Courses available for incoming Erasmus students

Lp.	ECTS	Course name	Short description	Semester
1.	3	**Analytical methods in biochemistry**	Introduction of basics of chemical analysis. Modern and classical methods of biomolecules isolation, purification and analysis. Basic knowledge of proteomics is also discussed. New methods of protein post-translational modifications determination. Application of NMR, FTIR, MS, CD, XRD, fluorescence and other methods etc along with various purification techniques (electrophoresis, chromatography etc.). Methods dedicated for small molecules (for example metabolites) and biomacromolecules.	Winter
2.	2	**Biocatalysis**	Homogenic and heterogenic catalysis. Catalysis with induction of asymmetry. Biocatalysts as an alternative for asymmetric synthesis in production of fine chemical of biological importance. Biocatalysts utilizing enzymes and microorganisms, practical strategies of choice between biotransformation systems. Biotransformation methods utilizing bacteria and fungi. Stability of biocatalytic processes. Methods of immobilization of biocatalysts. Examples of biocatalytic processes of industrial importance. Examples of biocatalytic mechanisms.	Winter
3.	5	**Biochemistry**	Introduction to the biochemistry: characterization of key bioactive molecules and process. Importance and characterization of chosen chemical molecules and their transformations in living organisms. Characterization of structure, properties and function of: amino acids, peptides, proteins, lipids, nucleosides, nucleoside phosphates, nucleic acids, saccharides etc. Introduction to regulatory processes, cell wall transport, signaling, protein production and modification.	Summer

4.	2	**Biomolecular process modeling in drug design**	Course include fundamental of molecular modeling methods basics of molecular quantum mechanics: ab initio methods, semi-empirical methods, methods exploiting density functionals (DFT). Biomolecular geometry optimization. Application of molecular modeling methods in studies of biochemical system reactivities. Study of thermodynamics and transition states of chemical reactions. Molecular docking: docking methods, scored functions of assessment of ligand–receptor interaction. Examination of structure-biological activity relation. Schedule: 1. Visualization of the structure of biomolecules. Adjustment of protein and ligand structures. 2. Modeling of quantities describing physicochemical properties of biological and chemical systems. Conformational analysis of ligands. 3. Modeling of chemical reaction (thermodynamics, transition states) using an example of a reaction of a drug with a specific receptor. 4. Examination of structure-biological activity relationships (QSAR). 5. Molecular docking processes. Investigation of ligand-receptor interaction (i.e. drug-protein).	Winter
5.	2	**Biopolymer and biodegradable polymers**	Starch – structure, properties, reactivity, modifications, applications of modified starches. Chitin and chitosan – structure, properties, reactivity, application of chitin and chitosan in regenerative medicine. Cellulose – structure, properties and directions of modification. Polylactic acid (PLA) – production, properties, application in the production of packaging, medical materials and textiles. Polyhydroxyalkanoates (PHA) – production, properties, application in the production of packaging, plastics and medical materials. Types of biodegradable polymers: natural polymers, polymers with bonds susceptible to hydrolysis, blends of biodegradable and non-degradable polymers. The main ways of biodegradation of the polymers. Factors affecting the biodegradation of the polymer. The methods of biodegradation by the action of micro-organisms.	Summer

6.	2	**Biosensors**	Classification of chemical biosensors. Theoretical basics of chemical/biochemical recognition. Electrochemical biosensors - potentiometric, amperometric and conductometric sensors. Optical biosensor, physics of optical fibers, optical fiber sensors – design, operation and examples. Mass sensors, basics of piezo- and pyroelectricity, chemical layers of mass sensors. Thermal sensors - pyroelectric sensors, gas catalytic sensors. Applications of chemical biosensors in industrial analytical control, clinical chemistry and environment protection. Prospects of development of chemical biosensors. Laboratory exercises include: – Determination of flavonoids with a biosensor. – Biosensors for the determination of glucose. – Determination of *o*-phenols with the use of an enzymatic biosensor with tyrosinase.	Winter
7.	4	**Cell biology**	Similarities and differences in structure of prokaryotic and eukaryotic cells. Basic research methods applied in studies of cell and its components. Evolution and function of subcellular structures. Mechanisms of cell membrane transport. Signal transduction in the cell. Cell cycle. Basic laboratory methods and safety rules and regulations. Microscopic observations of cells and tissues. Separation of chlorophylls and carotenoids be thin layer chromatography.	Summer
8.	2	**Ceramic materials**	Technological classification of ceramics and glasses. Porcelains as examples of traditional ceramics. Advanced ceramic materials. Oxides and non-oxides as structural ceramics. Porous ceramics. Ceramic-ceramic composites. Ceramic – organic composites. Organically modified ceramics. Ceramics and their composites applications in industry and medicine.	Summer
9.	1	**Chemical sensors**	Classification of chemical sensors. Theoretical basics of chemical recognition. Electrochemical sensors - potentiometric, amperometric and conductometric sensors. Optical sensor, physics of optical fibers, optical fiber sensors – design, operation and examples. Mass sensors, basics of piezo- and pyroelectricity, chemical layers of mass sensors. Thermal sensors - pyroelectric sensors, gas catalytic sensors. Applications of chemical sensors in industrial analytical control, clinical chemistry and environmental protection. The development prospects of chemical sensors.	Summer

10.	2	**Chemistry of cosmetics**	The key organic and inorganic compounds in cosmetics. Structure of skin, hair, and nails. Terminology of cosmetics. Organic, natural, and artificial ingredients. Labeling. Functional ingredients. Cleansers (detergents, surfactants, emulsifiers). Conditioners (silicones, cationic, occlusive, humectants, emollients). Film formers (hair polymers, skin polymers). Colors (hair colors, skin colors. Solvents, thickeners, preservatives, fragrances, adjusters, UV fillers, and plasticizers. Harmful ingredients in cosmetics. Irritating compounds and allergens. Dosage forms of cosmetics. Solutions, gels, foaming gels, serums, lotions, creams, powders.	Winter
11.	3	**Computer science**	Windows command line. Basics of computer networks configuration and diagnostics. Getting acquainted with the operation and operation of the CeL (Center of e-Learning). Privacy and data security (pendrives, data archiving, data encryption, e-mail, anti-virus, firewall, logins and passwords). Formatting documents (LibreOffice Writer), process diagrams (MsVisio or LibreOffice Draw), chemical structure editors (desktop: Accelrys, BioviaDraw and web-based: e-Babel, ChemExper, e-Molecules. Basics of programming in C++.	Summer
12.	2	**Electrochemical technologies**	Electrolysis process - general definitions. Area of electro-chemical engineering. Industrial electrochemical processes of inorganic compounds. Chloralkali industry processes. Electrolytic production of aluminium and magnesium. Hydrometallurgical processes. Electrochemical production of zinc. Electrolytic refining of copper. Industrial electrochemical processes of organic compounds. Electrohydro - dimerization of acetonitrile. Electrolytic production of sebacic acid. Electrochemical production of aromatic aldehydes. Application of electrochemical methods in waste recycling. Principles of electroplating processes. Batteries and fuel – cells.	Summer
13.	5	**Engineering thermodynamics**	Equations of state for gases and liquids. Selected thermodynamics functions for pure substances. Mixture of real gases and liquids. Equilibria in multi-phase systems. Methods of calculation of fugacity and activity coefficients. Liquid-liquid equilibrium (extraction). Liquid-vapor equilibrium (distillation, evaporation). Liquid-gas equilibrium (absorption). Solid-liquid equilibrium (crystallization). Solid-gas equilibrium (adsorption). Calculation of mechanical work in selected processes. Foundations of thermodynamic cycles.	Summer

14.	2	**Forensic biochemistry**	Students are introduced to general concepts of biochemistry in forensic sciences. Lectures include: knowledge about structures of harmful biological and synthetic compounds, metabolism of mentioned compounds, methods of their analysis and quantification. Traditional and modern methods of detection of various harmful compounds will be discussed. Compounds of interest will include illegal drugs, designer's drugs, toxins etc. Part of lectures will be dedicated for learning of methods of interpretation of analytical results including NMR, MS, and FTIR spectra	Summer
15.	8	**General and inorganic chemistry**	Structure of atom. Periodicity of chemical properties. Ionization energy, electron affinity, electronegativity. Metal and non-metals. Chemical bonds. Formal oxidation state. Molecular orbital and valence bond theory. States of matter. Gas state (ideal gas law, van der Waals equation). Properties of liquids. Solid state of matter. Ionic and molecular crystals. Phase transitions. Units for solution concentrations. Kinetics of reaction. Chemical equilibria.	Winter
16.	8	**General and inorganic chemistry**	Properties of solutions. Colligative properties. Electrolytes. Electrolytic dissociation. Strong and weak electrolytes. Acids and bases. Amphoterism. Hydrolysis of salt solutions. Buffers. Precipitation and dissolution. Properties of elements. Main group elements. Transition elements. Complex equilibria. Crystal field theory. Spectroscopic and magnetic properties. f-Block elements. Bonds in organometallic compounds.	Summer
17.	2	**General and inorganic chemistry**	Introduction of basics of chemical qualitative analysis. Division of cations and anions into analytical groups. Qualitative analysis of chosen cations, anions and salts. Characteristic reactions and control analysis of first group of cations. Characteristic reactions and control analysis of second group of cations. Characteristic reactions and control analysis of third group of cations. Characteristic reactions and control analysis of fourth and fifth group of cations. Characteristic reactions and control analysis of anions. Control analysis of salt.	Winter
18.	4	**Genetic engineering**	Generating of DNA fragments: cutting of genomic DNA with restriction enzymes, chemical synthesis, reverse transcription, polymerase chain reaction (PCR). Application of DNA fragments in molecular biology. Molecular cloning in prokaryotic and eukaryotic cells. Vector systems: plasmids, cosmids, phages, BACs and YACs. Construction of vectors: restriction enzymes, ligation. Mechanisms for development of transgenic organisms: transformation, transduction, transfection. Detection and analysis of transformants. Expression systems in bacteria and eukaryotes. Manipulating of gene expression. Controlled in vitro mutagenesis. Transgenesis of plants and animals. Purification and identification of recombinant proteins: affinity chromatography, electrophoresis, immunobloting, mass spectrometry.	Summer

19.	6	**Instrumental analysis**	Introduction – aims of course. Description of common terms in instrumental analysis (selectivity, sensitivity, detection limit etc.). Spectroscopic methods. Review of properties of electromagnetic radiation. Instrumental components (sources of radiation, wavelength selectors, detectors). Polarymetry. Atomic Emission Spectroscopy (arc and spark sources, detectors). AES based on plasma sources (DCP, ICP, MIP). Flame emission techniques. Atomic Absorption Spectrometry (AAS): principles, sample atomization techniques. Spectrometer components (light sources, flame and graphite furnace). Quantitative analysis: Beer's Law. UV/VIS spectroscopy. Mono and double beam spectrometers. Applications. Infrared spectroscopy (IR). Fourier transform IR spectroscopy (FTIR). Partition coefficient, retention parameters. Plate theory and optimization techniques. Gas Chromatography (GC). Stationary phases and column types. Detectors. Nuclear Magnetic Resonance spectroscopy (NMR): theory, environmental effects on NMR spec-tra, spec-trometers, applications of 1H-NMR. Molecular Mass Spectrometry – molecular mass spec-tra, ion sources, mass spectrometers applications. Separation methods. Chromatography – the principles and types of chromatographic methods used in mod-ern Liquid chromatog-raphy. Column efficiency. HPLC techniques – principles and appli-cations. Thin-Layer HPLC. Quantitative and qualitative methods in chromatography. Elec-troanalytical methods: in-troduction to electrochemistry. Potentiometric methods. Refer-ence electrodes. Ion selec-tive electrodes and their applications. Direct potentiometry and potentiometric titration. Voltamperometry and Polarography. Dropping Mercury Electrodes. Pulse polarography. Voltammetric methods.	Winter
20.	2	**Introduction to material science**	Introduction, definition of material, classification of materials in terms of arrangement, - crystals and glasses. The basic terms of crystallography: (space lattice, crystal axis, unit cell, space points, lines and planes). Miller indices of planes, directions in a crystal lattice. Crystallographic systems. Fourteen Bravais. Atom radius and ion radius. Coordination numbers and figures. Symmetry of crystals. Elements of group theory. Classification of crystals in terms of chemical bonding (ionic crystals, covalent crystals, metal crystals, molecular crystals). The most important structures of elements and chemical compounds. Monocrystals and polycrystals.	Winter
21.	2	**In vitro culture**	Plant mineral nutrition. Changes of plant physiology under in vitro conditions. Plant hormones: functional classification, chemical structure, application in in vitro culture. Regulation of cell division, tissue differentiation and organogenesis. Application of in vitro culture in research, agriculture, protection of endangered species and genetic diversity of agricultural plants.	Winter

22.	3	**Metabolomics and lipidomics**	Metabolomics is the systematic study of the unique chemical fingerprints that specific cellular processes leave behind. It is the study of their small-molecule metabolite profiles. The metabolome represents the collection of all metabolites in a biological organism, which are the end products of its gene expression. Metabolic profiling can give an instantaneous snapshot of the physiology of that cell/organ/organism. The aim of this module is to transfer knowledge regarding metabolites, metabolic profiling methods and also about analysis of metabolic information derived from single compounds and from complex metabolomic profiles.	Winter
23.	5	**Molecular biology**	Chemical structure of nucleic acids. Bacterial chromosome structure and function: replication, transcription, translation. Plasmids: structure, cellular function, application in genetic engineering. Transformation of bacterial cells. Sources of genetic variation in bacteria. Laboratory methods: isolation of nucleic acids, DNA cutting with restriction enzymes, nucleic acids electrophoresis, PCR.	Winter
24.	2	**Molecular biology**	Structure of eukaryotic chromosomes and genomes. Eukaryotic cell cycle. Replication of eukaryotic chromosomes. Transcription and translation in eukaryotes. Mitochondrial and chloroplast DNA. Laboratory methods: DNA ligation, reverse transcription.	Summer
25.	7	**Organic chemistry**	This course covers structure and bonding in organic compounds, hybridization, acidity and basicity, factors affecting boiling point, melting point, dipole moment and reactivity (electronegativity, inductive electron withdrawal, resonance and hydrogen bonds). Furthermore, it refers to isomerism (conformational, R,S /E,Z) and the mechanisms of addition and substitution /elimination reaction. The nomenclature and reactions of alkanes and alkenes are also discussed.	Winter
26.	7	**Organic chemistry**	The nomenclature, physical properties, preparations, and reactions of alkynes, aromatic compounds, alcohols and phenols, ethers, epoxides, sulfides, carbonyl compounds (aldehydes, ketones, carboxylic acids, esters, amides, acid anhydrides, acyl halides), amines and amino acids. Proteins, lipids and carbohydrates.	Summer

27.	2	**Packages of application software**	Computer software for chemical engineers. Application of MS Excel to discretize functions, create charts, perform array operations, do simple statistical analysis, perform operations with macros and solve and model chemical problems using Solver tool. Application of Origin Lab to prepare 2D and 3D charts, perform statistical processing of experimental data, perform differentiation and integration of discretized functions. Application of Matlab and/or Maple programs for arithmetic calculations, algebraic transformations, solution of linear and nonlinear equations, inequalities and systems of equations, symbolic and numerical function integration and differentiation, matrix algebra, solving differential equations, graphing functions. Introduction to programming in Matlab and/or Maple. Creation of simple programs for solving selected mathematical and chemical problems.	Winter
28.	7	**Physical chemistry**	Theory of ideal gases. Equations of gas laws. Theories of nonideal gases. Critical parameters. Chemical thermodynamics. System. Surroundings. Work. Heat. Reversible processes. Reversible, isothermic gas expansion. First thermodynamic law. Internal energy. Enthalpy. Heat capacitance of gases, liquids and solids. Thermochemistry. Formation enthalpy of chemical compounds. Heat of dissolution. Bond energy and enthalpy. Influence of temperature on reaction enthalpy. Second and third thermodynamic laws. Spontaneous processes. Carnot cycle. Entropy. Entropy changes in reversible and nonreversible processes. Entropy of mixing. Gibbs free enthalpy. Helmholtz free energy. Differentials and derivatives of thermodynamics functions. Influence of pressure and temperature on free enthalpy. Thermodynamic criteria for spontaneous processes. Partial molar quantities. Chemical potential. Phase equilibria and phase diagrams. Three – component systems. Gibbs phase rule. Clapeyron equation. Clausiuss – Clapeyron equation. Vapor pressure of ideal and nonideal solutions. Solubility of gases and liquids. Thermodynamics of ideal solutions activity. Activity coefficient. Temperature diagrams of two-component solutions. Azeotrops. Colligative properties of solutions. Distribution coefficient. Extraction. Chemical equilibrium. Thermodynamic equilibrium constant. Chemical equilibrium in gas phase. Influence of pressure and temperature on chemical equilibrium.	Winter

29.	7	**Physical chemistry**	Chemical kinetics. Reaction rate and order. Reactions with different orders. Determination methods of reaction rate and order. Influence of temperature on reaction rate constant. Arrhenius theory. Theories of reaction rates. Complex reactions. Kinetics of enzymatic reactions. Principles of catalysis. Electrolyte solutions. Hückel – Debye theory. Activity of electrolyte solutions. Specific and molar conductance of strong and weak electrolytes. Ions mobility. Ion transfer number. Thermodynamic of electrolyte solutions. Electrochemistry. Electrochemical half – cell and cell. Half – cell potential. Chemical reactions in half – cells. Nernst equation. Electromotive force of a galvanic cell. Thermodynamics of an electrochemical cell. Applications of electrochemical measurements. Batteries. Fuel – cells. Surface tension. Adsorption and adsorption equations. Intermolecular interactions. Symmetry of chemical molecules. Symmetry elements. Symmetry operations. Space groups.	Summer
30.	4	**Physical chemistry of polymers**	Basic definitions and classification of polymers. Structure of macromolecules. Intramolecular interactions in polymers. Molecular weights of polymers and dispersity. Methods of determination of molecular weights. Configuration of a single macromolecule. Tacticity, cis-trans isomers, microstructure (sequence of units). Types of polyreaction. Copolymers and crosslinking systems. Condensed state of polymer - crystalline and amorphous state of polymers. Polymer solutions and melts. Rubber elasticity. Liquid-crystalline polymers. **Laboratories**: Characterization of amorphous polymers (determination of glass transition temperature) and crystalline polymers (determination of melting point of the crystalline phase and the degree of crystallinity) by DSC; Determination of degree of crystallinity of poly(ethylene terephthalate) by means of density measurements and by DSC; Determination of the particle size in polymer solutions and dispersions using dynamic light scattering method; Determination of molecular weight of selected polymers by viscosity (viscosimetric) method; Determination of the reaction order (in relation to initiator) of styrene polymerization in bulk; Studies of the polyaddition kinetics of diisocyanates and polyols on the exampary model reaction of tolylene diisocyanate with 1-butanol in various solvents; Studies on the kinetics of free radical copolymerization and determination of reactivity coefficients for the styrene-acrylonitrile system; Determination of water vapor permeability rate by polymer coatings.	Winter
31.	2	**Plant biochemistry and physiology**	Chemical composition of plant cell and its organelles. Chemical composition of extracellular components of plant tissues and organs. Genetic control of plant cell structure and metabolism. Plant secondary metabolites: function in nature, application in pharmaceutical and cosmetic industry .	Winter

32.	4	**Polymer chemistry and technology**	Lecture: Introductory remarks. Classification of polymers and examples of polymer types. Polymer nomenclature. Structure of macromolecules and their relationship to the physical properties of polymers. Thermodynamic principles of polymerization. Radical polymerization and the main polymers obtained via radical mechanisms. Ionic polymerization of unsaturated monomers. Copolymerization. Polycondensation and the main polymers obtained by polycondensation. Ring-opening polymerization. Coordination polymerization. Polyolefins. Reactions of polymers. Chemical modification of polymers. Natural polymers. Laboratories: Synthesis of selected polymers. Modification of polymers. Identification of major groups of polymers.	Summer
33.	2	**Process design**	Introduction to methods of designing integrated systems technology. Characteristics of simulation programs. Basic rules for the selection of thermodynamic models. An introduction to computing simulation processes (flow of information, analysis of degrees of freedom, the classification of simulation methods). The calculation of chemical reaction processes and reactors. The criteria for evaluation of the project - pure chemical technology. Hierarchical method, an example application. Calculation of the heat exchangers. Basics of simultaneous methods. Calculation of separators with two liquid phases. Design Heuristics. The calculation of basic unit operations and analysis of the results (flash calculations, distillation, extractive distillation, absorption). Calculation of pipeline networks and their elements. The calculation of the basic operations of fluid transport (pumps, compressor, expander, valves). The use of sensitivity analysis as a tool for selection of parameters of the apparatus.	Winter
34.	7	**Spectroscopic methods of analysis**	Characteristic group rate for the chemical compounds in vibration IR and Raman spectroscopy. Influence of inductive effect, resonance effect and intermolecular interactions on the spectra parameters absorption spectra. Parameters defining the value of spectral parameters in ^{1}H-NMR i ^{13}C-NMR spectra. Design of ^{1}H-NMR spectra for the systems with different coupling constants. Recording techniques for ^{13}C-NMR spectra. Two-dimensional (2D) NMR spectroscopy. Design of ^{13}C-NMR NBD spectra using the additive rules. Identification of chemical compounds using the standard spectra directory. Determination of chemical compounds structure using empiric spectra-structural correlation IR, RA, UV/Vis, NMR, MS.	Winter

35.	3	**Technology of film forming materials**	Types and use of coating-forming substances as paints and lacquers. Natural and synthetic polymers used in coating technology. The excipients used in the technology of paints and lacquers. Manufacturing technologies and applications waterborne lacquers. Powder coatings. Solvent-borne and high-solid coatings. Methods for preparing substrates under coating layers. Methods and techniques for applying coating layers. Drying of the coatings. Methods for evaluation of the quality of coating systems and coatings. Aging and stabilization of polymer coatings	Winter