Preparation and reactions of amines.
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
60;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
60;#160;#160;#160; 3 hPreparation and reactions of halogen compounds, alcohols, phenols and ethers. Exercises for substitution and elimination reactions. #160; 2 hPart III. Compound containing carbon-heteroatom multiple bonds8.10. Reduction and oxidation of alcohols, carbonyl compounds and carboxylic acid derivativesPreparation of carbonyl compounds and carboxylic acids by oxidation. Preparation of alcohols and carbonyl compounds by reduction. Using Grignard and related reactions for the preparation of alcohols and carbonyl compounds. Using Friedel-Crafts and related reactions for the preparation of aromatic carbonyl compounds. #160;
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#1
60;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;
#160;#160;#160;#160;#160; #160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; 3 hPreparation and reactions of nitro compounds. Exercises regarding pKa.
#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; 2 h8.11. Reactivity of carbonyl compounds, carboxylic

acids and carboxylic acid derivativesComparison of the reactivities of aliphatic and aromatic carbonyl compounds, carboxylic acids and carboxylic acid derivatives - nucleophilic addition and nucleophilic addition-elimination reactions. Preparation and reactions of ?,ß-unsaturated carbonyl compounds and carboxylic acids. Inverse reactions.#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; #160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; #160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; #160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; 3 hTest 2.: Preparation and reactions of aromatic compounds.#160; Orientation rules. Preparation and reactions of halogen compounds. Mechanism, regio- and stereoselectivity of substitution and elimination reactions. Preparation and reactions of alcohols, phenols, ethers, nitro compounds and amines. #160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; #160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; #160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; #160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; 2 h 6.12. Oxo-enol tautomerism, carboxylic acids Oxo-enol tautomerism. Comparison of the reactivities of oxo-enol tautomers. Reactions taking place with the conjugate bases of carbonyl compounds and carboxylic acid derivatives (at ?-position). The chemistry of dicarbonyl and related compounds.#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; #160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; 3 hSupplementary test 1. or#160; 2 h6.13. Chemistry of carboxylic acids and carboxylic acid derivativesPhysical and chemical properties of carboxylic acids. Preparation and reactions of dicarboxylic acids - decarboxylation reactions. Carboxylic acid derivatives: preparation and reactions of ketene, acyl halides, acid anhydrides, azides, esters, amides, nitriles, imid acid esters - nucleophilic addition and nucleophilic addition-elimination reactions.#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; #160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; 3 hPreparation and reactions of carbonyl compounds. Preparation of carboxylic acids. Reactions of carbonyl compound and carboxylic acids.#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; #160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; #160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; 2 hExtra supplementary test 1. or 2.#160; #160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; #160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; #160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160;#160; #160;2 h7. Method of education:#160;

Subject code	Subject name	Requirement	ECTS credit
BMEVESZM704	Biocatalysis	Mid-semester mark	2

Course type	Course code	Course language	Timetable information
Lecture	12-ER	English	TUE:15:15-17:00(CH301)

The aim of the subject is to provide high-level scientific and practical knowledge to the future chemical and bioengineers of chemical and biological industries (pharmaceutical, agro- and fine chemical, cosmetic and food industries) with special focus on the development of problem solving skills related to chemical problems by using the tools of biotechnology.#160;Biotransformations and biocatalysisCharacteristic advantages and disadvantages of processes – Enzyme classification and nomenclature – Coenzymes – Enzyme kinetics – Protein structure and basics of enzyme action – Effect of conditions on enzyme activity – Characteristics of microbial transformations – Enzyme- and cell immobilizationDevelopment of novel biocatalystsGenetic engineering tools – Production of biocatalysts by recombinant organisms – Novel methods of modifications of enzyme properties by genetic methods: site directed mutagenesis, gene shuffling, directed evolution, metabolic engineering, random DNA cloning – Catalytic antibodies – High throughput test methodsStereochemical issues related to biocatalytic processesBasic terms of stereochemistry – Methods to determine enantiomeric composition – Classification of selective transformationsTypes of selectivities for biocatalytic processesMild conditions – Chemoselectivity – Regioselectivity – Diastereomer selectivity – Diastereotopic selectivity – Enantiomer selectivity – Enantiotopic selectivity – Parallel manifestation of multiple selectivitiesHydrolasesGeneral features of processes performed by hydrolasesCharacteristics of hydrolases used for preparative purposes – General features of transformations by hydrolases: hydrolytic processes in aqueous media – non-hydrolytic processes in organic solventsPreparative application of hydrolases: types of the applicable selectivitiesBiotransformations under mild conditions – Substrate specificity, chemoselectivity – Regioselective transformations – Diastereomer and diastereotopic selective processes – Enantiomer selective biotransformations: general considerations, transformations of amino acids and their derivatives, selective transformations of racemic acids (ester hydrolysis, alcoholysis, transesterification), selective transformations of racemic alcohols (ester hydrolysis, acylation, transesterification), racemic lactones, amines, epoxides and other compounds – Enantiotopic selective biotransformations: general considerations, transformations of compounds with a single prochiral center, reactions of meso compounds, enantiotopic and diastereotopic face distinctions by hydrolasesOxidoreductasesGeneral features of processes by oxidoreductasesFeatures of oxidoreductases applied for preparative purposes – Processes by oxidoreductases acting without external cofactor – General features of oxidoreductases acting with externally added cofactors – Cofactor regeneration methods by using oxidoreductasesPreparative use of oxidoreductases: types of useful selectivitiesReduction of racemic aldehydes – Oxidation of racemic alcohols – Reduction of achiral carbonyl compounds – Oxidation of prochiral and meso alcohols – Simultaneous manifestation of multiple selectivities in processes with oxidoreductases – Enzymatic Baeyer-Villiger-type oxidationsBaker's yeast as whole-cell system for preparative useGeneral considerations – Reduction of ketones: achiral ketones, racemic ketones, 1,2-dioxo compounds, 1,3-dioxo compounds, other dioxo compounds – Reduction of oxocarboxylic acid derivatives: 2-oxocarboylic acid derivatives, 3-oxocarboylic acid derivatives, 2-substituted-3-oxocarboylic acid derivatives, oxocarboxylic acid derivatives with carbonyl function at 4 or more distant position – Reduction of carbon-carbon double bond – Other reductions – Hydrolysis – Lyase activity – CyclizationsOther preparative application of enzymes and microorganismsOther enzymes: transferases (glycosidases, aminotransferases, phosphorylases) – Lyases (aldolases, oxynitrilases) – Selected examples of whole-cell biotransformationsIndustrial applications of biotransformationEnzyme and cell immobilization – Bioreactors – Stereoselective biotransformations carried out on an industrial scale#160;

Subject code	Subject name	Requirement	ECTS credit
BMEVEVMA606	Design of Experiments	Mid-semester mark	3

Course type	Course code	Course language	Timetable information
Lecture	Eng1-ER	English	THU:16:15-19:00(CHA11)
Practice	Eng2-ER	English	THU:16:15-19:00(CHA11)

To teach the basics and methods of mathematical statistical treatment of measurement data.To teach the design and analysis of the most basic full factorial experimental designs.Random variable, density and distribution function, expected value, variance. Continuous distributions, normal distribution, standard normal distribution, ?2, t and F distribution. Central limit theorem. Population and sample. Parameter estimation. Hypothesis testing, parametric tests. Mutual distribution of several random variables, correlation. Principles of regression, linear regression. Checking adequacy, weighted regression, parameter estimation, partition of SSQ, confidence intervals. Design of experiments. 2p full factorial: the design, orthogonality and rotatability, estimation of parameters, significance tests. 2p-r#160;fractional factorials. #160;

Subject code	Subject name	Requirement	ECTS credit
BMEVEVMA709	Computer Process Control	Mid-semester mark	4

Course type	Course code	Course language	Timetable information
Laboratory	eng_lab-ER	English	TUE:10:15-13:00(F211)
Lecture	english-ER	English	TUE:10:15-13:00(F211)

The process control gives funded knowledge about the control theory and practice. Currently, everywhere the computer is used, also for control. The compter helps, however, not only for the control but also for the design of the control sturctur. It enables the engineer to calculate controllability features and also modelling both steady state and dynamic.#160;Single input single output (SISO) processes, control of SISO systemsMultiple Input Multiple Output processes (MIMO), control of MIMO systemsState-space modelling, state-space modelsDetermination of gain arrayDesing of control structure for MIMO systems, Controlability indexes, Niederlinski index, Interconnection of control loops, measurement of the interconnection among control loops, relative gain array, condition number, singular valueMorari resiliency indexComplex steps of control sturcture design for MIMO systems.Uncertanity in the controler tuning, Skogestad-Morari methodDoyle-Stein criteriumAlternatives of the computer application for control and operation.On-line data collection, supervisory control, direct digital controlHardware toolsSampling theory, mathematical modeling, Time function, Laplace transormation, Frequency function„Z”-transformation, characters of the Z-transformationApplication of the Z – transformation, Sampling theory, Dead time in the Z domain,Stability in the Z-domainInternal Model Control,Model Based ControlSmith predictor#160;