ARISTOTLE UNIVERSITY OF THESSALONIKI

FACULTY OF SCIENCES

SCHOOL OF CHEMISTRY

ACADEMIC YEAR 2019-2020

A GUIDE

TO THE COURSES

(Courses and contents in English)

Thessaloniki 2019

The texts and the publication of the Undergraduate Study Guide were edited by the Committee for the Preparation and Publishing of the Guide to the Undergraduate Courses of the School of Chemistry, elected at the academic period of 2019-2020, consisting of the following members, in alphabetical order:

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CONTENT OF THEORETICAL AND LABORATORY/PRACTICE COURSES

Division of General and Inorganic Chemistry

Y01 General and Inorganic Chemistry I

Mandatory Course, 1st semester

lecture: 4h/week laboratory/practice: 4h/week ECTS: 10

Contents

Matter and energy, mass and weight. Units, measurement and equations. Distinguish elements, compounds, mixtures. Atomic and molecular mass. Calculate a percentage composition from formula. Empirical and molecular formulae. Balance chemical equations. Mole, molarity, normality, Avogadro's number. Characteristic properties of solids, liquids and gases. Endothermic and exothermic reactions. Structure of the nuclear atom and isotopes. Atomic structure, electronic shells and subshells, and orbitals. Energy level diagram for the hydrogen atom, and spectrum of atomic hydrogen. Quantum numbers for the hydrogen atom, and for other elements. Interpret orbitals in terms of probability s, p, and d electrons. Aufbau principle, Pauli principle and Hund's rules to build up electron configurations of the elements of the Periodic Table. Periodicity from configuration across and down the Table, and explain trends in radii, ionisation enthalpies, electron affinities and electronegativities. IUPAC Nomenclature of Inorganic Compounds. Classification of Inorganic Compounds. Ionic and covalent bonding. Metallic bonding and relate to metallic properties. Hybridisation of an atom in a given molecule. Lewis structures for simple molecules. Distinguish sigma and pi bonds. Orbital overlap of s, p, and d electrons, bond order. Molecular orbital energy-level diagram. Non-bonding and antibonding orbitals from s, p, and d combinations. Theories of resonance and p-orbital overlap. Dipoles in polar molecules. Covalent or ionic bonds. Occurrence of intermolecular interactions (van der Waals forces, and hydrogen-bonding). Inter- and intra-molecular hydrogen bonding and van der Waals (London) forces in a molecule. State the Bronsted and Lewis acid-base theory and its applications to salt hydrolysis, buffers and solubility. The theory of redox reactions.

Laboratory practice: Safety rules in Chemical laboratories. Reagent's hazards. Mass and volume measurement. Expression of solution concentration. Preparation of solutions with specific concentration. Simple methods for separation of mixtures. Decantation, filtration, centrification. Study of homogeneous and heterogeneous equilibrium and effect of mass and temperature on the

equilibrium. Equilibriums in aqueous solutions of electrolytes. The meaning of pH and its measurement using indicators and pH meters (Principle of pH meter operation). Estimation of the pK of a weak electrolyte. Preparation and study of the buffering ability of buffers. Estimation of the hydrolysis constant of salts in aqueous solutions. Principles and techniques of volumetric analysis. Preparation of standard solutions. Acidimetry – alkalimetry – complexometry – redox volumetric analysis. Redox reactions. Study of the reactivity series of metals and non-metals. Oxidative properties of typical oxidants in aqueous media. Voltaic cells, electrolysis, determination and application of electrolysis laws. Principles of spectroscopy. Application of electronic spectroscopy in the identification and study of inorganic compounds. Homeworks.

Y05 Inorganic Chemisrty II

Mandatory Course, 2nd semester

lecture: 2h/week laboratory/practice: 3h/week ECTS: 5

Contents

The origin of the elements. Systematic description of the Periodic Table group characteristics. Physical and chemical properties, production, chemical behavior, and common technological applications of the main group elements of the Periodic Table and their compounds: Hydrogen, Oxygen, Alkali metals, Alkaline earth metals, Boron, Aluminum, Carbon, Silicon, Nitrogen, Phosphorus, Sulfur, Halogens and Noble gases. Metals and metallurgy.

Laboratory courses/exercises: Basic laboratory techniques for the synthesis, isolation, purification and identification of inorganic compounds. Double-replacement reactions. Isolation of solid products of chemical reactions. Solid-state reactions. Single-replacement reactions. Synthesis, isolation and purity tests of alkali metal salts and boron compounds. Halogens and their oxidizing ability. Transition metals and their compounds: synthesis and isolation of copper and chromium compounds. Acid-base behavior of oxides. Allotropic forms of sulfur. Literature-based project (search the scientific literature and prepare a written report and oral presentation).

Y19 Inorganic Chemisrty III

Mandatory Course, 6th semester

lecture: 4h/week laboratory/practice: 4h/week ECTS: 10

Contents

d-Block elements: atomic properties, physical properties, and oxidation states. Coordination compounds and types of ligand. Coordination number and coordination geometries. Nomenclature of coordination compounds. Structural isomerism and stereoisomerism in coordination

compounds. Thermodynamic stability of coordination compounds and factors that influence their stability: formation constants, hard and soft acids and bases, chelate and macrocyclic effect, steric effects. Synthesis of coordination compounds: substitution reactions, thermal dissociation, reactions with oxidation of the metal center, reactions of the coordinating ligands, synthesis of isomeric complexes. Bond theories of coordination compounds: crystal-filed theory and ligand-field theory. Magnetic properties and UV-vis spectroscopy of coordination compounds: Orgel and Tanabe-Sugano diagrams). Kinetic stability of coordination compounds. Substitution reactions (mechanisms, substitution in octahedral and square planar complexes), isomerism reactions and redox reactions. Applications of coordination compounds.

Laboratory practice: Synthesis of Nickel(II) coordination compounds dithiocarbamate anions and phosphines as ligands: study of compounds with magnetic susceptibility measurements, electrical conductivity measurements and FTIR Spectroscopy. Synthesis of manganese (III) and nickel (II) coordination compounds with Schiff bases as ligands: study of compounds with magnetic susceptibility measurements and FTIR spectroscopy. Synthesis of cobalt(III) coordination compounds with water, ammonia and diethylamine as ligands: study of compounds with magnetic susceptibility measurements, electrical conductivity measurements and UV-vis spectroscopy (determination of the spectrochemical series of various ligands). Laboratory reports. Literature assignment.

H11 Material Chemistry

Semi-Mandatory Course, 5th semester

lecture: 4h/week laboratory/practice: --/week ECTS: 5

Contents

Basic principles of crystallography. Types of crystalline solids. Powder and single crystal X-ray diffraction, prediction and/or determination of crystal and molecular structure. Optical properties of solids. Physical and chemical properties of materials such as semicondictive polymers, metal oxides and semiconductors. Thin films and nanostructures. Conductivity mechanisms. Ionic and electronic conductivity in imperfect crystals. Models of point defects in non-stoichiometric oxides. Examples of applications. Intermolecular interactions and the formation of supramolecular structures. Liquid crystals. Organic materials. Systems with nonlinear optical properties. Molecular wires and switches. Membranes and transport systems. Biomaterials and nanomaterials. Micelles. Applications in synthesis and catalysis.

B02 Radiochemistry and Nuclear Chemistry

Core Elective Course, 4th semester

lecture: 2h/week laboratory/practice: 2h/week ECTS: 5

Contents

Structure and properties of the atomic nuclei. Radioactivity. Radioactive decay. Radioactive equilibrium. α., β. and γ. decay-spontaneous fission. Interaction of the nuclear radiation with the matter. Detection of the nuclear radiation. Nuclear reactions. Nuclear fission. Nuclear fusion. Actinides: Production and chemical behavior. The biological effects of the nuclear radiation and radiation protection. The uranium cycle-Nuclear energy. Reactors, accelerators and their applications.

Laboratory Practice: Radioactive decay. Radioactive equilibrium. α., β. and γ. decay. Interaction of the nuclear radiation with the matter. Nuclear reactions.

K316 Radioanalytical Chemistry and Applications of Nuclear Techniques

Elective Course, 7th semester

lecture: 4h/week laboratory/practice: --/week ECTS: 5

Contents

Subatomic particles-structure and decay of the atomic nuclei-Radioactive series. Absorption of nuclear radiation (Absorption of charged particles, neutrons and photons). The measurement of the nuclear radiation-Detectors. Nuclear reactions-cross section, Q-value and energy balance. Nuclear safety-radiation units. Natural radioactivity. Radioactive elements in the environment. Uranium: separation techniques, determination and applications. Methods for determination of radioactive elements. Nuclear wastes treatment. Radiochemical and nuclear methods of analysis. Neutron activation analysis, x-ray fluorescence. Radioactive tracers. Radioactive dating methods. Production of radioisotopes-Radiopharmacy. Application of radioisotopes and radiations in the chemistry and biology. Application of reactors in the art and technology.

Laboratory practice: Detection and measurement of nuclear radiation, measurement statistics, dead-time determination, absorption of nuclear radiation by the matter, alpha- and gamma-ray spectroscopy, natural radioactivity, determination of uranium and thorium.

K105 Chemical Education and the Experiment in the Teaching of Chemistry

Elective Course, 8th semester

lecture: 2h/week laboratory/practice: 2h/week ECTS: 5

Contents

Introduction to the principles of teaching of physical sciences. Principles of teaching as applied in chemistry. Factors influencing the teaching of chemistry. Teaching methods. Formulation and adoption of safety rules in the school lab. Organization and classification of reagents, utensils and laboratory space. Organizing the presentation of an experiment. Objective explanation, process description, discussion of observations and results. The interaction of trainees with the teacher and each other. Analysis and evaluation of experimental test results. Assessment of the achievement of the experimental objectives in terms of the extent and type of understanding of the principles and laws governing the phenomenon studied. The demonstration experiment. Organizing and presenting to groups of students. Demonstration in microscale and in a diaphragm. Grading of difficulty, complexity and accuracy of observations for experiments aimed at students of different ages and backgrounds. Interdisciplinarity in Chemistry experiments and reference to everyday Chemistry.

K109 History and Epistemology of Physical Sciences

Elective Course, 7th semester

lecture: 3h/week laboratory/practice: --/week ECTS: 5

Contents

Science and the scientific method. How philosophy faces science. Limits and practices of epistemology. The epistemological approach on the part of philosophers and experimental researchers. Philosophical trends that have influenced or influenced science, from antiquity to modern times. The foundation of the sciences in antiquity and the historical evolution of the ideas in them in their course to modern times. The foundation of the sciences in antiquity and the historical evolution of the ideas in them in their course to modern times. Historical evolution of perceptions about the natural world. The theoretical conception - the mechanistic perception - the quantum vision of the world. Distinction of Chemistry from the backbone of natural sciences and the course of evolution of theories and perceptions in it up to modern times

K301 Bioinorganic Chemistry

Elective Course, 8th semester

lecture: 3h/week laboratory/practice: --/week ECTS: 5

Contents

Evolution of life. Evolution and homeostasis stages. Creation of biological systems. Redox potentials and bioelements. Trace elements *in vivo*. Selective binding, cooperative and competitive activity of trace elements. The role of metal ions in biological systems. Bioinorganic

chemistry and applications (coordination compounds *in vivo*, metalloenzymes). Iron metalloproteins. Metalloenzymes of manganese and the role of manganese in the oxygen evolving center of photosystem II. Copper *in vivo*. Zinc enzymes. Molybdenum *in vivo*. Elements and their compounds used as drugs. Physical methods to study metalloenzymes. Interaction of metal ions and coordination compounds with nucleic acid and other biomolecules.

K302 Organometallic Chemistry and Catalysis

Elective Course, 8th semester

lecture: 4h/week laboratory/practice: --/week ECTS: 5

Contents

General principles, characteristic properties of organometallic compounds, formation of metal-carbon bonds. Structure, reactivity and applications of different classes of organometallic compounds. Role of organometallic compounds in some reactions with applications of industrial interest, catalysis. Synthetic organic reactions catalyzed by metals. Catalytic hydrogenation and oxidation. Mo and Ru catalysts in alkene metathesis reactions. RCM, ROMP, Cross metathesis. Organometallic compounds of Cu. Organometallic compounds of Pd. Heck-reaction, Suzuki-reaction, Pauson-Khand-reaction. Stille-couplin. Other organometallic reactions. General principles, characteristic properties of organometallic compounds, formation of metal-carbon bonds. Structure, reactivity and applications of different classes of organometallic compounds. Role of organometallic compounds in some reactions with applications of industrial interest, catalysis. Synthetic organic reactions catalyzed by metals. Catalytic hydrogenation and oxidation. Mo and Ru catalysts in alkene metathesis reactions. RCM, ROMP, Cross metathesis. Organometallic compounds of Cu. Organometallic compounds of Pd. Heck-reaction, Suzuki-reaction, Pauson-Khand-reaction. Stille-couplin. Other organometallic reactions.

K303 Physical Methods in Inorganic Chemistry

Elective Course, 8th semester

lecture: 3h/week laboratory/practice: --/week ECTS: 5

Contents

Basic principles of the spectroscopic techniques and other physical measurements that apply to inorganic and organometallic compounds. Selection rules in spectroscopy. Electronic absorption and emission spectroscopy. The interferometer and Fourier analysis. Mathematical background and applications. Vibration spectroscopy and analysis of normal coordinates. The magnetic behavior of inorganic systems. Elucidation of the structure of inorganic compounds through the

measurement of their magnetic susceptibility. EPR and NMR spectrometries and their applications in the structural characterization of inorganic and organometallic compounds

K304 Nanochemistry or Inorganic reaction mechanisms

Elective Course, 7th semester

lecture: 3h/week laboratory/practice: --/week ECTS: 5

Contents

Nanochemistry: Introduction to the nanoscale. Properties of nanoscale materials. Wet chemistry synthetic processes. Role of the surfactantants. Characterization processes. Magnetic properties at the nanoscale. Magnetic nanoparticles of iron, cobalt, nickel. Biomedical applications of magnetic nanoparticles (Drug carriers, magnetic hyperthermia, MRI contrast agents)

Inorganic reaction mechanisms: Classification of reactions mechanisms' of coordination compounds. Redox reactions. Inner and outsphere reactions. Substitution reactions. Dissociative, Associative process and Synchronous reactions. Nucleophilic substitution of coordination compounds. Addition and elimination reactions mechanisms'.

Y11 Principles of Quantum Chemistry and Spectroscopy

Mandatory Course, 3d semester

lecture: 4h/week laboratory/practice: --/week ECTS: 5

Contents

Historical outline of the early quantum mechanics. Schrödinger equation and its application in simple systems. Quantum mechanical study of hydrogenlike and polyelectronic atoms. The spin of the electron and antisymmetric wave functions. Quantum chemical study of molecular structure. Molecular Orbital Theory and LCAO. Quantum chemical study of diatomic molecules and p-conjugated systems. Principles of spectroscopy. Electron and vibrational spectroscopies.

H10 Computational Chemistry

Semi-Mandatory Course, 6th semester

lecture: 2h/week laboratory/practice: --/week ECTS: 5

Contents

Approximate methods of quantum chemistry (Pertubation and Variation methods) of Disturbances and Change Theory). Hartree-Fock Theory. Basis sets. Study of potential energy hypersurface of molecules. Population analysis and Natural orbitals. The practice of quantum chemical calculations. Molecular Mechanics. The tools of computational chemistry.

H 13 Real, Virtual and Hybrid Laboratories on Principles and Laws of Chemistry in formal and informal education.

Semi-Mandatory Course, 6th semester

lecture: 2h/week laboratory/practice: 2/week ECTS: 5

Contents

Applications that combine the real experiment in the real laboratory, where the physical presence of the learner is required, with the virtual experiment, concerning subjects on principles and laws of chemical science, such as:

Quantum description of atom. Periodic Table - Electronic configuration, Reactions' Stoichiometry, Types of Reactions, Determination of Quantities of Educts and Products, Measurement of Physicochemical Parameters, States of Matter, Thermochemistry, Properties of Solutions (Non-Electrolytic and Electrolytic), Chemical Equilibrium, Ionic Equilibrium, Chemical Kinetics, Redox reactions, Galvanic cells, Electrolysis.

A05 Computer Science in Chemistry

Core Elective Course, 2nd semester

lecture: 2h/week laboratory/practice: --/week ECTS: 5

Contents

Computer Architecture and Operation. Programming elements. Use word processing software, worksheet management, and electronic presentations. Chemical design and Internet used programs.

K101 Molecular Modeling

Elective Course, 8th semester

lecture: 2h/week laboratory/practice: --/week ECTS: 5

Contents

Definition of molecular modeling. Molecular graphs. Molecular engineering. Minimization of energy. Conformation analysis. Stuctural sudies of biomolecules and polymers. Calculation and visualization of molecular properties based on ab initio and semi-imperial calculations. Molecular dynamics. The technique of molecular docking.

KN102 Molecular Symmetry and Group Theory

Elective Course, 8th semester

lecture: 2h/week laboratory/practice: --/week ECTS: 10

Contents

Symmetry Elements and operations. Point Groups. Group theory and molecular symmetry. Point group representations. Character tables. Applications of Symmetry and Group Theory in Quantum Chemistry and Spectroscopy

K103 Applications of Computational Lectures in Chemistry

Elective Course, 8th semester

lecture: 4h/week laboratory/practice: --/week ECTS: 5

Contents

Introduction to Calculation Sheets (Excel). Graphs. Linear and non-linear minimum squares. Data mining, derivation and integration. Statistical analysis of data with worksheets. Creation of complex data and application in the reproduction and study of physico-chemical systems. Introduction to macros.

K104 Building, Presenting and Diffusing the Chemical Information

Elective Course, 7thsemester

lecture: 2h/week laboratory/practice: 2h/week ECTS: 5

Contents

Databases of chemical information and data. Format of molecular structure description files. Tools for building, visualization and saving 3D graphics. Graphics' file formats and editing software. Tools and techniques for writing scientific texts. Presentation tools. Structure, organization and running of a web site. Website'sdevelopmenttools.

K107 Development of Multimedia Material in Chemistry and Teaching Using e-learning Networks

Elective Course, 8th semester

lecture: 2h/week laboratory/practice: 2h/week ECTS: 5

Contents

Principles for the use of multimedia. Video, audio, and interactive 3D molecular graphics. Multimedia and Simulation in Chemistry Teaching. Tools for development of multimedia applications and simulations. Educational Portals. Modern and asynchronous distance learning. Course management systems. Evaluation in distance learning.

Division of Organic Chemistry and Biochemistry

Y15 Biochemistry I

Mandatory Course, 4th semester

lecture: 4h/week laboratory/practice: 3h/week ECTS: 5

Contents

Introduction. Water (physical properties and hydrogen bonding of water, structure of liquid water, The ion product of water: The pH scale, acids and bases, The Fitness of the aqueous environment for living organisms).

Amino acids-Proteins. Acid- base properties of amino acids, the amino acids as building blocks of proteins, common amino acids, rare amino acids, non protein amino acids. The stereochemistry of amino acids and the absorption spectra. Amino acid reactions of amino groups, carboxyl groups and residue groups. Classification of proteins, Protein structure (covalent backbone and amino acid sequence, peptides, primary, secondary, tertiary, quaternary structure, higher conformation of proteins). Biological role of proteins, structural and functional proteins, protein denaturation, structure function relationship of proteins.

Enzymes. Naming and classification of enzymes , Kinetics , enzyme cofactors, coenzymes, cytochromes, inhibition of enzymic reactions, enzymic specificity, enzyme substrate complexes and covalent enzyme-substrate compounds , enzyme function regulation, isoenzymes

Nucleic acids. Nucleic acids and primary structure. Secondary structure of nucleic acids, DNA, RNA properties in solution, the biosynthesis of nucleotides, nucleic acid catabolism. Recombinant DNA ,DNA replication , transcription and repair.

Protein synthesis. The genetic code, the mechanism of protein synthesis, regulation of protein synthesis, covalent modifications, higher conformational structures of proteins and subcellular localization. Cellular defense against viral components. Recombinant DNA.

Y17 Biochemistry II

Mandatory Course, 5th semester

lecture: 4h/week laboratory/practice: 3h/week ECTS: 5

Contents

Metabolism. Structure of cellular membranes. Transport of water and inorganic ions across membranes, The organization of membrane transport systems – passive transport systems, active transport systems, the γ-glutamyl cycle for amino acid transport, ionophores.

The tricarboxylic acid cycle. Bioenergetics principles and the ATP cycle. The flow sheet of respiration, oxidative respiration, intracellulara location of the enzymes of Krebs cycle, the reactions of Krebs cycle, anaplerotic reactions, regulation of Krebs cycle, the glyoxylate cycle, oxidation-reduction enzymes and electron transport, the respiratory chain, inhibitors of electron transport, proton exchanges during electron transport, microsomal electron transport, superoxide dismutase and catalase , electron transport in other systems.

Carbohydrates. Sugars, storage polysaccharides and cell walls. Glycoproteins and proteoglycans. Glycose metabolism. The stages of glycolysis. The phosphogluconate pathway. Metabolism of oligo- and polysaccharides, polysaccharide biosynthesis. Photosynthesis. Biosynthesis of mono- and glucose derivatives from glycose. Glycogen biosynthesis and degradation.

Lipids. The biosynthesis of lipids.Lipoproteins .Lipid metabolism. Biosynthesis of trialcylglycerols, biosynthesis of phosphoglycerides,Genetic disorders in metabolism of the complex lipids, the pathway of cholesterol biosynthesis, biosynthesis of prostagladins.

Proteins. The biosynthesis of amino acids and some derivatives: Metabolism of inorganic nitrogen essential and non essential amino acids. Nitrogen fixin organism, enzymic mechanism of nitrogen fixation, other steps in nitrogen cycle.

Vitamins. Vitamins and coenzymes.Water soluble and fat soluble vitamins. Hormones, hormonereceptors.

K308 Clinical Biochemistry

Elective Course, 7th semester

lecture: 4h/week laboratory/practice: 3h/week ECTS: 5

Contents

Sampling and maintenance of biological samples. Quality control in clinical chemistry. Analysis of proteins, amino acids and derivatives, carbohydrates, lipids and lipoproteins, enzymes. Immunological methods, automatic analyzers. Principles and methodology of molecular diagnostics. Cancer and cancer markers. Laboratory testing of endocrine, kidney, stomach and intestinal function. Acid-base balance and electrolytes. Hormones, hypertension mechanisms. Carbohydrates and diabetes. Diet. Blood clotting, clotting factors.

K309 Structural Biochemistry - Elements of Bioinformatics

Elective Course, 8thsemester

lecture: 2h/week laboratory/practice: 1h/week ECTS: 5

Contents

Structural Biochemistry. Protein structure motifs, α-structures, α / β structures, β-structures, folding and flexibility, DNA structures, helix-turn-helix, DNA recognition by eukaryotic transcription factors, transcriptional transcription factor structures, membrane protein structures, fibrous proteins, structures in the recognition of foreign molecules by the immune system, prediction, engineering and design of protein structures, elements of analysis and determination of protein structures.

Bioinformatics data. Principles of Structural Bioinformatics, Sequence Coordination, FASTA, BLAST, Multiple Sequencing, CLUSTALW, MOTIFS, Phylogenetic Trees, Prediction of Secondary Structure of Proteins and Nucleic Acids. Navigation in proteomics and protein engineering tools. Design of primers for polymerase chain reaction (PCR). Comparative design of protein structure, Analysis of microstructures.

K310 Molecular Cell Biology – Control of Metabolism

Elective Course, 7th semester

lecture: 3h/week laboratory/practice: --/week ECTS: 5

Contents

An overview of cells, the basic unit of life. Cells as experimental models. Prokaryotic cells, viruses, plasmids and transported genetic elements. The eukaryotic cell, structure and function of individual organelles, biological membranes and cytoskeleton. Intracellular transport and maturation of proteins. Cell cycle, cell division, differentiation and cell death. Regulation of the expression of genetic information. Cell signaling, signal transduction pathways.

K314 Biotechnology

Elective Course, 8thsemester

lecture: 3h/week laboratory/practice: --/week ECTS: 5

Contents

Growth of microorganisms. Improving strains with commercial value. Selection and isolation of strains. Site directed mutagenesis. Principles of recombinant DNA, protein engineering. Restriction nucleases, DNA sequence analysis, Nucleic acid hybridization, DNA cloning, DNA engineering, Genetic engineering, Applications of protein engineering, Fusion proteins.

Enzyme structural modification by chemical methodologies. Methods for enzyme immobilization. Enzyme binding to insoluble vectors. Intermolecular enzyme coupling. Enzyme encapsulation in liposomes or hydrophobic polymeric matrices. Properties of immobilized enzymes. Immobilization of coenzymes, polyenzymic systems and cell immobilization. Downstream

processing for enzymes of industrial value. Bioreactors. Characterization of biotechnological processes. Commercial production of primary and secondary metabolites. Industrial enzymes. Utilization of cellulose-lignocellulose. Microbial recovery of metals. Biochemical electrodes.

K315 Enzymology

Elective Course, 7th semester

lecture hours/week: 3 laboratory hours/week:-- ECTS: 5 credits

Contents

Nomenclature and Classification of Enzymes: Structure and role of enzymes-Criteria of enzymatic reactions – Quantitative determination of enzymes-Selection of method for detection of enzymatic activity-Sources of enzymes-Methods of extraction and purification of enzymes-Mechanisms of enzymatic reactions-Reactions of oxidoreduction-Reactions of groups transfer-Hydrolytic and non-hydrolytic reactions-Synthetic reactions-Kinetics of enzymatic reactions-Constants of Michaelis- Menten reactions-Factors affecting enzymatic reactions-Enzymatic reactions with many substrates-Active site of enzymes-Enzymes Inhibitors-Activators-Allosteric phenomenon and biological significance-Stereoselectivity of enzymes-Enzymes activity and post-translational modification of enzymes- Regulation of enzymes biosynthesis in bacteria and animal cells. Enzymes activity in non-conventional media.

YN06 Organic Chemistry I

Mandatory Course, 2nd semester

lecture: 6h/week laboratory/practice: --/week ECTS: 10

Contents

Structure and bonding in organic molecules: Coulomb forces, ionic and covalent bonds, resonance forms, atomic orbitals, molecular orbitals and covalent bonding, hybrid orbitals, structures and formulas of organic molecules. Structure and reactivity: kinetics and thermodynamics of simple chemical processes, acids and bases. Alkanes: nomenclature, properties, conformations, reactions. Cycloalkanes. Stereoisomers: optical activity, enantiomers, diastereomers, stereochemistry of organic reactions. Haloalkanes: nucleophilic substitution reactions, elimination reactions. Alcohols and ethers: nomenclature, properties, preparations, reactions. Introduction to spectroscopic methods NMR, IR, MS. Alkenes: structure, bonding, spectroscopy, preparations, reactions.

YN09 Organic Chemistry II

Mandatory Course, 4th Semester

lecture: 6h/week laboratory/practice: --/week ECTS: 10

Contents

Alkynes: structure bonding, spectroscopy, preparations, reactions. Delocalized pi systems: allylic systems, conjugated dienes, Diels-Alder cycloaddition, polymerization of conjugated dienes, UV-Vis spectroscopy. Benzene and aromaticity: structure, spectroscopic characteristics, resonance energy, electrophilic aromatic substitution, benzene derivatives and polycyclic aromatic hydrocarbons.

Aldehydes and ketones: structure of the carbonyl group, spectroscopic properties, preparations, nucleophilic addition reactions. Enols, enolates ions: a-carbonyl substitution reactions. Aldol condensation reactions, conjugate addition reactions. Carboxylic acids. Derivatives of carboxylic acids. Amines: structure, spectrometry of the amino group, preparations, reactions. Chemistry of benzene substituents: benzylic oxidation and reduction chemistry of phenols, arene diazonium salts. Enolate anions and Claisen condensation.

YE12 Laboratory Organic ChemistryI

Mandatory Course, 4th semester

lecture: 1h/week laboratory/practice: 4h/week ECTS: 5

Contents

Basic laboratory techniques. Recrystallization, extraction, drying, distillation, fractional distillation. Measurement of physical constants. Boiling with reflux. Separation of a mixture. Chromatographic methods. Steam distillation. Isolation of natural products.

YE16 Laboratory Organic Chemistry II

Mandatory Course, 5th semester

lecture: 1h/week laboratory/practice: 4h/week ECTS: 5

Contents

Simple syntheses of organic compounds. Synthesis of organic compounds in several stages. Use of protecting groups. Identification of organic compounds. Retrosynthetic analysis. Interconversion of functional groups. Protection of functional groups. Reactions forming C-C bond. Using spectroscopic methods (MS, IR, NMR) to determine the structure of organic compounds.

YN16 Organic Chemistry III

Mandatory Course, 5th semester

lecture: 4h/week laboratory/practice: --/week ECTS: 5

Contents

Carbohydrates, Heterocyclic compounds, Aminoacids, Peptides and Proteins, Nucleic acids, Lipids. The Organic Chemistry of Metabolic Pathways, Orbitals and Organic Chemistry: Pericyclic Reactions, Mechanisms of Organic Reactions.

B04 Spectroscopy of Organic Compounds

Core Elective Course, 4th semester

lecture: 4h/week laboratory/practice: --/week ECTS: 5

Contents

The use of IR, MS, NMR, UV-Vis spectroscopic methods in solving Organic Chemistry problems. Emphasis will be given to the MS spectra and NMR. NMR spectroscopy: Physical basis of the magnetic phenomenon. Pulse FT-NMR. Relaxation. Dynamic systems. NMR in solid state. Double resonance, decoupling. NMR spectra of other nuclei (other than ^{1}H and ^{13}C). NOE technique. Other newer techniques. Spectra of two dimensions. Applications in biological systems. Applications in Medicine. MS spectrometry: Fundamentals. Methods of cleavage of organic compounds. Ion analysis techniques. Modern ionization techniques. Molecular mass determination. Tandem MS. Applications of MS spectrometry in chemical analysis, environment, biology, geology, etc.

K302 Organometallic Chemistry and Catalysis

Elective course, 7th semester

lecture: 3h/week laboratory/practice: --/week ECTS: 5

Contents

General principles of organometallic chemistry. Characteristics properties of organometallic compounds. Formation of M-C bonds. Structure and reactivity of selected classes of organometallic compounds. The role of organometallic compounds in reactions with industry applications. Organic reactions catalyzed by metals. Catalytic hydrogenation and oxidation. Mo and Ru as catalysts in alkene metathesis. RCM, ROMP, Cross Metathesis. Organometallic compounds of Cu and Pd. Heck reaction, Suzuki reaction, Pauson-Khand reaction. Stille coupling reaction. Otherorganometallicreactions.

K305 Organic Synthesis

Elective course, 7th semester

lecture: 3h/week laboratory/practice: --/week ECTS: 5

Contents

Retrosynthetic analysis. Protecting groups. Oxidation. Reduction. C-C bond forming reactions. Forming C-C bonds: reactions of organometallic compounds. Forming C-C bonds: reactions of stabilized carbanions and other C-nucleophilic reagents.

KN306 Chemistry of Heterocyclic Compounds

Elective course, 7th semester

lecture: 3h/week laboratory/practice: --/week ECTS: 5

Contents

Nomenclature, composition, chemical properties of small, medium and higher heterocyclic rings with one or more heteroatoms (especially O, N and S). Simple condensed heterocyclic systems. Heterocyclic compounds with biological significance.

KN307 Chemistry of Natural Products

Elective course, 8th semester

lecture: 3h/week laboratory/practice: --/week ECTS: 5

Contents

Definition, isolation and Natural Products classification. General methods for isolating and purifying. Structure and biosynthesis of representative classes of natural products.

K313 Bioorganic Chemistry

Elective Course, 8th semester

lecture: 3h/week laboratory/practice: --/week ECTS: 5

Contents

The Fundamentals of Chemical Biology, The Chemical Origins of Biology, Chemistry of Biomolecules (peptides-proteins, DNA, RNA,carbohydrates, lipids). Peptide and Protein Structure. Protein Function. Glycobiology. Polyketides and Terpenes. Chemical Control of Signal Transduction.

K312 Pharmaceutical Chemistry

Elective Course, 8th semester

lecture: 4h/week laboratory/practice: --/week ECTS: 5

Contents

Preparations, chemical properties, purity definition, pharmaceutical properties and reactivity of the main categories of organic pharmaceutical compounds. General pharmaceutical kinetics.

Division of Physics, Analytic and Environmental Chemistry

Y02 Basic Principles of Analytical Chemistry

Mandatory Course, 1nd semester

lecture: 4h/week laboratory/practice: 6h/week ECTS: 10

Contents

Principles, methods and applications of Analytical Chemistry. Acid-base and redox reactions. Solutions. Solubility of substances, concentration of solution and activity. The mass and charge balance equations. Reaction rate and chemical equilibrium. Distribution equilibrium. Acid base theories. Weak acid and bases. The water dissociation and the pH scale. Hydrolysis of salts. Buffer solutions. Heterogeneous chemical equilibrium. The solubility product principle. Complex and redox systems equilibria. Laboratory practice and experimental exercises on the above principles.

Y08 Quantitative Chemical Analysis

Mandatory Course, 2nd semester

lecture: 3h/week laboratory/practice: 4h/week ECTS: 5

Contents

Introduction to quantitative chemical analysis. Categories of methods for quantitative chemical analysis. Errors in chemical analysis. Systematic and random errors.

Statistical treatment of analytical data. Confidence intervals and tests of significance. Performance characteristics of analytical methods. Sampling. Instruments and labware in the laboratory of quantitative analysis. Physical and chemical processes employed in quantitative chemical analysis. Methods of sample pretreatment and dissolution. Principles of titrimetric analysis. Classic acid base, precipitation, complexometric and redox titrations. Gravimetric methods. Laboratory exercises. Selected titrimetric and gravimetric methods.

Y18 Instrumental Chemical Analysis I

Mandatory Course, 6th semester

lecture: 2h/week laboratory/practice: 4h/week ECTS: 5

Contents

Introduction in instrumental chemical analysis. Spectrophotometry, spectrophotometric titration, fluorimetry, nephelometry, atomic absorption spectroscopy, atomic emission spectroscopy. Electrometric techniques of chemical analysis (potentiometric titration, gravimetric and

coulometric analysis, voltammetry, amperometric titration). Chromatographic techniques (TLC, GC, HPLC, SFC). Introduction in automated analysis. Flow injection analysis. Hyphenated techniques. Theoretical aspects of techniques. Principles of operation. Errors, interferences and troubleshooting. Applications of instrumental analytical techniques. Experimental.

H12 Metrology, Chemometrics and Quality Control

Semi-Mandatory Course, 6th semester

lecture: 3h/week laboratory/practice: --/week ECTS: 5

Contents

Introduction to metrology. The significance of chemical analysis. Quality. European community directives and actions. General principles of quality control and quality assurance. Quality systems. Quality control and Quality assurance. Technical and economical performance characteristics of analytical methods. Evaluation of analytical methods. Good laboratory practice. Calibration of measurements. Chemical calibrators and reference materials. Data management and reports. Control charts. Report of the results. Measurements' uncertainty. Quality manual. Reviews. Accreditation. Representative sampling. Propagation of errors. Significance tests. Calibration techniques of analytical methods. Regression analysis and reference curves. Correlation analysis. Errors. Chemometrical tools for the optimization of analytical methods. Experimental design. Multivariable analysis. Use of computer software for chemometric analysis

K203 Separation Methods in Chemical Analysis

Elective Course, 7th semester

lecture: 2h/week laboratory/practice: 2h/week ECTS: 5

Contents

Theoretical aspects of separation techniques. Sample preparation techniques. Pre-concentration. Solid phase extraction. Super critical fluid extraction. High Pressure Liquid Chromatography. Capillary electrophoresis. Ion chromatography. Gas chromatography. Hyphenated techniques GC-MS, LC-MS, preparative chromatography, chiral chromatography. Column switching techniques. Applications of separation techniques. Troubleshooting in HPLC. Principles, errors and interferences. Analytical method validation. Real sample analysis. Determination of caffeine, theobromine, theophylline, mefenamic acid, vitamins, paracetamol, in pharmaceuticals and biological samples, after solid phase extraction. Determination of inorganic ions by ion chromatography. Calculation of chromatographic parameters.

K204 Electroanalysis

Elective Course, 8th semester

lecture: 2h/week laboratory/practice: 3h/week ECTS: 5

Contents

Conductimetric, potentiometric titrations. Coulometry, Voltammetry-amperometry. Electrochemical biosensors. Analytical applications of electrochemical techniques in biological, environmental and pharmaceutical samples as well as in food and beverages. Speciation analysis of metals applying electrochemical techniques.

K205 Analytical Instruments

Elective Course, 8th semester

lecture: 2h/week laboratory/practice: 3h/week ECTS: 5

Contents

A) Optical systems. Introductory concepts and their link to the existing knowledge. Structural components. Use of optic elements in chemical organology. Examples.

B) Electric and electronic systems. Introductory concepts and their link to the existing knowledge. Structural components. Basic amplifier devices and circuits. Signal processing and its applicability to the measuring systems. Examples.

K209 Instrumental Chemical Analysis II

Elective Course, 7th semester

lecture: 2h/week laboratory/practice: 3h/week ECTS: 5

Contents

Atomic spectroscopy. Atomic Absorption spectrometry. Flame, graphite furnace and hydride generation atomizers. Inductively coupled plasma atomic emission spectrometry. Inductively coupled plasma mass spectrometry and ICPMS hyphenation with chromatography. X-ray fluorescence and absorption spectrometry. X-ray diffraction. X-rays photoelectron spectroscopy. Auger electron spectroscopy. Scanning and transmission electron microscopy. SEM-EDS. Kinetic methods of analysis. Automatic methods of chemical analysis. Automatic flow analysers. On-line preconcentration and separation methods. Hyphenation of on-line techniques with atomic spectrometry. Laboratory practice, experimental exercises and applications of the above techniques. Mass Spectrometry: Instrumentation, analytical operation and application in Chemical Analysis and bioanalysis. Identification and quantitation of analytes.

K210 Archaeometry and Chemistry of Archeological Materials

Elective Course, 8th semester

lecture: 2h/week laboratory/practice: 3h/week ECTS: 5

Contents

Introduction to Archaeometry. Archaeological materials and technology. Stones (obsidian, quartz, precious and semi-precieous stones, etc.) wood, leather, building materials, ceramics, glasses, enamels, dyes and pigments, metals and various other materials and objects. Investigation of the origin of archaeological artifacts and materials, and of their manufacturing technology and processes. Dating techniques: chemical dating, nuclear and radiochemical dating. The effects of the environment on the archaeological objects and findings, and corrosion. Introduction to conservation and restoration. Authentication tests. Laboratory exercises and application to the analysis, of stones, ceramics, glasses, metals, building materials. Dataevaluationandinterpretation.

K211 Specific Methods of Chemical Analysis

Elective Course, 8th semester

lecture: 2h/week laboratory/practice: 3h/week ECTS: 5

Contents

Types and composition of samples. Sampling, sample preservation, loss of sample ingredients. Sample pretreatment techniques. Wet digestion techniques with acids and mixtures. Fusion, dry ashing, oxygen plasma ashing. Effect of microwaves and radiation. Special devices for the dissolution of solid and liquid materials. Methods for chemical analysis of water (drinking, seawater), minerals and rocks (limestone, chromite), siliceous materials (ceramics, glass, cement), metals and alloys (brass and steel). Applications of separation, spectroscopic, electrochemical and automatic techniques in chemical analysis of various materials and substrates, and laboratory exercises. REACH regulation.

K212 Bioanalytical Chemistry

Elective Course, 8th semester

lecture: 2h/week laboratory/practice: 3h/week ECTS: 5

Contents

Introduction to bioanalytical chemistry. Description of different biological specimens and the problems these can introduce to the analysis. Macromolecular interactions, drug-protein interactions. Technologies for sample preparation. Utilization of enzymes in analytical chemistry (immobilized enzymes, receptors), immunoassay techniques, biosensors, electroanalytical techniques, electrophoresis (including capillary modes), micro and nano technologies,

centrifugation, enantiomeric separations. Biological Mass Spectrometry and hyphenation. Speciation and automated analysers in bioanalysis..

H06 Environmental Pollution Control

Semi-Mandatory course, 6th semester

lecture: 3h/week laboratory/practice: 3h/week ECTS: 5

Contents

Environmental pollution control procedures. Field measurements. Principles and methods of sampling from atmosphere and various emission sources. Types of sampling devices- Analytical methods for determination of gaseous pollutants. Levels and chemical composition of airborne particulate matter. Sampling and analysis of atmospheric deposition. Principles and techniques for water sampling- Samples preatreatment methods. Analytical methods for determination of various water quality parameters (organoleptic, nutrients, heavy metals, toxic elements, toxic organic compounds). Biosensors. Urban and industrial solid wastes. Characterization of toxicity of solid wastes-Leaching tests. Evaluation of the analytical results with respect to various environmental factors. Source identification and apportionment.

H07 Environmental Chemistry

Semi-Mandatory course, 5th semester

lecture: 4h/week laboratory/practice: --/week ECTS: 5

Contents

Structure and chemical composition of the atmosphere. Greenhouse effect. Depletion of stratospheric ozon. Pollution sources of the atmosphere. Ambient air quality standards. Atmospheric pollutants (emission sources, removal mechanisms, toxicity, elimination of emissions). Pollution of the atmosphere caused by trafic. Diffusion and dispersion of atmospheric pollutants. Smoke episodes - photochemical smog. Acid rain. Chemistry of natural waters. Pollution of surface and ground waters. Heavy metals. Toxic organic compounds. Fate of pollutants in waters (distribution-dispersion-chemical reactions). Limits of the quality of the water-legislation. Hygiene of drinking water. Soil pollution. Sewage-municipal and industrial waste waters. Urban solid wastes, industrial solid wastes. Principles of hazardous waste management.

K207 Chemistry and Ecosystem Management

Elective Course, 6th semester

lecture: 3h/week laboratory/practice: --/week ECTS: 5

Contents

Types and structure of ecosystems. Aquatic ecosystems. Aquatic life. Biogeochemical cycles of elements. Eutrophication. Eutrophication control strategies and models. Anthropogenic effects on ecosystem processes. Principles of ecotoxicology. Methods for measuring toxicity in the environment. Luminescent bacteria toxicity bioassays. Sediment quality criteria. Risk assessment methods. Principles for sustainable management. Systems for ecosystem management. International and European policies and practices for Sustainable Ecosystem Management. Case studies in sustainability ecosystem management and strategy. Environmental impact assessment.

K208 A Pollution Prevention and Environmental Protection

Elective Course, 7th semester

lecture: 3h/week laboratory/practice: 1h/week ECTS: 5

Contents

Principles and measures intended to protect the environment. Treatment of municipal and industrial wastewaters. Advanced oxidation treatment techniques. Treatment of industrial gaseous effluents. Methods intended to prevent, lessen, or remove pollutants emitted from mobile sources. Characterization of the environmental hazard from solid wastes. Methods for management-disposal of municipal and industrial solid wastes. Integrated-sustainable management. Solid waste treatment methods. Life-cycle analysis. Risk assessment. Potable water treatment-disinfection. Legislative framework for environmental pollution abatement. Remediation of polluted environmental systems.

K215 : Quality Assurance in Environmental Pollution Control and Management

Elective Course, 8th semester

lecture: 3h/week laboratory/practice: 1h/week ECTS: 5

Contents

The sense of Quality in environmental pollution control and management. Introduction to Quality Systems ISO and EN. Fundamentals in quality control and quality assurance (QC/QA) of environmental measurements - Standard ISO 17025 - Accreditation of testing laboratories - Validation/verification of environmental testing - Traceability - Sampling - Uncertainty. Examples/applications. Principles and description of Environmental Management Systems. Standards ISO 14001 and EMAS. Examples/applications of environmental management. Environmental legislation - Environmental Quality Standards

Y03 Applied Mathematics in Chemistry I

Mandatory Course, 1st semester

lecture: 5h/week laboratory/practice: --/week ECTS: 5

Contents

Functions, derivatives, partial derivatives. Applications of derivatives in science. Integrals: Indefinite, Definite. Applications of integrals. Differential equations: First order, linear differential equations, differential equations with partial derivatives. Applications of differential equations in chemistry and physics.

Y04 Physics

Elective Course, 1st semester

lecture: 4h/week laboratory/practice: --/week ECTS: 5

Contents

Introduction to mechanics (units, vectors, coordinate systems, particle motion, forces, inertial frame of reference, impulse, work, kinetic and potential energy, power. System of particles. Center of mass, momentum, conservation of momentum, collision. Potential Energy of diatomic molecule. Translational, rotational and vibrational energy of particles system. Mechanics of a solid body (angular momentum, rotational inertia, precession of a gyroscope). Oscillations (simple harmonic motion, damped simple harmonic motion, forced oscillations and resonance). Electricity (nature of electric charge, charge interactions, electric field, potential, capacitance, capacitors, electric dipole, dielectrics, dielectrics, polarization, electric displacement. Electric circuits, Ohm' s Law, Kirhoff' s laws. Magnetic field (electromagnetic induction, Lenz's law, self-inductance and mutual induction). Induced magnetism, magnetic properties of matter, magnetic susceptibility, relative magnetic permeability, diamagnetism, paramagnetism and ferromagnetism.

Y07 Physical Chemistry I (States of matter and Chemical Thermodynamics)

Mandatory Course, 2nd semester

lecture: 4h/week laboratory/practice: 3h/week ECTS: 5

Contents

Gases (state equations of ideal and real gases, gas mixtures etc). Liquids (surface tension, viscosity, vapor pressure, dielectric constant). Solids (basics of crystal structure, allotropic forms, amorphous solids).

Laws of thermodynamics. Basics of Statistical Thermodynamics. Thermochemistry.

Phase equilibrium (Gibbs phase rule and phase diagrams).

Chemical Equilibrium (gas phase reactions in homogeneous solutions and heterogeneous chemical reactions, effect of the pressure and temperature on the equilibrium of chemical reactions).

Laboratory practice: Experimental study of liquid surface tension, viscosity and refraction indices. Effect of Temperature on Solubility. Calorimetry.

Y10 Physical Chemistry II

Mandatory Course, 3rd semester

lecture: 4h/week laboratory/practice: 3h/week ECTS: 10

Contents

Non-electrolyte solutions. Phase diagrams. Thermodynamic description of mixing. Partial molar quantities. Chemical potential of a component in a solution. Ideal and ideal dilute solution (Rault's and Henry's low). Miscible, partially miscible and non miscible liquids. Colligative properties (Boiling point elevation, freezing point depression, osmotic pressure). Liquid-solid phase diagrams. Nernst's partition law. Colloids.

Electrolyte solutions. Ionic interactions. Conductivity of ionic solutions. Diffusion. Acid-base equilibria. Strong and weak electrolytes.

Heterogeneous equilibrium electrochemistry. EMF of galvanic cells and electrode potentials. Equilibrium and membrane potentials. Glass electrode. Selective interfaces and electrodes. Potentiometry – pHmetry. Electrode interfaces and structure of the double layer.

Laboratory practice: Boiling point-composition of two ideal miscible liquids. Phase diagrams of partially miscible liquids. Partition low. Conductivity of the electrolytes. pHmetry, determination of the pK of weak acids. Galvaniccells. Potentiometry.

Y13 Physical Chemistry III

Mandatory Course, 4th semester

lecture: 4h/week laboratory/practice: 3h/week ECTS: 10

Contents

Kinetic theory of gases (distribution of molecular speeds, molecular collisions, transport properties). Ionic motion in electrolytic solutions (diffusion, migration). Ionic mobility and conductivity of electrolytic solutions. Kinetic properties of macromolecules and colloids.

Chemical Kinetics. Simple homogeneous chemical reactions (kinetic equations of 1st, 2nd, 3rd and zero order reactions). Complicated homogeneous chemical reactions. Effect of temperature on

chemical reaction rates, activated complex theory. Chemical reaction mechanisms. Catalysis. Homogeneous and heterogeneous catalytic reactions. Photochemical reactions. Spectrophotometry and polarimetry.

Electrode reaction kinetics. Overpotential. Kinetic currents (Butler-Volmer and Tafel equations). Mass transfer and mixed current control. Voltammetric curves. Electrolysis (Faraday's law).

Laboratory practice: The effect of temperature and ionic strength on reaction rate. Conductometric, spectrophotometric and polarimetric monitoring of reaction kinetics.

H09 Electrochemical Reactions and Applications

Semi-Mandatory Course, 5th semester

lecture: 3h/week laboratory/practice: 2h/week ECTS: 5

Content

Electrochemical reactions and electrified interfaces. Parameters affecting the pathway of electrochemical reactions. Electron transfer kinetics. Mass transfer effects. Methods for the study of electrochemical reactions (polarography, cyclic voltammetry, rotating disc electrode, chronoamperometry).

Electrochemical systems of practical interest: Electrochemical systems for energy conversion (batteries, fuel cells etc.). Electrochemical processes-electrolysis. Electrocatalysis. Electrode modification. Electrodeposition of metals and conducting polymers. Corrosion, passivation and corrosion protection of metals. Photoelectrochemical applications.

Laboratory practice: Study of the electrode/solution interphase. Polarographic and voltammetric study of reversible and irreversible electrode reactions. Study of reactions of practical interest: electrodeposition, corrosion-passivation and corrosion protection of metals.

A06 Applied Statistical Analysis in Chemistry

Core Elective course, 3rd semester

lecture: 4h/week laboratory/practice: --/week ECTS: 5

Content

Elements of Probability theory. Introduction to Statistics: Samples, distributions, descriptive statistics, estimations, tests of the statistical hypothesis, analysis of variance (ANOVA). Applications in presentation and analysis of experimental data: Graphical data presentation, least squares method, confidence intervals, error estimation, data correlation. Using Excel and SPSS in data analysis and evaluation.

A08 Applied Mathematics in Chemistry II

Core Elective course, 2nd semester

lecture: 4h/week laboratory/practice: --/week ECTS: 5

Content

Use of open-source software, Mathematica and Excel to solve applied mathematical problems in Chemistry and in the analysis, processing and presentation of laboratory experimental data.

B06 Physics II

Core Elective course, 4th semester

lecture: 4h/week laboratory/practice: 1h/week ECTS: 5

Content

Mechanical waves, wave motion, superposition principle and interference of waves, standing waves and resonance, beats. AC current (AC circuits, impedance and complex numbers, energy and power in AC Circuits, resonance). Geometric and wave optics. Photometry. Lenses and systems of two or more optical elements. Light waves interference, diffraction of light. Polarization of light and rotation of the polarized light. Application of polarized light and refracted light in Chemistry. Emission and absorption spectra. Assessment of bibliographic research, laboratory exercises.

K110 Statistical Thermodynamics

Elective course, 8th semester

lecture: 4h/week laboratory/practice: --/week ECTS: 5

Content

From classical to statistical thermodynamics. Maxwell-Boltzmann statistics. Molecular partition function. Canonical ensample. Applications in the study of physicochemical systems. Statistical theories of chemical kinetics.

K201 Electrochemical Energy Systems and Environmental Protection

Elective course, 7th semester

lecture: 3h/week laboratory/practice: --/week ECTS: 5

Content

Introduction to the environmental electrochemistry: alternative energy sources, environmental parameters measurement, wastewater treatment.

Electrochemical production and storage of energy: fuel cells, batteries, supercapacitors, photovoltaic cells.

Environmental protection: removal of heavy metals, recovery of precious metals, direct and indirect oxidation of organic pollutants.

K202 Modeling and Optimization of Chromatographic Separations

Elective course, 8th semester

lecture: 4h/week laboratory/practice: 2h/week ECTS: 5

Content

Chromatographic separation mechanisms in reverse phase liquid chromatography, ion pair chromatography and hydrophilic interaction liquid chromatography. Effect of mobile phase composition, flow rate and column temperature on substance separation. Modeling the separation of substances under stable or changing conditions. Prediction of substance retention and optimization of segregation by means of algorithms.

Laboratory practice: Experimental study of the effect of mobile phase composition, flow rate and column temperature on the retention of biologically active substances (amino acids, catecholamines, nucleosides) on reverse phase columns. Analyzing experimental data with appropriate algorithms and finding optimal separation conditions under isocratic and isothermal conditions.

K206 Specific Topics in Colloidal Systems Chemistry

Elective course, 7th semester

lecture: 2h/week laboratory/practice: 2h/week ECTS: 5

Content

Interfacial chemistry, thermodynamics of interfaces. Surface tension, methods for measuring surface tension. Monolayers. Surfactants. Colloidal structures in surfactant solutions, micelles, (structure, critical micellar concentration, aggregation number, solubilization, importance of micelles in industrial and biological treatments). Stability of colloidal dispersions (DLVO theory, kinetics of coagulation) electrokinetic phenomena and measurement of ζ(zeta)-potential. Application of phase diagrams in colloids. Emulsions (preparation, properties, stability, destabilization). Microemulsions, Experimental methods of studying colloids.

Laboratory practice: Preparation of hydrophobic colloids - coagulation of hydrophobic colloids using electrolytes - effect of pH - protection against coagulation. Preparation of hydrophilic colloids - determination of isoelectric point of albumin. Determination of critical micelle

concentration and degree of ionization of the micelles, using conductivity measurements. Study of ternary systems - preparation of ternary diagrams. Measurement of the micelle radius using viscosity measurements. Measurement of surface and interfacial tension. Preparation of foams and study of their stability. Determination of the size of particles using the rate of their sedimentation.

K213 Dynamical Physico-Chemical Systems with Chaotic Behavior

Elective course, 7th semester

lecture: 2h/week laboratory/practice: 2h/week ECTS: 5

Content

Emergence of periodic and chaotic behavior in physico-chemical dynamical systems. Chemical clocks: oscillatory homogeneous and heterogeneous chemical reactions. Principles of thermodynamics for systems being far from the equilibrium and stability criteria of non-reversible changes. Linear stability analysis and bifurcation theory of non-linear dynamical systems. Characterization of the non-linear response of dynamical systems and route to chaos. Time series analysis. Fractal structures. Morphogenesis of static and dynamical chemical structures (Turing structures and chemical waves). Basics of modeling of physicochemical non-linear dynamical systems.

Laboratory practice: Oscillatory chemical reactions (i) homogeneous and non homogeneous Belousov-Zhabotinsky reaction, (ii) electrochemical oscillators.

H13 Real, Virtual and Hybrid Laboratories of Principles and Laws of Chemistry in Formal and Informal Education

Semi-Mandatory Course, 7th semester

lecture: 2h/week laboratory/practice: 2h/week ECTS: 5

Contents

Design and application of real, virtual and hybrid chemistry workshops, dealing with the Principles and Laws of Chemistry, on issues: States of matter, Chemical Equilibrium, Chemical Kinetics, Chemical Equilibrium of Electrolytes in aqueous solutions, Redox reactions, Electrolysis, Galvanic elements Creating mathematical models to understand phenomena related to Principles and Laws of Chemistry within an interactive learning environment. Methodology of assessment and integration of modern teaching methods in formal and informal education.

K316 Radio Analytical Chemistry and Nuclear Techniques Applications

Elective Course, 7th semester

lecture: 2h/week laboratory/practice: 2h/week ECTS: 5

Contents

Basic elements for the structure and properties of the atomic nucleus. Radioactivity. Radioactive decay. Radioactive balance. Breakdown types. Interaction of radiation with matter. Radiochemistry and Measurement of Radiation Radiology. Nuclear reactions. Biological effect of radiation and radioprotection elements. Physical radioactivity. Radioactive elements in the environment. Uranium and its applications. Methods of determination of radioactive elements. Nuclear Waste Management Methods. Radiochemical and nuclear methods of analysis (radio-analytical chemistry). Neutron activation. X-ray fluorescence. Radioactive tracers. Radiodestination. Production of radioisotopes. Radiopharmaceuticals. Applications of isotopes and radiation in chemistry, biology, medicine and technology. Laboratory Exercises Nuclear Radiation Detection and Measurement, Measurement Statistics, Determination of Dead Time, Material Absorption, A and C Spectroscopy, Physical Radioactivity, Uranium and Thorium Determination.

Division of Chemical Technology and Industrial Chemistry

H02 Macromolecular Chemistry

Semi-Mandatory Course, 6th semester

lecture: 4h/week laboratory/practice: --/week ECTS: 5

Contents

Introduction to macromolecular science. Nomenclature of polymers. Types and classification of polymers. Macromolecular configuration. Molecular weight distribution-average molecular weights and their determination. Solid state properties (crystalline and amorphous behavior, thermal transitions). Polymerization mechanisms. Chain polymerization (free radical, anionic, cationic, coordination, controlled, living radical). Reaction mechanism and polymerization kinetics. Degree of polymerization and effect of temperature. Main polymers produced from chain polymerization. Step polymerization mechanism and kinetics. Main polymers produced from step polymerization. Copolymerization (kinetics and average copolymer composition). Inorganic, thermosetting, natural and liquid-crystalline polymers. Applications of polymers (medicine, etc.).

H03 Industrial Organic Chemistry

Semi-Mandatory Course, 5th semester

lecture: 4h/week laboratory/practice: --/week ECTS: 5

Contents

Industrial organic chemistry and energy. Sources of energy. Renewable energy sources (organic photovoltaics, bio-fuels). Liquid hydrocarbons-Petroleum: Composition and classification of oils. Oil mining, refining (distillation, catalytic pyrolysis, catalytic reforming, alkylation, isomerization, carbonization) and refinery products (benzene, kerosene, Diesel, heating oil). Laboratory tests and calculation of properties of petroleum products. Bio-Diesel. Gaseous hydrocarbons-Natural Gas: Composition and properties of Natural Gas. Minong and treatment of NG. Benefits from its use. Liquefied Gas. Solid fuels-Coals: Origin and formation of coals. Chemical composition and physical properties of NG. Deposits and technological applications of coals. Processes for the exploitation of coals. Fats and oils. Carbohydrates. Basic chemical processes: Hydroformylation, sulfosis-sulfonosis, oxidation, hydrogenation and de-hydrogenation, nitrification, halogenations, alkylation, esterification. Industrial production of basic aliphatic and aromatic compounds.

K405 Polymer Technology

Elective Course, 8th semester

lecture: 4h/week laboratory/practice: --/week ECTS: 5

Contents

Polymer production processes [polymerization techniques, polymerization reactors, polymerization in homogeneous (bulk, solution) and heterogeneous (suspension, emulsion) systems, polycondensation processes). Polymer classes (plastics, elastomers, fibers, coatings, glues). Polymer additives (flame retardants, plasticizers, antistatic, reinforcing and foaming agents, fillers, UV stabilizers, impact strength improvers, dyes). Polymer processing (viscoelasticity, extrusion, injection molding, blow molding, thermoforming). Polymer blends. Composite and nanocomposite polymeric materials. Biodegradable polymers. Polymer recycling.

K407 Laboratory Techniques for the Synthesis and Characterization of Polymers

Elective Course, 7th semester

lecture: 1h/week laboratory/practice: 3h/week ECTS: 5

Contents

Synthesis of Polymers: Production of polymers by step polymerization (Nylon-6,10, polyurethane foam, Thiokol-A elastomer, Uria-phormaldehyde resin). Production of polymers by chain polymerization (poly(methyl methacrylate), polystyrene, etc.). Characterization of polymers: Determination of the number average molecular weight of a linear polyether using the end-group analysis. Determination of the viscosity average molecular weight using capillary viscometers. Introduction to Differential Scanning Calorimetry, Thermogravimetric Analysis and tensile strength measurements. Identification of textile fibers. Identification of unknown polymer.

K408 Colour Chemistry and Technology

Elective Course, 8th semester

lecture: 2h/week laboratory/practice: 2h/week ECTS: 5

Contents

Classification of dyes, properties of dyes, colour mixing, relation between dye structure and dye properties in relation to the dyeing of natural and synthetic fibres. Theory of dyeing and printing with pigments and dyes. Digital printing, dyeing of natural and synthetic fibres, dyeing of paper and medium density fibreboards. Pigments for coating. Colour measurement. Colour fastness. **Laboratory exercises** in dyeing, colour measurement, pigment printing. Visits to relative industries.

K414 Chemistry, Technology and Applications of Surface Active Agents

Elective Course, 7th semester

lecture: 2h/week laboratory/practice: 2h/week ECTS: 5

Contents

Surface active agents and detergents : Classification, chemical structures, preparation, properties. Detergent formulations (active and non active additives). Cosmetics, properties and preparation. Paper technology, composition, recycling, conservation. Paper specifications and dyeing methods for virgin and recycled paper.

H04 Food Chemistry I

Semi-Mandatory Course, 5th semester

lecture: 3h/week laboratory/practice: --/week ECTS: 5

Contents

Food nutrients (water, carbohydrates, proteins, lipids): Structural characteristics; Physical, chemical and techno-functional properties; Role in body functions; Usual sources; Effect of processing and storage; Effect of cooking; Applications in food industry.

H05 Food Processing and Preservation

Semi-Mandatory Course, 6th semester

lecture: 3h/week laboratory/practice: --/week ECTS: 5

Contents

Processing of raw materials in food industries, use of microorganisms and enzymes in food production, food preservation (chemical, biochemical and microbial spoilage of foods, biological safety of foods, environmental factors affecting microbial spoilage and biological safety of foods, preservation by dehydration, freezing, refrigeration, thermal processing and other physical methods, preservation with the use of food additives, salt, vinegar or sugar, preservation by smoking), packaging materials and edible packaging of foods.

K410 Food Analysis

Elective Course, 7th semester

lecture: 1h/week laboratory/practice: 6h/week ECTS: 5

Contents

General aspects of food examination (sampling and sample handling; method selection and application); Food examination using chemical and physicochemical methods for verification of

their composition and assessment of their authenticity, quality and nutritional value; Sensory and microbiological examination of foods.

K411 Food Quality Management

Elective Course, 8th semester

lecture: 3h/week laboratory/practice: --/week ECTS: 5

Contents

Evolution of quality systems and relevant legislation; Compulsory and optional quality assurance and quality management systems applied to food industries; Seminars and educational visits to laboratories and industries.

K412 Food Chemistry II

Elective Course, 8th semester

lecture: 3h/week laboratory/practice: --/week ECTS: 5

Contents

Food micronutrients (vitamins, minerals); Food constituents that determine the sensory characteristics of edible products; Food additives.

K413 Technology and Biotechnology of Foods and Beverages

Elective Course, 7th semester

lecture: 3h/week laboratory/practice: --/week ECTS: 5

Contents

Industrial production of foods, beverages and food components from conventional and non-conventional raw materials, Educational visits to food and beverage industrial units.

ΠΡ03 Enology I

Optional Course, 7th semester

lecture: 2h/week laboratory/practice: 2h/week ECTS: 5

(pre-requisite: **H04 Food Chemistry I –** co-requested: **K410 Food Analysis**)

Contents

Maturation and composition of grapes; Grape harvesting and transportation to winery; Grape mechanical processing; Composition, examination and processing of must; Alcoholic and other fermentations; Composition and examination of wine; Maturation and ageing of wine; Sulphur dioxide in wine-making; Educational visits to wineries.

ΠΡ04 Enology II

Optional Course, 8th semester

lecture: 2h/week laboratory/practice: 2h/week ECTS: 5

(pre-requisite: **H05 Food Processing and Preservation –** co-requested: **ΠΡ03 EnologyI**)

Contents

Economotechnical aspects and mechanical equipment in wineries; Red, white and rosé vinification; Special vinifications; Wine processing; Wine spoilage; Products and by-products from grapes and wine; Distilled beverages; Sensory analysis of wine and distilled beverages; Law and wine legislation; Educational visits to wineries.

ΠΡ05 Elements of Viticulture

Optional Course, 8th semester

lecture: 2h/week laboratory/practice: 2h/week ECTS: 5

Contents

Current situation and perspective of viticulture in the world, the European Union and our country; Products derived from viticulture; Vine morphology and anatomy; Annual cycle of the vine; Vegetative and reproductive cycles; Vine physiology; Vine systematic taxonomy; Rootstocks and grape varieties with emphasis on wine grape varieties; Vine training systems; Winter and summer pruning; Vine propagation material; Evaluation of the natural environment; Vineyard installation; Soil cultivation, weed management, fertilization and vineyard irrigation; Grape maturation and determination of harvest date.

Y14 Chemical Technology

Mandatory Course, 4th semester

lecture: 4h/week laboratory/practice: 2h/week ECTS: 5

Contents

Measurements and calculations in chemical technology, simple mass and energy balance exercise, unit systems. Fluid Flow Elements. Heat transmission elements. Water treatment, problems and solutions in the chemical industry. Wastewater treatment (urban and industrial). Brief description of the pumps. Hygiene and safety in the chemical industry. Tutorial exercises and applications

Laboratory practice: Forced air flow, ball mill crushing kinetics, flow of fluid through granular materials, heat transfer by physical transport and radiation, mass balances

H01 Unit Operations

Semi-Mandatory Course, 5th semester

lecture: 4h/week laboratory/practice: 2h/week ECTS: 5

Contents

Basic unit operations: study - techniques (industrial separation techniques): distillation, extraction, washing, gas absorption, drying, crystallization, fluid mixing, cooling tower, small solid particles techniques (study of the properties of small solid particles and their applications in ore beneficiation (enrichment), size reduction, precipitation, flocculation, centrifugation, filtration).

Laboratory practice: Laboratory and tutorial exercises of unit operations: Simulation of distillation column, Flotation enrichment, Filtration, Forced convection heat transfer , Air-cyclone.

H08 Green Chemistry

Semi-Mandatory Course, 5th semester

lecture: 4h/week laboratory/practice: --/week ECTS: 5

Contents

Green Chemistry as a necessity. Sustainable development. Brief historical review. How can this be implemented? Principles and Applications of Green Chemistry. Principles and Applications of Green Chemical Technology - Engineering. Environmental Planning Methodologies. Tools for estimating the environmental performance of a chemical process. Criteria for the Selection of Materials and Operating Modules of a Production Process. Definition and Methodology for Life Cycle Assessment. LCA Applications. Environmental Management Systems. Industrial Ecology. Basic concepts of catalysis. Industrial catalytic processes. Renewable raw materials for the production of chemicals and fuels - energy. 1st, 2nd and 3rd generation biofuels. Alternative and green solvents.

A07 Management in Chemical Industry

Core Elective Course, 4th semester

lecture: 3h/week laboratory/practice: --/week ECTS: 5

Contents

Economy of energy. Fossil and renewable energy sources. Energy storage. Fuell cells. Energy management in chemical industry. The use of mathematical models in chemical technology. Methodology of predictions in technology. Time series analysis. Predictions with constant, linear and polynomial models. Exponential weighting techniques. Prediction of probability distribution.

Chemical reactors, elements of simulation or reaction kinetics, case studies, elements of optimization of efficiency-profit, new products by blending, introduction to blending optimization.

B03 Chemical Processes

Core Courses, 4th semester

lecture: 4h/week laboratory/practice: --/week ECTS: 5

Contents

Principles of chemical processes, types of chemical reactors, design equations, simple and multiple reactions, combination of reactors, catalytic reactions & reactors, industrial applications: catalytic cracking of heavy petroleum fractions for the production of fuels.

K401 Technology of Inorganic Materials- Nanotechnology

Elective Course, 4th semester

lecture: 3h/week laboratory/practice: --/week ECTS: 5

Contents

Introduction to Nanotechnology. Advanced nanomaterials and their applications. Carbon based nanostructured materials: carbon nanotubes, fullerenes, graphene oxide, graphene. Preparation and characterization methods, properties and applications. Scanning Tunneling Microscopy, Atomic Force Microscopy. Magnetic nanomaterials. Application in environmental protection, catalysis and nanomedicine: target drug delivery, magnetic tomography and regenerative medicine. Corrosion and material's protection. Thermodynamic conditions. Corrosion of Natural Materials-Mechanisms. Methods and Technical Measurements for the Control and Evaluation of the corrosion of Natural Materials and Metals.

K402 Laboratory of Industrial Processes

Elective Course, 7th semester

lecture: 1h/week laboratory/practice: 2h/week ECTS: 5

Contents

Laboratory practice and tutorial exercises in basic physical and chemical processes (flocculation in batch and continuous systems, flotation, thermodynamic diagrams, water cooling tower, liquid/gases adsorption, gases absorption, residence time distribution, corrosion).

K403 Processes in Biotechnology

Elective Course, 8th semester

lecture: 3h/week laboratory/practice: --/week ECTS: 5

Contents

Applications of transport phenomena (fluid flow and mixing, heat transfer, mass transfer) to bio-processes. Mass and energy balances. Basic principles of kinetics in biological systems (autocatalytic, enzymatic, heterogeneous reactions, cell growth, enzyme inactivation, energy metabolism). Function and types of bioreactors (discontinuous, embolar flow and full mixing). Final (or downstream) processing. Separation - isolation - purification of biotechnologically produced products. Combined biodegradation processes. Industrial flow charts of biotechnologically produced products. Exercises and applications.

K404 Transport Phenomena

Elective Course, 8th semester

lecture: 4h/week laboratory/practice: --/week ECTS: 5

Contents

Viscosity. Newton's Law. Shear stress. Momentum balance. Applications. Heat transfer mechanisms (conduction, forced and natural convection, radiation). Applications. Solving heat transfer problems using a computer. Mass transport mechanisms (diffusion, advection, dispersion). Macroscopic - microscopic mass balance. Interphase mass transfer.

K406 Environmental Technology

Elective Course, 8th semester

lecture: 4h/week laboratory/practice: --/week ECTS: 5

Contents

General Principles of Good Environmental Practices (short description of ISO, LCA management systems, etc.). Principles of wastewater treatment (urban and industrial) by application of physicochemical and biological methods, with emphasis on the recovery of useful components and the reuse of treated water. Principles of treatment and disposal of solid waste (industrial - urban) with emphasis on recycling. Principles of processing industrial aerosols. Drinking water: main features and applied treatment for its production. Principles for dealing with other environmental problems (e.g. taste and odor problems). Visits to wastewater treatment plants and industrial wastewater industries and plants.

Contents of Courses Offered to other Departments

002Y andN004Y Organic Chemistry (Faculty of Agriculture)

Mandatory Courses, 2nd semester

lecture: 4h/week laboratory/practice: 2--/week ECTS: 5

Contents

Basic concepts in organic chemistry, nomenclature, stereochemistry, classes of organic compounds, classes of organic reactions, synthesis reactions and properties of chemical organic compounds, macromolecules.

002Y Organic Chemistry (Postgraduate program, Faculty of Agriculture)

Mandatory Course, 2nd semester

lecture: 4h/week laboratory/practice: --/week ECTS: 5

Contents

Basic concepts in organic chemistry, nomenclature, stereochemistry, classes of organic compounds, classes of organic reactions, synthesis reactions and properties of chemical organic compounds, macromolecules.