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	A12	English	MON:15:15-18:00(CHA11)

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.
Basic chemical and biological principles
Cells are the structural and functional units of all living organisms Prokaryotes, Eukaryotes,Basic cell chemistry,. Cells Are Made From a Few Types of Atoms, Chemical bonds, Water, the most abundant part of cells, Four types of non-covalent interactions, A cell is formed from carbon compounds.
Enzymes The catalysed reactions, Most enzymes are proteins, Enzymes are classified by the reactions they catalyse, How enzymes work, Enzymes Affect Reaction Rates, Not Equilibria, Specificity of Enzymes,Enzyme Kinetics, Enzymes are subject to reversible or irreversible inhibition,Reversible inhibition,Irreversible Inhibition, The regulation of enzyme activity.
Bioenergetics Cells obtain energy by the oxidation of organic molecules, Oxidation and Reduction Involve Electron Transfers,The free-energy change for a reaction determines whether it can occur, Activated carrier molecules: energy currencies, ATP is the most widely used activated carrier molecule, FADH2, NADH and NADPH are important electron carriers, Other activated carriers
Carbohydrate metabolism – glycolysis gluconeogenesis Glycolysis, The reactions of glycolysis, Fates of pyruvate and NADH, Energy yield of aerobic versus anaerobic glycolysis, Other functions of glycolysis, Regulation of glycolysis,Gluconeogenesis.
Carbohydrate metabolism – pentose-phosphate pathway Oxidative phase of the pentose phosphate pathway, The non-oxidative phase of the pentose phosphate pathway
Pyruvate dehydrogenase enzyme complex – TCA cycle Pyruvate Dehydrogenase Complex, Structure of PDC, Regulation of PDC, The TCA cycle, Reactions of the TCA cycle, Energetics of the TCA cycle, Regulation of the TCA cycle, TCA cycle in biosynthetic pathways and anaplerotic reactions, The glyoxylate cycle
Terminal oxidation – oxidative phosphorylation, ATP synthesis in the mitochondria Overview of terminal oxidation and oxidative phosphorylation, Electron transfer fromNADH to O2,The electrochemical potential gradient, ATP Synthase, Energy yield from the electron transport chain, Respiratory chain inhibition and sequential transfer, Coupling of electron transport and ATP synthesis,Regulation through Coupling, Uncoupling ATP synthesis from electron transport
Photosynthesis – Calvin cycle, General features of photophosphorylation Light absorption, Chlorophylls Absorb Light Energy for Photosynthesis,Light-Driven Electron Flow, The cytochrome b6f complex links photosystems II and I, Cyclic electron flow between PSI and the cytochrome b6f complex increases the production of ATP relative to NADPH,. Water is split by the oxygen-evolving complex, ATP synthesis by photophosphorylation, The ATP synthase of chloroplasts is like that of mitochondria, Carbohydrate biosynthesis in plants, Carbon Dioxide assimilation occurs in three stages, Photorespiration and the C4 and CAM pathways
Lipid metabolism – Fatty acid oxidation Lipid transport, Mitochondrial oxidation of fatty acids, Oxidation of a fatty acid with an odd number of carbon atoms, Oxidation of unsaturated fatty acids,Generation of ketone bodies,Biosynthesis of fatty acids,Cholesterol
Protein, amino acid metabolism Nutritionally nonessential amino acids have short biosynthetic pathways, Catabolism of proteins and of amino acid nitrogen, Transamination, Oxidative deamination of glutamate, Ammonia transport, Reactions of the urea cycle, Catabolism of the carbon skeletons of amino acids
Nucleotides Metabolism of purine and pyrimidine nucleotides,Purines and pyrimidines are dietarily nonessential, Biosynthesis of purine nucleotides, Biosynthesisof pyrimidinenucleotides
DNA replication Replication is semiconservative
13. Transcription
Translation The Genetic Code, Cracking of the Genetic Code, Wobble Hypothesis, Translational Frameshifting and RNA Editing, The process of protein synthesis,The ribosome, Transfer RNAs,Stages of the translation process

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(CH301)

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.   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   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.   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.   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.   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.   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.   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.

Laboratory practice
1.   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.   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.   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.   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.   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.   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.   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.

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); THU:14:15-17:00
Practice	A7-ER	English	TUE:08:15-11:00(CH307); THU:14:15-17:00

The subject provides theoretical and practical knowledge on the chapters of physical chemistry related to „change”. The rates of processes, as well as equilibrium electrochemistry are discussed. The three main chapters of physical chemistry II are Reaction Kinetics, Transport Processes and Electrochemistry.
Kinetics: rates of chemical reactions – Definitions: molecularity, order of reactions, rate of reaction. Zero-order reactions, first-order reactions, second-order reactions.– Equilibrium reactions. Consecutive and parallel reactions.– Homogeneous catalytic reactions, autocatalysis, enzyme kinetics, oscillating reaction.– Temperature dependence, collision theory, transition-state theory.– Determining the order and rate constant of a reaction.– Kinetics of heterogeneous reactions.– Kinetic salt effects.Electrochemistry – Chemical potentials and activities in electrolyte.– The electrochemical potential.– Electrochemical cells.– Thermodynamics of Galvanic cells, the Nernst equation.– Electrode potentials.– Types of electrodes.– Membrane potentials, glass electrodes.– Conductivity of electrolytes.– Electrode kinetics and polarization.– Corrosion, Protecting against corrosion.Transport phenomena– Definitions, thermodynamic driving forces.– Laws of diffusion: Fick laws, statistical view, steady state diffusion.– Heat conduction.– Viscosity, newtonian and non-newtonian fluids.Physical Chemistry Calculations in kinetics and electrochemistry

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 inliquid-liquid two-component systems. Two-component systems displaying either LCST or UCST will be investigated and the composition-temperaturephase 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. 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. 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.   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.

Subject code	Subject name	Requirement	ECTS credit
BMEVEFAM110	Materials science: traditional structural materials and polymers	Exam	4

Course type	**Course code**	**Course language**	**Timetable information**
Laboratory	ENG_lab	English	THU:08:15-12:00(HF4)
Lecture	theory	English	WED:14:15-16:00

Materials science explores the relationship between the processing technology, structure and properties of materials in order to meet the requirements of specific applications. The goal of the course is to offer information about the structure, properties and behavior of the frequently used structural and functional solid materials. The subject demonstrates the importance of the design, production and shaping of materials and products through real-lie examples. The course discusses in detail the structure-property correlations of plastics, metals and ceramics, as well as solid structural and functional materials based on renewable resources. This course highlights also the similarities and important differences between the studied structural materials.
8.1.Introduction.What is material science? The importance of the subject. Introduction of the structural materials, similarities and differences. Some interesting examples of structure property correlations.
8.2.Basic definitions of material science: primary bonds, forces between atoms and molecules. Basic properties of materials and their connection to their atomic structure. Basics of crystallography, the structural hierarchy of materials and its consequences.
8.3.Structure-property correlations in solid materials. Mechanical behavior, wave propagation and thermal properties.
8.4.Structure and mechanical properties of metals and polymers. Deformation mechanisms, plastic deformation of metals and its structural explanation. Dislocations and their consequences. Introduction into the continuum mechanics. Structural hierarchy of polymers. Diversity and fine structure of a polymer chain and its effect on the phase structure of the polymers. Physical states of polymeric materials. Structure and properties of semicrystalline polymers. The structural parameters, which deter-mines the mechanical and optical properties. Modeling of structure in order to predict properties.
8.5.Structure and properties of ceramics and wooden materials. Synthesis, processing and sintering. Parameters, which influences the properties of the ceramics, porosity and density. Chemical bonds in ceramic materials and their mechanical properties. Wood as a natural composite material. Structure and direction dependent properties. General correlation between structural parameter and stiffness of different wood types. Characterization of wooden materials, fracture mechanism.
8.6.Electrical conductivity. Structural explanation of electric conductivity, semiconductors. Electron as quasi element. Effective mass of electrons. Superconductivity.
8.7.The effect of processing on the structure of metals. Moving and interaction of dislocations and its consequences. Cold work of metals and its structural explanation. Crystal defects and their effect on the properties. Processing of ceramics and the effect of processing technique on the final properties.
8.8.Complex effects appear during the processing of polymers. Degradation, orientation, internal stresses. Changes of properties during processing. Effect of processing on the crystalline structure. Targeted modification of crystalline structure in order to achieve improved stiffness of better optical properties. Effect of nucleating agents.
8.9.Properties of heterogeneous systems. Basic factors determining the properties of composites. Precondition of reinforcing effect, particulate or fiber filled systems. Critical fiber length. Metal alloys and composites. Steel as composite material. Ceramic matrix composites, preparation and properties.
8.10.Heterogeneous systems based on polymeric materials. Parameters influencing properties. Mechanism of failure, micromechanical deformations. How to explore the limits of a composite material? How is it possible to improve the performance of a composite? Nano-sized fillers, nanocomposites: expectations, possibilities and limitations. Most important difficulties on the field of nanocomposites.
8.11.Non-conventional materials. Shape memory alloys and polymers. Structural explanation of shape memory. Example on applications using shape memory materials. Piezoelectric and electro strictive materials and their application. Magnetostriction.
8.12.Polymer gels and soft materials. Volume changes, swelling and coagulation of gels and their possible

application. Thermoresponsive gels and photoresponsive materials. Unique properties of soft materials, microfluidic valves, reactors.
Laboratory practice
1. Deformation of metals, alloys. Strengthening mechanisms, Effect of cold work on pure metals and alloys. Effect of heat treatment on cold worked metals.
2. Deformation of polymers: Complex processes during plastic deformation of polymeric materials. Tension and fracture tests. Deformation mechanisms in different physical states.
3. Deformation of wooden materials. Mechanical properties of different wood types parallel and perpendicular to the fiber direction. Tension and bending experiments. Effect of water content.
4. Swelling and unique properties of polymer gels.
https://www.ch.bme.hu/oktatas/targyak/BMEVEFAM110/en

Subject code	Subject name	Requirement	ECTS credit
BMEVEFAM114	Intellectual Property Management	Exam	4

Course type	Course code	Course language	Timetable information
Lecture	theory	English	

The goals of the course: to develop the IP awareness of the students, to demonstrate the effective usage of the IP information in order to support the literature search activity and to define the monopole IP rights.

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	MON:10:15-12:00(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.
Introduction
The importance, classification, general characteristics, most significant application areas and economic importance of biopolymers. Research trends in Hungary and abroad. The basics of carbohydrate chemistry.
2.Polysaccharides (plant based) I-II.
The cellulose macromolecule, its chemical structure, intra- and intermolecular interactions, fibrillar structure, crystallinity, accessibility. The most significant cellulose sources. The structure and chemistry of wood. Cellulose production. Cellulose derivatives (cellulose esters, cellulose ethers). The chemical and biological degradation of cellulose. Hemicelluloses. Pectins.
3. Polysaccharides (plant based) III.
Starch. The chemical structure, characteristics and chemical reactions of starch. Starch sources. Starch derivatives. The most significant application areas. Starch based blends.
(2 classes)
4. Polysaccharides (animal based)
Chitin. Chemical structure, availability, isolation. Physical and chemical characteristics, application areas (agriculture, industry, medicine)
Chitosan. Chemical structure, synthesis. Physical and chemical characteristics, application areas (agriculture, industry, horticulture, medicine)
5. Polyphenols
Lignins. The availability, biosynthesis and classification of lignins. The isolation, structure and reactions of lignins. The biodegradation of lignins. The characteristics of the lignin-holocellulose system, the chemistry of delignification. The chemical structure and availability of tannins. Hydrolysable and condensed tannins. The interactions of tannins with macromolecules (carbohydrates, proteins, polysaccharides, enzymes).
6. Proteins (Polyamides)
The primary, secondary and tertiary structure of proteins. Animal and plant based proteins. Wool keratin. The morphology, chemical and physical characteristics of wool. Silk fibroin. Regenerated protein fibers. New application areas. Collagens and gelatins. Enzymes.
7. Polyesters (synthetic) I-II
The importance and chemical structure of linear polyesters. The most significant linear polyesters (poly(glycolic acid), poly(lactic acid), polycaprolactone), isomers, crystallization; the synthesis of poly(lactic acid), its physical ageing and macroscopic properties. The lectures mainly discuss the general characteristics of linear polyesters through the example of poly(lactic acid).
8. Polyesters (microbial)
The chemical structure, synthesis (fermentation, bioreactors) and characteristics of microbial polyesters (polyhydroxyalkanoates); the role of crystallinity and its modification; the most significant polyhydroxyalkanoates (poly(3-hydroxybutyrate), poly(3-hydroxyvalerate), poly(3-hydroxyhexanoate)) and their copolymers.

9. Polyols, polyurethanes
Synthetic biodegradable polyols from natural sources (plant oils, carbohydrates, lignin), their chemical structure, reactions and industrial significance; the synthesis of polyurethanes based on the reaction of conventional isocyanates and natural based polyols.
10. The processing and application of biopolymers I-II.
Specific characteristics of the processing of biopolymers. The most significant application areas of biopolymers. Biopolymer based blends and composites.

Subject code	Subject name	Requirement	ECTS credit
BMEVEFAM213	Structural chemistry	Exam	5

Course type	Course code	Course language	Timetable information
Lecture	EA0	English	WED:10:15-12:00

The description of molecular properties based on quantum mechanical theory, the description of the structures of macroscopic materials and the relationships between the macroscopic and molecular properties, to explain the operation of instruments and experimental methods used to elucidate the chemical structure. The lectures provide a comprehensive system of the experimental methods used in structural chemistry, whereas the project work provides the students with an experience in how to apply their knowledge for solving problems in the field of structural chemistry.

Subject code	Subject name	Requirement	ECTS credit
BMEVEFAM502	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(CH301)

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.
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.

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	elm_ENG_ER	English	THU:12:15-15:00(CH307)
Practice	gyak_ENG_ER	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 number
of theoretical stages. Fenske equation. Minimum reflux 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.

Subject code	Subject name	Requirement	ECTS credit
BMEVEKFBEMK	Technical Chemistry for mobility students	Mid-semester mark	2

Course type	**Course code**	**Course language**	**Timetable information**
Lecture	elm_ENG_ER	English	WED:14:15-16:00

Subject code	Subject name	Requirement	ECTS credit
BMEVEKFM112	Energy production and its environmental impacts	Exam	4

Course type	**Course code**	**Course language**	**Timetable information**
Laboratory	lab_ENG_ER	English	TUE:10:15-12:00
Lecture	elm_ENG_ER	English	TUE:08:15-10:00

The concepts of energy, energy production and the environment, and the relationship between energy production and the environment. Characteristics, role and processing of conventional and alternative fossil fuels for energy production. Use of fossil fuels, thermal power plants, engines, propulsion, other thermal power plant concepts. Efficiency improvement potentials of fossil technologies. Fossil energy related emissions, pollutant management, emission reduction, water treatment and wastewater related to energy production. Current and future technologies for nuclear power generation. Environmental impacts of nuclear power generation, waste management. Types and definitions of renewable energy sources. Solar energy potential, solar collectors, semiconductors. Wind and hydropower potential, geothermal energy. Climate change and the energy sector, current and future opportunities for mobility. Energy storage and transport issues and options, battery technologies and environmental impacts. Prospects and trends in the energy sector in Hungary and the world.

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

Course type	**Course code**	**Course language**	**Timetable information**
Laboratory	A14	English	TUE:10:15-13:00(CH301)
Lecture	A13	English	TUE:10:15-13:00(CH301)

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.
Theory
The 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.
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 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. 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 CO2produced 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.
4.Aliivibrio fischeri bioluminescence inhibition test. Aliivibrio fischeriis a marine bacterium, which emits light under favourable conditions. Light emission is inhibited in the presence of toxic substances, which can be detected by luminometer
5. 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.

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

Course type	Course code	Course language	Timetable information
Lecture	E36eng	English	WED:10:15-12:00(CHA10); THU:10:15-12:00(CH304)

Get a basic overwiew of the principles of Chemistry, providing an introductory informations, including definitions etc. to be used in later specific subjects. The course consists of three parts. In the first one the macroscopic properties of the matter is discussed, including phase transitions. In the second part basic chemical priciples as acid-base, redox processes, chemical equlibria, electrochemistry and chemical kinetics will be covered briefly. In the third part the aromic and molecular structure, the chemical bonding and the rules in the periodic table is discussed.
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.
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:
-Strong acids and bases;
-Weak acids and bases;
-Hydrolysis of salts;
-Buffers and buffer capacities
Solubility equilibria: solubility product and its applications, common ion effect; speciation effect; temperature effect.

Electrochemisty:
-Electrolyte solutions. Electrical resistance and conductivity of dilute solutions;
-Electrolysis;
-Electrode potentials: standard hydrogen electrode, simple metal electrodes, redox electrodes,metal-insoluble salt electrodes, gas electrodes
-Composition dependence of electrode potentials in various electrode types: Nernst equation.
-Electrochemical cells, cell diagrams, cell reactions, half-cell reactions. Electromotive force.
-Basic terms in electrochemistry, direction of electrochemical processes.

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	A01eng	English	FRI:08:15-11:00(CH308)

The aim of the subject is to increase the knowledge of the freshman students on chemical calculations to the level, which provides competent basis for further chemical and technological disciplines (inorganic chemistry, organic chemistry, physical chemistry, unit operation, chemical technology etc.). The practice is held in small groups, depending on the former skills of the students.
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.
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:
-Strong acids and bases;
-Weak acids and bases;
-Hydrolysis of salts;
-Buffers and buffer capacities
Solubility equilibria: solubility product and its applications, common ion effect; speciation effect; temperature effect.
Electrochemisty:
-Electrolyte solutions. Electrical resistance and conductivity of dilute solutions;
-Electrolysis;
-Electrode potentials: standard hydrogen electrode, simple metal electrodes, redox electrodes,metal-insoluble salt electrodes, gas electrodes
-Composition dependence of electrode potentials in various electrode types: Nernst equation.
-Electrochemical cells, cell diagrams, cell reactions, half-cell reactions. Electromotive force.
-Basic terms in electrochemistry, direction of electrochemical processes.

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

Course type	Course code	Course language	Timetable information
Lecture	26eng	English	TUE:14:15-16:00(CH307); WED:14:15-16:00(CH305)

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.
INTRODUCTION
Hours
Fundamental concepts.
2

Example 1: determination of iron in beer, AAS. Standard addition.
1
Example 2: determination of aluminium in cement, AAS. Matrix effect, calibration.

1

Example 3: Ethanol content of blood, measurement by HS-GC. Internal standard method.
1
Example 4: Analysis of hydrocarbon mixtures (engine fuel) by GC
1

Reliability of analysis. Systematic and random errors. Accuracy and precision; limit of detection, limit of quantitation; range
1

VOLUMETRIC ANALYSIS AND GRAVIMETRY
Acid-base titrations. Volumetric analysis of strong acids and bases. Logarithmic equilibrium diagrams, titration curves. Indicator error.
1

Titration of weak acids and weak bases. Logarithmic equilibrium diagram, titration curves. Calculation of the pH of the equivalence point. Buffers. Indicators.
2

Polyprotic acids and bases. Analysis of carbonate- hydrogen carbonate mixtures. Acid-base titrations in non-aqueous media.
2

Complexometric reactions and titrations. Formation constants. Chelates. EDTA titrations. Indicators
2

Precipitation reactions. Precipitation titrations. Gravimetry..
2

Redox reactions and titrations: iodometry, bromatometry, permanganometry, titration curves and their interpretation
2

ELECTROANALYSIS
Introduction. Electrochemical cells. Overview of electroanalytical methods
1

Potentiometry. Galvanic cells. Activity. Reference electrodes.Liquid junction potentials
2

Potentiometry. Indicator electrodes. Redox electrodes. Nernst equation. Redox titrations with potentiometric endpoint detection
1

Ion-selective electrodes. Solid membrane electrodes: Glass electrode. Fluoride-selective electrodes. Precipitate-based electrodes.
2

Ion-selective electrodes. Liquid membrane electrodes. Selectivity. Direct potentiometry. Calibration. Standard addition
1

Conductometry. Introduction. Conductometric cells
1
Conductometric titrations
1

OPTICAL SPECTROSCOPY
Introduction. Properties of light. Spectrophotometers. Spectrum
2

Atomic spectroscopy. Theory of atomic spectroscopy. Introduction to analytical applications of atomic spectroscopy. Concept and benefits. Introduction to Atomic Absorption/Emission/Fluorescence Spectroscopy. Atomization. Thermal processes in atom sources. Boltzmann distribution
2

Atomic spectroscopy. Atomic absorption spectroscopy (AAS) with flame and electrothermal atomization.

Instrumentation.
2
Atomic spectroscopy methods. Flame optical emission spectrometry, flame photometry (F-OES). Inductively coupled plasma optical emission spectrometry (ICP-OES).. Inductively coupled plasma mass spectrometry (ICP-MS)
2

Molecular Spectroscopy. Basics of ultraviolet (UV) and Visible (VIS) Absorption Spectroscopy. Spectrophotometers. Lambert-Beer law, deviations from Lambert-Beer Law
2

MASS SPECTROMETRY
Introduction to mass spectrometry. Main units of mass spectrometers
2

SEPARATION METHODS

Introduction to separation methods. Categorization of separation methods. Chromatography
2

Basics of chromatographic separations. Chromatogram. Parameters characterising the separation efficiency Partition coefficient. Retention time. Number of theoretical plates.Zone broadening. Resolution
2

Gas Chromatography. Introduction. Columns. Capillary columns. Stationary phases. Injectors
2

Main parts of a gas chromatograph. Detectors
1

Quantitative analysis with gas chromatography. Calibration. Internal standard method. Temperature gradient method. Applications
1

Liquid chromatography. Classification and overview of liquid chromatography methods. Eluent strength
2

Main parts of HPLC systems. Pump. Injector. Columns. Detector
1

Electrophoresis. Principles. Instrumentation. Applications
2

IMMUNOANALYSIS
Basic concepts. Structure of antibodies. Antigen- antibody reactions
1

Analytical measurements based on antigen-antibody reactions. Classification and principle of label-based methods. Quantitative analysis by immunoassays
1

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	E18eng	English	TUE:17:15-20:00(CH304)

The main goal is to provide a basic knowledge about the UV, IR, MS and NMR spectroscopic methods used in organic chemistry. The course will be of interest to chemists and analysts in research and industry, especially those engaged in the synthesis and analysis of organic com-pounds including drugs, drug intermediates, agrochemicals, polymers and dyes.
Introduction
The 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 spectroscopy

Electronic 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 spectroscopy
Molecular 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 spectroscopy
The 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) spectroscopy
The 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.

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

Course type	Course code	Course language	Timetable information
Lecture	A29-ER	English	MON:10:15-12:00(CH304); WED:12:15-14:00(CH306)
Practice	A30-ER	English	MON:10:15-12:00(CH304); WED:12:15-14:00(CH306)

Modern basic studies in this field of natural sciences for chemical engineering students. During this course the students should learn the basics of organic chemistry, they should develop an organic chemistry aspect and gain proper theoretical and practical grounds for the further studies on material sciences, organic chemistry, chemical technology and biochemistry.
Part I. Basic of organic chemistry, structure and chemistry of hydrocarbons
Basics of organic chemistry, structures of carbon compounds
Development of organic chemistry. Structure of molecules: theory of covalent bonding, rationalization of chemical bonds.Classification of organic compounds. Nomencalture of basic hydrocarbons. Nomenclature of aliphatic and aromatic hydrocarbons.
Configuration, stereochemistry, conformation
Constitutional isomerisms. Stereoisomerism: E/Z isomerism, chirality, enantiomers and diastereomers. Inversion, retention and recemization. Conformation of aliphatic and alicyclic hydrocarbons.
Substitutional and groupfunctional nomenclature. The main functional groups.
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 kinetic and thermodynamic control. Acid-base equilibria. The concept of electrophilicity and nucleophilicity.
Exercise for nomenclature of organic compounds.
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.
Exercise for the CIP-system.
Reactivity of olefines and acetylenes, electrophilic addition, oxidation and polymerization
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.
Preparation of paraffins and cycloparaffins. Exercise for oxidation number. Reactions of paraffins. Conformation of paraffins and cycloparaffins.
Reactivity of monocyclic aromatic compounds, electrophilic substitution
The structure of benzene, aromaticity and aromatic character. The mechanism of electrophilic substitution, halogenation, nitration and sulphonation, Friedel-Craftsalkylation and acylation. Orientation rules.
Preparation and reactions of olefines. E/Z nomenclature of olefins. Elimination reactions. Preaparation and reactions of acetylenes.
Part II. Compound containing carbon-heteroatom single bonds
The theory of substitution and elimination

The mechanisms of aliphatic nucleophilic substitutions and eliminations, their regio- and stereochemistry. Factors influencing these reactions. Ambident nucleophiles. Aromatic nucleophilic substitution.
Test 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.
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.
Preparation and reactions of aromatic compounds. Exercises for SEAr and SNAr reactions.
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.
Preparation and reactions of halogen compounds, alcohols, phenols and ethers. Exercises for substitution and elimination reactions.
Part III. Compound containing carbon-heteroatom multiple bonds
Reduction and oxidation of alcohols, carbonyl compounds and carboxylic acid derivatives
Preparation of carbonyl compounds and carboxylic acids by oxidation. Preparation of alcohols and carbonyl compounds by reduction. Using Grignardand related reactions for the preparation of alcohols and carbonyl compounds. Using Friedel-Craftsand related reactions for the preparation of aromatic carbonyl compounds.
Preparation and reactions of nitro compounds. Exercises regarding pKa.
Reactivity of carbonyl compounds, carboxylic acids and carboxylic acid derivatives
Comparison 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.
Test 2.: Preparation and reactions of aromatic compounds. 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.
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.
Supplementary test 1. or
Chemistry of carboxylic acids and carboxylic acid derivatives
Physical 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.
Preparation and reactions of carbonyl compounds. Preparation of carboxylic acids. Reactions of carbonyl compound and carboxylic acids.
Extra supplementary test 1. or 2.

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

Course type	**Course code**	**Course language**	**Timetable information**
Lecture	14_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.
Biotransformations and biocatalysis
Characteristic 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 immobilization
Development of novel biocatalysts
Genetic 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 methods
Stereochemical issues related to biocatalytic processes
Basic terms of stereochemistry – Methods to determine enantiomeric composition – Classification of selective transformations
Types of selectivities for biocatalytic processes
Mild conditions – Chemoselectivity – Regioselectivity – Diastereomer selectivity – Diastereotopic selectivity – Enantiomer selectivity – Enantiotopic selectivity – Parallel manifestation of multiple selectivities
Hydrolases
General features of processes performed by hydrolases

Characteristics of hydrolases used for preparative purposes – General features of transformations by hydrolases: hydrolytic processes in aqueous media – non-hydrolytic processes in organic solvents
Preparative application of hydrolases: types of the applicable selectivities
Biotransformations 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 hydrolases
Oxidoreductases
General features of processes by oxidoreductases
Features 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 oxidoreductases
Preparative use of oxidoreductases: types of useful selectivities
Reduction 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 oxidations
Baker's yeast as whole-cell system for preparative use
General 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 – Cyclizations
Other preparative application of enzymes and microorganisms
Other enzymes: transferases (glycosidases, aminotransferases, phosphorylases) – Lyases (aldolases, oxynitrilases) – Selected examples of whole-cell biotransformations
Industrial applications of biotransformation
Enzyme and cell immobilization – Bioreactors – Stereoselective biotransformations carried out on an industrial scale

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

Course type	Course code	Course language	Timetable information
Lecture	elm_ENG_ER	English	THU:16:15-19:00(CH308)
Practice	gyak_ENG_ER	English	THU:16:15-19:00(CH308)

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 fractional factorials.