### SPECIALISATION – MATERIALS CHEMISTRY (since academic year 2008/2009)

L – lectures; T – tutorial; S – seminar; Lab – laboratories

**C** – credits are awarded based on continuous assessment; **C/E** – credits are awarded based on continuous assessment and final exam

#### TEACHING HOURS

<table>
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<tr>
<th>Course code</th>
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* - 15 h/student

### ELECTIVE COURSES

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Course title: Physicochemistry of interfaces
Course code: UMA-1
Type of course: obligatory
Level of course: advanced
Year of study: 1\textsuperscript{st} year of the 2\textsuperscript{nd} stage
Semester: I
Number of credits: 5
Name of lecturer: prof. Emilian Chibowski

Objectives of the course (preferably expressed in terms of learning outcomes and competences):
The introduction with basic contents concerning delivered during the course.

Prerequisites: received credits for laboratory and seminar on physical chemistry, passed exam on physical chemistry.

Course contents: 

- **Introduction:** characteristic of interfacial phenomena, capillarity, surface and interface free energy, surface enthalpy and entropy. 
- **Surface of liquids:** surface tension, Young-Laplace's equation, Kelvin's equation, methods of surface tension determination, components of surface tension, temperature dependence of surface tension, the liquid density and surface tension, parachor, surface tension of solutions, Szyszkowski equation, Traube's rule. 
- **Surface of solids:** surface free energy and its components, methods for the energy determination, contact angle and Young's equation, wetting of the solid surface by a liquid - spreading, immersional and adhesional, interfacial solid/liquid free energy. Lifshitz-van der Waals and Lewis acid-base interactions. 
- **Films on liquid surface:** methods of investigation, film pressure, classification - gaseous, liquid and solid films, structure of the films, duplex films, black films, Langmuir-Bludgett's films, bilayers and vesicles. Adsorption from solution on liquid surface: Gibbs adsorption and surface excess, Guggenheim-Adams's reduced surface excess, various definitions of surface excess and interrelationship, Gibbs adsorption equation and Gibbs adsorption isotherm, the adsorbed films and their structure, Gibbs monolayers, two-dimensional film and its gas law. Adsorption at solid/gas interface: description of the phenomenon, physical and chemical adsorption, Henry's equation, Freundlich's isotherm, theory and adsorption isotherm of Langmuir, potential field theory of Polanyi, Dubinin-Radushkevich equation, BET theory and adsorption isotherm, types of the adsorption isotherms, capillary condensation, preparation and structure of adsorbents, classification of adsorbents. Adsorption at solid/liquid interface: Description of the process, adsorption isotherm equation, surface excess and apparent adsorption, the isotherm types, ion exchange process, ion exchangers and their types. 
- **Colloidal systems:** characteristic of colloidal systems and their occurring, methods of preparation, properties of colloidal systems, electric charge of colloids, stability of the systems, DLVO theory of stability.

Recommended reading:


Teaching methods: lectures (30 h), laboratories (30 h)

Assessment methods: written final exam, partial tests during laboratories classes, credit for the lab exercises.

Language of instruction: English

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Course title: Theoretical Chemistry
Course code: UMA-2 and 7
Type of course: obligatory
Level of course: advanced
Year of study: 1\textsuperscript{st} year of the 2\textsuperscript{nd} stage
Semester: I and II
Number of credits: 9
Name of lecturer: prof. Władysław Rudziński and prof. Krzysztof Woliński

Objectives of the course (preferably expressed in terms of learning outcomes and competences):
The main goal is to teach the current methods of computational chemistry and their applications to important chemistry problems. This includes most popular quantum chemistry and statistical thermodynamics methods.

Prerequisites: Fundamentals of linear algebra, mathematical statistics and basic calculus as well as the elementary knowledge of quantum chemistry.

Recommended reading:

Teaching methods: lectures (45 h), tutorials (15), laboratories (30 h)

Assessment methods: exam

Language of instruction: English

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Course title: Crystallography
Course code: UMA-3
Type of course: obligatory
Level of course: advanced
Year of study: 1st year of the 2nd stage
Semester: I
Number of credits: 5
Name of lecturer: prof. Stanislaw Pikus

Objectives of the course (preferably expressed in terms of learning outcomes and competences): description of the molecular and crystal solid phase symmetry as a introduction for crystallochemistry and spectroscopy.

Prerequisites: Knowledge of fundamental concepts of geometry and mathematics.


(laboratory work) Description of the symmetry of molecules and crystal forms (symmetry elements, point groups, crystal systems, stereographic projection of crystal forms symmetry). Lattice symmetry, symmetry elements of lattices. Crystal Chemistry: description of the crystal structure, interpretation of the structural data. Powder X-ray diffraction, DSH method, identification of crystalline phase. Determination of unit cell for cubic crystalline phase.

Recommended reading:

Teaching method: lecture (15h), laboratories (30h)
Assessment methods: exam
Language of instruction: English

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Course title: Solid-state chemistry
Course code: UMA-4
Type of course: obligatory
Level of course: advanced
Year of study: 1st year of the 2nd stage
Semester: I  
Number of credits: 3  
Name of lecturer: prof. Anna Derylo-Marczewska  
Objectives of the course (preferably expressed in terms of learning outcomes and competences): acquaintance of students with the basics of solid-state chemistry useful in various applications in science and technology.  
Prerequisites: advanced level of general chemistry and physical chemistry.  
Recommended reading:  
Teaching methods: lectures (15 h), laboratories (15 h)  
Assessment methods: exam  
Language of instruction: English

Course title: Technology and Properties of New Polymers  
Course code: UMA-5  
Type of course: obligatory  
Level of course: advanced  
Year of study: 1st year of the 2nd stage  
Semester: I  
Number of credits: 4  
Name of lecturer: prof. Barbara Gawdzik / dr Małgorzata Maciejewska  
Objectives of the course (preferably expressed in terms of learning outcomes and competences): The main goal is to present information about world tendencies in polymer chemistry. Attention will be specially focused on technologies and applications of new polymers.  
Prerequisites: Knowledge from organic and macromolecular chemistry.  
Course contents: Polymers of high thermal resistance: polyimides, poly(bismaleimides), poly(amideimides), poly(etherimides), aromatic poly(sulfones) and poly(sulfides), aromatic heterocyclic polymers: poly(benzimidazoles), poly(benzoxazoles), poly(hydantoines), poly(quinoxalines). Polymers of high chemical stabilities: epoxy resins, epoxyacrylic and epoxymethacrylic resins. Fire resistant polymers: polymers containing halogen or nitrogen atoms, role of antipirenes. Liquid crystal-polymers: thermotropic liquid crystal-polymers, liotropic polymers. Biodegradable polymers: aliphatic poly(esters), poly(hydroxyacids), poly(hydroxyesters), poly(lactides) and poly(lactones). Polymers applications in medicine and pharmacy.  
Recommended reading:  
Teaching methods: lectures (30 h), laboratories (30 h)  
Assessment methods: credit (final colloquium)  
Language of instruction: English
**Course title:** Optical Fibres Technology  
**Course code:** UMA-6  
**Type of course:** obligatory  
**Level of course:** advanced  
**Year of study:** 1st year of 2nd stage  
**Semester:** I  
**Number of credits:** 5  
**Name of lecturer:** dr Jan Wójcik  

**Objective of the courses (preferably expressed in terms of learning outcomes and competences):**  
The main goal is to teach the fabrication methods of optical fibres. Also, the basic properties of the different kinds of optical fibres will be done.  

**Prerequisites:** Fundamentals of optics, theory of solids state including glasses.  

**Course contents:** The technical, social and economical reasons of introduction of optical fibres technology. The basics of optical fibres operation, constructional materials, classification of optical fibres according to materials, length of transmission. Definitions of the basic parameters: attenuation, dispersion, numerical aperture, mechanical strength, optical and structural parameters. Spectral attenuation, components of spectral attenuation, attenuation caused by different materials. Theoretical limit of attenuation. Optical purity of materials. Cleanliness of laboratory.  
Technology and kinds of optical cables. Mechanical strength and life-time of optical fibres.  

**Seminar:** Optical cables. Glass technology. Glass fibres technology. Optical glasses. Technical and laboratory glasses. Fused silica glasses. Planar and strip waveguides. Elements of optical fibres technique.  

**Laboratory:** PCS optical fibres, fibre drawing, fibre structure, spectral attenuation, numerical aperture, far-field mode distribution. Multimode fibres, MCVD method, spectral attenuation, determination of attenuation components, bending attenuation. Singlemode fibres, their technology, characteristics, cut-off wavelength, mode-field diameter, spectral attenuation, attenuation as a fiber length function, reflectometry, connectors attenuation, fibres splicing. Optical fibre cables, cables structure, measurements of cables parameters, causes of attenuation increase, battery effect. Mechanical strength of fibres, test machine, histograms, Weibull distribution, proof-test, fibres life-time.  

**Recommended reading:** The literature will be given at the first lecture.  

**Teaching methods:** Lectures (30h), seminar (15h), laboratory (30h)  
**Assessment method:** credit  
**Language of instruction:** English

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**Course title:** Instrumental analysis  
**Course code:** UMA-8  
**Type of course:** obligatory  
**Level of course:** basic  
**Year of study:** 1st year of the 2nd stage  
**Semester:** II  
**Number of credits:** 7  
**Name of lecturer:** prof. Andrzej L. Dawidowicz, assist. prof. Małgorzata Grabarczyk  

**Objectives of the course (preferably expressed in terms of learning outcomes and competences):**  
The aim of the subject is to acquaint the students with most important instrumental analytical methods with regard to the spectroscopic and electrochemical ones. By the end of course student should known the fundaments of chromatographic process and should be able to: optimize the chromatographic separation of...
complex mixtures, chose the most proper chromatographic equipment for chromatographic analysis, understand the problems of chromatographic separation.

Prerequisites: Basic knowledge concerning physical and analytical chemistry.

Course contents: The characterization of chromatographic process; types of chromatography; fundamental chromatographic definitions and chromatographic nomenclature. Resolution and efficiency of chromatographic separation; kinetic theory of concentration zone spreading; the influence of selectivity and efficiency on resolution of chromatographic system. Stationary phases for GC and LC; Columns for GC and LC; Mobile phases for GC and LC. Equipment for GC and HPLC. Qualitative and quantitative analysis by chromatography. Optimization of chromatographic process. Chromatographic separation of non-ionic samples in normal phase and reversed phase systems. Separation of ionic samples in RP systems; Ion pair chromatography. Ion exchange chromatography. Chromatographic separation of macromolecules.

Methods of environmental samples acquiring and problems relative to their proper preparation for the determination with instrumental methods, selection of the proper mineralization method. Division of the instrumental methods into spectroscopic and electrochemical ones with discussion of the basic chemical principles that they are based on.


Voltammetry and voltammetry with preconcentration. Stages of the voltammetric process with preconcentration – exemplary electrode reactions in the course of the individual measurement step. Types of the electrodes in use. Interferences in the voltammetry with preconcentration method and exemplary means of their elimination.


Recommended reading:
1. Lecture notes.
Course title: Spectroscopy
Course code: UMA-9
Type of course: obligatory
Level of course: basic
Year of study: 1\textsuperscript{st} year of the 2\textsuperscript{nd} stage
Semester: II
Number of credits: 4
Name of lecturers: prof. Andrzej Patrykiejew and dr Piotr Borowski

Objectives of the course (preferably expressed in terms of learning outcomes and competences):
The main goal is to teach the interpretation of the IR, Raman, NMR, and MS spectra as well as the basic experimental aspects of molecular spectroscopy.

Prerequisites: Fundamentals of physics, quantum chemistry and organic chemistry.

Course contents:
Interaction of a matter and electromagnetic radiation, theoretical and experimental fundamentals of molecular spectroscopy. Vibrational (IR and Raman) spectra: (i) one-dimensional harmonic oscillator and its spectrum, (ii) anharmonicity, (iii) vibrations of polyatomic molecules (force fields, normal modes, group vibrations), (iv) IR spectroscopy (apparatus, methodology, interpretation of spectra), (v) scattering of the electromagnetic radiation, Raman spectroscopy (apparatus, methodology, interpretation of spectra). NMR spectra: (i) interaction between the magnetic field and the nuclei (the Zeeman effect), (ii) shielding of the nuclei (chemical equivalence), (iii) NMR spectroscopy (apparatus, methodology), (iv) $^1$H NMR spectroscopy (homo-, enantio-, diastereo-, and heterotopic protons, spin-spin coupling, magnetic equivalence, interpretation of spectra), (v) $^{13}$C NMR spectroscopy (decoupling techniques, DEPT techniques, interpretation of spectra). MS spectra: (i) MS spectrometry (sample ionization methods, analyzers, methodology), (ii) fragmentation, (iii) interpretation of spectra. Other techniques: (i) rotational spectroscopy, (ii) electron spectroscopy, (iii) ESR spectroscopy, (iv) photoelectron spectroscopy.

Recommended reading:

Teaching methods: lectures (15 h), laboratories (30 h)
Assessment methods: credit
Language of instruction: English

Elective courses
Course title: Trace analysis; activation analysis and radiochemical methods; chromatographic methods in trace analysis
Course code: PFA-1
Type of course: elective
Level of course: advanced
Year of study: 1\textsuperscript{st} year of the 2\textsuperscript{nd} stage
Semester: I or II
Number of credits: 4
Objectives of the course (preferably expressed in terms of learning outcomes and competences):
Students should: optimize the chromatographic separation of complex mixtures in the context of trace analysis; apply the most important experimental techniques allowing for analytical procedure of traces by chromatography; chose the most proper chromatographic equipment for trace analysis; understand the problems of trace analysis.
Student should be able to: demonstrate an understanding of the basics nuclear spectroscopy analysis; demonstrate an understanding and apply basic radioisotope method of analysis; show a basic level of competency in the practical skills, problem solving, data processing and analysis associated with the field of radioisotope method of analysis.
Moreover, student ought to know: the basic scheme of trace analysis, basic knowledge concerning preparation of samples for trace analysis, how to chose the appropriate method to resolve the problem of analysis of samples with complex matrix, interferences in most commonly used method in trace analysis and their elimination.

Prerequisites: Basic knowledge concerning chromatography, instrumental analysis and physical chemistry. Completion of radiochemistry course. Basic knowledge about instrumental methods of analysis.

Course contents: Chromatographic methods in trace analysis. Sensitivity optimization (injection of large volume sample, effect of column efficiency, effect of column diameter, effect of particle size). Importance of detection in chromatographic trace analysis. Detectors for GC and HPLC. Peak height vs. peak area in quantitative analysis of traces. The most important concepts in trace analysis – LOD, LOQ, baseline noise, signal to noise ratio, operation and dynamic linearity, detector sensitivity, detector time constant, etc. Sample derivatization for chromatographic analysis of trace. Derivatization for GC analysis, derivatization for HPLC analysis. Post-column derivatization. Sample preparation procedures for chromatographic trace analysis.
Isotope dilution analysis - Fundamentals, methods, applications advantages and drawbacks. Direct isotope dilution analysis. Reverse isotope dilution analysis. Derivative IDA. Substechiometric IDA.

Recommended reading:
1. J.R. Dean, Methods for environmental trace analysis, John Willey and Sons, Chichester, 2003.
2. P.R. Loconto, Trace environmental quantitative analysis, principles, techniques and application, Marcel Dekker, Inc. New York, 2006.
5. C.F. Poole, The essence of chromatography, Elsevier Science; Amsterdam, 2002.

Teaching methods: lectures (30 h), laboratories (30 h)
Assessment methods: credits and final exam
Language of instruction: English

Course title: Modern diffraction methods in crystalline state investigations
Course code: PFA-2
Type of course: elective
Level of course: advanced
Year of study: 1st year of the 2nd stage
Semester: I or II
Number of credits: 4
Objectives of the course (preferably expressed in terms of learning outcomes and competences):
The main goal is to teach the current modern X-ray diffraction methods and their applications to characterization of crystalline state.

Prerequisites: Fundamentals of crystallography.


Recommended reading:

Teaching methods: lectures (30 h), laboratories (30 h)

Language of instruction: English
precursors transformation into the final form (drying, calcination, reduction). The modern approach for catalysts design.

**Recommended reading:**

**Teaching methods:** lectures (30 h), laboratories (30 h)

**Assessment methods:** credits and final exam

**Language of instruction:** English

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**Course title:** Physical adsorption on solid surfaces – theoretical bases and applications  
**Course code:** PFA-4  
**Type of course:** elective  
**Level of course:** advanced  
**Year of study:** 1st or second year of the 2nd stage  
**Semester:** I, II or III  
**Number of credits:** 1  
**Name of lecturer:** prof. Andrzej Dąbrowski  

**Objectives of the course (preferably expressed in terms of learning outcomes and competences):**  
An aim of the lecture is the introduction to the adsorption processes, with particular reference to the theoretical description using various models of the solid surface. After the short discussion of historical aspects of the development of the knowledge about the physical adsorption, will be introduced the thermodynamical description of the adsorption of gases, their mixtures and liquid solutions on heterogeneous solid surfaces, and also the indispensable knowledge about the kinetics the adsorption and the molecular modeling of adsorption processes. Finally, examples of the practical application of the adsorption, both in the industry and in the environmental protection will be presented.

**Prerequisites:** the average advanced level of English language, passed exams: physical chemistry and the statistical thermodynamics.


**Recommended reading:**  

**Teaching methods:** lectures (15 h)  
**Assessment methods:** credit or exam  
**Language of instruction:** English

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**Course title:** An outline of green chemistry  
**Course code:** PFA-5  
**Type of course:** elective  
**Level of course:** advanced  
**Year of study:** 1st or second year of the 2nd stage  
**Semester:** I, II or III  
**Number of credits:** 1  
**Name of lecturer:** prof. Janusz Ryczkowski  

**Objectives of the course (preferably expressed in terms of learning outcomes and competences):**
The main goal is to deliver the current knowledge of various aspects in broad area of green chemistry.

**Prerequisites:** Fundamentals of physical chemistry, chemical technology and elementary knowledge of spectroscopy methods.

**Course contents:** Atom economy – principles and examples. Selected solutions in area of homogeneous and heterogeneous catalysis as well as biocatalysis. The use of catalytic systems for pollution abatement with the special emphasis on destruction of volatile organic compounds, reduction of carbon and nitrogen oxides emissions. Examples of technologies improvement will be given, too.

**Recommended reading:**

**Teaching methods:** lectures (15 h)

**Assessment methods:** credit (Power point presentation or poster) or exam

**Language of instruction:** English

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**Course title:** Introduction to heterogeneous catalysis

**Course code:** PFA-6

**Type of course:** elective

**Level of course:** advanced

**Year of study:** 1st or second year of the 2nd stage

**Semester:** I, II or III

**Number of credits:** 2

**Name of lecturer:** prof. Janusz Ryczkowski

**Objectives of the course (preferably expressed in terms of learning outcomes and competences):**
The introduction of students with the basic nomenclature concerning the heterogeneous catalysis, occurring in English-speaking elaborations. Training the students how to write their theoretical chapter of the master thesis, as well as short speeches and presentations in English.

**Prerequisites:** English knowledge at the average advanced level, passed an exam in chemical technology, the skill of using selected components of the MS Office pack.

**Course contents:** The basic nomenclature, the preparation of catalysts, the characterization of supports and catalysts, industrial examples of catalytic reactions, catalysts deactivation, application of physicochemical methods for the catalysts characterization. The detailed course contents will be established with the students according to their interest.

**Recommended reading:** All available manuals and specialistic scientific periodicals in English, and also internet resources of the Main Faculty Library of UMCS.

**Teaching methods:** tutorials (30 h)

**Assessment methods:** credit (on the ground of a prepared poster or PowerPoint presentation as well as a 6-page elaboration in English, in the form of a camera-ready text for a perspective publication) or exam.

**Language of instruction:** English