Undergraduate study programme

Course: General Chemistry		
Language: Croatian		
Lecturer: Dr. Svjetlana Krištafor, Assistant Professor; Dr. Ivana Steinberg, Assistant Professor		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**2**	**30**
Seminar	**2**	**30**
		Overall: 90
		ECTS: 8

PURPOSE: To gain a basic knowledge in general chemistry and chemical calculation; to introduce students to the world of chemistry emphasizing the structure of matter; acquiring basic laboratory skills; to be able to apply knowledge gained in this course in more advanced courses and throughout ones career.

THE CONTENTS OF THE COURSE:

1st week: Introduction to the course; the importance of chemistry and chemical principles; definitions – chemistry today; atom – an overview of discoveries;

2nd week: The discovery of electron and nucleus; introduction to quantum mechanics; the characteristics of electromagnetic radiation – atomic spectra; quantum theory.

3rd week: Quantum theory and atomic structure; atomic orbitals and energy levels; electronic structure and periodic table.

4th week: Chemical bonds – ionic and covalent bonds; Lewis structures; Resonance.

5th week: Ionic character of covalent bond; intermolecular forces; formal charge; metallic bond; molecular structure and shape; molecular orbital theory; electron configurations and bond order of diatomic molecules

6th week: Valence bond theory and hybridization; geometry of molecule; multiple bonds; coordination compounds.

7th week: The properties of gases; the gas laws; applications of ideal gas law; the kinetic model of gases; real gases; liquids and solids – structure.

8th week: Thermochemistry; enthalpy and entropy; Gibbs free energy; physical equilibria; phase transitions.

9th week: Chemical equilibria; acids and bases

10th week: Aquaeous equilibria; buffers; titrations; solubility equilibria

11th week: Electrochemistry – oxidation/reduction equations; electrochemical cells;

12th week: Coordination compounds; the electronic structure of complexes; spectrochemical series; the colours of complexes

13th week: Chemical kinetics; reaction rates and mechanisms; Nuclear chemistry

14th week: Selected topics on application of chemical principles

15th week: Selected topics on application of chemical principles; Revision and the summary of the course

GENERAL AND SPECIFIC COMPETENCE:

The main objective of this course is to give students a basic foundation in chemistry, including development of skills required for problem solving and the application of basic chemical concepts. Students will learn to think at the atomic structural level of matter and to relate the electronic structure of atoms to the chemical properties of elements. The understanding of how atoms combine with one another and its importance in relation to the research in pharmaceuticals, agricultural chemicals, polymers and synthetic materials. After completion of this course, students will be able to use the periodic table and understand the symbolism and language of chemistry. After the successful completion of the laboratory part of this course, students will have acquired the skills necessary for scientific work – critical thinking and observation skills, ability to safely handle chemical reagents.

KNOWLEDGE TESTING AND EVALUATION:

Three written tests during the semester

Written and oral examinations

Exam related to laboratory practice (successful completion of laboratory practice is needed for completion of the course)

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student survey

LITERATURE:

1. I. Filipović, S. Lipanović: "*Opća i anorganska kemija*", Školska knjiga, Zagreb, 1991.
2. M. Sikirica: "*Stehiometrija*", Školska knjiga, Zagreb, 1991.
3. P. Atkins, L. Jones: "*Chemical Principles: The Quest for Insight*", 4th ed. New York, NY: W.H. Freeman and Company, 2007.

Course: Analytical Chemistry I		
Language: English		
Lecturer: Assist. Prof. Šime Ukić, Ph. D.		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	2	30
Laboratory	2	30
Seminar	1	15
		Overall: 75
		ECTS: 6

PURPOSE: To introduce students with analytical and critical approach in chemical analysis of samples. Chemical equilibrium principles will be applied in order to obtain useful information, *i.e.* to identify and determine analyte in analytical samples.

THE CONTENTS OF THE COURSE:

Lectures and seminars:

1. Introduction to basics of chemical analysis and analytical chemistry. Sample-analyte-matrix-signal-information.
   SEMINAR: Systematic analysis of cations from I and II group.
2. Chemical principles in separation and identification of analyte. The influence of media: aqueous and non-aqueous media.
   SEMINAR: Systematic analysis of cations from III to VI group.
3. Chemical equilibrium in prediction of analytical reactions for separation and determination of analyte in diverse matrices. Micro and macro concentrations of analyte. Limit of detection.
   SEMINAR: 1st preliminary exam for laboratory practice.
4. Acid-base reactions. Polyprotic acids. Buffer systems.
   SEMINAR: Calculation examples.
5. Complexometric reactions. Prediction of ligand exchange reactions with change of solution’s pH value.
   SEMINAR: Calculation examples.
6. Parallel reactions of proton, electron, and ligand exchange.
   SEMINAR: Calculation examples.
7. Equilibrium in heterogeneous systems. Basic principles of precipitation related with pH value, type of ligand, excess of reagent and presence of foreign ion.
   SEMINAR: 1st partial test.
8. Precipitate dissolving: principles and conditions. Change into weak electrolyte, change into complex or electrone exchange.
   SEMINAR: Systematic analysis of anions.

9. Solubility diagrams for sulphide, hydroxide and carbonate species. Stability of anions at diverse pH values and diverse potentials. Pourbaix diagrams.
SEMINAR: 2nd preliminary exam for laboratory practice.

10. Selective dissolving and precipitating of chloride and sulphide. Removing the interferences.
SEMINAR: Calculation examples.

11. Selective dissolving and precipitating of hydroxide. Amphoterism.
SEMINAR: Calculation examples.

12. Selective dissolving and precipitating of carbonate. Determination of diverse water harnesses.
SEMINAR: Calculation examples.

13. Selective dissolving and precipitating of complex laboratory sample. Selection of appropriate method for sample analysis.
SEMINAR: 1st partial test.

14. Separation methods. Chromatography.
SEMINAR: Students' presentations of given topics.

15. Decomposition and dissolving of complex solid sample. Interpretation of analytical result.

Laboratory practice:

1. Analysis of chloride and sulphide in acidic medium.
2. Analysis of hydroxide and sulphide in alkali medium.
3. Analysis of alkali and earth alkali salts.
4. Analysis of salt soluble in water.
5. Analysis of salt insoluble in water.
6. Determination of phenol compounds by thin-layer chromatography
7. Rapid tests for ion analysis in drinking water

GENERAL AND SPECIFIC COMPETENCE:

Student obtains:

- basic analytical knowledge necessary for individual work in analytical laboratory,
- correct approach to chemical analysis of sample,
- ability for critical conclusion of experimental work,
- ability to comply correctly laboratory reports in accordance with good laboratory practice.

KNOWLEDGE TESTING AND EVALUATION:

Two (2) preliminary exams for laboratory practice and two (2) partial tests during the semester. Students can be released from exam if they collect sufficient points from the preliminary exams and tests. If not, they need to pass written and oral exam.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student survey.

LITERATURE:

1. Š. Cerjan-Stefanović, Osnove analitičke kemije, Tehnološki fakultet, Zagreb, 1983.

2. G. Charlot, Les methodes de la chimie analytique, Masson et Cie, Paris, 1990.
3. D.C. Harris, Quantitative Chemical Analysis, W.H. Freedman and Co., New York, 2001.
4. Z. Šoljić, Računanje u kvantitativnoj kemijskoj analizi, Sveučilište u Zagrebu, Zagreb 1998.
5. Z. Šoljić, Kvalitativna kemijska analiza anorganskih tvari, FKIT, Zagreb, 2003.
6. D.A. Skoog, D.M. West, F.J. Holler, Osnove analitičke kemije, 1st ed., Školska knjiga, Zagreb, 1999.
7. M. Kaštelan-Macan, Kemijska analiza u sustavu kvalitete, Školska knjiga, Zagreb, 2003.

Course: INORGANIC CHEMISTRY (AC))

Language: Croatian

Lecturer: : Dr. sc. Stjepan Milardovic, associate professor

TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**3**	**24**
Seminar	**0**	**0**
		Overall: 54
		ECTS: 5

PURPOSE:

Introducing students with properties of chemical elements and chemical compounds using the information about ionization energy, electron affinity, electronegativity, standard-state reduction potentials, atomic radii, etc. Introducing with the periodic trends in the chemical and physical properties of the elements Introducing to some aspect of bioinorganic chemistry, organometallic chemistry, and theoretical model of chemical structures and with industrial and analytical aspect of inorganic chemistry.

THE CONTENTS OF THE COURSE:

1. The low of chemical periodicity and periodic table. Periodic trends in physical and chemical properties along the periods and along the groups. Periodicity of chemical properties (electronegativity, ionization energy, electron affinity, oxidation numbers, standard-state reduction potential), periodic trends in physical properties (melting point, boiling points, etc.)

2. Hydrogen

The general atomic and physical properties of molecular hydrogen, preparation in industrial and laboratory scale. Ionized form of hydrogen (ionic hydrides, covalent hydrides, polymeric and intermediate hydrides). The hydrogen bond and hydrogen isotopes.

3.The elements of 18th group (noble gases)

Atomic and physical properties of the elements. Preparation production and use.

Compounds of xenon and compounds of other noble gases

4.The elements of 17^{th} group (the halogens)

The general chemical properties of the halogens group of elements, physical and chemical trends along the group, the change of electronegativity along the group, properties of compound concerning oxidation numbers in the range :-1, 0, +1, +3, +4, +5, +7. Chemical reactivity of diatomic halogens, preparation and properties of hydrogen halides. Psudohalogens, preparation and properties. Oxoacid and oxoacid salts (preparation and properties).

5. The elements of 16^{th} group (chalcogens)

The general chemical properties of the chalcogens group of the elements. The properties of compounds concerning oxidation numbers in the range –2, –1, 0, +2, +3, +4,+6. Chemical properties and preparation of dioxygen (O2) ozone (O3) and atomic oxygen (O). The properties of oxygen compounds concerning negative oxidation state (O^{2-}), (O_2^{2-}),(O_2^-), (O_3^-) and positive oxidation state (O_2^+). Physical properties and structure of water, oxoacids of sulphur, selenium and tellurium, thioacids. Redox properties along the group.

6. The elements of 15^{th} group (nitrogen group of the elements)

The general chemical properties of the nitrogen group of the elements. The change of electronegativity along the group, properties of compounds concerning oxidation states in the range –3, -1, 0, +1, +3, +5. Preparation and chemical properties of ammonia and ammonium salts, nitric acid, hydrazine, nitrogen oxides (N_2O, NO, NO_2, N_2O_3, N_2O_5) and oxoacid of nitrogen. Preparation, use and chemical properties of hydrides of nitrogen, phosphorus, arsenic, antimony and bismuth.

7. The 14^{th} group of the elements (carbon group)

The general chemical properties of the carbon group of the elements. Preparation, physical and chemical properties of carbon (diamond, graphite, fullerene, graphene) CO and CO_2.

Chemical properties of the carbon (negative oxidation state) compounds (carbides) and silicon (silicides). Chemical properties, preparation and use of silicates and silicon. Chemical and physical properties of germanium tin and lead compounds of positive oxidation state (+2, +4). Lead battery.

8. The 13^{th} group of the elements (boron group)

The general chemical properties of the boron group of the elements. Properties of compounds concerning oxidation states in the range –3, -1, 0, +1, +2, +3. Preparation, use and chemical properties of ortoboric acid. Preparation, use and chemical properties of aluminium, aluminium trihalides, amphoteric properties of aluminium and aluminium passivity. Chemical properties of indium and gallium compounds.

9.The 2nd group of the elements (alkaline earth metals)

Chemical reactivity and trends of chemical and physical properties along the group. Introduction to hydrides, oxides, oxoacides, hydroxides and organometallic compounds.

10. The 1st group of the elements (alkali metals)

Chemical reactivity and trends of chemical and physical properties along the group. Introduction to hydrides, peroxides, superoxide's, hydroxides and organometallic compounds. Preparation of NaOH, $NaHCO_3$, NaCl and gypsum.

11. Preparation and properties of metals

12.

Chemical reactivity and trends of chemical and physical properties along the group of the lanthanides and actinides. The general properties of the elements of the 4th and 5th group of the elements, oxides, sulphides, oxoanions and complexes of titanium, zirconium and hafnium.

13.

Chemical reactivity and trends of chemical and physical properties along the d-group of elements (vanadium, chromium and manganese). Oxides and the most important compounds (oxidation states 2, 3, 4, 5 and 6).

14.

Chemical reactivity and trends of chemical and physical properties along the d-group of elements (iron, cobalt and nickel) and 8th, 9th and 10th group of elements. Oxides, oxyanions, complexes.

15.

Chemical reactivity and trends of chemical and physical properties along the d-group of copper and zinc (11th and 12th group of elements). Oxides, oxyanions, complexes, biochemistry of copper.

Laboratory practice

Experiments 1 day

- Hydrogen production by reaction of aluminium and sodium hydroxide
- Iodine preparation by iodate reduction
- Preparation and properties of oxygen
- The properties of metal oxides and hydroxides
- Preparation of sodium thiosulphate

Experiments 2 day

- Preparation of silver thiosulphate and its reactivity
- Preparation and properties of nitrogen
- Preparation of ammonia
- Preparation of sodium carbonate

Experiments 3 day

- Preparation of the lead(IV) oxide. Lead-Acid Battery
- Preparation of lead(II) chloride
- Preparation of boric acid

Experiment 4 day

- Preparation of potassium aluminium sulphate dodecahydrate
- Preparation of copper(II) oxide
- Preparation of copper(I) chloride
- Preparation of tetraaminecopper(II) sulphate monohydrate

Experiments 5 day

- Preparation of sodium chromate
- Preparation of chromium(III) oxide
- Preparation of potassium chromium alum
- Precipitation and properties of manganese(II) hydroxide

- Preparation of potassium manganite and permanganate

Experiments 6 day

- The reduction by vanadium salts in Joneses reductor
- Preparation of iron(II)sulphate pentahydrate
- Precipitation and properties of iron(III) hydroxide
- Preparation of potassium hexacyanoferrate(III)

Experiments 7 day

- Preparation of Mohr’s salt
- Complexes of cobalt
- Preparation of mercury(I) iodide
- Preparation of mercury(II) oxide

Experiment 8 day

- Titration of a phosphoric acid solution with sodium hydroxide
- Titration of silver nitrate solution with potassium iodide

GENERAL AND SPECIFIC COMPETENCE:

The main general competence is to understand the basic of inorganic chemistry and adequate application of low of periodicity to predict the properties of elements or compounds. Using the modern theory of bonding to predict the structure, reactivity, acid-base properties and redox properties of elements and compounds.

KNOWLEDGE TESTING AND EVALUATION:

Write exam and oral exam

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Continuous evaluation.

LITERATURE:

1. I. Filipović i S. Lipanović: “ Opća i anorganska kemija”, Školska knjiga, Zagreb, 1991.

2. N. N. Greenwood, A. Earnshaw: “ Chemistry of the Elements”, Pergamon Press, Oxford, 2002.

3. D. F.Shriver and P.W. Atkins; Inorganic Chemistry”, Oxford University Press, third edition, 1999.

Course: Stoichiometry I		
Language: Croatian, English		
Lecturer: dr. sc. Lidija Furač		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**0**	
Seminar	**0**	
		Overall: 30
		ECTS: 4

PURPOSE:

To deepen the theoretical foundation for understanding chemical calculations by meaningful and logical analysis of a problem and integration of already acquired knowledge to independently decide how to solve especially complex problems of chemical calculations

THE CONTENTS OF THE COURSE:

Week 1. Equations and chemical calculus. Dimensional analysis. Significant figures. The general approach to solving complex problems of chemical calculation.

Week 2. Atomic mass. Molecular mass. Molar mass. Moles. Inconverting moles, mass and number of chemical entities. Stoichiometry laws.(The law of conservation of mass, The law of equivalent proportions,The law of definite proportion, The law of multiple proportions).

Week 3. Quantitative relationships in chemical compounds. The quantitative composition of chemical compounds. The empirical formulas of the chemical compound. The composition of matter.

Week 4. Chemical reaction and stoichiometric coefficients. Quantitative relationships in chemical reactions. Quantitative relationships of substances and mixtures of components

Week 5. The stoichiometry of the chemical reaction. The limiting reagent (reactant). Excess reactant. Stoichiometric amounts of reactants. Stoichiometric amounts of products.u

Week 6. The reactants in the stoichiometric ratio. Yield percent of reaction. Yield percent of the limiting reactant. Yield percent of the excess reactant.

Week 7. Stechiometry of chemical reaction in solid-solid systems.

Week 8. Test 1

Week 9. The composition of the solution . Stoichiometry of the chemical reaction in solid – solution system

Week 10. Stoichiometry of the chemical reaction in solution-solution system.

Week 11. The law of combining volumes. Avogadro's law. The molar volume of gas. The relation of volume and weight of the chemical reactions. Changing the volume of gases with changing pressure and temperature.low of

Week 12. Stechiometry of chemical reaction in gas - gas systems and redox reactions.

Week 13. Stechiometry of chemical reaction in gas-solutions systems.

Week 14. The stoichiometry of chemical reactions in determining the composition of the mixture. The stoichiometry of chemical reactions applied to very complex systems (gas-solid-solution).

Week 15. Test 2.

GENERAL AND SPECIFIC COMPETENCE:

- knowledge and understanding of essential facts, concepts, principles and theories relating to chemistry
- ability to recognise and solve qualitative and quantitative problems using the appropriate chemical principles and theories
- numerical reasoning, numeracy and calculation skills, including such aspects as error analysis, order-of-magnitude estimations, and correct use of units
- competence in presenting chemical related material and arguments in writing and orally, to an informed audience,

KNOWLEDGE TESTING AND EVALUATION:

Regular attendance. Attendance at all tests. Solving homework.

Class attendance 0,6 (15%), Seminar essa 0,6 (15%), Tests 2.

LITERATURE:

1. M. Sikirica, *Stehiometrija*, XX. Izdanje, Školska knjiga, Zagreb, 2008.

2. . T. Cvitaš, I. Planinić, N. Kallay, *Rješavanje računskih zadataka u kemiji, I dio*, Hrvatsko kemijsko društvo, Zagreb, 2008.

3. I. Filipović, S. Lipanović, *Opća i anorganska kemija I dio*: *opća kemija*, Školska knjiga, Zagreb, 1996.

4. . R. Chang, *General Chemistry: The Essential Concepts*, 4^{th} edition, The Mc Graw-Hill Comp., Inc., New York, 2006.

5. M. S. Silberberg, *Chemistry: The Molecular Nature of Matter and Change*, 4^{th} edition, The Mc Graw-Hill Comp., Inc., New York, 2006

Optional literature:

1. L. Furač , Interna skripta, Fakultet kemijskog inženjerstva i tehnologije, Zagreb,2013.
2. I. Lovreček, *Kemijsko računanje*, 3. izdanje, Sveučilišna naklada Liber, Zagreb, 1978.
3. B. S. Grabarić, B. Tripalo, *Iskazivanje fizikalnih veličina u kemiji i biokemiji*, Prehrambeno-tehnol. biotehnol. rev. 31 (1) 19-33 (1993)

4. M. Brezinšćak, *Mjerenje i računanje u tehnici i znanosti*, Tehnička knjiga, Zagreb 1971.
5. T. Cvitaš, N. Kallay, *Fizičke veličine i jedinice Međunarodnog sustava*, Hrvatsko kemijsko društvo i Školska knjiga, Zagreb 1980., 1981., 1985.
6. A. Petreski, B. Sever, *Kemija*: *Zbirka riješenih primjera i zadataka iz opće kemije*, Profil International, Zagreb 2005.
7. M. Mazalin-Zlonoga, A. Petreski, Kemija 2: *Zbirka riješenih primjera i zadataka iz anorganske kemije*, Profil International

Course: Stoichiometry II		
Language: Croatian, English		
Lecturer: dr. sc. Lidija Furač		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**0**	
Seminar	**0**	
		Overall: 30
		ECTS: 4

PURPOSE:

To deepen the theoretical foundation for understanding chemical calculations by meaningful and logical analysis of a problem and integration of already acquired knowledge to independently decide how to solve especially complex problems of chemical calculations

THE CONTENTS OF THE COURSE:

Week 1.:Equations and chemical calculus. Dimensional analysis. Significant figures. The general approach to solving complex problems of chemical calculation.
Week 2: Thermochemistry. Heat, work, free energy and enthalpy. Heats of Reaction and chemical Change. Exotermic and Endotermic Processes. Hess's law and application of the Thermochemical equations. Heat capacity. Stoichiometry of Thermochemical Equations.

Week 3: Chemical equilibrium. The law of mass action. Equilibrium Constant. Le Chatellier's principle. Chemical equilibrium in the reaction system: gas-gas, gas-solid, solution-solid (slightly soluble salts).

Week 4:Equilibria in electrolyte solutions. The activity of ions. Ionic strength of a solution. The concentracion equilibrium constant. Ionization constant. Ion- product constant for water, pH scale. Solutions of monoprotic strong acids and bases.

Week 5: Solutions of monoprotic weak acids and bases. Relative acid-base strenght and the net direction of reaction.

Week 6: Test 1.

Week 7. Equilibria of salt solutions. Hydrolysis. Hydrolysis constant. Acid-base properties of salt solutions. Salts of monoprotonic strong acid cations and weakly basic anions. Saline solutions of strong bases and monoprotic weak acids. Mixtures of monoprotonic strong acids and metal cations as Lewis acids.

Week 8: Equilibria in the mixture of strong monoprotonic acids and salts of monoprotonic strong acid cations and weakly basic anions. Equilibria in mixtures of solutions of strong bases and salts of strong basic anions and weak acidic cations.

Week 9: Acid-base equilibria in buffer solutions. The essential features of a buffer. Solutions of weak monoprotonic acids and their salts their with strong bases; addition of a strong acid or a strong base in such a solution. Solutions of weak bases and their salts with strong monoprotonic acids; addition of a strong acid or a strong base to this solution.

Week 10: Polyprotic acids. Equilibria in mixture solutions: strong and weak polyprotic acids and their salts. Hydrolysis of salts of polyprotic acids. Solution of weak polyprotic acids and their salts with strong bases. Addition of a strong acid or base to such a solution. Addition of a strong acid to a solution of the appropriate salts of polyprotic acids with strong bases.

Week 11: Physical properties of solutions. The solubility of solids and gases. Colligative properties of solutions. Osmotic pressure. Analytical approach to solving complex problems – examples.

Week 12: Raoult's law. Vapor pressure above the solution. Solution of a non-volatile substances in a volatile solvent. A solution of a volatile substance in a volatile solvent. Freezing point depression. Boiling point elevation.

Week 13: Electrochemistry. Electrode potential. The standard hydrogen electrode. The standard redox potential. Nernst equation for electrode potential. Galvanic cell. Redox equilibria.

Week 14. Electrolysis. Faraday's laws. The current efficiency. The Stoichiometry of Electrolysis.

Week 15. Test 2.

GENERAL AND SPECIFIC COMPETENCE:

- ability to recognise and solve qualitative and quantitative problems using the appropriate chemical principles and theories
- numerical reasoning, numeracy and calculation skills, including such aspects as error analysis, order-of-magnitude estimations, and correct use of units
- competence in presenting chemical related material and arguments in writing and orally, to an informed audience,

KNOWLEDGE TESTING AND EVALUATION:

Students write 2 tests during the semester. The condition of exemption from examination is the minimum to get 60% of the total number of points on each test.

Class attendance 0,6 (15%), Seminar essay 0,6 (15%), Tests 2.

LITERATURE:

1.M. Sikirica, *Stehiometrija*, XX. Izdanje, Školska knjiga, Zagreb,

2. R. Chang, *General Chemistry: The Essential Concepts*, 4th edition, The Mc Graw-Hill Comp., Inc., New York, 2006.

3. M. S. Silberberg, *Chemistry: The Molecular Nature of Matter and Change*, 4th edition, The Mc Graw-Hill Comp., Inc., New York, 2006

4. Filipović, S. Lipanović, *Opća i anorganska kemija I dio*: *opća kemija*, Školska knjiga, Zagreb, 1996.

5. 5. T. Cvitaš, I. Planinić, N. Kallay, *Rješavanje računskih zadataka u kemiji, I i II dio*, Hrvatsko kemijsko društvo, Zagreb, 2008.

6. 6. T. Cvitaš, N. Kallay, *Fizičke veličine i jedinice Međunarodnog sustava*, Hrvatsko kemijsko društvo i Školska knjiga, Zagreb 1980., 1981., 1985.

Optional literature:

1. P. Atkins, L. Jones, *Chemical Principles: The Quest for insight*, 2nd edition, W. H. and Comp., New York, 2002.

2. I. Lovreček, *Kemijsko računanje*, 3. izdanje, Sveučilišna naklada Liber, Zagreb, 1978.

3. M. Brezinšćak, *Mjerenje i računanje u tehnici i znanosti*, Tehnička knjiga, Zagreb 1971.

4. A. Petreski, B. Sever, *Kemija*: *Zbirka riješenih primjera i zadataka iz opće kemije*, Profil International, Zagreb 2005.

5. M. Mazalin-Zlonoga, A. Petreski, Kemija 2: *Zbirka riješenih primjera i zadataka iz anorganske kemije*, Profil International, Zagreb 2005

6. M. Mazalin-Zlonoga, A. Petreski, *Anorganska kemija*: *Zbirka riješenih primjera i zadataka iz anorganske kemije*, Profil International, Zagreb 2005.

Course: Organic Chemistry I		
Language: English		
Lecturer: Prof. Silvana Raić-Malić, Ph.D.		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**3**	**45**
Laboratory	**2**	**30**
Seminar	**0**	**0**
		Overall: 75
		ECTS: 7

PURPOSE:

The main objective of the course is to familiarize students with the basic principles of modern organic chemistry, understanding the structure-activity relationship of organic compounds and application of methods in the synthesis of organic compounds in biosciences and industry.

THE CONTENTS OF THE COURSE:

1. CARBON COMPOUNDS AND INTRODUCTION TO STRUCTURAL THEORY OF ORGANIC CHEMISTRY: introduction to structural theory: the empirical and structural molecular formulas, isomers, tetrahedral structure of methane; chemical bonds - the octet rule, ionic and covalent bonds, Lewis structures, resonance; quantum mechanics, atomic and molecular orbitals; structure of methane and ethane: sp^3-hybiridization; structure of ethene: sp^2-hybiridization, *cis*-*trans*-isomerism; structure of ethyne: sp-hybridization.
2. INTRODUCTION TO ORGANIC REACTIONS: ACIDS AND BASES: Types of chemical reactions and their mechanisms; acid-base reactions, Brönsted, Lowry and Lewis definitions of acids and bases; heterolysis of carbon bond (carbocations and carbanions), the strength of acids and bases, the relationship between structure and function of acid, the acidity of carboxylic acids, organic compounds as bases; introduction to the mechanisms of organic reactions.
3. CLASSES OF CARBON COMPOUNDS, FUNCTIONAL GROUPS: Hydrocarbons: alkanes, alkenes, alkynes and aromatic compounds; functional groups in organic molecules, alkyl halides, alcohols, ethers, amines, aldehydes and ketones, carboxylic acids, esters, amides, nitriles. The relationship of the structure and physical properties of the molecules (hydrogen bonding, van der Waals forces).
4. ALKANES – CONFORMATIONAL ANALYSIS AND INTRODUCTION TO SYNTHESIS: Conformational analysis of alkanes, relative stability of cycloalkanes - ring tension, *cis*- and *trans*-isomerism of cycloalkanes, syntheses of alkanes and cycloalkanes.
5. STEREOCHEMISTRY AND CHIRALITY I: The biological significance of chirality; isomerism: constitutional isomers and stereoisomers; chiral

molecules and enantiomers, enantiomer nomenclature (Cahn-Ingold-Prelog system of rules *R*, *S*), relative and absolute configuration, optical activity of enantiomers, molecules with multiple chiral centers, *meso*-compounds, Fischer projection formula, stereoisomerism of cyclic compounds.

6. STEREOCHEMISTRY AND CHIRALITY II: Heteroatoms as centers of chirality, axial chirality, helical structure, homochirality in nature, pseudochirality, prochirality, diastereomers, preparation of enantiomerically pure compounds (fractional crystallization of racemates, chromatographic separation of enantiomers on chiral stationary phases), chiral drugs interactions of drug enantiomer and receptor.

7. IONIC REACTIONS - NUCLEOPHILIC SUBSTITUTION REACTIONS OF ALKYL HALIDE: Nucleophilic substitution reactions: nucleophiles, leaving groups; kinetics, mechanism and stereochemistry of S_N1 and S_N2 reactions (carbocations); examples of organic synthesis by functional group transformation in S_N2 reactions.

8. IONIC REACTIONS - ELIMINATION REACTIONS OF ALKYL HALIDE: The impact of nucleophile on the elimination and substitution competitive reactions; mechanism of E1 and E2, stereoselectivity and regioselectivity of reaction E1, stereospecifity of substituted cyclohexane in E2 reactions, regioselectivity in elimination reactions (Hoffman's and Zaitsev's rule), carbanionic mechanism of elimination (E1cB).

9. ALKENES AND ALKYNES I: SYNTHESIS AND PROPERTIES: Determining of *E*-and *Z*-configuration, the relative stability of alkenes, cycloalkenes, synthesis of alkenes by dehydrohalogenation of alkyl halide and dehydration of alcohols, and stability of carbocation and molecular rearrangement, synthesis of alkynes in elimination reactions, acidity of terminal alkynes.

10. ALKENES AND ALKYNES II: THE ADDITION REACTION: Hydrogen halides addition to alkenes (Markovnikov's rule), the stereochemistry of ionic addition reaction of alkenes, oxymercuration and demercuration of alkenes (Markovnikov's additions) synthesis of alcohol by hydroboration and oxidation of alkenes (*syn*-hydration, anti-Markovnikov's rule), hydroboration of alkenes and synthesis of alkyl-borane, halogen addition to alkenes, the stereochemistry of the addition reaction of halogen to alkenes.

11. STRUCTURE DETERMINATION OF ORGANIC COMPOUNDS BY NUCLEAR MAGNETIC RESONANCE AND MASS SPECTROMETRY: Introduction to nuclear magnetic resonance spectroscopy (NMR), the spin of protons, shielding and deshielding effects of protons, chemical shift, chemical equivalent and non-equivalent protons, splitting of signal: the spin-spin coupling, ^{1}H and ^{13}C one- and two-dimensional nuclear magnetic resonance spectroscopy (1D and 2D NMR), introduction to mass spectrometry, ionization and fragmentation of molecular ion, determination of molecular formula and mass, applications of mass spectrometry in biomedicine.

12. RADICAL REACTIONS: Energy of homolytic bond cleavage and relative stability of radicals, selectivity in radical substitution reactions, chlorination of methane - energy activation, halogenation of higher alkanes, the geometry of alkyl radicals, radical additions to alkenes (anti-Markovnikov's addition of hydrogen halide), radical polymerization of alkenes, radicals in biology, medicine and industry.

13. ALCOHOLS: Synthesis of alcohols from alkenes, reactions of alcohols, alcohols as acids, conversion of alcohols to alkyl halides, the reaction mechanism of alcohols with hydrogen halides, alcohol derivatives with leaving groups: tosylates, mesylates and triflates, the reaction of alcohols with aldehydes and ketones – preparation of hemiacetals and acetals, silyl ethers as protecting groups of alcohols, sugar alcohols.

14. ETHERS: synthesis of ethers, silyl protecting groups of ethers, reactions of ethers (cleavage of ethers by strong acids), cyclic ethers (epoxides): synthesis by epoxidation of alkenes, Sharpless asymmetric epoxidation of alkenes; reaction of epoxides (acid-catalyzed ring-opening reaction, crown ethers: phase-transfer catalysts.

GENERAL AND SPECIFIC COMPETENCE:

The main goal of student education is to acquire the principles of organic chemistry and methods of organic synthesis, and their application in the synthesis of new compounds.

Specific competences: to acquire the basic techniques in the synthesis of organic compounds and their identification.

KNOWLEDGE TESTING AND EVALUATION:

Continuous monitoring of knowledge and evaluation of student work through homeworks (6) and tests (3) during the semester.

Written and oral exams.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student survey.

LITERATURE:

1. T. W. G.Solomon, C. B. Fryhle, Organic Chemistry, J. Wiley, 2004.
2. J. Clayden, N. Greeves, S. Warren, P. Wothers, Organic Chemistry, Oxford University Press, Oxford, 2001.
3. S. Pine, Organic chemistry, written in Croatian, translated by: I. Bregovec, V. Rapić, Školska kniga, Zagreb, 1994.
4. K. Peter, C. Vollhardt, N. E. Shore, Organic Chemistry: Structure and function, W. H. Freeman and Company, 5th Ed., 2007.
5. L. G. Wade Jr., Organic Chemisty, Pearson Prentice Hall, London, 2006.
6. V. Rapić, The nomenclature of organic compounds, written in Croatian, Školska knjiga, 3rd revised and supplemented Ed., Zagreb, 2004.

Course: Physical Chemistry I		
Language:		
Lecturer: Marica Ivanković ; Jelena Macan		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**3**	**45**
Laboratory	**2**	**30**
Seminar	**0**	**0**
		Overall: 75
		ECTS: 6

PURPOSE:

Understanding of basic laws and theories of physical chemistry as applied in practice of chemical engineering. Development of capabilities of logical problem solving and equation derivation.

THE CONTENTS OF THE COURSE:

1. week: Introduction, phase states of matter, ideal gas – equation of state
2. week: Kinetic-molecular theory of gasses, velocity and energy of gas molecules, Maxwell-Boltzmann distribution
3. week: Real gasses – equation of state, liquefaction
4. week: First partial exam
5. week: Thermodynamics: heat and work, The first law, internal energy, enthalpy, heat capacities
6. week: Thermochemistry: Hess's law, Kirchhoff's law, adiabatic processes
7. week: Spontaneous processes and equilibrium, Carnot cycle, The second law of thermodynamics, reversibility of processes
8. week: Gibbs free energy, The third law of thermodynamics, dependence of Gibbs energy on temperature and pressure, fugacity
9. week: Second partial exam
10. week: deal and non-ideal mixtures, chemical potential, Gibbs-Duhem equation
11. week: Phase equilibria, Clapeyron and Clausius-Clapeyron equation, triple point, phase rule
12. week: Raoult's law, colligative properties of mixtures, Henry's law
13. week: Distillation, vapour pressure diagrams, boiling diagrams
14. week: Basics of phase equilibria of three-component systems, distribution law, crystallization, osmotic equilibrium
15. week: Third partial exam

Laboratory work:
1. Determination of molecular mass by V. Meyer's method
2. Calorimetry – determination of heat of reaction
3. Cryoscopy
4. Boiling diagram
5. Nernst distribution law

GENERAL AND SPECIFIC COMPETENCE:

Describing the basic physical chemistry laws regarding gasses, thermodynamics and phase equilibria.
Applying knowledge of mathematics and deriving the equations (clearly describing the physical

phenomena under consideration).
Preparing and performing laboratory experiments.
Analysis and interpretation of experimental results.
Preparation of laboratory reports.

KNOWLEDGE TESTING AND EVALUATION:

Exams, partial exams, entrance and final colloquium in laboratory work.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student opinion surveys

LITERATURE:

P. Atkins, J. de Paula, Atkin's Physical Chemistry, 8th edition, Oxford University Press, Oxford 2006.

Course: Analytical Chemistry II, Applied chemistry study programme, Undergraduate, 2nd year, required		
Language: Croatian		
Lecturer: **Dragana Mutavdžić Pavlović, PhD, associate professor**		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**1**	**15**
Seminar	**1**	**15**
		Overall: 60
		ECTS: 5

PURPOSE: The aim of this course is to teach the students who have mastered with mechanisms and balance of homogeneous and heterogeneous chemical reactions, how to apply them to the real sample and introduce them with the choice of analytical system and management of the analytical process from sample to the optimal information.

THE CONTENTS OF THE COURSE:

Lectures and seminars:

1. Systems approach to the chemical analysis. Previous and final information. Sample and sampling. Representative sample. Undersampling. Sample preparation for analysis. The separation of the analyte.
2. The choice of method. Absolute and comparative methods. Performance characteristics of chemical measurement system. The presentation of student's seminar papers.
3. Evaluation of analytical data. Errors of analytical system. Measurement uncertainty.

   Seminar: Significant digits. Statistical tests of significance.
4. Gravimetric determination. The formation of the precipitate. Nucleation and crystal growth. The particle size and purity of the precipitate. Reagents for precipitation. Deposition in a homogeneous medium. Electrogravimetry.
5. *Seminar*: Gravimetric factor. Assignments from the gravimetric determination.
6. Titrimetry. Acid-base reactions in aqueous and non-aqueous medium. Change in pH during titration. Titration of polyprotic acids. The selection of indicators.

   Seminar: Curves of acid-base titration.
7. Salts titration. The composition of the acid solution as a function of solution pH. Equivalent units. The presentation of student's seminar papers.
8. *Seminar*: The tasks of the acid-base titration. Repetition.
9. 1st partial test
10. Oxidoreduction titration. Redox indicators. Impact on the electrode potential of the

system. Permanganatometry. Iodometry. Titrations by iodine. Bromatometry.

11. *Seminar*: Titration curves in redox titrations. The presentation of student's seminar paper.
12. *Seminar*: Assignments from oxidoreduction titration.
13. Precipitation titrations. Indication of end point titration. Complexometric titrations. Influence of the pH-value on titration process. Metal indicators. The presentation of student's seminar papers.
14. *Seminar*: Titration curves in settling and complex titrations. Assignments from precipitation and complexometric titrations. Repetition.
15. 2nd Partial Test

Laboratory exercises (block courses in five terms):

1. Gravimetric determination of sulfate.
2. Electrogravimetric determination of copper in bronze samples.
3. Preparation and standardization of HCl. Statistical data analysis (Q-test). Standardization of the secondary standard NaOH.
4. Preparation of standard solution of $KMnO_4$. Determination of Fe and Sb by redox titrations.
5. Determination of Cu in real samples by redox titration. Determination of chloride in seawater by the *Mohr* method. Determination of water hardness.

GENERAL AND SPECIFIC COMPETENCE:

The student acquires the term of real samples and trained for solving the analytical problems.

KNOWLEDGE TESTING AND EVALUATION:

Written and oral examination. The possibility of release written part of the exam if you collect enough points (during the semester).

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student questionnaire.

Note: A second year student can evaluate only the commitment and the attitude of teachers. Their knowledge of the course in the second year of the study was too small to make relevant score about the course.

LITERATURE:

Required literature:

1. M. Kaštelan-Macan, Analitička kemija I. dio, Sveučilište u Zagrebu, Zagreb 1990.
2. Z. Šoljić, Računanje u kvantitativnoj kemijskoj analizi, Sveučilište u Zagrebu, Zagreb 1998.
3. Z. Šoljić, M. Kaštelan-Macan, Volumetrija, FKIT, Zagreb 2002.
4. Z. Šoljić, Laboratorijske osnove kvantitativne kemijske analize, FKIT, Zagreb, 2006.
5. material from lectures

Recommended literature:

6. M. Kaštelan-Macan, Kemijska analiza u sustavu kvalitete, Školska knjiga Zagreb 2003.
7. D. A. Skoog, D. M. West, F. J. Holler, Osnove analitičke kemije, Školska knjiga Zagreb, 1999.

Course: Physical Chemistry II		
Language:		
Lecturer: Krešimir Košutić		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**3**	**45**
Laboratory	**2**	**30**
Seminar	**Part of lecture**	
		Overall: 75
		ECTS: 6

PURPOSE:

Understanding of basic laws and theories of physical chemistry as applied in practice of chemical engineering. The course is not only a collection of facts but an introduction to ways of thinking about the world. Development of capabilities of logical problem solving and equation derivation.

THE CONTENTS OF THE COURSE:

1. week: Description of chemical equilibrium (Gibbs energy minimum), thermodynamic equilibrium constant, Response of equilibrium to temperature (van’t Hoff equation)to pressure,
2. week: Response of equilibrium to pressure, NH_3 syntesis, Heterogeneous chemical equilibrium
3. week: Surface phenomena: surface tension, surface films
4. week: Surface phenomena: adsorption, adsorption isotherms (Freundlich, Langmuir, B.ET.)
5. week: First partial exam, Conductivities of electrolyte solutions, weak electrolytes (Ostwald’s dilution law)
6. week: Conductivities of strong electrolyte solutions, (Debye-Huckel theory and law)
7. week: Equilibrium electrochemistry, half- reaction and electrodes, electrode potential
8. week: Galvanic cells, electromotive force, Nernst equation
10. week: Physical processes, Diffusion, Fick’s first and second law of difusion
11. week:Rates of chemical reaction- definition, rate laws and rate constants, reaction order,and determination of rate law, The chemistry of stratospheric ozone-ozone decomposition
12. week: Kinetics of complex reaction (reverse,-parallel, and consecutive reactions)
13. week: Kinetics of complex reations-chain reaction, Explosion, Polymerization kinetics
14. week: Kinetic and thermodynamic control of reactions, Temperature

dependence of reaction rates
15. week: Catalysis and catalyst-homogeneous and heterogeneous catalysis;
Second partial exam

Laboratory work:
1. Surface tension
2. Adsorption (Freundlich isotherm)
3. Determination of transport number (Hittorf method)
4. Conductivity of electrolyte solutions
5. Electromotive force of galvanic cell
6. Determination of constant rate and reaction order of chemical reaction (decomposition of H_2O_2, inversion of sucrose)

GENERAL AND SPECIFIC COMPETENCE:

Describing the basic physical chemistry laws regarding chemical equilibria, surface phenomena (surface tension and adsorption), equilibria in electrolyte solution, and chemical kinetics.
Applying knowledge of mathematics and deriving the equations (clearly describing the physical phenomena under consideration).
Preparing and performing laboratory experiments.
Analysis and interpretation of experimental results.
Preparation of laboratory reports.

KNOWLEDGE TESTING AND EVALUATION:

Entrance and final colloquium in laboratory work, partial exams, oral exam

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student opinion surveys

LITERATURE:

P. Atkins, J. de Paula, Atkin's Physical Chemistry, 8th edition, Oxford University Press, Oxford 2006.

Course: Organic Chemistry		
Language: English		
Lecturer: Prof. Irena Škorić, Ph.D.		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**3**	**45**
Laboratory	**2**	**30**
Seminar	**-**	
		Overall: 75
		ECTS: 6

PURPOSE: To explain the basic principles of modern organic chemistry and their application in industry and to familiarize the students with structure-activity relationship of organic compounds.

THE CONTENTS OF THE COURSE:

1. Aromatic compounds: properties and reactions; polycyclic aromatic compounds
2. Reactions of aromatic compounds: Basic mechanistic principles of electrophilic aromatic substitution reactions part of which are reactions of halogenations, nitration, sulfonation, alkylation, and Friedel-Crafts acylation; Understanding of impact of substituents on the reactivity and regioselectivity of obtained products.
3. Conjugated unsaturated systems: reactivity of a compound in a reaction of allylic substitution which undergoes by a path of allylic radical intermediate. Explanation of the stability of the allylic radical intermediate by molecular-orbital theory and resonance theory. Application of this reaction in allylic bromination. Understanding of stability of conjugated 1,3-butadiene by delocalization (electron resonance); understanding of principles of electrophilic 1,2- and 1,4-addition on conjugated dienes (kinetic and thermodynamic control of the reaction) and stereochemistry of 1,4-cycloaddition reactions of diene and dienophile (Diels-Alder Reaction).
4. Aldehydes and ketones I. Nucleophilic addition on carbonyl group: synthesis of aldehydes by reduction of starting acyl chloride, ester or nitirile group. Synthesis of ketones from starting alkyne, secondary alcohol or nitrile. Mechanism of acid-catalyzed addition of nucleophile on the carbonyl group of an aldehyde or ketone. Mechanism of hemiacetal and acetal formation; application of acetals as protecting groups in multistep synthesis. Reactions of addition of primary and secondary amine on aldehyde and ketone. Mechanism of addition of hydrogen cyanide on the carbonyl group.

5 Aldehydes and ketones II. Aldole reactions: Chemical reactivity of hydrogen atoms in α-position of carbonyl group and keto-enol tautomerism; reaction of enolate anion; mechanism of acid and base catalyzed enolization; mechanism of acid and base catalyzed reactions of halogenations of aldehydes and ketones; aldole reaction and its synthetic application.

6. Colloquium I
7. Carboxylic acid and its derivatives: Structure and chemical reactivity of carboxylic acid and its derivatives: chloride, anhydride, ester (lactone), amide (lactama) and nitrile; Methods of synthesis of carboxylic acids; synthesis of derivatives of carboxylic acids by interconversion of functional groups in acyl-chloride and the mechanistic principles of nucleophilic elimination reaction on the acyl group.
8. Synthesis and reactions of β-dicarbonyl compounds. Chemistry of enolate anion: Synthesis of β-ketoesters by Claisen condensation and the mechanism of nucleophilic addition and elimination of this reaction; Synthesis of derivatives of malonic acid by Knoevenagel reaction and Michael addition and the mechanism of this reactions; Mannich reaction and its mechanism; Synthesis of enamine by Storck reaction.
9. Amine and like compound with nitrogen: trigonal pyramidal structure of amine and the structure of primary, secondary and tertiary amine and their nomenclature; Familiarization of the structure of aryl amine, basic heterocyclic amine and biologically important amines (derivatives of 2-phenylethylamine, vitamins B_6 and B_1, histamine); Principles of synthesis of amines by alkylation of ammonia, Gabriel synthesis, reductive amination of aldehydes and ketones, reduction of nitrile, oxime and amide and Hofmann and Curtius rearrangement reactions of amide. Reactions which are amides subject to: acid-base reactions, reactions of alkylation, electrophilic aromatic substitution, diazotization; Synthesis of aryl-diazonium salts which are used in preparation of benzene derivatives (Sandmeyer reaction, reaction of diazo copulation).
10. Phenol and aryl-halides: Structure, acidity and nomenclature of phenols; methods of laboratory synthesis of phenol (e.g. Hydrolysis of aryl-diazonium salt), industrial synthesis of phenol (base hydrolysis of chlorobenzene-nucleophilic aromatic substitution reaction); application of phenol in Williams synthesis of ether, Kolbe synthesis of acetyl salicylic acid (aspirin); Claisen rearengament of allyl-phenyl ether; nucleophilic aromatic substitution: addition-elimination mechanism.
11. Colloquium II
12. Heterocyclic compounds
13. Molecular orbitals. Orbital symmetry. Thermal and photochemical cyclization reactions. Electrocyclic and cycloaddition reactions. Principles and stereoscpecifity of electrocyclic reactions in 4 electron systems; reactions of (4+2) and (2+2) cycloadditions on the basis of molecular orbital theory.
14. Carbohydrates: structure and nomenclature of monosaccharide; display mode of structures of monosaccharide by fisher projection and Haworth formulas and conformation formulas in hemiacetal form; Relative and absolute configuration of monosaccharide.
15. Amino acids and proteins: Structure of essential amino acids and understanding of their role as building units in protein synthesis; synthesis of amino acids; enantioselective synthesis and separation of racemic mixtures of amino acids; Structure of primary and secondary polypeptide and amide linkage; method of polypeptide (protein) synthesis.
16. Synthetic polymers; Colloquium III.

GENERAL AND SPECIFIC COMPETENCE:

Students that successfully complete this course will be equipped to:

- recognize and use vocabulary of organic chemistry

- draw correct structural representations of organic molecules
- write acceptable transformations and mechanism for aromatic, carbonyl and heterocyclic compounds
- use their knowledge in stereochemistry while analyzing mechanisms in organic chemistry
- work in a laboratory for Organic synthesis: isolation, purification and identification of organic compounds.

KNOWLEDGE TESTING AND EVALUATION:

Continuous assessment of knowledge via colloquiums; written and oral exam if the student fails on the colloquiums or wants a better grade.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student questionnaire

LITERATURE:

1. T. W. Graham Solomons, Organic Chemistry. 2007, Wiley
2. Clayden, Greeves, Warren and Wothers, Organic Chemistry. 2001, Oxford University Press.
3. S. H. Pine, “Organska kemija” (translated to Croatian by I. Bregovac, V. Rapić), Školsla knjiga, Zagreb, 1994.
4. V. Rapić, “Nomenklatura organskih spojeva”, Školska knjiga, III izmjenjeno i nadopunjeno izdanje (III amended and supplemented edition), Zagreb, 2004.

Course: Chemical and Biochemical Engineering		
Language: English		
Lecturer: Associate prof. Zvjezdana Findrik Blažević, PhD		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**3**	**45**
Laboratory	**-**	**-**
Seminar	**2**	**30**
		Overall: 75
		ECTS: 5

PURPOSE: To familiarize students with the application of mass and energy conservation law on chemical processes, and introduce them with chemical engineering process analysis and calculation of stationary and non-stationary processes.

THE CONTENTS OF THE COURSE:

1st week – Introduction (chemical engineering – biochemical engineering – environmental engineering – biotechnology, environmentally friendly technology). Differences between chemical and biochemical engineering.

2nd week – Basic terms in chemical engineering (mass balances, mass transfer phenomena, reaction engineering aspects). Basic laws, terms and techniques in chemical engineering calculations. Processes and process variables. Mass balances (basic equation, differential and integral mass balance)

3rd week – Calculations based on stationary mass balance equations (linear equation systems). Mass balance equations for a physical process in a single process unit.

4th week – Mass balance equations of the chemical process in a single process unit.

5th week – Mass balance equations of burning processes.

6th week – Energy and chemical engineering. Basic terms in energy balances. General energy balance equation. Energy balance of closed systems. Energy balance of opened systems (stationary process).

7th week - First preliminary exam

8th week – Energy balances of multi-component systems. Energy balances of the process without chemical reaction.

9th week – Definition of reaction engineering. Reactors and bioreactors.

10th week –Ideal types of reactor. Mass balances in ideal reactor types.

11th week – Chemical reaction kinetics. Chemical reaction rate. Kinetic model. Reaction order.

12th week Experimental methods of reaction rate determination. Integral and differential methods of data analysis. Initial reaction rate method.

13th week – Biocatalysis. Biocatalysts. Structure of biocatalysts.

14th week – Enzyme kinetics. Microbial growth kinetics. Heterogeneous biocatalysts. Heterogeneous biocatalysis. Interphase and between phase diffusion. Chemical reaction and residence time distribution.

15th week Aeration. Mass transfer phenomena in biological systems. Engineering conditions in bioreactor design. Mixing in biological systems.

GENERAL AND SPECIFIC COMPETENCE

Students acquire basic knowledge needed for solving of practical problems during analysis of processes by application of chemical engineering methodology.

KNOWLEDGE TESTING AND EVALUATION:

1. Partial preliminary exams
2. Written exam

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student survey

LITERATURE:

D.M. Himmelblau, Basic Principles and Calculations in Chemical Engineering, Prentice Hall, New Jersey, 1982.
R.M. Felder, R.W. Rousseeau, Elementary Principles of Chemical Processes, J. Wiley, New York, 1986.
J.E. Bailey, D.F. Ollis, Biochemical Engineering Fundamentals McGraw-Hill (1986).
A. Scragg ed. Biotechnology for Engineers - Biological Systems in Technological Processes, Ellis Horwood Limited, Chichester, (1988)
K. van't Riet, J. Tramper, Basic Bioreactor Design, Marcel Dekker, New York, (1991)
H.W. Blanch, D.S. Clark, Biochemical Engineering, Marcel Dekker, New York, (1996)

Course: Transport Phenomena and Separation Processes (32100)		
Language: English		
Lecturer(s): Assis. Prof. Krunoslav Žižek, PhD Full Prof. Aleksandra Sander, PhD		
TEACHING	*WEEKLY*	*SEMESTER*
Lectures	2	30
Laboratory	1	15
Seminar	1	15
		Overall: 60
		ECTS: 4

PURPOSE:

Study of transport phenomena (this are: momentum, heat and mass transfer).
Analysing the fundamentals of unit operations by using principle of unique approach to transport phenomena that bear chemical engineering discipline and applied sciences as well.

THE CONTENTS OF THE COURSE:

The flow of viscous fluids, fluid rheology, conservation laws for fluid flow (mass, momentum and energy balances).

Momentum, heat and mass flux, steady-state and unsteady-state flow, Dynamics of homogenous fluids.

Analysis of laminar and turbulent flow, velocity distributions, energy loss (in terms of pressure drop), Theory of boundary layer, flow equations.

Characterization of dysperse systems (coarse ones), fundamentals of mechanical macroprocesses.

Solid-liquid separation processes (sedimentation & filtration), efficiency of separation of particles from fluids (that is net separational capability of equipment), selecting the equipment for such separation.

Mixing process for liquid-liquid and solid-liquid dysperse systems, design and scaling of process units for mixing technology.

1st partial exam

Heat transfer by conduction through one- and multi-layered wall.

Heat transfer by convection in laminar and turbulent flow.

Heat pass by both mechanisms (conduction & convection), energy transport by radiation.

Mass transfer by diffusion and by convective mechanism.

Physical-chemical fundamentals of thermal separation processes.

Description of evaporation and crystallization operations.

Drying technology.

Distillation.

Absorption and extraction processes.

2nd partial exam

Lectures are consecutively followed by lab tutorials and seminars.

GENERAL AND SPECIFIC COMPETENCE:

Get acquainted with transport phenomena (momentum, heat and mass transfer), conservation laws they involve, and with the effects of flow regime (that is hydrodynamic conditions) on heat and mass transfer.

To utilize the equations in a procedure of pipeline design, and for estimation of transport coefficients upon heat and mass transfer phenomena.

To define the properties of particulate systems (for both, dysperse phase and dysperse medium), to learn for the ways of showing/displaying and approximating the particle size distribution.

To adopt the fundamentals of unit operations.

To analyze mechanical separation processes and to study mixing technology for liquid-liquid and solid-liquid dysperse systems.

To learn about thermal separation processes and to gain basic knowledges for selecting the separation process system.

These are essential for gaining subsequent knowledges on the study programme.

KNOWLEDGE TESTING AND EVALUATION:

These are realised by implementing:

1. the screen of their knowledge via preliminary exams related to laboratory assignments, furthermore by two partial exams and finally by oral exam,
2. continuous monitoring of students: class attendance (both lectures and seminars), impression of seminar essay.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

By student questionnaire.

LITERATURE:

Richard G. Griskey, Transport Phenomena and Unit Operations, John Wiley & Sons, Inc., 2006.

R. Byron Bird, Transport Phenomena, Revised 2nd Edition, John Wiley & Sons, Inc., 2006.

R.W. Fahrien, Fundamentals of Transport Phenomena, Mc Graw-Hill, New York, 1983.

J.D. Seader, E.J. Henley, Separation Process Principles, John Wiley & Sons, Inc. 2006.

M. Rhodes, Introduction to Particle Technology, John Wiley, London 1998.

M. Hraste, Mehaničko procesno inženjerstvo, Hinus, Zagreb 2003.

Internal script by Full Prof. Antun Glasnović, PhD “Prijenos tvari i energije” (available via Faculty pages at www.fkit.unizg.hr).

Lectures for the course Transport Phenomena and Separation Processes by Full Prof. Aleksandra Sander, PhD and Assis. Prof. Krunoslav Žižek, PhD (also available via Faculty pages at www.fkit.unizg.hr).

Course: Thermodynamics of Real Systems		
Language: Croatian		
Lecturer: Prof. dr. sc. Marko Rogošić		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	2	30
Laboratory	0	0
Seminar	1	15
		Overall: 45
		ECTS: 5.0

PURPOSE:

Within the framework of this course the students will get acquainted with the application of fundamental laws of thermodynamics as well as mathematical methods for solving the chemical engineering problems of: estimation of thermodynamic functions of pure substances, mixtures and solutions, phase equilibria calculation, chemical equilibria calculation.

THE CONTENTS OF THE COURSE:

Week 1

Introduction to thermodynamics of real systems – what is thermodynamics, what does it deal with, classification of thermodynamics, course contents, prerequisites, basic definitions: thermodynamic systems, functions, parameters, phases, states, processes, laws of thermodynamics,

Volumetric properties of real fluids – *pT*-diagram, Gibbs phase rule, ideal gas equation, deviations from ideality, compressibility coefficient, Joule-Thomson coefficient, liquefaction of real fluid

Seminar: getting acquainted with the seminar numeric problems programme, (Rogošić)

Week 2

Volumetric properties of real fluids – gas particles interaction, Lennard-Jones potential, virial equation, Boyle temperature, BWR equation

Volumetric properties of real fluids – van der Waals equation, parameters, liquefaction work, equilibrium pressure, corresponding states principle, thermodynamic similarity principle, critical compressibility coefficient, Pitzer acentric coefficient, Lee-Kesler correlation

Seminar – numeric problems: Volumetric properties of real fluids (Rogošić)

Week 3

Volumetric properties of real fluids – third order polynomial equation of states, Redlich-Kwong, Soave-Redlich-Kwong, Peng-Robinson, calculation of *pvT*-

properties, comparison of equations, gas mixtures

Thermodynamic properties of real fluids – steam (heat) tables and diagrams, construction of *ph* and *sT*-diagrams, departure functions, corresponding states principle, thermodynamic similarity principle, Yen-Alexander and Lee-Kesler correlation for enthalpy and entropy

Seminar – numeric problems: Volumetric properties of real fluids (Rogošić)

Week 4

Thermodynamic properties of real fluids – fugacity and fugacity coefficient, fugacity as a departure function, calculating Gibbs energy using fugacity, fugacity vs. pressure and fugacity vs. temperature correlations, fugacity and the corresponding states principle, fugacity and the thermodynamic similarity principle

Thermodynamics of real solutions – ideal solution definition, volume, enthalpy and entropy of mixing, the causes of non-ideality of real solutions

Seminar – Equations of state of real fluids (Rogošić)

Week 5

Thermodynamics of real solutions – partial molar functions in two- and multicomponent real systems, Gibbs-Duhem equation, partial fugacity and partial fugacity coefficient, mixing functions, excess functions

Thermodynamics of real solutions – activity and activity coefficient, standard states of pure gas, liquid and solid as well as of gas and liquid mixture components, Poynting factor, Lewis-Randall rule, infinitely dilute solution, Henry law for real solutions

Seminar – numeric problems: Thermodynamic properties of real fluids (Rogošić)

Week 6

Thermodynamics of real solutions – determination of partial molar functions using the methods of intercept, tangent, apparent molar functions, as well as by the Gibbs-Duhem equation, Gibbs energy vs. activity and activity coefficient correlation

Activity coefficient models – activity coefficient models: Margules, power series, Van Laar, Wohl, regular and athermal solutions, Scatchard-Hildebrand; Flory-Huggins interaction parameter, solubility parametar, determination of model parameters

Seminar – numeric problems: Thermodynamics of real solutions (Rogošić)

Week 7

Activity coefficient models – activity coefficient models: Wilson, Tsuboka-Katayama, Hiranuma, NRTL, UNIQUAC; structural group contribution models: ASOG, UNIFAC

Recapitulation – thermodynamics of real solutions and activity coefficient models, preparation for partial exam

Seminar – Preparation for partial exam 1 (Rogošić)

Week 8

Partial exam 1 – volumetric properties of real fluids, thermodynamic properties of real fluids, thermodynamics of real solutions, activity coefficient models

Thermodynamic equilibrium – equilibrium criteria in isolated and closed systems, system stability criteria, reacting systems, thermodynamic interpretation of Le Chatelier principle

Seminar – numeric problems: Thermodynamics of real solutions (Rogošić)

Week 9

Vapour–liquid equilibria – equilibrium criteria using chemical potentials and partial fugacities, phase non-ideality description using equation of states and activity coefficient models, equilibrium criteria for ideal vapour and liquid phase, respectively

Vapour–liquid equilibria – phase diagrams, *Txy*-diagram, *pxy*-diagram, *xy*-diagram, systems of regular behaviour, azeotropic systems, bubble point, dew point, flash, numerical methods in vapour–liquid equilibrium calculations

Seminar – numeric problems: Thermodynamics of real solutions (Rogošić)

Week 10

Liquid–liquid equilibria – equilibrium criteria using chemical potentials, phase diagrams, vapour pressure vs. composition, Gibbs energy of mixing vs. composition, miscibility as influenced by temperature and pressure, determination of model parameters using experimental data, ternary diagrams, lever rule

Solid–liquid equilibria – equilibrium criteria using chemical potentials and partial fugacities, phase diagrams, eutectics, intermolecular compounds, peritectics, calculation of solubility of a solid in a liquid, Schroeder equations, ternary eutectics, eutectic troughs

Seminar – numeric problems: Vapour–liquid equilibria (Rogošić)

Week 11

Solid–gas equilibria – equilibrium criteria using chemical potentials and partial fugacities, supercritical fluids as solvents, calculation of solubility of a solid in a fluid (gas)

Chemical equilibria – chemical equilibrium criterion: minimum Gibbs energy, stoichiometric sum of chemical potentials, homogeneous chemical reactions, standard Gibbs energy of reaction, standard Gibbs energy of reaction vs. temperature correlation

Seminar – numeric problems: Solid–liquid equilibria (Rogošić)

Week 12

Chemical equilibria – examples of solving homogeneous chemical equilibria problems, chemical equilibria at multireaction systems, determination of minimum number of reaction, Denbigh method, matrix elimination method

Chemical equilibria – determination of global minimum Gibbs energy of a systems, heterogeneous chemical equilibria

Seminar – Preparation for partial exam 2 (Rogošić)

Week 13

Partial exam 2 – thermodynamic equilibrium, vapour–liquid equilibria, liquid–

liquid equilibria, solid–liquid equilibria, chemical equilibria, thermodynamics of irreversible processes

Recapitulation – discussion on the course content, lectures, seminars, questions and answers, preparation of final written and oral exam

Seminar – numeric problems: Repetition (Rogošić)

GENERAL AND SPECIFIC COMPETENCE:

General competences:

Application of fundamental laws of thermodynamics in combination with literature or own experimental data for solving the chemical engineering problems of: 1. estimation of thermodynamic functions of gases and liquids depending on the given pressure, temperature and composition, 2. characterisation of vapour–liquid and liquid–liquid equilibria and 3. characterisation of chemical equilibria

Special competences:

Calculation of thermodynamic functions of real fluids using equations of state: virial, vdW, RK, SRK, PR, Lee-Kesler

Calculation of thermodynamic functions of real solutions using activity coefficient models: Margules, Van Laar, Wilson, NRTL, UNIQUAC, UNIFAC, ASOG

Calculation of activity coefficient model parameters using experimental data

Calculation of equilibrium temperature, pressure and phase composition for the vapour–liquid equilibria: bubble point, dew point, flash calculations

Calculation of equilibrium phase composition for the liquid–liquid equilibria

Calculation of equilibrium composition in reacting systems as dependent on pressure and temperature: gas phase reactions, multiple gas phase reactions, heterogeneous reactions

KNOWLEDGE TESTING AND EVALUATION:

2 compulsory partial exams during the semester (if failed – final oral exam)

Final written exam for numeric seminar problems

Final oral exam

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student inquiry

LITERATURE:

Compulsory:

M. Rogošić, Internal textbook, www.fkit.unizg.hr, 2013.

S.I. Sandler, Chemical, Biochemical and Engineering Thermodynamics, 4th Ed., Wiley, New York, 2006.

Additional:

J.M. Smith, H.C. Van Ness, M.M. Abbott, Introduction to Chemical Engineering Thermodynamics, 5th Ed., McGraw-Hill, New York, 1996.

J.M. Prausnitz, R.N. Lichtenthaler, E.G. de Azevedo, Molecular Thermodynamics of Fluid Phase Equilibria, 3rd Ed., Prentice Hall, Englewood

Cliffs, 1999.

B.E. Poling, J.M. Prausnitz, J.P. O'Connell, The Properties of Gases and Liquids, 5th Ed., McGraw-Hill, New York, 2000.

Course: Ecotoxicology		
Language: English		
Lecturer: doc.dr.sc. Lucija Foglar		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	
Laboratory	**-**	
Seminar	**-**	
		Overall: 30
		ECTS: 4

PURPOSE: The explanation of the basic concepts in ecotoxicology, types of toxic substances, the basics of quantitative aspects of toxicity and regulations in ecotoxicology. The presence of contaminants in the environment with emphasis on the toxicity of various chemical compounds. Methods of risk assessment and the prevention and disposal of harmful effects of accidents with chemicals.

THE CONTENTS OF THE COURSE:

1. Introduction, definitions and history of ecotoxicology. Overview of the main types of pollutants (inorganic, organic ...). Toxins and toxicity. The patway the toxic effects of the toxins.
2. Kinds of adverse effects. Toxicity as a result of interaction of chemical compounds (toxicity of mixtures).
3. Environmental Pollution. Fundamentals of input, biotransformation, detoxification, elimination and accumulation of harmful substances.
4. Absorption of harmful substances. Absorption and Distribution of toxins in the humans.
5 The effects of pollutants on populations, communities and ecosystems. Changes in the level of ecosystems, the effects of environmental pollution on the appearance and physiology of ecosystems.
6. Pollution of sea, water, soil and the atmosphere. The spread of non-native plant and animal species and the effects on populations, communities and ecosystems.
7. Global changes caused by human activity, acid rain, greenhouse effect, circulating toxins in the biosphere.
8. Risk assessment of contaminants, risk assessment for human health and environmental assessment / ecotoxicological risk. Biomarkers and biomonitoring.
9. Options of prevention, action and disposal of harmful effects of accidents with chemicals (chemical accidents).
10. Legislative regulation and toxicology tests in Croatia and the EU. Toxicity tests and methods.

GENERAL AND SPECIFIC COMPETENCE:

Students will understand all the negative aspects of anthropogenic activities, with an emphasis on chemical pollution of nature and the environment. Students will be trained to independently and objectively assess the harmfulness of chemical substances on living world on the basis of available information. Also, at the end of the course, students will have a basic knowledge of how and by which research methods obtain basic information on the prevention and action at accidents with chemicals.

KNOWLEDGE TESTING AND EVALUATION:

Partial tests and seminars with ecotoxicology data, written and oral exam

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student questionnaire

LITERATURE:

1. Foglar, L. Intern textbook *Ecotoxicology*
2. Newman, M.C., *Fundamentals of ecotoxicology*, Lewis Publishers, New York, 2001.
3. Walker, C.H., Hopkin, S.P., Sibly, R.M., Peakall, D.B., *Principles of Ecotoxicology*, Taylor&Francis, London, 2006.

Course: Matlab/Simulink		
Language: English language		
Lecturer: Ph.D. Nenad Bolf, Assist. Prof.		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**0**	**0**
Seminar	**1**	**15**
		Overall: 45
		ECTS: 4

PURPOSE:

Instruct the students to use the software package MATLAB / Simulink and its advanced functions for the purpose of implementing chemical engineering calculation, display and analysis of measurement data, modelling and process optimization.

THE CONTENTS OF COURSE:

MATLAB/Simulink high-level language. Work environment and basic operations.

Working with matrices and fields. Data structure and programming.

Simulation of the processes and systems. Methods and tools for simulation.

MATLAB advanced functions. Drawing and graphic display. Two-dimensional and three-dimensional graphics. Animation.

Fundamentals of symbolic computations in MATLAB. The functions of symbolic computation. Examples of linear algebra. Solving symbolic equations. Special functions. Working in a graphical environment.

Processing of measurement data in the Curve Fitting Toolbox. Parametric and nonparametric adjustment.

Linear and nonlinear adjustment procedures. Statistical parameters of quality adjustment.

Spline Toolbox. The implementation and application of regression analysis methods.

Case-study. First partial exam.

System Identification Toolbox. The development of dynamic process models using identification methods.

Parametric and nonparametric identification. Model validation.

System Identification Toolbox graphical interface. Example of identification based on data from industrial processes.

Fundamentals of Simulink. Modelling, simulation and analysis of dynamic systems. Interaction of MATLAB and Simulink.

Simulink graphical environment. Design of the process models, graphic, work with blocks. Analysis of the results of simulations.

Examples of linear and nonlinear systems, continuous and discrete models, hybrid systems.

Solving real-life problems. Results analysis.

Second partial exam.

GENERAL AND SPECIFIC COMPETENCE:

Apply information technology and programming fundamentals. Solve engineering problems by applying available software packages. Apply mathematical methods and software in case-study solving.

Apply advanced features for analyzing and displaying data. Perform symbolic functions and calculations. Process and analyze measurement data using software tools. Develop process models in a graphical user interface using Simulink. Resolve examples of continuous, discrete and hybrid systems.

KNOWLEDGE TESTING AND EVALUATION:

homework and seminars, partial exams, written exams

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student's survey

LITERATURE:

Course material, presentations and simulations on the course web page.

Ž. Ban, J. Matuško, I. Petrović, Primjena programskog sustava MATLAB za rješavanje tehničkih problema, Graphis, Zagreb, 2010.

D. Grundler, T. Rolich, A. Hursa. MATLAB i primjena u tekstilnoj tehnologiji, Sveučilište u Zagrebu, Tekstilno-tehnološki fakultet, Zagreb, 2010.

MATLAB, The Language of Technical Computing, The MathWorks, Inc., 2012

S.T. Karris, Introduction to Simulink with Engineering Applications, Orchard Publications, 2006

Course: Electrochemistry		
Language: English		
Lecturers: Sanja Martinez and Zoran Mandić		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**2**	**30**
Seminar	**2**	**30**
		Overall: 90
		ECTS: 7

PURPOSE:

- to enable students to gain fundamental and applied knowledge in electrochemistry and electrochemical processes.

- to educate students in electrochemical calculations, electrochemical instrumentation, electrochemical methods.

- provide an experience that encourages development of independent thought and engineering approach to solving complex interdisciplinary tasks in industrial settings and new technologies

- to sustain continuing professional development

THE CONTENTS OF THE COURSE:

1. Week:

   Introduction to Electrochemistry: About the course. Development of electrochemistry as a scientific discipline. The research area of electrochemistry and application of electrochemistry. The basic electrochemical concepts.
   Seminar: solving examples in electrochemical equilibria.

2. Week:

   Conductors and conductivity - Part I: Galvanic circles. Charge transfer through the electrified interface. Principle of electroneutrality. Faraday's law. Mass transfer in the electrolyte.
   Seminar: solving examples in application of Faraday law.

3. Week:

   Conductors and conductivity - Part II: 3 Flow of electric current through the electrolyte. Flow of electric current through the metal. The flow of current through a semiconductor. Intrinsic semiconductors. Extrinsic

semiconductors. Contacts of various conductors in an electrochemical cell. Metal-metal contact. Metal-electrolyte contact. Semiconductor-electrolyte contact.
Seminar: solving examples in semiconductors.

4. Week:

Electrochemical potentials: Electrochemical potential and electrochemical equilibrium. Internal, external and surface potential. Measuring the relative electrode potential. Nernst relation. The definition of the standard electrode potential and reference electrodes. Calomel reference electrode. Silver-silver chloride reference electrode. Copper-copper sulfate reference electrode. Work function of metal. Absolute electrode potential. The potentials at the solutions-solution interface.
Seminar: solving examples of application of Nernst equation.

5. Week:

Models of electrochemical double layer: Helmholtz model. Gouy-Chapman model. Piossonovu -Boltzmann distribution. Stern's model. Capacity of double layer. Electrocapillarity. Electrokinetic effects.
Seminar: solving examples in electrokinetic effects.

6. Week
Electrochemical thermodynamics: EMF of a galvanic cell. Thermodynamic parameters of galvanic cells. Thermal effects in galvanic cell.
Seminar: solving examples in electrochemical thermodynamics.

7. Week:

First knowledge testing and progress evaluation.

8. Week:

Electrochemical kinetics: Charge transfer at solid/liquid interface. Butler-Volmer equation. Polarization resistance. Tafel equation. Reversibility and irreversibility.
Seminar: solving examples in electrochemical kinetics

9. Week:
Mass transport in electrochemical reactions: Diffusion, migration and convection, Ficks' laws of diffusion. Steady and non-steady states in electrochemical reactions.
Seminar: examples in mass transport

10. Week
Electrochemical systems: two electrode systems, three electrode systems, four electrode systems, electrochemical cell design, electrodes, electrochemical instrumentation, prerequisites for doing electrochemical measurements.Electrochemical methods introduction.

Seminar: examples in electrochemical systems

11. Week

Electrochemical methods: Chrono methods (chronoamperometry, chronoculometry, chronopotentiometry), cyclic voltammetry, electrochemical impedance spectroscopy.

12. Week

New phase formation on solid/liquid interface: Metal electrodeposition, electroplating, electrodeposition of polymer layers, nucleation and growth, nucleation kinetics.
Seminar: phase formation
Nano-structured polymeric surfaces and supra-molecular chemical structures.
Laboratory: Desing of conducting polymer battery.

13. Week

New phase formation on solid/liquid interface: the growth of oxide layers on metals, Pourbaix diagrams.

14. Week

Practical aspects of electrochemistry: Electrocatalysis, electrochemical energy conversion and storage, industrial electrochemistry

15. Second knowledge testing and progress evaluation.

Laboratory exercises: (1a) Conductivity of semiconductors; (1b) Conductivity of the electrolyte; (1c) Transport number; (2) Thermodynamics of galvanic cells; (3) Investigation of the electrochemical double layer on solid electrodes; (4) Electrified phase boundary glass / water - Determination of the electrokinetic zeta potential; (5) Electrode process under activation control; (6) The electrode process under diffusion control - 6a. Stationary linear diffusion polarization, 6 b. Non-stationary linear diffusion polarization.

GENERAL AND SPECIFIC COMPETENCE:

General competencies:

- Ability to design and conduct scientific experiment and data interpretation
- Ability to work in a team and development of good communications skills
- Developing of communication skills in written, oral and graphical forms
- Ability to apply gained knowledge in the application of electrochemical methods for scientific and technical purposes
- Recognition of practical engineering problems including economic, social, political and environmental issues.
-

Specific competencies

- Knowledge of fundamental concepts in electrochemistry
- Application of electrochemical calculus
- Knowledge of electrochemical methods and electrochemical instruments
- Recognition of the importance of electrochemistry in material science and engineering
- Recognition of electrochemistry in the development of new technologies
- Knowledge of electrochemical literature.

KNOWLEDGE TESTING AND EVALUATION:

Two progress evaluations during the course.

Knowledge testing after the laboratory work.

Written exam.

Oral exam.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student’s poll.

LITERATURE:

1. Internal written materials
2. 1. V. S. BAGOTSKY, Fundamentals of Electrochemistry, John Wiley & Sons, Inc., New Jersey, 2006
3. 2. J. M. Bockris, A.M.K. Reddy, Modern Electrochemistry 1, Ionics, 2nd Ed., Plenum Press, New York, 1998
4. 3. J. M. Bockris, A.M.K. Reddy, M. Gamboa Aldeco, Modern Electrochemistry 2 A, Fundamentals of Electrodics, 2nd Ed., Plenum Press, New York, Kluwer Academics/Plenum Publishers, New York, 2000
5. 4. J. M. Bockris, A.M.K. Reddy, Modern Electrochemistry 2 B, Electrodics in Chemistry, Engineering, Biology and Environmental Science, 2nd Ed., Plenum Press, New York, Kluwer Academics/Plenum Publishers, New York, 2000.
6. 5. C. H. Hamann, A. Hamnett, W. Vielstich, Electrochemistry, 2nd Ed., Wiley VCH, New York, 1998

Course: Chemistry of natural and synthetic polymers		
Language: English		
Lecturer: Assoc. Prof. Marijana Hranjec, PhD., Full Prof. Ante Jukić, PhD.; Full Prof. Silvana Raić-Malić, PhD.		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**3**	**45**
Laboratory	**3**	**45**
Seminar	**0**	**0**
		Overall: 90
		ECTS: 7

PURPOSE:

Understanding and acquiring of theoretical and practical knowledge in the field of chemistry, synthesis and characterization of natural and synthetic polymers and their basic building blocks.

THE CONTENTS OF THE COURSE:

1st week: Introduction: definitions and structure of natural macromolecules - from monomers to polymers.

2nd week: The stereochemistry and properties of α-amino acids and peptides. Peptide nomenclature. Synthesis and reactions of amino acids. The synthesis of polypeptides: the application of protective groups. Merrifield synthesis of the polypeptide on the solid phase.

3rd week: The structure of proteins - primary, secondary, tertiary and quaternary structure. Determination of the primary structure. Polypeptides in nature - the structure of myoglobin and hemoglobin. Classification, nomenclature and structure of the enzyme. Enzymes as biological catalysts.

4th week: Pyrimidine and purine nucleosides and nucleotides. Nucleoside chemistry.

5th week: Polynucleotides - deoxyribonucleic (DNA) and ribonucleic (RNA) acids. Covalent structure and nomenclature of DNA – Watson's and Crick's double helix of DNA. Genetic code. Nucleotide sequencing. Laboratory synthesis of oligonucleotides. Application of genomics and proteomics.

6th week: Carbohydrates - definition. Classification of carbohydrates. Photosynthesis and Metabolism. Monosaccharides - structural formula. Mutarotation. Synthesis of glycosides and other reactions of monosaccharides. Fischer proof of (+) - D-glucose configuration.

7th week: Disaccharides. Synthesis and Structure. Application - natural sweeteners. Polysaccharides. Starch, cellulose and their derivatives.

8th week: Other biologically important sugars; proteoglycans, glycoproteins and glycolipids.

9th week: Other important macromolecules - macromolecules that include polysaccharide structure. The aminoglycoside antibiotics, macrolides, porphyrins and fullerenes.

10th week: Structure and properties of synthetic polymers; configuration, conformation, molar mass distribution. Linear, branch and cross-linked polymers. Nomenclature. Application of polymeric materials. Principles and classification of polymerizations; step-growth polymerization (polycondensations), chain-growth (linear) polymerization: radical, ionic, ring-opening, coordination. Industrial polymerization processes: homogeneous, heterogeneous; emulsion polymerization, solution polymerization, suspension polymerization, and precipitation polymerization. Process optimization. / Step-growth polymerizations. Equilibrium and degree of polymerization. Reaction rate. Molar mass distribution. Multifunctional polycondensations. Step-growth copolymerization.

11th week: Polymers of step-growth polymerizations. Polyesters, saturated and unsaturated. Polycarbonates. Polyamides. Polyurethanes. Polyepoxides. Phenolic resins. / Free radical polymerizations. Initiation and initiators. Propagation. Termination. Transfer reactions. Kinetic chain length. Reaction rate. Inhibition and inhibitors. Effect of temperature on rate and degree of polymerization. High-conversion polymerizations.

12th week: Free radical copolymerization. Copolymerization rate. Monomer structure and copolymerization reactivity. Copolymerization types. High-conversion copolymerization. Structure and composition of copolymers. Multi-component copolymerization. Graft and block copolymers. / Polymers of radical polymerizations. Polyethylene. Fluoropolymers. Poly(vinyl chloride). Polystyrene. Styrene-butadiene copolymers. Acrylate and vinyl-acetate polymers.

13th week: Anionic polymerizations and corresponding polymers. Initiation and initiators. Propagation. Termination – living anionic polymerizations. Anionic copolymerization. Styrene-butadiene copolymers. Polysiloxanes. Cationic polymerizations and corresponding polymers. Initiation and initiators. Propagation. Termination. Cationic copolymerization. Polyoxymethylene. Polyisobutene. Poly(vinyl ethers). Coordination polymerization and corresponding polymers. Mechanism and kinetics of Ziegler-Natta and metallocene catalysis stereospecific polymerizations.

14th week: Polypropylene. Polyethylene. Ethylene-propylene copolymers. Polyisoprene. Polybutadiene. Functionalization of polyolefin. New polymerization processes. Reversible-deactivation radical polymerization ("controlled" radical or "living" radical polymerization); stable-free-radical-mediated polymerization, aminoxyl-mediated radical polymerization, atom-transfer radical polymerization, reversible-addition-fragmentation chain-transfer polymerization. Free radical polymerizations with multifunctional radical initiators.

GENERAL AND SPECIFIC COMPETENCE:

Connecting and applying the general principles of the macromolecules in the chemistry of life. Introducing students to the chemistry of basic building blocks of natural and synthetic polymers and correlations of three-dimensional structure of biomolecules with their biological functions.

KNOWLEDGE TESTING AND EVALUATION:

Colloquiums related to laboratory practices.
3 partial tests during the semester (60% of points on each of the tests enables the release from the oral exam).
Written exam (50% of the points needed for passage).
Oral exam.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student survey.

LITERATURE:

K. P. C. Vollhardt, N. E. Schore, Organic Chemistry: Structure and Function, 5th edition, W. H. Freeman and Company, New York, 2007.
L. G. Wade, Organic Chemisty, 6th, Pearson Education, Inc., New Jersey, 2006.
M. Waring, Sequence-Specific DNA binding Agents, RSC Publishing; Thomas Graham House Science, Cambridge, 2006.
T. W. Graham Solomons, C. B. Fryhle, Organic Chemistry, John Wiley and Sons, Inc., New York, 2004.
Z. Janović, Polimerizacije i polimeri, Hrvatsko društvo kemijskih inženjera i tehnologa, Zagreb, 1997.
G. Odian, Principles of polymerization, 4th Edition, Wiley-Interscience, New York, 2004.
N. Raos, S. Raić-Malić i M. Mintas, Lijekovi u prostoru: farmakofori i receptori, Školska knjiga, Zagreb, 2005.
K. Davis, K. Matyjaszewski, Statistical, gradient, block and graft copolymers by controlled / living radical polymerizations, Advances in Polymer Science, Springer-Verlag, Berlin, Heidelberg, 2002.
P. Munk, Introduction to macromolecular science, Wiley-Interscience, New York, 1989.
S. H. Pine, Organska kemija (prijevod I. Bregovec, V. Rapić), Školska knjiga, Zagreb, 1994.

Course: Instrumental analytical chemistry, Applied Chemistry
(3rd year, 5th semester, univ. bacc. appl. chem.)

Language: English

Lecturer: Associated professor Danijela Ašperger, Ph.D.

TEACHING	WEEKLY	SEMESTER
Lectures	**2**	**15**
Laboratory	**1**	**15**
Seminar	**-**	**-**
		Overall: 45
		ECTS: 6

PURPOSE:

The aim of this course is to introduce the theoretical principles, practical work and use the instruments of equipment and procedures for instrumental methods of chemical analysis. The choice of method will be depend on knowledge of the basic principles of individual method or group of methods and the understanding of their benefits and limitations.

THE CONTENTS OF THE COURSE:

Lectures:

1. Introduction into the program of course, instructions for work in the laboratory. Introduction - types of analytical signals, the basic components of instruments, instrumentation development, and classification of instrumental methods.
2. Spectrometry, history of spectroscopic techniques, fundamentals of spectrometry, a classification of spectrometry - molecular and atomic spectrometry.
3. Classification of spectrometry considering the result of interaction of the sample with energy: absorption, induced absorption, emission, polarization of EMR, scattering, mass to charge ratio.
4. Spectrometry radiation of electrons and ions, and mass spectrometry.
5 The first partial test.
6. Electroanalytical methods - history, fundamentals, classification, electrochemical cell.
7. Potentiometry, conductometry, electrogravimetry.
8. Voltammetry, amperometry, coulometry.
9. Electrophoresis - fundamentals, classification, capillary electrophoresis.
10. The second partial test.
11. Separation instrumental methods, chromatography - introduction, basics, classification of chromatography, gas chromatography.
12. Liquid chromatography, chromatography at the super critical conditions, planar chromatography, ion chromatography, size exclusion chromatography.

13. Thermal methods.
14. The third partial test.
15. Presentation of seminar papers.

Laboratory:
1. UV/VIS spectrometry - determination of iron and/or chromium - the method of external standards.
2. EMR scattering spectrometry - turbidimetric determination of sulfate.
3. Atomic absorption spectrometry - determination of copper content - method of standard addition.
4. Potentiometry: potentiometric titration and data processing - determination of salicylic acid.
5. Direct potentiometry - determining the concentration of chloride or fluoride.
6. Conductometry - determination of acids mixture by conductometric titration.
7. Compensation of laboratory exercise.

GENERAL AND SPECIFIC COMPETENCE:

Introduction to instrumental methods, and connect with process analysis.

KNOWLEDGE TESTING AND EVALUATION:

Written and oral examination. The possibility of release written part of the exam if you collect enough points.

The oral part of the exam with the teacher.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student questionnaire.

LITERATURE:

1. D. A. Skoog, D. M. West, F. J. Holler, Osnove analitičke kemije, Školska knjiga Zagreb, 1999.
2. M. Kaštelan-Macan, Kemijska analiza u sustavu kvalitete, Školska knjiga Zagreb 2003.
3. I. Piljac, Elektroanalitičke metode, RMC, Zagreb 1995.
4. Radni materijal s predavanja.
5. Radni materijal za vježbe (interna skripta).

ADDITIONAL LITERATURE:

1. Analitika okoliša, ed. M. Kaštelan-Macan i M. Petrović, HINUS and Fakultet kemijskog inženjerstva i tehnologije, Zagreb, 2013.
2. J. M. Miller, Chromatography-Concepts and Contrasts, Wiley-Interscience, New Jersey, 2005.
3. K. H. Koch, Process Analytical Chemistry. Control, Optimization, Quality, Economy, Springer Verlag, Berlin 1999.
4. D. A. Skoog, F. J. Holler, T. A. Nieman, Principles of Instrumental Analysis, Saunders College Publishing 1997.

Course: Molecular spectroscopy		
Language: English		
Lecturer: **Prof. Irena Škorić, Ph.D., Prof. Vesna Volovšek, Ph.D.**		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**1**	**15**
Seminar		
		Overall: 45
		ECTS: 6

PURPOSE: To inform students with physical base of molecular spectroscopy and with application of individually each method in chemistry, especially with interpretation of spectra in determination of structures of organic compounds.

THE CONTENTS OF THE COURSE:

1. Interaction of electromagnetic radiation and matter, Electromagnetic spectrum, Quantization of energy and molecular energy levels, Absorption and emission of electromagnetic radiation, Half-width and intensities of spectral transitions.
2. Molecular symmetry, Elements of symmetry, Point groups, Tables of character, Election rules and transition probability.
3. Vibrational spectroscopy, Experimental methods.
4. Molecular vibrations of diatomic molecules, Molecular vibrations of polyatomic molecules, Characteristic vibration.
5. Analysis of vibrational spectra.

COLLOQUIUM

6. NMR spectroscopy: Basic approaches, Nuclear magnetic moment. ^{1}H NMR spectra: Chemical shift and shielding, Integrals, Chemical environment and chemical shift, Magnetic anisotropy, Coupling constant.
7. NMR spectroscopy. ^{13}C NMR spectra: Chemical shifts of carbon-13, integration in ^{13}C NMR spectrum, NOE effect, Heteronuclear coupling of carbon with deuterium, Fluorine-19 and Phosphorus-31.
8. NMR spectroscopy. Spin-spin coupling: Mechanism of coupling, coupling constants of spectrum of first and second order, Long-range coupling.
9. – 11. NMR spectroscopy. Additional chapters in one-dimensional NMR: Exchange of protons in H_2O and D_2O, Tautomerism, Protons on the nitrogen atom, Effect of the solvent on chemical shift; Advanced NMR techniques: DEPT experiment, Two-dimensional spectroscopic methods: COSY, HETCOR

COLLOQUIUM

12. UV/Vis spectroscopy and fluorescence: Instrumentation, Presentation of spectra, Solvents, Chromophores, Effect of conjugation

13. UV/Vis spectroscopy and fluorescence: Woodvards rule for enons, Aromatic compounds, Visible spectrum, Color in compounds

COLLOQUIUM

14. Mass spectroscopy: Mass spectrometer, GC/MS, Mass spectrum, Determination of molecular weight and formula, Effect of isotopes

15. Mass spectroscopy: Fragmentation

COLLOQUIUM

GENERAL AND SPECIFIC COMPETENCE:

Students will be able to analyze obtained results and apply it in determination of structures of organic compounds, by combining spectroscopic methods which they studied in this course.

KNOWLEDGE TESTING AND EVALUATION:

Exam will be held through colloquiums after each major methodological units. Students who do not pass colloquia (total 4) will take written test.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student questionnaire

LITERATURE:

1. Banwell, C. N., McCash, E. M., *Fundamentals of Molecular Spectroscopy*, McGraw-Hill College, 1995.
2. Pavia, D. L., Lampman, G. M., Kriz, G. S., *Introduction to Spectroscopy*, Third Edition, Brooks/Cole Thomson Learning, Australia, 2001.
3. Silverstein, R. M., Webster, F. X., *Spectrometric Identification of Organic Compounds*, Sixth Edition, John Wiley & Sons, Inc., New York, USA, 1997.

Course: Biochemistry

Language: English

Lecturer: Dr. Tatjana Gazivoda Kraljević, assis. prof.; Dr. Marijana Hranjec, assoc. prof.

TEACHING	WEEKLY	SEMESTER
Lectures	**2**	**30**
Laboratory	**0**	**0**
Seminar	**1**	**15**
		Overall: 45
		ECTS: 4

PURPOSE:

Introduce students to the molecular logic of biochemical processes in living organisms and dynamics of synthesis and degradation of natural biomacromolecules: proteins, polysaccharides, lipids and nucleic acids. Studying of cell metabolism and the regulation and control principles.

THE CONTENTS OF THE COURSE:

1st week: Introduction to biochemistry, relationship between science and biomedical knowledge, Protein structure and function, peptide bond, conformation and dynamic aspects of the structure, basis of research and principles of protein isolation

2nd week: Proteins with special function: hemoglobin, a model globular protein, hemoglobin interaction with ligands, structure, function and regulation, cooperative binding of oxygen, myoglobin

3rd week: The differences between monomers and tetramers. Fibrillar proteins - collagen, elastin

4th week: Enzymes and enzyme catalysis - regulation activities of metabolic important enzymes - strategies and mechanisms, allosteric regulation of enzymes, activators and inhibitors, coenzymes and prosthetic groups: structure and function, proteins that bind to DNA.

5th week: Production and storage of metabolic energy - basic concepts and properties. Glycolysis - metabolic pathway, control and regulation, allosteric regulated enzymes, hexokinase, phosphofructokinase, pyruvate kinase, ATP production, the importance of NADH oxidation and reaction and LDH reaction.

6th week**: Gluconeogenesis - metabolic pathway, generation of glucose from non-carbohydrate carbon substrates, the difference between *g*lycolysis and gluconeogenesis, biotine, the role of oxaloacetate, regulation of *g*lycolysis and gluconeogenesis*.***

7th week**: Oxidative decarboxylation of pyruvate, citric acid cycle. The**

synthesis of acetyl-CoA from pyruvate, pyruvate dehydrogenase complex, coenzymes and prosthetic groups, the synthesis of citrate and review of synthetic steps in the citric acid cycle, the energy changes in the reaction, the cycle is source of biosynthetic precursor and energy for the cell.

8th week: Cellular bioenergetics, ATP cycle, respiratory chain and oxidative phosphorylation. Redox potentials and changes in free energy, the cascade oxidation of the coenzyme NADH and FADH2, oxygen is the final acceptor of H + and electron, proton pump and creating a gradient of H +, the ATP synthase mechanism and structure , energy efficiency of the complete oxidation of glucose, regulation of oxidative phosphorylation.

9th week: Pentose phosphate pathway, direct oxidation of glucose and the formation of ribose-5-phosphate and NADPH. Transaldolase and transketolase connect the pentose phosphate pathway and glycolysis.

10th week: Glycogen metabolism: glycogenesis and glycogenolysis, hormonal regulation. Phosphorylase and phosphorolytic cleveage of glycogen, the synthesis of UDP-glucose. Hormonal regulation of synthesis and degradation. Cascade reactions and control of phosphorylation of the enzyme, cAMP. The metabolism of glycogen in the liver and the control of blood glucose concentration.

11th week: Fatty Acid Metabolism*:* degradation of triglycerides, beta-oxidation of fatty acids, biosynthesis of fatty acids, biosynthesis of triacylglicerol.Urea cycle and different ways of nitrogen elimination from the body, alanine and glutamine cycle transfer of nitrogen from various tissues in the liver, oxidative deamination of glutamate synthesis of carbamoyl phosphate, urea cycle enzymes, connection between urea cycle and the citric acid cycle, the mechanism of toxicity of NH4 + ions in the brain.

12th week: Amino acids metabolism. Amino acid degradation and the urea cycle. Transamination and degradation of amino acids, the reaction mechanism and the role of pyridoxal phosphate in the transamination of amino acids, serine and threonine dehydratase, degradation of branched amino acids, aromatic amino acid degradation and synthesis of adrenaline , ketogenic amino acids, biosynthesis of non-essential amino acid, serine, glycine.

13th week: Nucleic acids - structure, function, biosynthesis and degradation of nucleotides. Structure of nucleotides, biosynthesis of purine and pyrimidine bases, deoxyribonucleotides synthesis, degradation of purine bases and uric acid synthesis, degradation of pyrimidine, characteristics and replication of DNA, structure and types of RNA, protein synthesis, the course of transmission genetic information.

14th week: Information in biological systems. DNA - genetic role, structure, genome organization, chromosomes and genes. Packing of DNA, histones. DNA conformations. Replication of DNA and replication fidelity. Mistakes in DNA and their repair. RNA and translation of genetic messages. Synthesis and modification of functional RNA molecules: mRNA and transcription, tRNA, activation and the role in protein synthesis, structure of ribosomes and rRNA.

15th week: Genetic code and gene and protein. Protein synthesis. Control of gene expression in prokaryotes Lac operon and the Trp operon. The chromosomes of eukaryotes and control of the expression of eukaryotic genes. Introns and exons.

GENERAL AND SPECIFIC COMPETENCE:

After completing the course, students acquire the ability of critical reflection on the biochemical processes and metabolic reactions in various organs and tissues that are important for the understanding of physiological and pathological processes.

KNOWLEDGE TESTING AND EVALUATION:

3 partial written tests during the semester (60% of points on each of the exams brings the release of the oral examination).
Written exam (50% of the points needed for passage).
Oral examination.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student survey.

LITERATURE:

J. M. Berg, J. L. Tymoczko, L. Stryer: Biochemistry, fifth edition, Freeman, New York, 2002.
L. Stryer: Biokemija, Školska knjiga, Zagreb, 1991.
D. Voet, J. G. Voet, Biochemistry 3rd ed., J. Wiley & Sons, New York 2004.
P. Karlson, Biokemija za studente kemije i veterine, Školska knjiga, 2004.

Course: Electrochemical and Corrosion Engineering		
Language: English		
Lecturers: MarijanaKraljićRoković and Sanja Martinez		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**2**	**30**
Seminar	**0**	**0**
Field work		**1 (day)**
		Overall:60
		ECTS: 7

PURPOSE:

The objective of the first part of this course is to provide the knowledge considering electrochemical reactors and its application as well as to give introduction about most important electrochemical industrial processes.

Metallic materials are the basic building blocks of many structures in today's industrial society and knowledge of the causes of corrosion and the ways of its prevention is of great technological and economic importance. It is especially important for the health and safety of people and the environment. The objective Corrosion Engineering part of the course Electrochemical and corrosion engineering is to familiarize students with the phenomenon of electrochemical corrosion of metallic materials and principles of protection techniques as well as to teach students to apply this knowledge in practical situations.

THE CONTENTS OF THE COURSE:

Week 1
Introduction to electrochemical engineering. Equilibrium cell potential and Gibbs energy. Cell voltage. Characteristic parameters of electrochemical process.

Week 2
Mass balance of electrochemical processes. Heat balances of electrochemical processes. Joule heating. Heat balances for aluminium production process..

Week 3
Current and potential distribution

Week 4
Mass transport in electrochemical reactor (diffusion, convection, migration). Hydrodynamic boundary layer and Nernst diffusion layer. Forced and free convection in electrochemical reactor. Dimensionless numbers defining mass transport in electrochemical reactor.

Week 5
Electrochemical cell and electrode design, separators (membranes and diaphragms), electrode materials and catalysis. Process optimisation.

Week 6

Aluminium production (Hall-Heroult Process). Chlor-alkali production. Electroplating.

Week 7
Exam

Week8:

Introduction to corrosion and corrosion engineering - Corrosion Costs and purpose of the study of corrosion; corrosion process (theory of homogeneous corrosion); steady state of the corrosion process; common corrosion reactions; analogy of corrosion and galvanic cell;calculating the enthalpy change of the free corrosion reactions - EMFof the corrosion cell.

Week 9:

Kinetics of corrosion process - rate of corrosion, corrosion system out of equilibrium - polarization; theory of mixed potentials (kinetics of uniform corrosion), polarization resistance, Wagner Traudi equation;

Week 10:

Thermodynamics of corrosion process Nernst equation and Pourbaixovi diagrams, corrosion potential, measuring the potential of corrosion systems;

Week 11:

Localized corrosion - causes of localized corrosion; galvanic corrosion; potential and current distribution in a galvanic cell; corrosion due to the formation of the concentration cell; corrosion in crevices; pitting corrosion; stress corrosion cracking; corrosion fatigue; hydrogen induced cracking and other forms of corrosive damage caused by hydrogen; intergranular corrosion; selective dissolution; erosion corrosion; other types of corrosion in conjunction with mechanical action of the environment: cavitation, fretting corrosion and wear corrosion.

Week 12: Corrosion protection techniques - protection against corrosion by selection of corrosion resistant materials

Week 13: Corrosion protection techniques - electrochemical techniques for corrosion protection

Week 14: Corrosion protection techniques - protection by inhibitors, inorganic and organic.

Week 15: Exam

<u>Laboratory exercises –Electrochemical engineering</u>
1. Current and potential distribution
2. Zinc electroplating
3. Electrolytic silver refining

<u>Laboratory Exercises and Field Work-Corrosion Engineering</u>
Week 8: Field work
Week 9: Determination of corrosion rate by DC electrochemical techniques

Week 10: Application of Pourbaix diagrams in corrosion
Week 11: Passivity of carbon and stainless steel
Week 12: Galvanic corrosion
Week 13: Cathodic protection - current distribution
Week 14: Corrosion protection by organic coatings

Laboratory exercises
1. Current and potential distribution
2. Zinc electroplating
3. Electrolytic silver refining

GENERAL AND SPECIFIC COMPETENCE:

General competencies:

- Ability to design and conduct scientific experiment and data interpretation
- Ability to work in a team and development of good communications skills
- Developing of communication skills in written, oral and graphical forms
- Analyze and optimize the electrochemical processes practice.
- Apply methodologies of chemical and electrochemical engineering in practice.
- Manage and plan electrochemical processes.

Specific competencies

- Applying fundamental knowledge of electrochemistry and chemical engineering to electrochemical cell design.
- Applying electrochemical engineering to solve different practical problems.
- Familiarity with the most important electrochemical processes.
- Applying fundamental knowledge of electrochemistry and chemical engineering to solve practical problems of corrosion.
- Defining and describing mathematically corrosion phenomena and processes.
- Using the laboratory and field electrochemical measuring equipment in the field of corrosion and corrosion protection.
- Performing and interpreting the meaning of measurements in corrosion, especially of the corrosion rate.
- Recognizing of various forms of localized corrosion.
- Properly choosing the appropriate technique for the protection of systems susceptible to corrosion.

KNOWLEDGE TESTING AND EVALUATION:

Two progress evaluations during the course.

Knowledge testing after the laboratory work.

Written exam.

Oral exam.

MONITORINGOF THE COURSE QUALITY AND SUCCESSFULNESS:

Student’s poll.
LITERATURE: 1. Electrochemical engineering lectures at faculty web sites 2. H. Wendt, G. Kreysa, Electrochemical Engineering: Science and Technology in Chemical and Other Industries, Springer, Berlin, 1999. 3. D. Pletcher, F. C. Walsch, Industrial Electrochemistry, Chapman and Hall, 1990. 4. Corrosion Engineering lectures at E-learning system Merlin 5. D. A. Jones, Principles and Prevention of Corrosion: Pearson New International Edition, 2nd Ed, Pearson Education, Limited, 2013 6. P. Roberge, Handbook of Corrosion Engineering, 2nd Ed, McGraw-Hill, New York, 2012 7. R. Winston Revie, Uhlig's Corrosion Handbook, 3rd Ed, Wiley, New York, 2011 8. Y. Mike Tan, R. Winston Revie, Heterogeneous Electrode Processes and Localized Corrosion, Wiley, New York, 2013 9. K. Richard Trethewey, J. Chamberlain, Corrosion for students of science and engineering, Longman, Harlow, 1988

Course: Introduction to Environmental Chemistry		
Language: English		
Lecturer: Prof. Silvana Raić-Malić, Ph.D., Assist. Prof. Šime Ukić, Ph.D.		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**1**	**15**
Seminar	**0**	**0**
		Overall: 45
		ECTS: 4

PURPOSE:

To introduce students with chemical balances and possible interactions of natural components of environment with pollutants in water, sediments, soil and atmosphere.

THE CONTENTS OF THE COURSE:

1. Classification, nomenclature and examples main group of organic compounds present in the environment. Classification of organic compounds by their chemical structures, impact of organic compounds on the environment.
2. Organic pollutants of water.
3. Organic pollutants of air.
4. Organic pollutants of soil.
5. Application of green organic chemistry in elementary organic reactions. Examples of the use of alternative, non-toxic solvents and reagents in the synthesis of some organic compounds, catalyses and biocatalyses. Photocatalytic degradation reactions of organic pollutants.
6. Presentation of student works.
7. 1st test.
8. Environmental chemical analysis. Analytical process. Evaluation and interpretation of data. Classical methods of chemical analysis.
9. Instrumental analytical methods. Process analysis *in situ*. Analysis of pollutant traces.
10. Water. Water classification. Water quality indicators. Water pollution by heavy metals and other inorganic species. Reaction of organic compounds with metals in water. Sampling, separation and analysis of water-pollutants.
11. Suspended colloid particles in water. Sediment. Equilibrium on phases' border. Traces of metal in sediment and suspended particles.
12. Mineral composition of soil. Soil-pollution by inorganic pollutants. Mechanisms of pollutants' mobility and bounding in soil. Soil analysis. Pollutants mobility in soil. Environmental quality information based on chemical analysis.
13. Composition of the atmosphere. Gasses. Acid-base reactions in atmosphere.

Acid rains. Reactions of atmospheric ozone. Primary and secondary atmospheric pollutants. Inorganic pollutants. Floating particles. Sampling and determination of atmospheric pollutants.
14. Presentation of student works.
15. 2nd test.

Laboratory practice:

1. Synthetic step in the preparation of selected compound or drug under microwave irradiation.
2. Water analysis: water sampling, determination of temperature, total solid, pH value, water hardness (calcium, magnesium, carbonate, and total), alkalinity, and sulphate amount.
3. Soil analysis: determination of the amount of humus and soil acidity.

GENERAL AND SPECIFIC COMPETENCE:

Introducing with the pollutants in environment and the way of their discovering and determination.

KNOWLEDGE TESTING AND EVALUATION:

Two (2) partial tests during the semester. Students can be released from exam if they collect sufficient points (55) from 2 tests.
Written exam and oral exam.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student survey.

LITERATURE:

1. K. M. Doxsee, J. E.Hutchison, Green Organic Chemistry: Strategies, Tools and Laboratory Experiments, Thomson Learning Inc., New York, USA, 2004.
2. S. E. Manahan, Environmental Chemistry, Eight edition, CRC Press LCC, New York, USA, 2005.
3. M. Kaštelan-Macan, M. Petrović, V. Tomašić, A.J.M. Horvat, S. Babić, T. Bolanča, D. Mutavdžić Pavlović, J. Macan, D. Ašperger, Š. Ukić, G. Klobučar, A. Štambuk, R. Sauerborn Klobučar, S. Ferina: Analitika okoliša, M. Kaštelan-Macan, M. Petrović (ur.), HINUS i Fakultet kemijskog inženjerstva i tehnologije, Zagreb, 2013.
4. D.A. Skoog, D.M. West, F.J. Holler, Osnove analitičke kemije, Školska knjiga Zagreb, 1999.
5. E. Prohić, Geokemija, Targa Zagreb, 1998.
6. F.W. Fifield, P.J. Haines, Environmental Analytical Chemistry, Blackwell Science, 2000.
7. W. Stumm, J. J. Morgan, Aquatic Chemistry, Chemical Equillibria and Rates in Natural Waters, 3rd ed., Wiley-Interscience, New York, 1996.

Course: Chemistry in Environmental Protection		
Language: Croatian, English		
Lecturer: red. prof. Tomislav Bolanča, red. prof. Felicita Briški, dr. sc. Lidija Furač, senior lecturer		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**1**	**15**
Seminar	**0**	
		Overall 45
		ECTS: 4

PURPOSE:

THE CONTENTS OF THE COURSE:

Week 1: Environmental quality management. Social and commercial aim of environmental protection. Emissions and alowed value. Standards, norms, good laboratory practice and legislative.

Week 2: Environmental analysis parameters. Electrochemical, spectrometric and separation techniques in environmental analysis. Economical, ecological and technological parameters of analysis. Selection of optimal analytical technique. Accreditation.

Week 3: Environmental quality monitoring. Aims of monitoring. Monitoring of stationary and mobile emissions. Monitoring of ambient. Sampling and methodology for sampling frequency reduction. Determination of sampling position. Monitoring protocol. Metrology in environmental protection.

Week 4: Risk assessment in environmental protection. Multivariate analysis in environmental protection. Estimation and dispersion of pollutants in environment. Multi criteria decision making.

Week 5. 1st midterm test.

Exercises 5 hours: monitoring and multivariant analysis of environment.

Week 6: Cycling of matter and energy in nature. Atmosphere: physical and chemical characteristic of the layers, composition and significance. Classification of the gaseous chemical species. Photochemical reactions. Ozone. The destruction of the ozone layers. Pollutants: waste gases, organic compounds, particulate matter, toxic metals, radioactive particles. Acid rains. Greenhouse gases. Photochemical smog. Devices for control and removal of contaminants before air emissions.

Week 7: Water: the hydrologic cycle in nature, physical and chemical characteristics and properties. Gases in water. The carbonate equilibrium. Alkalinity. Chemical reactions and equilibrium: acid-base and complexation. Chemical reactions and equilibrium: precipitation and dissolution, redox reactions (pE - pH diagrams) .Heterogenic equilibrium. Adsorption and surface complexation.

Week 8: Pollutions in water: heavy metals, metalloids, metallo-organic complexes, inorganic and organic species. Wastewater treatment: filtration, coagulation, flocculation, sedimentation,

Week 9: The relationships between soil-water-air. Chemical reactions in the soil: ion exchange, redox reactions, complexation. Macro and micro nutrients of the soil. The cation exchange capacity (CEC). Pollutants in the soil and their control: pesticides, polychlorinated biphenyls (PCBs) volatile organic compounds (VOCs), gases (NO, NO2), waste oil, waste. Waste disposal.

Week 10:2nd midterm test.

Exerci ses 5 hours: Computer modeling of the process of release of pollutants into the environment by Visual Minteqa software.

Week 11: Carbon, sulfur, nitrogen and phosphor cycle in environment: aerobic and anaerobic biological processes, classification and sampling of water, physico-chemical and biological analysis.

Week 12:Nitrates in water wells and their impact on health, processes of nitrate removal from drinking water, filtration and oxidation od drinking water, characterization of waste water, physico-chemical and biological treatment of waste water, biomass kinetics, substrate and biomass balance in flow systems.

Week 13: Soil as natural phenomena, chemistry and microbiology of soil (types and their energetic metabolism), chemical reactions of litothrophic microorganisms in soil, succesion of fungi microflora in soil.

Week 14: Biochemical processes during degradation of organic fraction in solid waste, sanitary landfill and compositing material.

Week 15: 3rd midterm test.

Exercises 5 hours: Physico-chemical and bacteriological analysis of drinking, natural and waste water samples.

GENERAL AND SPECIFIC COMPETENCE:

- knowledge and understanding of essential facts, concepts, principles and theories relating to chemistry and chemical engineering,
- ability to recognise and solve qualitative and quantitative problems using the appropriate chemical principles and theories,
- competence in presenting chemical and chemical engineering related material and arguments in writing and orally, to an informed audience,
- computational and data-processing skills, relating to chemical information and data, ability to engage in interdisciplinary team-working,

KNOWLEDGE TESTING AND EVALUATION:

Students writes 3 mid terms exams during the semester. The condition of exemption from examination is the minimum to get 60% of the total number of points on each test.

Experimental work	**0,5**
Tests	3
Seminar essay	0.5

LITERATURE:

1.M. Pinta: Trace Elements Analysis, AnnArbor Science, Michigan, 1985.

2. C. Baird: Environmental Chemistry, W.H. Freeman and Co., New York, 1999.

3. D. G. Crosby: Environmental Toxicology and Chemistry, Oxford Unvesitety Press, Oxsord, 1999.

4. S. E. Manahan, Environmntal Chemistry, 7 th ed., Lewis Publisher, Boca Raton, 2000.

5. S. E. Manahan, Environmntal Chemistry, 7 th ed., Lewis Publisher, Boca Raton, 2000.

6. R.E. Caret, K.J. Denniston, J.J.Toping: Principles and Applications of Inorganic, Organic and Biological Chemistry, Wm. C. Brown Publishers, Dubuque, 1997

7. J. E. Girard: Principles of Environmental Chemistry, Jones and Bartlett Publishers, INC., Sudbury, 2005.

Optional literature:

1. D.A. Skoog, D.M. West, F.J. Holler: Osnove analitičke kemije, 1. izd., Školska knjiga, Zagreb, 1999.

2. J. Weiss: Handbook of Ion Chromatography, 3rd ed., Wiley-VCH, Weinheim, 2004

3. E. R. Weiner, Applications of Environmental Aquatic Chemistry, CRC Press, Boca Raton, 2007.

4. S. E. Manahan, Fundamentals of Environmental and Toxicological Chemistry, CRC press, Boca Raton, 2013

Course: Introduction to nanotechnology		
Language: English		
Lecturer: Prof. Stanislav Kurajica; Prof. Sanja Lučić Blagojević		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**0**	**0**
Seminar	**1**	**15**
		Overall:45
		ECTS: 4

PURPOSE:

Accepting of the basic terms of nanotechnology. Acquiring knowledge on properties of nanomaterials. Getting acquainted with methods of preparation and characterization of nanomaterials. Acquaint with the most important kinds of nanomaterials and its applications.

THE CONTENTS OF THE COURSE:

1. Concepts of nanoscience and nanotechnology, molecular nanotechnology. History of nanotechnology, Gordon E, Moore, Richard P. Feynman, Eric K. Drexler, R. Kurzweil. Phenomena on nano-level: quantum effects, surface to volume ratio, the dominance of electromagnetic forces.

2. Properties of nanomaterials: physical, mechanical, chemical, optical, electrical, magnetic. Tunelling effect, quantum confinement, quantum dots, nanostructure, magical numbers. Hall-Petch effect, superparamagnetism, giant magnetoresistance, lotos effect.

Laboratory exercise 1. The determination of crystallite size using Scherrer method.

3. Characterization of nanomaterials. Scanning electron microscope, transmission electron microscope, scanning tunneling microscope, atomic force microscope.

Laboratory exercise 2. Synthesis of silver nano-particles.

4. Nano-manufacturing: top-down approach: photolitography, soft litography, microcontact printing, nano-print litography, dip-pen nanolitografy, high-energy milling, PVD, CVD.

Laboratory exercise 3. The preparation of superparamagnetic nano-particles.

5. Nano-manufacturing: bottom-up approach: precipitation, crystallization, colloids, colloid stabilization, solid suspensions, self-assembly, micelles, thin films, self-assembled monolayers, dendrimers, super-latices, sol-gel method. Nanomanipulation, contact and contactless nanomanipulation. The aims for nanomanipulation.

Laboratory exercise 4. Sol-gel synthesis of SiO_2 nanoparticles.

6. Trends in nanotechnology: Nanomaterials (nano-structured materials, smart materials, ageless materials), nanoproducts (electronics, medicine, environment, industrial technology). Nanorobots. The applicative potential of nanomaterials. Sociological

acceptance of nanomaterials. Riscs of nanotechnology Future of nanotechnology.

7. I. Partial exam

8. Carbon nanostructures; Fullerene – synthesis, properties, reactivity, potential application; Carbon nanotubes – molecular and supramolecular structure, intrinsic properties, synthesis, purification, modification, application

9. Nanoscale electronic, Development of microelectronic devices and technology, Structure and operation of MOF transistor; Transistor scaling, Nanoscaled MOFSET transistors;

10. Molecular electronic – possibilities, preparation and investigation of molecular devices; Molecular switches, transistors and similar devices; Electronic with DNA molecules; Single electron electronic devices

11. Nanocomposites – preparation, structure and properties

12.-13. Nanobiotechnology – biomimetic nanostructures, interface with biologic structure and functions: Biomolecular motors – MEMS and biomolecular motors. Operations and functions of motor proteins; Biotechnology of motor proteins; Science and engineering of molecular motors, Engineered devices; Molecular motors in technological application

14. II. Partial exam

GENERAL AND SPECIFIC COMPETENCE:

Knowledge of basic concepts of nanoscience and nanotechnology. Noticing the diversity properties of nano-materials and macro-materials and understand the reasons of these differences. Knowledge of ways of getting nanomaterials on the principle top-down and bottom-up. Knowledge of basic methods of characterization of nanomaterials. Understanding the trends in nanotechnology.

KNOWLEDGE TESTING AND EVALUATION:

Partial exams, written/oral exam

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student questionnarie

LITERATURE:

1. Di Ventra M., Evoy S., Heflin R.J., Introduction to Nanoscale Science and Technology, Springer, 2004.
2. Owens P.,Introduction to Nanotechnology, John Wiley & Sons, 2003.
3. Wilson M., Kannangara K., Smith G., Simons M., Raguse B., Nanotechnology, basic science and emerging technologies, Chapman &Hall, 2002.

Course: Planning of organic chemistry		
Language: English		
Lecturer: Dr. Marijana Hranjec, assoc. prof.		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**1**	**15**
Seminar	**0**	**0**
		Overall: 45
		ECTS: 4

PURPOSE:

Introducing students to the basic principles of simple and multistep synthesis in the laboratory and industry. Planning of synthesis and retrosynthesis of target organic molecules. Critical thinking when choosing the most suitable synthetic routes for the implementation of organic synthesis in the laboratory.

THE CONTENTS OF THE COURSE:

1st week: Introduction. Planning of organic synthesis: synthetic plan, strategy and control. Retrosynthesis.

2nd week: Chemoselectivity. Regioselectivity: controlled aldol reactions.

3rd week: Stereoselectivity: stereoselective aldol reactions. An alternative strategy for the synthesis of enones.

4th week: Creating of a new C-C bond, which leads to an increase in molecular structure? *Ortho*-strategy for aromatic compounds. Controlled Michael additions.

5th week: Specific enol equivalents. Enolates. Allyl anions. Homoenolates. The acyl anion equivalents. Written assessment by 1st partial exam.

6th week: C-C double bond. Synthesis of double bonds defined stereochemistry.

7th week: Vinyl anion equivalents. Electrophilic attack on alkenes.

8th week: Vinyl cations. Palladium catalysed reactiones. Allylic alcohols.

9th week: Stereochemistry. Control of stereochemistry and the relative control of the stereochemistry. Resolution.

10th week: Asymmetric synthesis of natural products used as starting reactants. Asymmetric Catalysis: formation of C-O and C-N bonds. Written assessment by 2nd partial exam.

11th week: Asymmetric catalysis: the formation of C-H and C-C bonds. Asymmetric strategies based on used substrates.

12th week: Enzymes: Biological methods in asymmetric synthesis. Strategy of asymmetric synthesis.

13th week: The strategy of functional groups. Functionalization of pyridine nuclei. The oxidation of aromatic compounds.

14th week: Functionalization of pericyclic reactions: synthesis of nitrogen heterocycles by cycloadditions and sigmathropic rearrangements.

15th week: Synthesis and chemistry of azoles and other heterocycles having two or more heteroatoms. Written assessment by takehome exam.

GENERAL AND SPECIFIC COMPETENCE:

Planning of synthesis and retrosynthesis of targeted organic molecules, critical thinking when selecting the most suitable synthetic routes for the implementation of organic synthesis in the laboratory.

KNOWLEDGE TESTING AND EVALUATION:

Exams related to laboratory practices.
2 partial written tests during the semester (60% of points on each of the exams brings the release of the oral examination).
Takehome exam.
Written exam (55% of the points needed for passage).
Oral examination.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student survey.

LITERATURE:

P. Wyatt, S. Warren, ORGANIC SYNTHESIS: STRATEGY AND CONTROL, John Willey and Sons, New York, 2007.
T. W. G. Solomons, ORGANIC CHEMISTRY, 8th Ed, John Willey and Sons, New York, 2004.
F. Serratosa, J. Xicart, ORGANIC CHEMISTRY IN ACTION, 2nd Ed, Elsevier, Amsterdam, 1996.
S. H. Pine, ORGANSKA KEMIJA (prijevod I. Bregovec, V. Rapić), Školska knjiga, Zagreb, 1994.

Course: Heterocyclic Chemistry		
Language: English		
Lecturer: Dr. Tatjana Gazivoda Kraljević, assis. prof.		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**1**	**15**
Seminar	**0**	**0**
		Overall: 45
		ECTS: 4

PURPOSE:

Introduce students to the major classes of heterocyclic compounds and their reactions and to highlight their importance in research, organic reactions and application in industry

THE CONTENTS OF THE COURSE:

1st week: Introduction to heterocyclic compounds: structure and properties of heterocycles; classification; aromaticity; examples of pharmacologically active heterocyclic compounds.

2nd week: Nomenclature of monocyclic compounds: Hantzsch-Widman rules. Nomenclature of bicyclic compounds, macrocyclic polyethers and annulene

3rd week: Three-membered heterocycles: oxirane, thiirane, aziridine: structures, properties, reactivity, reaction and synthesis

4th week: Presentation of seminar papers: oxirene and thiirene; azirines; azete and 1,2-dihydroazete.

5th week: Four-membered heterocycles: structure, properties; oxetane, thietane, azetidine, oxete, thiete; azetes: reactions and synthesis

6th week: Five-membered heterocyclic compounds from alkanes and alkenes order with oxygen, sulfur and nitrogen: structure, properties, reactions and synthesis.

7th week: 1st partial written exam

8th week: Furan, thiophene and pyrrole: properties, reactivity; reactions at the C-atom and the heteroatom, metalation reactions, electrocyclic reactions; benzo[b]furan, benzo[b]thiophene and indole: the most important reactions and synthesis.

9th week: Azoles and benzoazoles: properties, reactivity, reaction with an electrophilic reagent at the C- or N-atom, reaction with a nucleophilic reagent, metalation reactions, electrocyclic reactions; oxazoles, thiazoles: the most important reactions and synthesis

10th week: Six-membered heterocycles: properties; pyridine, pyridinones, aminopyridines, alkylpyridines, pyridine N-oxides: synthesis and reactions.

11th week: Presentation of seminar papers: Oxane and dioxane; Thiane, dithiane and thiine; Piperidine, pyrimidine and pyrazine; Aziridine, azepine and azocine; Triazoles and thiazoles

12th week: Benzopyridines: properties, reactivity; synthesis; quinoline and quinoline derivatives: reaction with the electrophilic and nucleophilic reagents, metalation reaction, reaction with reducing agents..
13th week: Pyran, pyrilium salts and pyrones: structures, properties, reactivity, reaction with the electrophilic and nucleophilic reagents; synthesis; coumarins, flavonoids and chromones
14th week: Seven-membered heterocycles with oxygen and nitrogen: the structure, properties, reactions, synthesis; Macrocyclic heterocycles: structure, properties and synthesis; crown ethers, cryptands, metallcrowns, sferandes

15th week: 2nd partial written exam

GENERAL AND SPECIFIC COMPETENCE:

After completing the course students will be able to identify and solve qualitative and quantitative problems using suitable chemical principles and theories and present materials related to the case study (oral and written). Students will be able to recognize and name some heterocyclic compounds, to understand the impact of hetero atoms and factors that influence the reactivity of functional groups in the ring structure and to plan synthesis of heterocyclic systems
the ability of critical reflection on the biochemical processes and metabolic reactions in various organs and tissues that are important for the understanding of physiological and pathological processes.

KNOWLEDGE TESTING AND EVALUATION:

2 required a written partial exames during the semester (60% of points on each of the assessment brings the release of the oral examination).
The work assigment.
Written exam (55% of the points needed for passage).
Oral exam.
Evaluation criteria - total 100 points: partial exames - 85 points, work assigment - 6 points, laboratory exercises - 4 points, attend lectures - 2 points, e-learning 3 - points

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student questionary.

LITERATURE:

J. A. Joule, K. Mills, Heterocyclic Chemistry, Wiley-VCH, 5th Ed, 2010.
A. R. Katritzky, C. A. Ramsden, J. A. Joule, V. V. Zhdankin, Handbook of Heterocyclic Chemistry, Elsevier, 3rd Ed, 2010.
M. B. Smith, J. March, March\'s Advanced Organic Chemistry, Wiley-VCH, 6th Ed, 2007

Graduate study programme

Course: Integrated Chemical Systems		
Language: Croatian and English		
Lecturer: Dr Ivana Steinberg, Assistant Professor		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**-**	**-**
Seminar	**2**	**30**
		Overall: 60
		ECTS: 6

PURPOSE:

Adopting fundamental concepts of *nano* and *micro*-integrated chemical systems (ICS) and their function, form and application in the context of multidisciplinary fields of modern science and technology. Enabling students to understand and apply systematic approach in analysis and synthesis of ICSs, using previously adopted knowledge in related fields of chemistry and engineering. Becoming familiar with real examples of hight-tech integrated chemical systems including DNA chips, organic solar cells, microfluidic diagnostic chips.

THE CONTENTS OF THE COURSE:

Week	Lectures and seminars
1	Introduction to the course, concepts of Integrated Chemical Systems
2	Examples of ICSs: glucose biosensor, organic solar cells, organic light emitting diode, *Lab-on-a-chip* systems: chemical function, form, application
3	Integrated chemical *analytical* systems (ICAS): examples of chemical sensors and biosensors
4	Building blocks and ICS fabrication techniques I Functional materials – examples
5	Building blocks and ICS fabrication techniques II Self-assembly of molecules and materials
6	Building blocks and ICS fabrication techniques III Microsystem Technologies

7	Building blocks and ICS fabrication techniques IV Chemical methods of *nano*- and *micro*-functionalisation of ICSs
8	Introduction to microfluidics as *enabling* technology for ICAS
9	Miniaturisation of analytical systems: *Lab-on-a-chip*
10	Integrated chemical *analytical* systems (ICAS)
11	Integrated chemical *synthetic* systems (microreactors) Microfluidic chemical synthesis *(Plant-on-a-chip)*
12	Students' presentations
13	Students' presentations
14	Final revision and summary of the course
15	Final Exam

GENERAL AND SPECIFIC COMPETENCE:

General: individual and team based project research, presentation skills

Specific: Understanding the role of chemistry in development of integrated micro- and nano chemical systems, synthesis of knowledge from different fields of chemistry and related areas, adopting systematic approach to solving problems, adopting modern chemistry related terminology in English language - selected parts of lectures are given in English, selected reading materials and final assignment are in English

KNOWLEDGE TESTING AND EVALUATION:

Lectures and seminars are compulsory; regular homework assignments and problem solving exercise, written and oral presentations; compulsory reading for seminar discussions; presentation of final assignment, final written exam

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student survey

LITERATURE:

1. Allen J. Bard, *Integrated Chemical Systems: A Chemical Approach to Nanotechnology,* John Wiley & Sons Ltd., New York, 1994.

2. G. A. Ozin, A. C. Arsenault, *Nanochemistry: A Chemical Approach to Nanomaterials,* RSC, Cambridge, 2005.

3. A. Rios, A. Escarpa, B. Simonet, *Miniaturization of Analytical Systems: Principles, Design and Applications*, Wiley, Chichester, 2009.

4. F. A. Gomez (Editor*), Biological Applications of Microfluidics,* John Wiley & Sons, New Jersey, 2008.

Course: Introduction to Environmental Chemistry		
Language: English		
Lecturer: Prof. Silvana Raić-Malić, Ph.D., Assist. Prof. Šime Ukić, Ph.D.		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**1**	**15**
Seminar	**0**	**0**
		Overall: 45
		ECTS: 4

PURPOSE:

To introduce students with chemical balances and possible interactions of natural components of environment with pollutants in water, sediments, soil and atmosphere.

THE CONTENTS OF THE COURSE:

16. Classification, nomenclature and examples main group of organic compounds present in the environment. Classification of organic compounds by their chemical structures, impact of organic compounds on the environment.
17. Organic pollutants of water.
18. Organic pollutants of air.
19. Organic pollutants of soil.
20. Application of green organic chemistry in elementary organic reactions. Examples of the use of alternative, non-toxic solvents and reagents in the synthesis of some organic compounds, catalyses and biocatalyses. Photocatalytic degradation reactions of organic pollutants.
21. Presentation of student works.
22. 1st test.
23. Environmental chemical analysis. Analytical process. Evaluation and interpretation of data. Classical methods of chemical analysis.
24. Instrumental analytical methods. Process analysis *in situ*. Analysis of pollutant traces.
25. Water. Water classification. Water quality indicators. Water pollution by heavy metals and other inorganic species. Reaction of organic compounds with metals in water. Sampling, separation and analysis of water-pollutants.
26. Suspended colloid particles in water. Sediment. Equilibrium on phases' border. Traces of metal in sediment and suspended particles.
27. Mineral composition of soil. Soil-pollution by inorganic pollutants. Mechanisms of pollutants' mobility and bounding in soil. Soil analysis. Pollutants mobility in soil. Environmental quality information based on chemical analysis.
28. Composition of the atmosphere. Gasses. Acid-base reactions in atmosphere.

Acid rains. Reactions of atmospheric ozone. Primary and secondary atmospheric pollutants. Inorganic pollutants. Floating particles. Sampling and determination of atmospheric pollutants.

29. Presentation of student works.
30. 2nd test.

Laboratory practice:

4. Synthetic step in the preparation of selected compound or drug under microwave irradiation.
5. Water analysis: water sampling, determination of temperature, total solid, pH value, water hardness (calcium, magnesium, carbonate, and total), alkalinity, and sulphate amount.
6. Soil analysis: determination of the amount of humus and soil acidity.

GENERAL AND SPECIFIC COMPETENCE:

Introducing with the pollutants in environment and the way of their discovering and determination.

KNOWLEDGE TESTING AND EVALUATION:

Two (2) partial tests during the semester. Students can be released from exam if they collect sufficient points (55) from 2 tests.
Written exam and oral exam.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student survey.

LITERATURE:

1. K. M. Doxsee, J. E.Hutchison, Green Organic Chemistry: Strategies, Tools and Laboratory Experiments, Thomson Learning Inc., New York, USA, 2004.
2. S. E. Manahan, Environmental Chemistry, Eight edition, CRC Press LCC, New York, USA, 2005.
3. M. Kaštelan-Macan, M. Petrović, V. Tomašić, A.J.M. Horvat, S. Babić, T. Bolanča, D. Mutavdžić Pavlović, J. Macan, D. Ašperger, Š. Ukić, G. Klobučar, A. Štambuk, R. Sauerborn Klobučar, S. Ferina: Analitika okoliša, M. Kaštelan-Macan, M. Petrović (ur.), HINUS i Fakultet kemijskog inženjerstva i tehnologije, Zagreb, 2013.
4. D.A. Skoog, D.M. West, F.J. Holler, Osnove analitičke kemije, Školska knjiga Zagreb, 1999.
5. E. Prohić, Geokemija, Targa Zagreb, 1998.
6. F.W. Fifield, P.J. Haines, Environmental Analytical Chemistry, Blackwell Science, 2000.
7. W. Stumm, J. J. Morgan, Aquatic Chemistry, Chemical Equillibria and Rates in Natural Waters, 3rd ed., Wiley-Interscience, New York, 1996.

Course: Chemistry in Environmental Protection		
Language: Croatian, English		
Lecturer: red. prof. Tomislav Bolanča, red. prof. Felicita Briški, dr. sc. Lidija Furač, senior lecturer		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**1**	**15**
Seminar	**0**	
		Overall 45
		ECTS: 4

PURPOSE:

THE CONTENTS OF THE COURSE:

Week 1: Environmental quality management. Social and commercial aim of environmental protection. Emissions and alowed value. Standards, norms, good laboratory practice and legislative.

Week 2: Environmental analysis parameters. Electrochemical, spectrometric and separation techniques in environmental analysis. Economical, ecological and technological parameters of analysis. Selection of optimal analytical technique. Accreditation.

Week 3: Environmental quality monitoring. Aims of monitoring. Monitoring of stationary and mobile emissions. Monitoring of ambient. Sampling and methodology for sampling frequency reduction. Determination of sampling position. Monitoring protocol. Metrology in environmental protection.

Week 4: Risk assessment in environmental protection. Multivariate analysis in environmental protection. Estimation and dispersion of pollutants in environment. Multi criteria decision making.

Week 5. 1st midterm test.

Exercises 5 hours: monitoring and multivariant analysis of environment.

Week 6: Cycling of matter and energy in nature. Atmosphere: physical and chemical characteristic of the layers, composition and significance. Classification of the gaseous chemical species. Photochemical reactions. Ozone. The destruction of the ozone layers. Pollutants: waste gases, organic compounds, particulate matter, toxic metals, radioactive particles. Acid rains. Greenhouse gases. Photochemical smog. Devices for control and removal of contaminants before air emissions.

Week 7: Water: the hydrologic cycle in nature, physical and chemical characteristics and properties. Gases in water. The carbonate equilibrium. Alkalinity. Chemical reactions and equilibrium: acid-base and complexation. Chemical reactions and equilibrium: precipitation and dissolution, redox reactions (pE - pH diagrams) .Heterogenic equilibrium. Adsorption and surface complexation.

Week 8: Pollutions in water: heavy metals, metalloids, metallo-organic complexes, inorganic and organic species. Wastewater treatment: filtration, coagulation, flocculation, sedimentation,

Week 9: The relationships between soil-water-air. Chemical reactions in the soil: ion exchange, redox reactions, complexation. Macro and micro nutrients of the soil. The cation exchange capacity (CEC). Pollutants in the soil and their control: pesticides, polychlorinated biphenyls (PCBs) volatile organic compounds (VOCs), gases (NO, NO2), waste oil, waste. Waste disposal.

Week 10:2nd midterm test.

Exerci ses 5 hours: Computer modeling of the process of release of pollutants into the environment by Visual Minteqa software.

Week 11: Carbon, sulfur, nitrogen and phosphor cycle in environment: aerobic and anaerobic biological processes, classification and sampling of water, physico-chemical and biological analysis.

Week 12:Nitrates in water wells and their impact on health, processes of nitrate removal from drinking water, filtration and oxidation od drinking water, characterization of waste water, physico-chemical and biological treatment of waste water, biomass kinetics, substrate and biomass balance in flow systems.

Week 13: Soil as natural phenomena, chemistry and microbiology of soil (types and their energetic metabolism), chemical reactions of litothrophic microorganisms in soil, succesion of fungi microflora in soil.

Week 14: Biochemical processes during degradation of organic fraction in solid waste, sanitary landfill and compositing material.

Week 15: 3rd midterm test.

Exercises 5 hours: Physico-chemical and bacteriological analysis of drinking, natural and waste water samples.

GENERAL AND SPECIFIC COMPETENCE:

- knowledge and understanding of essential facts, concepts, principles and theories relating to chemistry and chemical engineering,
- ability to recognise and solve qualitative and quantitative problems using the appropriate chemical principles and theories,
- competence in presenting chemical and chemical engineering related material and arguments in writing and orally, to an informed audience,
- computational and data-processing skills, relating to chemical information and data, ability to engage in interdisciplinary team-working,

KNOWLEDGE TESTING AND EVALUATION:

Students writes 3 mid terms exams during the semester. The condition of exemption from examination is the minimum to get 60% of the total number of points on each test.

Experimental work	**0,5**
Tests	3
Seminar essay	0.5

LITERATURE:

1.M. Pinta: Trace Elements Analysis, AnnArbor Science, Michigan, 1985.

2. C. Baird: Environmental Chemistry, W.H. Freeman and Co., New York, 1999.

3. D. G. Crosby: Environmental Toxicology and Chemistry, Oxford Unvesitety Press, Oxsord, 1999.

4. S. E. Manahan, Environmntal Chemistry, 7 th ed., Lewis Publisher, Boca Raton, 2000.

5. S. E. Manahan, Environmntal Chemistry, 7 th ed., Lewis Publisher, Boca Raton, 2000.

6. R.E. Caret, K.J. Denniston, J.J.Toping: Principles and Applications of Inorganic, Organic and Biological Chemistry, Wm. C. Brown Publishers, Dubuque, 1997

7. J. E. Girard: Principles of Environmental Chemistry, Jones and Bartlett Publishers, INC., Sudbury, 2005.

Optional literature:

1. D.A. Skoog, D.M. West, F.J. Holler: Osnove analitičke kemije, 1. izd., Školska knjiga, Zagreb, 1999.

2. J. Weiss: Handbook of Ion Chromatography, 3rd ed., Wiley-VCH, Weinheim, 2004

3. E. R. Weiner, Applications of Environmental Aquatic Chemistry, CRC Press, Boca Raton, 2007.

4. S. E. Manahan, Fundamentals of Environmental and Toxicological Chemistry, CRC press,Boca Raton, 2013

Course: Chemical and biochemical processes in soil and sediment, Applied chemistry study programme, Graduate, 1st year, optional

Language: Croatian

Lecturer: (by alphabetical order) **Lucija Foglar, PhD, assistant professor and Dragana Mutavdžić Pavlović, PhD, associate professor**

TEACHING	WEEKLY	SEMESTER
Lectures	**2**	**30**
Laboratory	**2**	**30**
Seminar		
		Overall: 60
		ECTS: 6

PURPOSE: Teach the students who have mastered during undergraduate study mechanisms of chemical reactions and equilibria, how to apply them to the real sample and that the interaction of natural ingredients of soil and sediment as possible with organic and inorganic pollutants. Multidisciplinary approach to monitoring environmental quality.

THE CONTENTS OF THE COURSE:

Lectures and seminars:

1. Soil as part of the environment. Soil Science. The classification of soils. The geological conditions of the soil genesis. Pedogenic factors and processes.
2. Composition of soil. Chemical and physical properties of soil. Humus. The importance of soil organic matter. Forms of nutrients in the soil. Water in soil. Microelements.
3. Degradation of soil. Anthropogenic changes in the soil. Inputs of organic and inorganic contaminants in soil and their interaction with different types of soil. Mobility of pesticides, PCBs and antibiotics in soil.
4. Classification of soil damages. Bioremediation of soil. Soil sampling. Analysis of soil.
5. Sediment as part of the environment, the formation and classification; re-deposition by water, wind and ice. Identification. The interactions at the interface.
6. Soil condition and Soil protection in the Republic of Croatia.
7. Presentation of student's seminar papers.
8. 1st partial test (Chemical part of course)
9. Fundamentals of biochemical processes in soil and sediment. The importance of nutrients, micronutrients and environmental factors in the transformation process. The biochemical processes of nitrogen compounds conversion in soil and sediment. The processes of nitrification, assimilation, ammonification, denitrification and nitrogen fixation.
10. The transformation of the organic matter in the soil. Degradation processes of inorganic and organic carbon. Carbonates in the soil. The carbonification process.

11. Phosphates in soil and sediment. The biochemical processes of phosphate conversion.
12. The biochemical processes of sulfur compounds – oxidation of sulfide, sulfate reduction; sulphate-reducing and sulphide-oxidizing bacteria.
13. The role of iron in the biochemical processes in soil and sediment. The bacteria that oxidize Fe.
14. Presentation of student's seminar papers
15. 2nd partial test (Biochemical part of course)

Laboratory exercises:

1. Soil/sediment analysis: a) Determination of mechanical composition

b) Hygroscopicity determination by *Mitschelichu*

c) pH determination

d) Specific conductivity determination

e) Determining the nature of humus

f) Humus determination by *Tjurin* and *Kochman*

g) Carbonate determination

h) Capacity determination and saturation state of the adsorption complex

i) Determination of available phosphorus by *AL*-method

j) Determination of exchangeable divalent cations

2. Microbiologal soil/sediment analysis:

a) Determination of the microorganism's presence in soil and sediment.

b) Monitoring the process of nitrification and denitrification in soil and sediment.

c) Microbial degradation of organic matter in soil and sediment.

GENERAL AND SPECIFIC COMPETENCE:

Enabling the students to understand all aspects of chemical and biochemical processes that occur in soil and sediment. Students learn to independently and objectively estimate which chemical and biochemical conversion of chemical substances coming on the basis of available information (the type of contaminants, soil characteristics, etc..).

KNOWLEDGE TESTING AND EVALUATION:

The oral part of the exam

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Continuous evaluation. Student questionnaire.

LITERATURE:

Working material from lectures
Working material for exercises (internal script)
D. A. Skoog, D. M West, F. J. Holler, Principles of Instrumental Analysis, Saunders College Publishing 1995. (optional and recommended literature)

Course: Water Chemistry		
Language: English		
Lecturer: Senior lecturer Lidija Furač, Ph. D., Assist. Prof. Šime Ukić, Ph. D.		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	2	30
Laboratory	2	30
Seminar	0	0
		Overall: 60
		ECTS: 6

PURPOSE:

Students are introduced with basic chemical processes in natural water.

THE CONTENTS OF THE COURSE:

1. Introduction to water chemistry. The importance of water for earth life. Legislative water regulations in The Republic of Croatia. Chemical structure of water molecule. Dipole character of water. Hydrogen bounding.
2. Dissolving of minerals. Dissociation of salts. Solubility product constant. Consequences of dissolving: hydrolysis.
3. Dissolving mechanisms: chemical and physical-chemical salvation factors (hydrolysis, hydration). Water hardness. Mechanisms of the hardness removing.
4. Nucleation. Physical-chemical aspect of nucleus formation. Precipitation and precipitate properties. Turbidimetry.
5. Crystal growing. Kinetics of crystal growing. Impurities in crystal lattice: occlusion, inclusion and mechanical entrapment.
6. Regulation of chemical composition of natural water. Holding constant pH value: buffer systems. Masking of unwanted factors (inactivation by changing into complex or precipitate)
7. Ion chromatography: Ion exchange process. Quantitative and qualitative chromatographic aspects.
8. Ion chromatography: Analysis of cations. Analysis of anions. Suppression of the baseline noise.
9. Redox processes. Redox equilibrium. Redox conditions and potential in natural water. pE-pH diagrams. Influence of complex species on redox potential. Measuring of redox potential in natural water.
10. Geochemical cycle of metal traces. Toxicity in rivers, lakes and oceans. Distribution of dissolved metals in surface waters. Transport

of metals into underground water. Equilibrium phenomena on solid-liquid phase boundary. Formation of surface complexes on hydrous oxide-surface.

11. Empirical and mechanistic adsorption model. Charge distribution on phase boundary. Total and surface charge as a function of pH value. Point of zero charge. Intrinsic equilibrium constants. Surface charge and potential in electric double layer.
12. Models of surface complexation. Diffuse layer models. Constant capacitance model. Triple-layer model.
13. Photochemical processes in water. Photo-reactions. Photo-redox reactions. Photolysis of transition-metal complexes. Role of dissolved iron species. Heterogenic photochemistry.
14. Processes of water purification. Waste water. Drinking water. Water quality. Aeration. Coagulation. Flocculation. Sedimentation. Filtration. Removing of water hardness. Ion-exchange.
15. Test.

GENERAL AND SPECIFIC COMPETENCE:

Education about chemical properties of water, as basic mover of earth life.

KNOWLEDGE TESTING AND EVALUATION:

Written and oral exam.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student survey

LITERATURE:

1. D.A. Skoog, D.M. West, F.J. Holler, Osnove analitičke kemije, 1st ed., Školska knjiga, Zagreb, 1999.
2. V.L. Snoeyink, D. Jenkins, Water Chemistry, Wiley, New York, 1980.
3. H. Small, Ion Chromatography, Plenum Press, New York, 1989.
4. W. Stumm, J. J. Morgan, Aquatic Chemistry, Chemical Equillibria and Rates in Natural Waters, 3rd ed., Wiley-Interscience, New York, 1996.
5. J. Weiss, Handbook of Ion Chromatography, 3rd ed., Wiley-VCH, Weinheim, 2004.

Course: Introduction to nanotechnology		
Language: English		
Lecturer: Prof. Sanja Lučić Blagojević; Prof. Stanislav Kurajica		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**0**	**0**
Seminar	**2**	**30**
		Overall:60
		ECTS: 6

PURPOSE:

Accepting of the basic terms of nanotechnology. Acquiring knowledge on properties of nanomaterials. Getting acquainted with methods of preparation and characterization of nanomaterials. Acquaint with the most important kinds of nanomaterials and its applications.

THE CONTENTS OF THE COURSE:

1. Concepts of nanoscience and nanotechnology, molecular nanotechnology. History of nanotechnology, Gordon E, Moore, Richard P. Feynman, Eric K. Drexler, R. Kurzweil. Phenomena on nano-level: quantum effects, surface to volume ratio, the dominance of electromagnetic forces.

2. Properties of nanomaterials: physical, mechanical, chemical, optical, electrical, magnetic. Tunelling effect, quantum confinement, quantum dots, nanostructure, magical numbers. Hall-Petch effect, superparamagnetism, giant magnetoresistance, lotos effect.

Laboratory exercise 1. The determination of crystallite size using Scherrer method.

3. Characterization of nanomaterials. Scanning electron microscope, transmission electron microscope, scanning tunneling microscope, atomic force microscope.

Laboratory exercise 2. Synthesis of silver nano-particles.

4. Nano-manufacturing: top-down approach: photolitography, soft litography, microcontact printing, nano-print litography, dip-pen nanolitografy, high-energy milling, PVD, CVD.

Laboratory exercise 3. The preparation of superparamagnetic nano-particles.

5. Nano-manufacturing: bottom-up approach: precipitation, crystallization, colloids, colloid stabilization, solid suspensions, self-assembly, micelles, thin films, self-assembled monolayers, dendrimers, super-latices, sol-gel method. Nanomanipulation, contact and contactless nanomanipulation. The aims for nanomanipulation.

Laboratory exercise 4. Sol-gel synthesis of SiO_2 nanoparticles.

6. Trends in nanotechnology: Nanomaterials (nano-structured materials, smart materials, ageless materials), nanoproducts (electronics, medicine, environment, industrial technology). Nanorobots. The applicative potential of nanomaterials. Sociological

acceptance of nanomaterials. Riscs of nanotechnology Future of nanotechnology.

7. I. Partial exam

8. Carbon nanostructures; Fullerene – synthesis, properties, reactivity, potential application; Carbon nanotubes – molecular and supramolecular structure, intrinsic properties, synthesis, purification, modification, application

9. Nanoscale electronic, Development of microelectronic devices and technology, Structure and operation of MOF transistor; Transistor scaling, Nanoscaled MOFSET transistors;

10. Molecular electronic – possibilities, preparation and investigation of molecular devices; Molecular switches, transistors and similar devices; Electronic with DNA molecules; Single electron electronic devices

11. Nanocomposites – preparation, structure and properties

12.-13. Nanobiotechnology – biomimetic nanostructures, interface with biologic structure and functions: Biomolecular motors – MEMS and biomolecular motors. Operations and functions of motor proteins; Biotechnology of motor proteins; Science and engineering of molecular motors, Engineered devices; Molecular motors in technological application

14. II. Partial exam

GENERAL AND SPECIFIC COMPETENCE:

Knowledge of basic concepts of nanoscience and nanotechnology. Noticing the diversity properties of nano-materials and macro-materials and understand the reasons of these differences. Knowledge of ways of getting nanomaterials on the principle top-down and bottom-up. Knowledge of basic methods of characterization of nanomaterials. Understanding the trends in nanotechnology.

KNOWLEDGE TESTING AND EVALUATION:

Partial exams, written/oral exam

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student questionnarie

LITERATURE:

1. Di Ventra M., Evoy S., Heflin R.J., Introduction to Nanoscale Science and Technology, Springer, 2004.
2. Owens P.,Introduction to Nanotechnology, John Wiley & Sons, 2003.
3. Wilson M., Kannangara K., Smith G., Simons M., Raguse B., Nanotechnology, basic science and emerging technologies, Chapman &Hall, 2002.

Course: Alternative energy sources		
Language: English		
Lecturer: Veljko Filipan, Marijana Kraljić Roković		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory		
Seminar	**2**	**30**
Field work		**3 (day)**
		Overall: 60
		ECTS: 6

PURPOSE:

Proposed program provides insight to different types and sources of energy focusing on renewable energy sources. The objective of this course is to present an overall energy picture, to present different energy transformations and processes as well as to show relationship between energy consumption, economy and environment protection.

THE CONTENTS OF THE COURSE:

1.Intoduction: general view on energy; definitions, classification;
2. Conventional energy sources and energy conversions; thermal and nuclear power plants;
3. Nonconventional energy sources, conversions, and energy production;
4. Processes and technologies for water energy conversion;
5. Wind energy, resources and applications;
6 Energy of the Earth and the possibility of using energy from the environment;
7. Fieldwork, special case studies;
8. 1st Partial Exam;
9. Solar energy: basic of solar energy, possibilities of solar energy conversion to other forms of energy.
Seminar: calculation tasks related to solar energy radiation
10. Solar energy: photovoltaic cells
Seminar: I-U characteristic of silicon photovoltaic cell, preparation and characterisation of dye sensitive solar cell
11. Electrochemical power sources: battery, supercapacitors, fuel cells
Seminar: Characterisation of battery and calculation of specific parameters, Characterisation of supercapacitor and calculation of specific parameters, Characterisation of fuel cell and calculation of specific parameters.
12 Biomass, biogas and biofuels
Seminar: Students present seminar essay related to biomass and biofuels

13. Renewable energy in industrial application. Energy storage. Smart grids.
Seminar: Students present seminar essay related to energy storage and smart grids.
14. The main aspects of legislation corresponding to renewable power sources
15. 2nd Partial Exam

GENERAL AND SPECIFIC COMPETENCE:

Beside different alternative forms of energy this course includes the knowledge of general energetic that facilitate to understand and overcome the issues in the field of energy sustainability.

KNOWLEDGE TESTING AND EVALUATION:

Two progress evaluations during the course.
Written exam
Oral exam, seminar work

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

student survey

LITERATURE:

- Lectures at faculty web sites
- K. Kordesch, G. Simader, FuelCells and Their Applications, VCH, Weinheim, 1996.
- C. A. Vincent, B. Scrosati, Modern Batteries: An Introduction to Electrochemical Power Sources, Second Edition, John Wiley & Sons, Inc., New York, 1997.
- T. M. Letcher, Future Energy: Improved, Sustainable and Clean Options for our Planet, Elsevier, Amsterdam, 2008.

Course: Fuel Cells		
Language: English		
Lecturer: Full Prof. Ante Jukić, PhD.		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**2**	**30**
Seminar	**0**	**0**
		Overall: 60
		ECTS: 6

PURPOSE:

Understanding and acquiring of theoretical and practical knowledge regarding conversion of chemical energy into electricity that occurs in fuel cells – electrochemical engines. Fuel cells are considered as an alternative and possible replacement of internal combustion engines due to their low ecological impact.

THE CONTENTS OF THE COURSE:

1st week: Introduction: structure of energy sector, transition towards sustainable energy.

2nd week: Fuel cells basics. Principle of operation. Reversible hydrogen-oxygen fuel cells. Anode and cathode reactions.

3rd week: History of fuel cell. Basic structure and design of fuel cells.

4th week: Fuel cells types according to electrolyte, temperature and fuel.

5th week: Advantages/disadvantages of different types of fuel cells.

6th week: Applications of fuel cells; stationary electric power, distributed generation, vehicle motive power, auxiliary power systems, derivative applications.

7th week: Production and properties of fuels. Methane reformer.

8th week: Fuel cell performance; the role of Gibbs free energy and Nernst potetial, ideal and actual performance, cell efficiency.

9th week: Mechanism and kinetics of electrode reactions.

10th week: Electrochemical impedance spectroscopy.

11th week: Proton and ionic conductivity.

12th week: Electrocatalysis. Nanostructured catalysts.

13th week: Polymer Electrolyte Fuel Cell (PEFC).

14th week: Solid oxide fuel cell (SOFC).

GENERAL AND SPECIFIC COMPETENCE:

Connecting and applying the general engineering principles and electrochemistry in the fuel cell technology. To familiarize students with design, operation and application of fuel cells of different types as well as the need for further technical improvement.

KNOWLEDGE TESTING AND EVALUATION:

Colloquiums related to laboratory practices.
Written exam (50% of the points needed for passage).
Oral exam.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student survey.

LITERATURE:

Jukić, Ante: Fuel cells – electrochemical engines, lectures, Faculty of chemical engineering and technology, Zagreb, 2009-2013.
Fuel Cell Handbook (Seventh Edition), EG&G Technical Services, Inc., 2004. (http://www.netl.doe.gov/technologies/coalpower/fuelcells/seca/pubs/FCHandbook7.pdf)
Jukić, Ante: Basics of electrochemical impedance spectroscopy, Faculty of chemical engineering and technology, Zagreb, 2001.
Fuel Cell Technology Handbook, Gregor Hoogers (Ed.), CRC Press, London, 2003.
Progress Report for Hydrogen, Fuel Cells and Infrastructure Technologies Program, U.S. Department of Energy, 2002.

Course: Planning of organic chemistry		
Language: English		
Lecturer: Dr. Marijana Hranjec, assoc. prof.		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**2**	**30**
Seminar	**0**	**0**
		Overall: 60
		ECTS: 6

PURPOSE:

Introducing students to the basic principles of simple and multistep synthesis in the laboratory and industry. Planning of synthesis and retrosynthesis of target organic molecules. Critical thinking when choosing the most suitable synthetic routes for the implementation of organic synthesis in the laboratory.

THE CONTENTS OF THE COURSE:

1st week: Introduction. Planning of organic synthesis: synthetic plan, strategy and control. Retrosynthesis.

2nd week: Chemoselectivity. Regioselectivity: controlled aldol reactions.

3rd week: Stereoselectivity: stereoselective aldol reactions. An alternative strategy for the synthesis of enones.

4th week: Creating of a new C-C bond, which leads to an increase in molecular structure? *Ortho*-strategy for aromatic compounds. Controlled Michael additions.

5th week: Specific enol equivalents. Enolates. Allyl anions. Homoenolates. The acyl anion equivalents. Written assessment by 1st partial exam.

6th week: C-C double bond. Synthesis of double bonds defined stereochemistry.

7th week: Vinyl anion equivalents. Electrophilic attack on alkenes.

8th week: Vinyl cations. Palladium catalysed reactiones. Allylic alcohols.

9th week: Stereochemistry. Control of stereochemistry and the relative control of the stereochemistry. Resolution.

10th week: Asymmetric synthesis of natural products used as starting reactants. Asymmetric Catalysis: formation of C-O and C-N bonds. Written assessment by 2nd partial exam.

11th week: Asymmetric catalysis: the formation of C-H and C-C bonds. Asymmetric strategies based on used substrates.

12th week: Enzymes: Biological methods in asymmetric synthesis. Strategy of asymmetric synthesis.

13th week: The strategy of functional groups. Functionalization of pyridine nuclei. The oxidation of aromatic compounds.

14th week: Functionalization of pericyclic reactions: synthesis of nitrogen heterocycles by cycloadditions and sigmathropic rearrangements.

15th week: Synthesis and chemistry of azoles and other heterocycles having two or more heteroatoms. Written assessment by takehome exam.

GENERAL AND SPECIFIC COMPETENCE:

Planning of synthesis and retrosynthesis of targeted organic molecules, critical thinking when selecting the most suitable synthetic routes for the implementation of organic synthesis in the laboratory.

KNOWLEDGE TESTING AND EVALUATION:

Exams related to laboratory practices.
2 partial written tests during the semester (60% of points on each of the exams brings the release of the oral examination).
Takehome exam.
Written exam (55% of the points needed for passage).
Oral examination.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student survey.

LITERATURE:

P. Wyatt, S. Warren, ORGANIC SYNTHESIS: STRATEGY AND CONTROL, John Willey and Sons, New York, 2007.
T. W. G. Solomons, ORGANIC CHEMISTRY, 8th Ed, John Willey and Sons, New York, 2004.
F. Serratosa, J. Xicart, ORGANIC CHEMISTRY IN ACTION, 2nd Ed, Elsevier, Amsterdam, 1996.
S. H. Pine, ORGANSKA KEMIJA (prijevod I. Bregovec, V. Rapić), Školska knjiga, Zagreb, 1994.

Course: Petrochemistry		
Language: English		
Lecturer: Full Prof. Ante Jukić, PhD.; Assoc. Prof. Elvira Vidović, PhD		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**1**	**15**
Seminar	**0**	**0**
		Overall: 45
		ECTS: 4

PURPOSE:

Production of basic organic chemical products is mainly based on petroleum derivatives and natural gas. The aim of the course is to familiarize with the theoretical facts of conversion of hydrocarbons, reaction mechanisms and the major industrial processes to obtain basic organic chemicals, such as methane, syngas (hydrogen, CO), synthetic gasoline and diesel fuel, ammonia, methanol, olefins (ethene, propene , butene, butadiene) and their basic derivatives, aromatic hydrocarbons(benzene, toluene and xylene, BTX) and their main derivatives.

THE CONTENTS OF THE COURSE:

1. Introduction.
2. / 3. Thermal degradation of hydrocarbons in the process of pyrolysis of ethane and naphtha: reaction mechanisms, kinetic and thermodynamic data.
4. Reactions of hydrogenation.
5. Reactions of alkylation and isomerization.
6. Reactions of dehydrogenation.
7. Reactions of arbonylation and hydroformylation.
8. Reaction mechanisms, kinetics and thermodynamic data of oxidation of hydrocarbons.
9. Catalytic oxidation in a homogeneous liquid phase in the process of production of alcohols, aldehydes and ketones, vinyl acetate, and terephthalic acid.
10. Heterogeneous catalytic oxidation of olefins and aromatic hydrocarbons in the process of production of ethylene oxide, acrylic acid, maleic anhydride and phthalic acid.
11. Reactions of oxidation via hydroperoxide intermediate steps.
12. Ammooxidation of propene and butene.
13. / 14. Reaction mechanisms and kinetics of radical, anionic, cationic and coordinative dimerization, oligomerization and polymerization of olefins and vinyl monomers.

GENERAL AND SPECIFIC COMPETENCE:

Knowledge of the reaction pathways and technological schemes of organic chemical industry.

KNOWLEDGE TESTING AND EVALUATION:

Continuous assessment through the two exams, written or oral exam.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

student survey

LITERATURE:

A. Jukić: Petrochemistry, lecture (www.fkit.hr)

E. Vidović: Petrochemistry, lecture (www.fkit.hr)

A. Chauvel i G. Lefebvre: *Petrochemical processes - technical and economic characteristics*: Vol. I. *Synthesis gas derivatives and major hydrocarbons*; Vol. II. *Major oxygenated, chlorinated and nitrated derivatives*. Technip, Paris, 2001.

P. Leprince: *Petroleum refining, Vol. 3, Conversion processes*, Technip, Paris, 2001.

Course: Structure Determination of Organic Compounds		
Language: English		
Lecturer: Dr. Tatjana Gazivoda Kraljević, assist. prof.		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**0**	**0**
Seminar	**2**	**30**
		Overall: 60
		ECTS: 6

PURPOSE:

Expose the basic principles of spectroscopic methods: ultraviolet and visible spectroscopy (UV / Vis), infrared spectroscopy (IR), one- and two-dimensional nuclear magnetic resonance (1D and 2D 1H and 13C NMR) and mass spectrometry and its application in determining the structure of organic compounds.

THE CONTENTS OF THE COURSE:

1st week: Introduction to spectroscopic methods.

2nd week: Ultraviolet - visible spectroscopy (UV / VIS): electronic transitions, basic photophysical processes, the absorbance (Lambert-Beer's law), chromophores, examples of UV / Vis spectra.

Seminar - Analysis and interpretation of UV / VIS spectra.

3rd week: Infrared spectroscopy (IR): vibrations of covalent bonds in molecules (stretching and bending), the area of the functional groups and the fingerprint area, examples of the IR spectra.

Seminar - Analysis and interpretation of IR spectra.

4th week: Nuclear magnetic resonance (1H and 13C NMR): physical principles, spectral parameters (chemical shift d, spin-spin coupling constant J, relative intensity of signals, factors affecting the chemical shift, the Nuclear Overhauser Effect (NOE).

Seminar - Analysis and interpretation of 1H and 13C NMR spectra.

5th week: 1H NMR spectroscopy: spin-spin coupling (H-H), multiplets (n + 1), the splitting scheme, the first and second order spin systems.

Seminar - Analysis and interpretation of 1H NMR spectra.

6th week: 1H NMR: two spin systems (AX, AB, AM); three spin systems (AX2, AB2 AMX, ABX ABC); four spin systems (AX3, AB3, a2x2, A2B2, AA'XX 'AA'BB'); five spin systems A2X3, A2B3, ABX3; examples of first and second order spin systems.

Seminar - Analysis and interpretation of 1H NMR spectra by first and second order spin systems.

7th week: 1st partial exam

8th week: 13C NMR spectroscopy: spin-decoupling in 13C NMR; coupled and decoupled spectra, APT, DEPT

Seminar - Analysis and interpretation of 13C NMR spectra.

9th week: Two-dimensional (2D) NMR spectroscopy: Homonuclear correlation methods 1H-1H (COSY, DQF-COSY, ECOSY) and 13C-13C (inadequate)

Seminar - Analysis and interpretation of 2D NMR spectra

10th week: Two-dimensional (2D) NMR spectroscopy: heteronuclear correlation methods 1H-13C (HETCOR, HSQC, HMQC, HMBC); Correlation methods through space 1H-1H (NOESY) and 13C-13C (ROESY).

Seminar - Analysis and interpretation of 2D NMR spectra

11th week: Mass spectrometry (MS): ionization methods, mass spectrometer of high resolution, the fragmentation of organic compounds

Seminar - Analysis and interpretation of mass spectra

12th week: Mass spectrometry (MS): fragmentation of organic compounds, gas chromatography and mass spectrometry (GC / MS), liquid chromatography and mass spectrometry (LC / MS)

Seminar - Analysis and interpretation of mass spectra

13th week: Chirooptical methods: optical activity and rotation of linearly polarized light; Optical rotatory dispersion (ORD) and circular dichroism (CD).

Seminar - Analysis and interpretation of ORD and CD spectra

14th week: Determination of the structure of organic compounds on the basis of complementary information obtained using various spectroscopic methods.

Seminar - Examples of determining the structure of organic compounds on the basis of complementary information obtained using various spectroscopic methods. Analysis and interpretation of spectra.

15th week: 2nd partial exam

GENERAL AND SPECIFIC COMPETENCE:

Apply spectroscopic methods to determine the structure of organic compounds on examples from the literature and own experimental data in solving chemical engineering problems. On the basis of complementary information obtained using various spectroscopic methods to analyze and interpret the spectra and determine the structure of organic compounds.

KNOWLEDGE TESTING AND EVALUATION:

2 partial written tests during the semester (60% of points on each of the exams brings the release of the oral examination).
Written exam (50% of the points needed for passage).
Oral examination.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student questionary.

LITERATURE:

1. R. M. Silverstein, F. X. Webster, Spectrometric Identification of Organic Compounds, Wiley, 1997.
2. H. Friebolin: Basic One- and Rwo-Dimensional NMR Spectroscopy (3.izd.), Wiley-VCH, Verlag GmbH, Weinheim, 1998.
3. E. Pretzsch, P. Bühlmann, C. Affolter, Structure Determination of Organic Compounds, Springer, 2000.
4. B. D. Smith, B. Boggess, J. Zajicek: Organic Structure Elucidation, University of Colorado, 1998.
5. T. Gazivoda Kraljević, Određivanje struktura organskih spojeva, internal papers, 2012.

Course: Organic chemistry in drug development		
Language: English		
Lecturer: Dr. Marijana Hranjec, assoc. prof.; Dr. Tatjana Gazivoda Kraljević, assis. prof.		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**2**	**30**
Seminar	**0**	**0**
		Overall: 60
		ECTS: 6

PURPOSE:

To introduce students with the importance of synthetic organic chemistry in drug development and distribution of drugs by selected therapeutic groups; examples of efficient and selective synthesis of compounds with pharmacological activities.

THE CONTENTS OF THE COURSE:

1st week: Introduction to rational approach to drug design; definitions and objectives of the research related to medicinal chemistry; receptors and the effects of medicines; strategy of finding leading compounds; structure-activity relationship (SAR).

2nd week: The targets of drug action, enzymes; enzyme substrates as drugs, enzyme inhibitors as drugs; regulation of enzymes.

3rd week: Strategies in drug development: natural compounds; development of new drugs; rational approach to drug design; bioisosteres in drug development, the use of prodrugs.

4th week: General and local anesthetics: division; modes of action; mechanism of action, examples.

5th week: Sedatives and hypnotics: division (barbiturates and nebarbiturati); ways and mechanisms of action; degradation of barbiturates; structure-activity relationship (SAR); synthesis of benzodiazepines.

6th week: Anticonvulsants and muscle relaxants: the division; modes of action; mechanism of action; chemotherapy of epilepsy; muscle neuroblockers.

7th week: Antipyretic and narcotic analgesics: division; mechanism of action; salicylic acid derivatives, quinoline derivatives; characteristics and limitations of opiate analgesics, morphine analogs.

8th week: Cardiovascular drugs: mechanism of action; cardiac glycosides; antihypertensives; antiarrhythmics; vasodilators.

9th week: Antihistamines: division; causal factors of allergic diseases;

mechanism of action of antihistamines; histamine H1 receptor antagonists; histamine H2 receptor blockers.

10th week: Nonsteroidal anti-inflammatory drugs (NSAIDs): division; mechanism of action; heteroariloctene derivatives, aryl propionic and salicylic acid, gold compounds.

11th week: Sulfonamides: division; mechanism of action; sulfonamides in general, urinary and intestinal infections; bacterial resistance to sulfonamide drugs.

12th week: Anthelmintics and antimalarials: classification, mechanism of action; analogs of quinoline, guanidine, pyrimidine; piperazines, benzimidazoles, natural products.

13th week: Antibiotics: classification; β-lactames, aminoglycoside and quinolone antibiotics; tetracyclines, SAR.

14th week: Anticancer drugs: classification; mechanism of action; alkylating agents; DNA intercalation; photodynamic therapy; inhibitors of protein kinases; topoisomerase inhibitors; inhibitors of microtubules and tubulines.

15th week: Antiviral drugs: classification, replication and transformation; compounds which inhibit the early phase of viral replication; compounds that interfere with the replication of virus nucleic acid; mechanisms of action.

GENERAL AND SPECIFIC COMPETENCE:

Qualifying students to solve the problem of synthesis of target molecules with pharmacological effects in research and development laboratories, pharmaceutical companies and research institutes.

KNOWLEDGE TESTING AND EVALUATION:

Exams related to laboratory practices.
2 partial written tests during the semester (60% of points on each of the exams brings the release of the oral examination).
Oral presentation of seminar assay
Written exam (50% of the points needed for passage).
Oral examination.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student survey.

LITERATURE:

A. Kar, MEDICINAL CHEMISTRY, New Age International (P) Ltd. Publishers, New Delhi, 2007.
R. B. Silverman, THE ORGANIC CHEMISTRY CHEMISTRY OF DRUG DESIGN AND DRUG ACTION, Academic Press, Inc, San Diego, 1992.
D. Lednicer, STRATEGIES FOR ORGANIC DRUG SYNTHESIS AND DESIGN, John Wiley and Sons, New Jersey, 2009.
M. Mintas, S. Raić-Malić, MEDICINSKA KEMIJA, Medicinska naklada, Zagreb 2009.
J. R. Hanson, CHEMISTRY AND MEDICINES, RSC Publishing, Cambridge, 2006.
R. R. Nadendla, PRINCIPLES OF ORGANIC MEDICINAL CHEMISTRY, New Age International, New Delhi, 2005.

Course: Chemistry of Natural Compounds		
Language: English		
Lecturer: Prof. Silvana Raić-Malić, PhD.		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**2**	**30**
Seminar	**0**	**0**
		Overall: 60
		ECTS: 6

PURPOSE:

The purpose of the course is to present chemistry of natural compounds involved in secondary metabolism of living beings. In the framework of this course, students will be introduced with the structures, chemical reactions and biological activity of representatives of natural compounds.

THE CONTENTS OF THE COURSE:

1. Lipids. Triglycerides and fatty acids (saturated and unsaturated). The reactions of fatty acids. Phospholipids.
2. Non-glicerides (sphingolipids, steroids, wax). Biomembranes, complex lipids (lipoproteins, glycolipids).
3. Prostaglandins and related compounds. Nomenclature and synthesis. Prostacyclins, thromboxanes, leukotrienes, epoxyeicosatrienoic acid.
4. Steroids: structure and function. Cholesterol. Bile salts. Steroid hormones.
5. Terpenes: isoprene rule. Biosynthesis of terpenoids. Determination of the structure of terpenoids. Monoterpenoids. Sesquiterpenoids. Diterpenoids. Triterpenoids. Polyterpenoids.
6. Vitamins: water-soluble vitamins, fat-soluble vitamins.
7. 1^{st} test.
8. Alkaloids. Structural characteristics, physical properties and functions. Extraction and isolation. Classification of the alkaloids according to chemical structure. Tropane, quinoline, isoquinoline, indole, purine alkaloids.
9. Phenols, natural dyes and pigments I: Flavonoids. Classification, biogenesis, natural source, isolation and separation, total synthesis. Anthocyanidins. Leukoanthocyanines and leukoanthocyanidins. Tannins. Naphthoquinones. Coumarins.
10. Phenols, natural dyes and pigments II: Flavonoids, Quinonoids, polyenes, carotenoids.

11. Plant hormones: auxins, gibberellins, cytokinins, brassinosteroids, ethylene, abscisic acid, jasmonic acid.
12. Insect growth regulators: pheromones and allelochemicals. The hormones of the endocrine glands: brain hormones and juvenile hormones: sesquiterepenes, juvenile. Secretions of exocrine glands: pheromones (sex, aggregation, alarm, epideictic, trail. Total synthesis of pheromones. Pyrethrins and synthetic pyrethroids analogues.
13. Marine natural products: terpenoids, sesquiterpenes, diterpenes, carotenoids, sterols, phenols, halogenated compounds, adenochromes, marine toxins, bioluminescence.
14. 2nd test.

GENERAL AND SPECIFIC COMPETENCE:

To introduce students with the diversity of natural compound classes, their structural characteristics, basic chemical reactions and properties of bioactive natural compounds as secondary metabolites.

KNOWLEDGE TESTING AND EVALUATION:

Two (2) partial tests during the semester. Students can be released from exam if they collect sufficient points (55) from 2 tests.
Written exam and oral exam.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student survey.

LITERATURE:

1. S. V. Bhat, Chemistry of Natural Products, Narosa Publiching House Pvt. Ltd., New Delhi, Indi, 2005.
2. T. W. Graham Solomons, C. B. Fryhle, Organic Chemistry, John Wiley and Sons, Inc., New York, 2004.
3. S. H. Pine, Organic chemistry, written in Croatian, translated by: I. Bregovec, V. Rapić, Školska kniga, Zagreb, 1994.
4. L. G. Wade, Organic Chemisty, 6th, Pearson Education, Inc., New Jersey, 2006.

Course: Corrosion and environment		
Language: Croatian		
Lecturer: Helena Otmačić Ćurković		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**VII**
Laboratory	**2**	**VII**
Seminar	**-**	
		Overall: 4
		ECTS: 5

PURPOSE: The aim of the course is to present corrosion processes, the mechanism and kinetic of corrosion reactions. The influence of corrosion of structural materials on environment and economy is examined. Corrosion protection methods are presented and a special emphasis is placed on those protection methods that pollute the environment. Possibilities for replacing various toxic substances and risky procedures with new non-toxic compounds and procedures that do not present hazard to environment are analyzed.

THE CONTENTS OF THE COURSE:

1.Types and causes of pollution.

2.Corrosion of metals: causes, theoretical background and types of corrosion processes. Dependence of corrosion rate and forms of corrosion damage on environment.

3. Effects of corrosion on environment: influence of corrosion products on environment (water, soil). Endangerment of human lives and environment by the corrosion of structural materials.

4. Importance of adequate corrosion protection and monitoring in various industries: chemical, food, pharmaceutical, oil and gas industry.

5. Corrosion in human body. Corrosion in nuclear power plants and canisters for nuclear waste storage. Corrosion stability of stainless steel in various environment

6. Presentation of student works. Discussion

7. Preliminary exam

8. Visiting industrial facilities related to the corrosion protection

9. Biocorrosion. Increased corrosion in polluted environments.

10. Corrosion protection methods that negatively influence to the ecological system: metal protection by treatment of corrosion medium; environmental compliance of corrosion inhibitors (problem of toxic inhibitors); design and investigation of new non-toxic corrosion inhibitors.

11. Electrochemical methods for corrosion protection: cathodic protection (problem of soluble anodes). Organic coatings (toxic additives to protective coatings; pigments of heavy metals, organic solvents).

12. Protective coatings: problems in surface preparation, metallic coatings (highly toxic electroplating baths);

13. The analysis of possibilities for replacing toxic methods by newly-developed environmentally acceptable corrosion protection methods and practices

14. Presentation of student works. Discussion

15. Preliminary exam

GENERAL AND SPECIFIC COMPETENCE: -Understanding of hazards that corrosion and inadequate corrosion protection present to environment and human health;

- Recognizing how some of the corrosion protection methods may endanger environment and human health due to the release of toxic compounds;

- Ability to determine which corrosion protection method is the most adequate for given corrosion issue;

- Relating presence of pollution and climatic parameters to the corrosion level of various structural materials.

KNOWLEDGE TESTING AND EVALUATION:

Preliminary exam. Oral presentation of seminar papers. Written exams.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Continuous evaluation.

LITERATURE:

1. E.Stupnišek-Lisac i H. Otmačić Ćurković, Korozija i okoliš, interna skripta 2012.

2. E.Stupnišek-Lisac: Korozija i zaštita konstrukcijskih materijala, FKIT, Zagreb 2007.

3. S.K. Sharma: Green Corrosion Chemistry and Engineering, Wiley-VCH, Germany, 2012.

Course: POLYMER ENGINEERING MATERIALS

Chemical Engineering

graduation; 1st and 2nd year (1st and 3th semester)

Applied Chemistry

graduation; 1st and 2nd year (1st and 3th semester)

Language: English

Lecturer: Prof. Emi Govorčin Bajsić, PhD

TEACHING	WEEKLY	SEMESTER
Lectures	**2**	**30**
Laboratory	**2**	**30**
Seminar	**0**	**0**
		Overall: 60
		ECTS: 4

PURPOSE:

Review of polymer systems and properties of importance for the polymers like engineering materials as well as basic of processing and designing of polymer engineering materials properties.

THE CONTENTS OF THE COURSE:

1st week: Term and review of polymer materials. Structure features and composition.

2nd week: Requirements and properties of polymer engineering materials. Mechanic static properties. Deformation and rheology.

3rd week: Viscoelastic properties. Time dependence of deformation and stress.

4th week: Thermal properties. Thermomechanical curve. Deformation states.

5th week: Rheologycal properties. Rheologycal models.

6th week: Cyclic stress. Viscoelastic functions. Relaxation spectrums. Specificity of polymer engineering materials.

7th week: Durability of materials. Physical degradation. Aging with chemical reaction. Degradation. Kinetic models.

8th week: Wear and perishing of polymer engineering materials.

9th week: Multiphase polymer systems. Modification of properties.

10th week: Modelling of multiphase polymer systems for individual application. Additives.

11th week: Overview of procedure of processing. Extrusion. Moulding.

12th week: Specificity of processing of thermoplastics, duromers, elastomers and thermoplastic elastomer.

13th week: Cellular materials. Forming.

14th week: Reinforced materials. Forming of reinforced materials, thermoplastics and duromers. Control of properties through process features.

15th week: Polymer waste. Mixed polymer waste. Recycling.

GENERAL AND SPECIFIC COMPETENCE:

Understanding structure/properties relations of polymer engineering materials. Importance for processing and application.

KNOWLEDGE TESTING AND EVALUATION:

Partial tests (2 times) (written) or exam (written and/or oral)

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student questionnaire.

LITERATURE:

Materials received on the lecture and web site materials.

1.C. Hall, Polymer Materials, J. Wiley & Sons, New. York, 1990.

2.V. Eisele, Introduction to Polymers Physics, Spring Verlag, New York, 1990.

3.R. G. Griskey, Polymer Process Engineering, Hapman and Hall, New York, 1995.

4.W.M. Kuliche, Fliessverhalten von Stoffen und Stoffgemischen, Huthig & Wepf Verlag Basel, 1996.

Additional literature:

1.H.L.Williams, Polymer Engineering Elsevier Sci. Publ. Comp. , N.Y., 1985.

2.A.A. Collyer and L.A. Ultracki, Polymer Rheology and Processing, Chapman & Hall, Hampshire, 1990.

Course: Bioreaction technique		
Language: English		
Lecturer: Associate prof. Zvjezdana Findrik Blažević, PhD Associate prof. Ana Vrsalović Presečki, PhD		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**1**	**15**
Seminar	**1**	**15**
		Overall: 60
		ECTS: 5

PURPOSE: Upgrading of the theoretical knowledge acquired in previous courses in the field of biochemical engineering. Acquiring practical and theoretical knowledge required for the implementation of bioprocesses. Learning computer techniques of experimental data analysis.

THE CONTENTS OF THE COURSE:

1st week - Preparation of heterogeneous biocatalyst-immobilized biocatalysts – methods of immobilization.

2nd week - Methods for characterization of immobilized biocatalysts.

3rd week - Application of immobilized biocatalysts. Industrial processes with immobilized biocatalysts.

4th week - The use of biocatalysts in non-conventional media.

5th week - Stability of biocatalysts. Deactivation of biocatalysts. Models of the biocatalyst deactivation. Methods of biocatalyst stabilization.

6th week - Mathematical modeling of complex reaction systems based on experimental data using a computer (software package SCIENTIST).

7th week – First preliminary exam

8th week - Products obtained by using microbial whole cells. The conditions for the microbial growth. Mechanisms for regulation of metabolism. Characteristics of primary and secondary metabolism.

9th week – Microbial growth kinetics- Monod kinetics. Microbial growth kinetics on multiple carbon sources. The kinetics of substrate consumption and product formation during the cultivation of microorganisms.

10th week **-** Mass balances (biomass and substrate) of the continuous cultivation of microorganisms. Continuous microbial cultivation with biomass recycle. Continuous cultivation of microorganisms in the multistage bioreactor system.

11th week - Efficiency of microbial processes (yields, conversion, space-time yield)

12th week - Types of bioreactors. The selection of a bioreactor for microbial cultivation. Aeration. The basic theory of oxygen transfer across gas-liquid interface.

13th week - Techniques of microbial cultivations. Methods for monitoring the bioprocesses.

14th week – Steps in downstream processing for bioproduct recovery from fermentation broth. Methods for biomass separation from fermentation broth. Method of the cell disintegration. Concentration and purification of the bioproduct.

15th week - Second preliminary exam

GENERAL AND SPECIFIC COMPETENCE:

Acquiring basic and advanced knowledge of chemical engineering methodology needed to solve practical problems in biotransformation analysis and implementation of bioprocesses.

KNOWLEDGE TESTING AND EVALUATION:

1. Partial preliminary exams
2. Written exam

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student survey

LITERATURE:

1. J.E. Bailey, D.F. Ollis, Biochemical Engineering Fundamentals McGraw-Hill (1986).
2. A.Scragg ed. Biotechnology for Engineers - Biological Systems in Technological Processes, Ellis Horwood Limited, Chichester, (1988)
3. K. van't Riet, J. Tramper, Basic Bioreactor Design, Marcel Dekker, New York, (1991)
4. H.W. Blanch, D.S. Clark, Biochemical Engineering, Marcel Dekker, New York, (1996)

Course (optional): Nondestructive methods of chemical analysis in art and archaeology, Applied Chemistry (1st year, 1st semester, mag. appl. chem.)

Language: English

Lecturer: Associated professor Danijela Ašperger, Ph.D.

TEACHING	WEEKLY	SEMESTER
Lectures	**2**	**15**
Laboratory	**1**	**15**
Seminar	**0**	**-**
Field work (days)	**5 visitations x 2 hours**	**Part of lectures and laboratory exercises.**
		Overall: 45
		ECTS: 5

PURPOSE:
Introduce students to access materials analysis which does not allow classical sampling and through this classical preparation of samples for analysis. Application to restoration and conservation work.

THE CONTENTS OF THE COURSE:

Lectures:

1. Introductory lecture; introduction to the course, with terms of examination, instructions for exercises. The role of analytical chemistry in art and archeology, the role of scientific analytical work in education of restorers-conservators.
2. Tasks of laboratory, laboratory techniques and methods. Introduction to analytical system: access to object which cannot be damaged, preparing the object for analysis, microsampling, laser microsampling, electrochemical microsampling.
3. Introduction to the application of classical and modern instrumental techniques for determining the chemical composition and surface analysis of the object: spectroscopic, electroanalytical and separation methods.

4 Application of atomic and molecular spectroscopy in restoring and preserving objects of historical and cultural importance.

5. Applying of X-ray fluorescence and diffraction in restoring and preserving objects of historical and cultural importance.
6. Application analysis of ion beams (PIXE, PIGE, RBS) and neutron activation analysis in the restoration and preservation objects of historical and cultural importance.
7. Application of Infrared and Raman spectroscopy for the restoration and preservation objects of historical and cultural importance.
8. Application of photographic research in restoring and preserving objects of historical and cultural importance: infrared photography and reflectography.
9. Application of photographic research in restoring and preserving objects of historical and cultural importance: ultraviolet reflectography and fluorescence.
10. Application of photographic research in restoring and preserving objects of historical and cultural importance by x-ray radiography and X-ray computer

tomography.
11. Application of separation chromatographic methods for restoring and preserving objects of historical and cultural importance.
12. Impact of microorganisms and other impacts on the deterioration of objects of historical and cultural importance - fumigation of art.
13. Dendrochronology - absolute and relative dating of the past.
14. Students seminars on a given topic.
15. Final exam of lectures and of laboratory exercises.

Laboratory exercises:

1. Anodic sampling and thin layer chromatography analysis of archaeological bronze.
2. Sample preparation for binder's analysis by thin layer chromatography – ultrasonic extraction.
3. Analysis of binders - resins, oils, waxes in the castle wall murals Brezovica.
4. Determination of the pigments with infrared spectroscopy.

Field work:

1. Visitation to Archaeological Museum - analysis of mummies.
2. Visitation to Natural science laboratory in the Croatian Conservation Institute - access to the object from sampling to analysis and writing reports.
3. Visitation to the Croatian State Archives (Palace Lubinsky) - a central laboratory for restoration and conservation of paper and leather.
4. Visitation to the Ethnographic Museum - a central laboratory for restoration and conservation of textiles and other supporting items (jewelry, feathers).
5. Visitation to the castle Brezovica within multidisciplinary research with the Academy of Fine Arts.

GENERAL AND SPECIFIC COMPETENCE:

Introduction to the analysis of works of art and archaeological objects, for which is usually impossible to take macro samples and through this is emphasized the importance of using methods that enable analysis "*in situ*" or the analysis after micro-sampling of objects.

KNOWLEDGE TESTING AND EVALUATION:

Written and oral examination. The possibility of release written part of the exam if you collect enough points. The oral part of the exam with the teacher.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student questionnaire.

LITERATURE:

Lectures:

1. V. Desnica, Instrumentalna analiza, Interna skripta, Akademija likovnih umjetnosti, Zagreb, 2012.

Laboratory exercise:

2. D. Ašperger, Nedestruktivne metode kemijske analize u umjetnosti i arheologiji, Interna skripta, Fakultet kemijskog inženjerstva i tehnologije, Zagreb, 2011.

ADDITIONAL LITERATURE:

1. E. Ciliberto, G. Spoto, Modern analytical methods in art and archeology, Wiley-Interscience, New York, 2000.
2. K. Janssens, R. van Grieken (Eds), Non-destructive microanalysis of cultural heritage materials, Elsevier, 2004.

Course: Environmental Engineering and Management		
Language: English		
Lecturer: Dr. Ana Lončarić Božić, associate professor Dr. Hrvoje Kušić, assistant professor		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**0**	**0**
Seminar	**0**	**30**
		Overall:30 + 0 + 0
		ECTS: 6

PURPOSE:

Introducing environmental engineering and management issues with the aim to assess sustainable technologies.

THE CONTENTS OF THE COURSE:

1. **week:** Introduction to environmental engineering..
2. **week:** Engineering approach to analysis of environmental problems.
3. **week:** Environmental pollutants. Control of significant environmental impacts (air, water, soil and waste).
4. **week:** National environmental legislation.
5. **week:** Noise pollution.
6. **week:** Heat and light pollution.
7. **week:** Strategy for odor control.
8. **week:** 1st partial exam.
9. **week:** Waste management and treatment technologies.
10. **week:** Risk assessment and management.
11. **week:** Cleaner and low-waste technologies.
12. **week:** Compliance with environmental management systems.
13. **week:** Public communication principles.
14. **week:** Integrated environmental management concept.
15. **week:** 2nd partial exam.

GENERAL AND SPECIFIC COMPETENCE:

Adoption of sustainable development concept in environmental engineering and management practice. Correlation of pollution sources and minimization opportunities with sustainable technologies. Acquaintance with main legal requirements in environmental protection. Adoption of sustainability principles and tools in environmental protection and management.

KNOWLEDGE TESTING AND EVALUATION:

1. Partial exams

2. Written exam

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student survey

LITERATURE:

1) E.S. Rubin, C.I. Davidson, Introduction to Engineering & the Environment, McGraw Hill, New York, 2001.

A. P. Calow, Blackwell's Concise Encyclopedia of Environmental Management, Blackwell Science, Oxford, 1999.

B. Lectures

Course: Risk Assessment		
Language: English		
Lecturer: **Assoc. Prof. Ana Lončarić Božić, PhD** **Prof. Sanja Papić, PhD**		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**0**	**0**
Seminar	**0**	**30**
		Overall: 60
		ECTS: 6

PURPOSE:

Overview of risk assessment concepts. Value of risk assessment in environmetal management.

THE CONTENTS OF THE COURSE:

1st week - Introduction to risk concepts, general categories of risk and methods for quantitatively risk determination.

2nd week - Major components of risk assessment: hazard assessment, dose-response, exposure assessment, risk characterization.

3rd week - Environmental risk assessment and management of chemicals. Predicted environmental concentration (PEC) and predicted no effect concentration (PNEC).

4th and 5th week - OECD/ISO/EU test methods – a vital component of the environmental risk assessment of chemicals. Physico-chemical methods, biodegradation methods, bacterial toxicity methods, aquatic toxicity methods, soil, sediment and avian toxicity test methods. Limitations of OECD and other test methods.

6th week - Procedure of environmental risk assessment according to EU Directives. Assessment factors: aquatic, STP microorganism, sediment, terrestrial.

7th week - Environmental risk management; EU Directives and international agreements which control directly or indirectly the quantities of specific chemicals or chemical classes which may be used in or discharged to the environment; EQU-Environmental Quality Objectives; BATNEEC-Best Available Techniques not Entailing Excessive Cost. Precautionary principle.

8th week – 1st partial exam

9th week – Legal requirements for risk control at industrial sites. Principles and goals of Seveso III directive;

10th week – Risk assesment elements for major-accidents hazards. Risk matrix as a risk management tool.

11th week – Correlation of waste management activities with specific health hazards and environmental risks. Risk assessment framework for waste landfills; exposure paths.

12th week – Methodology for data collection and analysis within the risk assessment procedure. Qualitative and quantitative methods in risk assessment.

13th week – Application of Bayesian decision theory in quantitative risk assessment. Examples. Development and application of conceptual models. Case studies.

14th week – Logic trees and their application in risk assessment. Risk analysis; examples of event tree and fault tree.

15th week – 2nd partial exam

GENERAL AND SPECIFIC COMPETENCE:

Understanding the basic principles of risk analysis and risk assessment methodologies in ecology. Adoption of methodology for data collection and analysis, and qualitative and quantitative methods in risk assessment.

KNOWLEDGE TESTING AND EVALUATION:

1. Partial preliminary exams

2. Written exam

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

University of Zagreb student survey

LITERATURE:

1) R. E. Hester, R. M. Harrison, Risk Assessment and Risk Management, The Royal Society of Chemistry, Cambridge, 1998.

2) D. T. Allen, D. R. Shonnard, Green Engineering, Prentice Hall PTR, New York, 2002.

Course: Polymer nanocomposites		
Language: English		
Lecturer: Prof. Sanja Lučić Blagojević		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**0**	**0**
Seminar	**0**	**0**
		Overall: 30
		ECTS: 6

PURPOSE:

To introduce students with access of design of nanocomposite polymer materials aiming to achieve specific properties. The objective can be achieved by integrating knowledge from the field of polymer materials, inorganic materials, and knowledge about the modelling of the interface polymer / filler.

THE CONTENTS OF THE COURSE:

L1 - Polymeric materials. The importance and application of polymeric materials. Classification of polymer materials by origin, by application properties, according to the type of repeating units, according to the forms of macromolecules. Mechanisms of polymerization: step, chain; homogeneous and heterogeneous processes of polymerization. The structure of polymers: configuration and conformation of macromolecules. Super-molecular structures. Physical properties of polymers. Additives to polymer materials. Fillers as modifiers of properties.

L2 - Differences between micro and nanocomposites. Polymer Composites. Interphase polymer - filler: mechanisms of adhesion, the application of adsorption theory. Thermodynamics of interfacial free energy, coefficient of wetting, thermodynamic work of adhesion. Chemisorption theory. Differences between nanocomposites and microcomposites: filler particle size, size of the interface, morphology, fraction of matrix in the interphase layer.

L3-5 The types of nanofillers. *Carbon nanotubes*: molecular and supramolekulna structure, properties (mechanical properties, electrical properties). Processing of nanotubes: laser ablation, arc discharge, chemical vapor deposition. Composition and purification of the reaction products. Surface modification (covalent and non-covalent)

The layered nanofillers: types, structure, organic modification of layered nano-filler. *Equi-axed nanofillers*: types, production, surface modification.

Quantum dots: types, structure, quantum effects, properties. Surface modification of quantum dots: with amphiphilic polymers, multidentate polymeric ligands, polymers functionalized at the ends of the chain, quantum dots encapsulated by dendrimers.

1st partial exam

L7-9 Preparation of polymer nanocomposites. The distribution and the dispersibility of fillers in the polymer matrix. *Preparation process for composites with carbon*

nanotubes: preparation of the solution, stirring the mass of the polymer, the mixing in the melt, in situ polymerization.
Preparation of nanocomposites with layered nano-fillers: intercalated and exfoliated morphology, instrumental techniques for morphology investigation. Methodology and thermodynamics of individual processes: intercalation of polymer or prepolymer, in situ intercalation polymerization, melt intercalation. The impact of factors on the morphology of the melt intercalation process. The degradation of the system during the preparation of the melt intercalation.
Preparation of polymer nanocomposites with equi-axed nano-fillers. The process for preparing the melt and solution, in situ polymerization of the polymer, the in situ polymerization of the inorganic phase is formed.
Preparation of nanocomposite system quantum dot / polymer. Quantum dots in polymer colloids - a methodology for preparing nanocomposites with different methods, advantages and disadvantages of different methods of preparation. Systems of layer-by-layer quantum dot / polymer. Controlled binding of polymer layers and quantum dots. Quantum dots in polymers bulk and thin polymer films.

L10-11 Properties and application of polymer nanocomposites. Mechanical properties: the influence of types of nano-filler, filler particle size and thermodynamics of the polymer / filler morphology, failure mechanisms and features of the mechanical behavior (modulus, tensile strength, toughness). Effect of nanofiller on the permeability of gases and liquids: the concept of tortuous diffusion. Dimensional stability of nanocomposites. The thermal stability of the nanocomposites. Effect of nanofillers on flammability of polymers. Electrical properties. Optical and optoelectronic properties.

L12 2nd partial exam

L13-15 Student seminars

GENERAL AND SPECIFIC COMPETENCE:

The course develops the general students' competence of analysis and synthesis of scientific knowledge and presentation in oral form.

Specific competencies courses include connecting knowledge engineering polymer materials and surface and interfacial engineering in multiphase polymer systems, broadening and deepening the knowledge of the structure, properties, production and application of polymer nanocomposites as advanced materials, and knowledge about the selection of techniques and methods for the characterization of multiphase systems and quality control of the final products.

KNOWLEDGE TESTING AND EVALUATION:

Partial exams, writing and oral exam

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student questionnaire.

LITERATURE:

1. P. M. Ajayan, L. S. Schadler, P. V. Braun, Nanocomposite Science and Technology, Wiley – VCH, 2003.
2. T. J. Pinnavaia, G. W. Beall, Polymer-Clay Nanocomposites, John Wiley and Sons Inc., 2001.
3. A. I. Nakatani, R. P. Hjelm, M. Gerspacher, R. Krishnamoorti, Filled and Nanocomposite Polymer Materials, Vol.661, Materials Research Society, 2001.
4. R.Vaia, R. Krishnamoorti, Polymer nanocomposites: Synthesis, Characterization and Modeling, American Chemical Society, 2001.
5. Y. S. Lipatov, Polymer Reinforcement, Chem. Tec. Publishing, Ontario, 1995.

Course: Environmental management systems		
Language: English		
Lecturer: Associate prof. Ana Lončarić Božić, PhD		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**0**	
Seminar	**01**	
		Overall: 3045
		ECTS: 6

PURPOSE: Introduction to the aims, methodology and structure of Environmental Management Systems (EMS). Overview of knowledge and skills for development and implementation if EMS as one of sustainable development tools.

THE CONTENTS OF THE COURSE:

1st week – Preventive approach in environmental protection and management. Basic principles and elements of sustainable development. Introduction to EMS based on Deming’s cycle.

2nd week – Basic terms and definitions. Overview of ISO 14001 (HR EN ISO 14001:2009) standard. Purpose of standardisation. Positive features of EMS implementation.

3rd week –Basic roles and focus of EMS. Structure and main elements of EMS. Concept of continual improvement.

4th week – Requirements of ISO 140001 for EMS. Environmental policy. Objectives and targets. Examples of setting “smart“ objectives.

5th week –Elements of planning process. Environmental aspects and impacts. Identification of legal requirements and significant aspects. Case studies.

6th week – Significance of defined roles, resources and responsibilities for successful implementation of EMS. Competences and communication.

7th week –Types and management of EMS documentation. Differences between documents and records. Case studies.

8th week –1st partial exam

9th week – Emergency preparedness and response. Analysis of processes and activities, aspects and potential impacts; case study.

10th week – Assessment of compliance of EMS with ISO 14001 standard. Identification of non-conformances and appropriate corrective and preventive actions. EMS audit and management review. Identification of significant aspects and impacts: service industry case study.

11th week – Basic elements and methodology of Life cycle assessment (LCA) methodology. LCA as sustainable development tool.

12th week – Cleaner production. Correlation of EMS with waste management strategy within Cleaner production. Identification of waste sources and corresponding preventive measures of Cleaner production. Cleaner production methodology; case study.

13th week – Differences and similarities of environmental management systems according to EMAS and ISO 14001.

14th week – Occupational health and safety; OHSAS18001. Integrated management systems.

15th week – Programme Responsible care. Principles and guidelines. Correlation of Responsible care elements with environmental management system.

GENERAL AND SPECIFIC COMPETENCE:

Adoption of proactive approach in environmental protection and management. Understanding the opportunities of continual improvement of environmental performances by adoption and implementation of EMS.

KNOWLEDGE TESTING AND EVALUATION:

1. Partial preliminary exams

2. Written exam

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student survey

LITERATURE:

1) Sheldon, C.: ISO 14000 and Beyond, Environmental management systems in real world, Greenleaf Publishing, UK,1997.
2) Lectures

Course: Technology Management and Innovation		
Language: Croatian and English		
Lecturer: Dr Ivana Steinberg, Assistant Professor		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**1**	**15**
Laboratory	**-**	
Seminar	**1**	**15**
		Overall: 30
		ECTS: 4

PURPOSE:

To introduce master level students to the concepts of innovation in relation to commercialisation of novel technologies. Adopting basic ideas and conceptual approaches to development of innovative products or services including scientific, technological, organisational, financial and business aspects.

THE CONTENTS OF THE COURSE:

Week	Lectures and seminars
1	Introduction to the TM&I course
2	Innovation and R&D
3	Intellectual Property
4	Technology Transfer & Strategic Exploitation of IP
5	New product development (NPD)
6	The Six Phases of NPD
7	Introduction to Project Management I
8	Introduction to Project Management II
9	Introduction to Project Management III
10	Technology Start-Up Company Funding, Business Plans (BP)
11	Summary of TM&I course
12	Final Revision/Instructions for student BP presentation

13	BP presentations Q&A session: Discussion
14	BP presentations Q&A session: Discussion
15	BP presentations Q&A session: Discussion

GENERAL AND SPECIFIC COMPETENCE:

General: presentation skills, individual and team-based work, innovative thinking, business and entrepreneurial skills

Specific: basic understanding of the processes involved in commercialisation of intellectual property, searching and using patent databases, simple project planning using appropriate techniques and software, preparing a simple business plan related to innovative product or service based on a chosen patent, adopting terminology related to technology management and innovation in English - selected parts of lectures and reading materials are given in English, final assignment can be presented in English

KNOWLEDGE TESTING AND EVALUATION:

Lectures and seminars are compulsory, regular homework assignments and problem solving exercises, written and oral presentations, compulsory reading for seminar discussions, presentation of final assignment (business plan)

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student survey

LITERATURE:

1. The Management of Technological Innovation. Strategy and Practice. M. Dodgson, D. Gann, A. Salter. Oxford University Press, 2008.

2. Intellectual Property for Managers and Investors. S.J. Frank. Cambridge University Press, 2006.

3. Project Manager: Mastering the Art of Delivery in Project Management. Richard Newton. Financial Times / Prentice Hall, 2007.

Course: Advanced separation techniques in environmental analysis		
Language: English		
Lecturer: prof. dr. sc. Sandra Babić, prof. dr. sc. Tomislav Bolanča		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**2**	**30**
Seminar		
		Overall: 60
		ECTS: 6

PURPOSE:

The main purpose of this course is to provide knowledge about separation techniques and their application in environmental analysis, modern analytical instrumentation, data analysis and interpretation.

THE CONTENTS OF THE COURSE:

1. Sampling from the environment. Sampling errors. Sampling plans. Uzorkovanje iz okoliša. Pogreške uzorkovanja. Planiranje uzorkovanja. Sampling procedures: water, soil, sediment and air.
2. Extraction methods for liquid samples: Liquid-liquid extraction. Solid-phase extraction.
3. Extraction methods for liquid samples (continuation): Membrane extraction. Microextraction techniques
4. Extraction methods for solid samples: Soxhlet and automated Soxhlet, ultrasound assisted extraction, microwave assisted solvent extraction, pressurized liquid extraction, supercritical fluid extraction, superheated water extraction.
5. Extraction methods for gas samples: cryogenic trapping, solvent extraction, enrichment on immobilized sorbents.
6. Capillary electrophoresis. Basic principles. Electroosmotic flow. Instrumentation. Detection and application.
7. Capillary electrochromatography. Basic principles. mIntruments. Columns and application.
8. High performance liquid chromatography. Basic principles and instrumentation. Separation mechanisms. Reverse phase, normal phase and ion chromatography.
9. Thin layer chromatography. Ultra high performance liquid chromatography.
10. Detection in liquid chromatography. UV/VIS and PDA detection.

Refractometry. Fluorimetry. Conductometry. Amperometry and voltammetry.

11. Supercritical fluid chromatography. Supercritical fluid. Separation mechanisms, instrumentation and applications.

12. Gas chromatography. Basic principles and instrumentation. Liquid and solid stationary phases. Capillary gas chromatography.

13. Detection in gas chromatography. Flame ionization detection. Thermal conductivity detection. Electron capture detection. Application of gas chromatography.

14. Two dimensional separation. Heart cutting. Instrumentation and application in liquid and gas chromatography.

15. Mass spectrometry. Hyphenated techniques.

GENERAL AND SPECIFIC COMPETENCE:

Development of general knowledge on advanced separation techniques and specific knowledge on application of separation techniques in environmental analysis.

KNOWLEDGE TESTING AND EVALUATION:

2 midterm exams

writing exam

oral exam

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student survey

LITERATURE:

1. Analitika okoliša, M. Kaštelan-Macan, M. Petrović (ur.), HINUS i Fakultet kemijskog inženjerstva i tehnologije, Zagreb, 2013.
2. C. Zhang, Fundamentals of Environmental Sampling and Analysis, John Wiley & Sons, New Jersey 2007.
3. S.C. Molodoveanu, V. David, Sample Preparation in Chromatography, Elsevier, 2002.
4. L.R. Snyder, J.J. Kirkland, J. W. Dolan, Introduction to Modern Liquid Chromatography, Wiley, New York, Chichester, Brisbane, Toronto, 2010.
5. H. M. Mcnair, J.M. Miller, Basic Gas Chromatography, Wiley, New York, Chichester, Brisbane, Toronto, 2009.
6. L. Mondello, A.C. Lewis, K.D. Bartle. Multidimensional Chromatography, Wiley, New York, Chichester, Brisbane, Toronto, 2002.

Course (optional): Nondestructive methods of chemical analysis in art and archaeology, Applied Chemistry (2nd year, 3rd semester, mag. appl. chem.)		
Language: English		
Lecturer: Associated professor Danijela Ašperger, Ph.D.		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**15**
Laboratory	**2**	**15**
Seminar	**0**	**-**
Field work (days)	**6 visitations x 2 hours**	**Part of lectures and laboratory exercises.**
		Overall: 60
		ECTS: 6

PURPOSE:
Introduce students to access materials analysis which does not allow classical sampling and through this classical preparation of samples for analysis. Application to restoration and conservation work.

THE CONTENTS OF THE COURSE:

Lectures:

1. Introductory lecture; introduction to the course, with terms of examination, instructions for exercises. The role of analytical chemistry in art and archeology, the role of scientific analytical work in education of restorers-conservators.
2. Tasks of laboratory, laboratory techniques and methods. Introduction to analytical system: access to object which cannot be damaged, preparing the object for analysis, microsampling, laser microsampling, electrochemical microsampling.
3. Introduction to the application of classical and modern instrumental techniques for determining the chemical composition and surface analysis of the object: spectroscopic, electroanalytical and separation methods.
4 Application of atomic and molecular spectroscopy in restoring and preserving objects of historical and cultural importance.
5. Applying of X-ray fluorescence and diffraction in restoring and preserving objects of historical and cultural importance.
6. Application analysis of ion beams (PIXE, PIGE, RBS) and neutron activation analysis in the restoration and preservation objects of historical and cultural importance.
7. Application of Infrared and Raman spectroscopy for the restoration and preservation objects of historical and cultural importance.
8. Application of photographic research in restoring and preserving objects of historical and cultural importance: infrared photography and reflectography.
9. Application of photographic research in restoring and preserving objects of historical and cultural importance: ultraviolet reflectography and fluorescence.
10. Application of photographic research in restoring and preserving objects of historical and cultural importance by x-ray radiography and X-ray computer

tomography.
11. Application of separation chromatographic methods for restoring and preserving objects of historical and cultural importance.
12. Impact of microorganisms and other impacts on the deterioration of objects of historical and cultural importance - fumigation of art.
13. Dendrochronology - absolute and relative dating of the past.
14. Students seminars on a given topic.
15. Final exam of lectures and of laboratory exercises.

Laboratory exercises:

1. Anodic sampling and thin layer chromatography analysis of archaeological bronze.
2. Sample preparation for binder's analysis by thin layer chromatography – ultrasonic extraction.
3. Analysis of binders - resins, oils, waxes in the castle wall murals Brezovica.
4. Determination of the pigments with infrared spectroscopy.

Field work:

1. Visitation to Archaeological Museum - analysis of mummies.
2. Visitation to Natural science laboratory in the Croatian Conservation Institute - access to the object from sampling to analysis and writing reports.
3. Visitation to Metal workshop in the Croatian Conservation Institute -Apoxiomen from the sea to the museum exhibits.
4. Visitation to the Croatian State Archives (Palace Lubinsky) - a central laboratory for restoration and conservation of paper and leather.
5. Visitation to the Ethnographic Museum - a central laboratory for restoration and conservation of textiles and other supporting items (jewelry, feathers).
6. Visitation to the castle Brezovica within multidisciplinary research with the Academy of Fine Arts.

GENERAL AND SPECIFIC COMPETENCE:

Introduction to the analysis of works of art and archaeological objects, for which is usually impossible to take macro samples and through this is emphasized the importance of using methods that enable analysis "*in situ*" or the analysis after micro-sampling of objects.

KNOWLEDGE TESTING AND EVALUATION:

Written and oral examination. The possibility of release written part of the exam if you collect enough points. The oral part of the exam with the teacher.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student questionnaire.

LITERATURE:

Lectures:

1. V. Desnica, Instrumentalna analiza, Interna skripta, Akademija likovnih umjetnosti, Zagreb, 2012.

Laboratory exercise:

2. D. Ašperger, Nedestruktivne metode kemijske analize u umjetnosti i arheologiji, Interna skripta, Fakultet kemijskog inženjerstva i tehnologije, Zagreb, 2011.

ADDITIONAL LITERATURE:

1. E. Ciliberto, G. Spoto, Modern analytical methods in art and archeology, Wiley-Interscience, New York, 2000.
2. K. Janssens, R. van Grieken (Eds), Non-destructive microanalysis of cultural heritage materials, Elsevier, 2004.

Course: Corrosion Stability of Materials		
Language: English		
Lecturers: Sanja Martinez		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**2**	**30**
Seminar	**0**	**0**
		Overall: 60
		ECTS: 6

PURPOSE:

Links previously acquired knowledge of electrochemistry, electrochemical engineering, corrosion and protection of metallic materials to solving practical corrosion problems. Teaches about the latest trends, equipment, literature, normative documents and engineering practice in the field of corrosion and protection of metallic materials.

THE CONTENTS OF THE COURSE:

WEEK 1: CORROSION RATE: meaning of corrosion rate measurement, calculation and estimation of corrosion rate, the rate of corrosion of various metallic materials in a variety of corrosive environments.
WEEK 2: EXAMPLES OF LOCALIZED CORROSION Part I: galvanic corrosion, pitting corrosion, corrosion in the gap, practical examples.
WEEK 3: EXAMPLES OF LOCALIZED CORROSION Part II: microbial corrosion, corrosion under mechanical wear, stress corrosion cracking, practical examples.
WEEK 4: DETERMINING THE CAUSE CORROSION: laboratory methods for determining the causes of corrosion.
WEEK 4: Knowledge testing and progress assessment.
WEEK 6: FIELD WORK: Visit to the industry.
WEEK 7: INTEGRITY MANAGEMENT OF METALLIC CONSTRUCTIONS: integrity management and corrosion management, deterministic and probabilistic approach to assessing corrosion, risk analysis, standardization in the field of corrosion management.
WEEK 8: INDIRECT METHODS OF CORROSION TESTING: ultrasonic inspection method and magnetic flux leakage, measuring methods and potential gradients along the structure.
WEEK 9: CORROSION MONITORING: methods of corrosion monitoring in various corrosion systems, the design of the monitoring system, the interpretation of monitoring data, examples from practice.
WEEK 10: FIELD WORK Attending scientific or professional lecture, seminar or conference.
WEEK 11: Knowledge testing and progress assessment.
WEEK 12: APPLICATION OF ELECTROCHEMICAL TECHNIQUES in protection

against corrosion by coatings and linings.
WEEK 13: APPLICATION OF ELECTROCHEMICAL TECHNIQUES in protection of immersed and underground structures.
WEEK 14: APPLICATION OF ELECTROCHEMICAL TECHNIQUES in conservation and restoration practice.
WEEK 15: Knowledge testing and progress assessment.

Laboratory Exercises:

1. Galvanic corrosion.
2. Metallization by cementation.
3. Applications of cementation process in corrosion.
4. Determination of the effectiveness of the protection of bronze by wax coatings trough application of polarization (DC) techniques.
5. Measuring of "on" and "off" potentials.
6. Measuring of potential ("close interval potential survey" CIPS) and the potential gradient ("direct current voltage gradient" DCVG) on pipelines.
7. Determining the effectiveness of the protection by coatings using method of electrochemical impedance spectroscopy.
8. Corrosion monitoring - measuring the corrosion rate under various corrosive conditions.
9. Knowledge testing after the laboratory work.

GENERAL AND SPECIFIC COMPETENCE:

General competencies:

- Ability to apply knowledge of mathematics, natural science and engineering problems in practice.
- Ability of designing conducting and interpreting experiments.
- Ability to apply the techniques, skills and modern engineering tools necessary for engineering practice.
- Ability to recognize, formulate and solve engineering problems.
- Ability of involvement in teamwork and the ability to apply communication skills in the engineering context.
- Ability of effective communication in written, oral and graphic form.
- Recognizing the need of continuous lifelong learning.
- Recognizing of professional issues including ethical responsibility, safety, creative entrepreneurship loyalty and commitment to engineering profession.
- Recognition of current problems in engineering practice, including economic, social, political and environmental problems and global impact.

Specific competencies

- Understanding the fundamental electrochemical and corrosion concepts applied to problems of corrosion engineering.
- Knowledge of characteristics of certain corrosive environment and the ways of determining corrosivity of the environment.
- Ability to recognize different forms of corrosion in practice.
- Knowledge of various methods of corrosion protection.
- Knowledge of measurement methods applicable in the field of corrosion.
- Knowledge of corrosion literature and normative documents and regulations in the field of corrosion and protection.
- Knowledge of the latest trends, equipment and engineering practices in corrosion

engineering.

KNOWLEDGE TESTING AND EVALUATION:

Two progress evaluations during the course.

Knowledge testing after the laboratory work.

Written exam.

Oral exam.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student’s poll.

LITERATURE:

1. Pierre R. Roberge, Handbook of Corrosion Engineering, 2nd ed, McGraw-Hill, 2012
2. B. Kermani , T. Chevrot, Eds, Recommended practice for corrosion management of pipelines in oil and gas production and transportation, EFC, 2012
3. P. Dillmann, D. Watkinson, E. Angelini, A. Adriaens, Eds, Corrosion and Conservation of Cultural Heritage Metallic Artefacts, Woodhead Publishing, 2013

Course: Hydrogen Energy and Economy		
Language: English		
Lecturer: Full Prof. Ante Jukić, PhD.		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**2**	**30**
Seminar	**0**	**0**
		Overall: 60
		ECTS: 6

PURPOSE:

Understanding and acquiring of theoretical and practical knowledge regarding production, storage, transport and use of hydrogen as environmentally attractive energy carrier.

THE CONTENTS OF THE COURSE:

1st week: Introduction: structure of energy sector, transition towards sustainable energy.

2nd week: Status and trends in production and application of alternative fuels.

3rd week: Hydrogen properties. Comparison of hydrogen with other common fuels.

4th week: Thermal processes for hydrogen production.

5th week: Hydrogen use: petroleum refining, ammonia production, petrochemical industry.

6th week: New processes for hydrogen production. IGCC.

7th week: Water electrolysis.

8th week: Fproduction of hydrogen by photolytic and bioconversion processes.

9th week: Hydrogen storage.

10th week: Hydrides.

11th week: Fuel cells.

12th week: CO_2: Carbon **c**apture and storage.

13th week: Advantages and drawbacks of hydrogen as an energy carrier.

14th week: Hydrogen economy - need for technical improvement and R&D programmes.

GENERAL AND SPECIFIC COMPETENCE:

To familiarize students with the processes and technologies of production, storage, transport and use of hydrogen as fuel of the future. The introduction of hydrogen as energy carrier will force a major evolution on the energy sector, hence initiating a large spectrum of new technologies that in turn will induce huge R&D efforts in order to make them competetive. The whole supply chain from production to end-use, through transport and distribution, is involved.

KNOWLEDGE TESTING AND EVALUATION:

Colloquiums related to laboratory practices.
Written exam (50% of the points needed for passage).
Oral exam.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student survey.

LITERATURE:

Jukić, Ante: Hydrogen as energy carrier, lectures, Faculty of chemical engineering and technology, Zagreb, 2010-2013.
T. M. Letcher (Ed.), Future Energy: Improved, Sustainable and Clean Options for our Planet, Elsevier, Amsterdam, 2008.
D. Sperling, J.S. Cannon. The Hydrogen Energy Transition: Moving Toward the Post Petroleum Age in Transportation, Elsevier, Academic Press, 2004.
S. Dunn. Hydrogen Futures: Toward a Sustainable Energy System, Int. J. Hydrogen Energy 27 (2002) 235-264.
The Hydrogen Economy: Opportunities, Costs, Barriers and R&D Needs, National Research Council (2004).
Progress Report for Hydrogen, Fuel Cells and Infrastructure Technologies Program, U.S. Department of Energy, 2002.
Hydrogen Production Roadmap – Technology Pathways to the Future, FreedomCAR & Fuel Partnership, 2009.
K. J. Gross, K. R. Carrington, S. Barcelo, A. Karkamkar, J. Purewal, Recommended Best Practices for the Characterization of Storage Properties of Hydrogen Storage Materials, NREL, 2009.
Pathways to Commercial Success: Technologies and Products Supported by the Hydrogen, Fuel Cells & Infrastructure Technologies Program, HFCIT Program, U.S. Department of Energy, 2009.
Fuel Cell Handbook (Seventh Edition), EG&G Technical Services, Inc., 2004. (http://www.netl.doe.gov/technologies/coalpower/fuelcells/seca/pubs/FCHandbook7.pdf)
D. Steward, G. Saur, M. Penev, T. Ramsden, Lifecycle Cost Analysis of Hydrogen Versus Other Technologies for Electrical Energy Storage, Technical Report NREL/TP-560-46719, 2009.

Course: Heterocyclic antitumor drugs		
Language: English		
Lecturer: Dr. Marijana Hranjec, assoc. prof.		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**2**	**30**
Seminar	**0**	**0**
		Overall: 60
		ECTS: 6

PURPOSE:

To introduce students to the basic principles of action of anticancer drugs with heterocyclic nucleus in their structure. Division of anticancer drugs according to the mechanisms of their biological action. Emphasis on drugs whose mechanism of action is based on interaction with biomacromolecules DNA and RNA.

THE CONTENTS OF THE COURSE:

1st week: Introduction and basic principles of chemotherapy. The role of chemistry in chemotherapy. The basic division of anticancer drugs according to the mechanisms of their biological action. Antimetabolites.

2nd week: Anticancer drugs that inhibit the activity of the hormone. Antiandrogens. Inhibitors of estrogen.

3rd week: Anticancer drugs whose action is based on a radical mechanisms. Anthracyclines and related analogs. Actinomycin D. Photodynamic anticancer therapy.

4th week: DNA alkylating and non-alkylating anticancer drugs. Derivatives of nitrogen mustards. Aziridines. Epoxies. Nitrosoureas. Triazenes. Methylhydrazine. 1,3,5-triazines. Complexes of organic molecules with platinum.

5th week: Alkylating and non-alkylating DNA groove binders. Netropsin and distamycin. Hoechst 33258. Mitomycines. Pyrrolo[1,2-*a*]benzodiazepines.

6th week: DNA intercalators. Basic principles of intercalation into DNA and RNA. Ellipticines and analogs. Actinomycines. Quinoline derivatives. Intercalators with indole and naphthalimide nuclei. Acridines.

7th week: Written assessment by 1st partial exam.

8th week: Anticancer agents as topoisomerase I and II inhibitors. Drugs that act as poisons to topoisomerase. Catalytic topoisomerase inhibitors.

9th week: Inhibitors of tubulin and microtubules.

10th week: Role of protein kinases in chemotherapy. Inhibitors of tyrosine kinases.

11th week: Other principles of targeted chemotherapy.

12th week: Anticancer drugs isolated from natural products.

13th week: Overview of the most important commercial anticancer drugs, which are used in chemotherapy. Glivec. Taxol.

14th week: Written assessment by 2nd partial exam.

GENERAL AND SPECIFIC COMPETENCE:

Group of anticancer drugs with regard to the mechanism of their biological action in chemotherapy. Knowing the specific structural characteristics of certain groups of heterocyclic anticancer drugs. Modern methods used in chemotherapy (inhibitors of specific enzymes).

KNOWLEDGE TESTING AND EVALUATION:

Exams related to laboratory practices.
2 partial written tests during the semester (60% of points on each of the exams brings the release of the oral examination).
Written exam (55% of the points needed for passage).
Oral examination.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student survey.

LITERATURE:

C. Avendano, J. C. Menéndez, MEDICINAL CHEMISTRY OF ANTICANCER DRUGS, Elsevier B.V., 2008.
D. E. Thurston, CHEMISTRY AND PHARMACOLOGY OF ANTICANCER DRUGS, CRS Press, 2007.
M. Mintas, S. Raić-Malić, MEDICINSKA KEMIJA, Medicinska naklada, Zagreb 2009.
J. R. Hanson, CHEMISTRY AND MEDICINES, RSC Publishing, Cambridge, 2006.
R. R. Nadendla, PRINCIPLES OF ORGANIC MEDICINAL CHEMISTRY, New Age International, New Delhi, 2005.

Course: Microwave assisted synthesis		
Language: English		
Lecturer: Dr. Marijana Hranjec, assoc. prof.		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**2**	**30**
Seminar	**0**	**0**
		Overall: 60
		ECTS: 6

PURPOSE:

To introduce students to the principles of microwave synthesis, comparison of classical thermal reactions of organic synthesis with microwave assisted synthesis. Application of microwaves in the synthesis of different classes of organic compounds, with particular emphasis on heterocyclic derivatives.

THE CONTENTS OF THE COURSE:

1st week: Microwave synthesis, introduction. The theory of microwave synthesis and microwaves. Comparison of microwave and classical heating in the synthesis of organic compounds.

2nd week: Microwave ovens. Microwave reactors for organic synthesis. Microwave synthesis techniques. Reactions carried out without a solvent. Water as the solvent. Solid phase synthesis.

3rd week: How to begin with microwave synthesis. Development of microwave methods. The choice of solvent. Optimization of reaction. Monitoring for the reaction. Safety aspects.

4th week: Transition metals as catalysts in the microwave synthesis of heterocycles. Palladium catalysed reactions.

5th week: Scale-up of organic synthesis assisted by microwaves. Limitations and problems in the scale-up microwave synthesis.

6th week: Microwaves in Green Chemistry and sustainability synthesis assisted by microwaves.

7th week: Written assessment by 1st partial exam.

8th week: Overview of microwave synthesis of natural products. Synthesis of steroids and alkaloids. Microwave synthesis of interesting building blocks for natural products.

9th week: Microwave synthesis of heterocyclic compounds. Five-membered heterocycles. Six-membered heterocycles.

10th week: Microwave synthesis of heterocycles with thiophene and furan nucleus. Microwave synthesis of pyridones and their derivatives. β-lactams and their derivatives.

11th week: Microwave synthesis of fused cyclic compounds. Benzimidazoles, benzothiazoles, quinolines, quinolones and their derivatives as biologically active heterocycles.

12th week: Microwave synthesis of heterocycles on the solid phase. Combinatorial microwave synthesis. Use of a polymer in a microwave synthesis.

13th week: Cycloaddition and cyclocondensation reactions in microwave synthesis of heterocycles. Aromatic and non-aromatic five-and six-membered heterocyclic rings.

14th week: Written assessment by 2nd partial exam.

15th week: Oral presentation of seminar assay.

GENERAL AND SPECIFIC COMPETENCE:

After completing the course, students acquire the ability of critical thinking of microwave assisted synthesis, all the possibilities and advantages compared to conventional thermal heating, techniques and equipment.

KNOWLEDGE TESTING AND EVALUATION:

Exams related to laboratory practices.
2 partial written tests during the semester (60% of points on each of the exams brings the release of the oral examination).
Oral presentation of seminar assay.
Written exam (50% of the points needed for passage).
Oral examination.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student survey.

LITERATURE:

C. O. Kappe, D. Dallinger, S. S. Murphree, PRACTICAL MICROWAVE SYNTHESIS FOR ORGANIC CHENMISTS, Wiley-WCH, Weinheim, 2009.
M. Larhed, K. Olofsson, TOPICS IN CURRENT CHEMISTRY 266, Microwave methods in Organic Synthesis, 1-289, Springer-Verlag, Heidelberg, 2006.
Radni materijal s predavanja.
Radni materijal za vježbe (interna skripta).
E. Van der Eycken, C.O.Kappe, TOPICS IN HETEROCYCLIC CHEMISTRY, Microwave-Assisted Synthesis of Heterocycles, 1-301, Springer-Verlag, Heidelberg, 2006.
C. O. Kappe, CONTROLLED MICROWAVE HEATING IN MODERN ORGANIC SYNTHESIS, Angew. Chem. Int. Ed., 43 (2004) 6250-6284.

Course: Antivirotics and Cytostatics		
Language: English		
Lecturer: Prof. Silvana Raić-Malić, PhD.		
TEACHING	**WEEKLY**	**SEMESTER**
Lectures	**2**	**30**
Laboratory	**2**	**30**
Seminar	**0**	**0**
		Overall: 60
		ECTS: 6

PURPOSE:

The main purpose of the course is to familiarize students with the design, synthesis and physiological mechanism of action of some antiviral and anticancer drugs.

THE CONTENTS OF THE COURSE:

Antivirotics

1. Viral diseases, RNA- and DNA viruses, the structure of viruses. Strategy in developing anti-viral drugs.
2. Drugs against diseases caused by herpes viruses and HIV.
3. Nucleoside and non-nucleoside antiviral agents as inhibitors of replication of viral nucleic acid (interferons, zidovudine, acyclovir, idoxuridine, trifluorothymidine).
4. Acyclic and carbocyclic nucleoside analogs.
5. Inhibitors of ribosome translation (methisazone).
6. Protease inhibitors. Inhibitors of gene expression (oligonucleotides). Inhibitors of virus binding process
7. 1st test

Cytostatics

8. Cancer and chemotherapy of cancer. Antimetabolites.
9. Inhibitors of hormone activity. Selective modulators of estrogen receptors.
10. DNA-alkylating agents.
11. DNA-intercalators and topoisomerase inhibitors.
12. Inhibitors of tubules and microtubules formation.
13. Inhibitors of protein and receptor kinases. Proteasome inhibitors.
14. Presenting of seminar paper.
15. 2nd test.

GENERAL AND SPECIFIC COMPETENCE:

To introduce students with the basic principles of organic chemistry in the development of antivirotics and cytostatics, the main representatives of antiviral and anticancer agents and their structural characteristics, synthetic pathways for the preparation of some representatives of antivirotics and cytostatics and mechanisms of action of the compounds according to their targets.

KNOWLEDGE TESTING AND EVALUATION:

Two (2) partial tests during the semester. Students can be released from exam if they collect sufficient points (55) from 2 tests.
Written exam and oral exam.

MONITORING OF THE COURSE QUALITY AND SUCCESSFULNESS:

Student survey.

LITERATURE:

1) C. Avendano, J. C. Menendez, Medicinal Chemistry of Anticancer Drugs, Elsevier, Amsterdam, Belgija, 2008.
2) D. E. Thurston, Chemistry and Pharmacology of Anticancer Drugs, CRC Press, Taylor & Francis Group, New York, USA, 2007.
3) C. K. Chu, Antiviral Nucleosides: Chiral Synthesis and Chemotherapy, Elsevier, Amsterdam, Belgija, 2003.
4) E. De Clercq, Advances in Antiviral Drug Design, Elsevier Science, Ltd., Amsterdam, Belgija, 2004.
5) Mladen Mintas, Silvana Raić-Malić, Medicinska kemija, Medicinska naklada, Zagreb, 2009.
6) Nenad Raos, Silvana Raić-Malić, Mladen Mintas, Lijekovi u prostoru: farmakofori i receptori, Školska knjiga, Zagreb, 2005.