Zał. Nr 1 do ZW 78/2023

PROGRAM OF STUDIES

FACULTY: **Chemistry**

MAIN FIELD OF STUDY: **Advanced Nano and Biomaterials - MONABIPHOT**

BRANCH OF SCIENCE: **engineering and technology**(major)**/ natural sciences**

DISCIPLINES: D1 **materials engineering** (major discipline)

D2* **chemical sciences**

EDUCATION LEVEL: **second-level studies** (4-semester)

FORM OF STUDIES: **full-time studies**

PROFILE: **general academic**

LANGUAGE OF STUDY: **English**

Content:

Resolution no. … of the Senate of Wroclaw University of Science and Technology

In effect since 2024/2025

Zał. Nr 2 do ZW 78/2023
Attachment no. 1. to the Program of Studies

ASSUMED LEARNING OUTCOMES

FACULTY: **Chemistry**
MAIN FIELD OF STUDY: **Advanced Nano and Biomaterials - MONABIPHOT**
EDUCATION LEVEL: **second-level studies**
PROFILE: **general academic**

Location of the main-field-of study:

Branch of science: **engineering and technology** Discipline: **materials engineering**

Branch of science: **natural sciences** Discipline: **chemical sciences**

Explanation of the markings:
Reference to PRK characteristics:
P7U – universal first-degree characteristics corresponding to education at the second-level studies - 7 PRK level
P7S – second degree characteristics corresponding to education at the second-level studies - 7 PRK level

after the underscore:
W – category "knowledge" (extension: G = depth and scope, K = context),
U – category "skills" (extension: W = use of knowledge, K = communication, O = work organization, U = learning),
K – category "social competences" (extension: K = critical assessment, O = responsibility, R = professional role),
INŻ – learning outcomes leading to obtaining engineering competences.

Symbols of main field of study learning outcomes at the second cycle of studies for the Advanced Nano and Biomaterials – MONABIPHOT(an)

before the underscore:
K – directional learning outcomes,
2 – second cycle of studies
A – general academic profile
an – direction code,
after the underscore:
W – knowledge category, **U** – skills category, **K** – social competence category

Main field of study learning outcomes	Description of learning outcomes for the main-field-of study **Advanced Nano and Biomaterials - MONABIPHOT** After completion of studies, the graduate:	Reference to PRK characteristics		
		Universal first degree characteristics (U)	Second degree characteristics typical for qualifications obtained in higher education (S)	
			Characteristics for qualifications on 6 / 7* levels of PRK	Characteristics for qualifications on 6 and 7 levels of PRK, enabling acquiring engineering competences
KNOWLEDGE (W)				
K2Aan_W01	Has in-depth knowledge of the composition, method of synthesis and characterization of nanomaterials and biomaterials. Has knowledge of the applications of nanomaterials and biomaterials as well as the selection of the appropriate method for characterizing this type of materials.	P7U_W	P7S_WG	P7S_WG_INŻ
K2Aan_W02	Knows methods of producing metallic, polymeric and biomaterials. Understands the impact of various additives on the properties of manufactured materials.	P7U_W	P7S_WG	P7S_WG_INŻ
K2Aan_W03	Has structured knowledge of the physical fundamentals of the interaction of electric fields, magnetic fields and electromagnetic waves with a liquid crystal. Has knowledge of the classification of liquid crystals in terms of their structure, symmetry, factor causing the formation of mesophases and spatial structures.	P7U_W	P7S_WG	P7S_WG_INŻ
K2Aan_W04	Has in-depth knowledge of modern methods of imaging materials using various microscopic techniques.	P7U_W	P7S_WG	P7S_WG_INŻ
K2Aan_W05	Has basic knowledge of selecting and fitting a mathematical model to experimental data.	P7U_W	P7S_WG	
K2Aan_W06	Knows the factors determining the mechanical and functional properties of the main engineering materials: metals, alloys, polymers and nanomaterials, knows their structure, examples of applications and the impact of additives on the properties of these materials.	P7U_W	P7S_WG	P7S_WG_INŻ
K2Aan_W07	Knows issues of the construction of lasers and other light sources and the generation of electromagnetic radiation in selected spectral ranges. Knows the effects of EM radiation on matter.	P7U_W	P7S_WG	P7S_WG_INŻ
K2Aan_W08	Has structured, theoretically based general knowledge covering key issues in the field of spectroscopy. Knows the light sources used in spectroscopy. Knows new trends in spectroscopy.	P7U_W	P7S_WG	

K2Aan_W09	Knows the concepts and principles of intellectual property protection, patent protection and copyright.	P7U_W	P7S_WK	
K2Aan_W10	Has knowledge about authorized inference methods.	P7U_W	P7S_WK	
K2Aan_W11	Knows the basic concepts of entrepreneurship and the functioning of an enterprise. Has basic knowledge of management processes and related organizational structures. Knows the basic elements of organizing a business.	P7U_W	P7S_WK	P7S_WK_INŻ
K2Aan_W12	Has in-depth knowledge of the technology of combining materials using physical and chemical methods.	P7U_W	P7S_WG	P7S_WK_INŻ
K2Aan_W13	Has knowledge of the chemical and physical characteristics of materials and their impact on their functional properties	P7U_W	P7S_WG	
K2Aan_W14	Understands the connection between the technology of obtaining materials and composites and their structure and properties.	P7U_W	P7S_WG	
K2Aan_W15	Has general knowledge of research conducted in modern materials engineering and nanomaterials engineering.	P7U_W	P7S_WG	
K2Aan_W16	Lists and explains advanced processes in creating new materials and current trends in their development.	P7U_W	P7S_WG	
K2Aan_W17	Has in-depth knowledge of mathematical and IT tools enabling understanding, quantitative description, modeling and design of materials or engineering objects or chemical/biotechnological processes.	P7U_W	P7S_WG	P7S_WG_INŻ
K2Aan_W18	Has in-depth knowledge of exact and natural sciences as well as engineering and technology, allowing the use of methods and concepts necessary to describe materials, chemical or biotechnological processes.	P7U_W	P7S_WG	P7S_WG_INŻ
SKILLS (U)				
K2Aan_U01	Is able to assess the behavior of nanomaterials, biomaterials and polymers in various conditions.	P7U_U	P7S_UW	P7S_UW_INŻ
K2Aan_U02	Is able to design experiments for nanomaterials, polymeric materials and biomaterials.	P7U_U	P7S_UW P7S_UK	P7S_UW_INŻ
K2Aan_U03	Is able to conduct literature research on a specific scientific and research problem. Has basic skills in planning and conducting scientific research.	P7U_U	P7S_UU P7S_UK	
K2Aan_U04	Is able to conduct scientific experiments, develop and interpret their results and relate them to appropriate theories or scientific hypotheses. Is able to determine directions for further learning and implement the self-education process. Is able to apply the principles of safe work in a chemical laboratory.	P7U_U	P7S_UU P7S_UK P7S_UW	P7S_UW_INŻ
K2Aan_U05	Is able to present the goals and results of his scientific work in the form of an oral presentation, using modern information and communication techniques. Is able to prepare, in Polish or a foreign	P7U_U	P7S_UK P7S_UW	P7S_UW_INŻ

	language, a scientific study presenting the results of his/her own scientific research.			
K2Aan_U06	Has linguistic resources appropriate for a specialized language and is able to use the specialized language in all linguistic activities to communicate in a professional environment in the field of study, understands foreign language texts in his field of study and is able to interpret them.	P7U_U	P7S_UW P7S_UK	
K2Aan_U07	Has language skills in the fields of science and scientific disciplines relevant to the field of study studied, in accordance with the requirements specified for levels A1/A2 and B2+ of the Common European Framework of Reference for Languages.	P7U_U	P7S_UW P7S_UK	
K2Aan_U08	Is able to think critically and argue his position.	P7U_U	P7S_UK	
K2Aan_U09	Is able to identify the priorities of his actions, both individually and when working in a group.	P7U_U	P7S_UW P7S_UO	
K2Aan_U10	Is able to independently plan and implement continuous training and guides others in this area	P7U_U	P7S_UU	
K2Aan_U11	Is able to determine the chemical, physicochemical and mechanical properties of materials and nanostructures	P7U_U	P7S_UW P7S_UK	
K2Aan_U12	Uses information technologies to solve tasks, including engineering ones. Selects and applies mathematical and IT methods/tools in planning, designing, optimizing and analyzing experiments, objects and chemical processes.	P7U_U	P7S_UW	P7S_UW_INŻ
K2Aan_U13	Is able to investigate photochemical phenomena occurring in nano and biomaterials.	P7U_U	P7S_UW P7S_UK	P7S_UW_INŻ
K2Aan_U14	Is able to conduct a research experiment in the field of liquid crystals.	P7U_U	P7S_UW P7S_UK	
K2Aan_U15	Is able to independently develop and present the state of knowledge based on scientific publications.	P7U_U	P7S_UW P7S_UK	
K2Aan_U16	Is able to independently perform material tests using advanced techniques, and is able to analyze and interpret the obtained results.	P7U_U	P7S_UW P7S_UK	P7S_UW_INŻ
K2Aan_U17	Applies microscopic techniques for qualitative and quantitative interpretation of chemical, physical and biological phenomena	P7U_U	P7S_UW P7S_UK	P7S_UW_INŻ
SOCIAL COMPETENCES (K)				
K2Aan_K01	is ready to critically evaluate his knowledge and received content.	P7U_K	P7S_KK	
K2Aan_K02	understands the need for entrepreneurial thinking and action and is aware of the need to act in the public interest.	P7U_K	P7S_KO	
K2Aan_K03	understands the need to take initiatives, inspire and organize activities for the benefit of the socio-economic environment.	P7U_K	P7S_KO	
K2Aan_K04	cooperates responsibly in the group, taking on various roles, including managerial ones.	P7U_K	P7S_KR	

K2Aan_K05	is ready to comply with the principles of professional ethics and respect the law, including copyright.	P7U_K	P7S_KR	
K2Aan_K06	recognizes the importance and understands the non-technical aspects and consequences of scientific and engineering activities, including their impact on the environment, as well as the associated responsibilities.	P7U_K	P7S_KK P7S_KO	
K2Aan_K07	is aware of the social role of a technical university graduate and the need to maintain the ethos of the engineering profession.	P7U_K	P7S_KR	
K2Aan_K08	is ready to recognize the importance of knowledge in solving problems in the field of study and related sciences; recognizes the need to seek expert opinion when difficulties arise in solving problems.	P7U_K	P7S_KK	

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Attachment no. 2. to the Program of Studies

DESCRIPTION OF THE PROGRAM OF STUDIES

Main field of study: Advanced Nano and Biomaterials - MONABIPHOT	**Profile:** general academic
Level of studies: 2nd level studies (4 sem. magisterskie)	**Form of studies:** full-time

1. General description

1.1 Number of semesters: ***4***	*1.2 Total number of ECTS points necessary to complete studies at a given level:* ***120***
1.3 Total number of hours: ***1515***	*1.4 Prerequisites (particularly for second-level studies):* ***are set out in the Order-"The conditions and procedures for recruitment" in the Wroclaw University of Science and Technology***
1.5 Upon completion of studies graduate obtains professional degree of: ***magister inżynier***	*1.6 Graduate profile, employability:* *The alumnus has theoretical knowledge and skills enabling him to solve issues related to the design and characterization of modern materials, including nanomaterials, biomaterials and materials interacting with light. He/she has in-depth practical and theoretical knowledge of the field of advanced nano and biomaterials, he/she represents. Has the ability to interpret and quantitatively describe basic physicochemical phenomena, conduct laboratory and research work, and manage teams and organize the work of such*

	teams. He/she fluently speaks specialized language in the field of research on bio and nanomaterials as well as liquid crystals and polymers. He/she is prepared to start studies at the Doctoral School. The alumnus knows the basics of programming and uses the Internet efficiently.
1.7 Possibility of continuing studies: ***Possibility to apply for admission to the Doctoral School, postgraduate studies***	***1.8 Indicate connection with University's mission and its development strategy:*** *The mission and strategy of Wrocław University of Science and Technology were defined in the document entitled: "Strategy of Wrocław University of Science and Technology 2023-2030". The second-cycle study program in* ***Advanced Nano and Biomaterials-Monabiphot*** *fits into the key areas of the strategy and the overarching strategic goals both in the area of education, scientific research and cooperation with the environment. It is also consistent with the mission of "creating and transmitting knowledge that responds to new challenges and opportunities emerging before society, economy and civilization.* *The study program is consistent with the strategic goals by: (1) developing creative skills in the nature of scientific work through an increased number of classes related to the completion of a diploma thesis, (2) a large share (over 50%) of active classes, such as laboratories, exercises, seminars and projects , (3) ensuring a balance between the general and specialized knowledge, (4) providing students with knowledge and skills covering the latest achievements of science in the field of innovative material technologies, (5) developing social competences, with particular*

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

	emphasis on the development of skills teamwork, (6) developing the ability to work using the project method.

2. Detailed description

2.1 Total number of learning outcomes in the program of study: W (knowledge)= 18, U (skills) = 17, K (competences) = 8, W + U + K = 43

2.2 For the main field of study assigned to more than one discipline - the number of learning outcomes assigned to the discipline:

D1 26 (major) (this number must be greater than half the total number of learning outcomes)

D2 17

2.3 For the main field of study assigned to more than one discipline - percentage share of the number of ECTS points for each discipline:

D1 60% ECTS points

D2 40% ECTS points

2.4a. For the general academic profile of the main field of study – the number of ECTS points assigned to the classes related to the University's academic activity in the discipline or disciplines to which the main field of study is assigned – DN (must be greater than 50% of the total number of ECTS points from 1.2)

83 pkt ECTS

2.4b. For the practical profile of the main field of study - the number of ECTS points assigned to the classes shaping practical skills (must be greater than 50% of the total number of ECTS points from 1.2)

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
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2.5 Concise analysis of compliance of the assumed learning outcomes with the needs of the labor market

The labor market needs in the field of **Advanced Nano and Biomaterials - MONABIPHOT** are indirectly presented in this Study Program under the heading Profile of the graduate, employment opportunities. The preparation of graduates listed there is reflected, among others, in the following learning outcomes: (1) Knows methods of producing metallic, polymeric and biomaterials. Understands the influence of various additives on the properties of manufactured materials, (2) Has basic knowledge of the selection and adjustment of a mathematical model to experimental data., (3) Is able to assess the behavior of nanomaterials and biomaterials as well as polymers in various conditions, (4) Is able to design experiments for nanomaterials, polymeric materials and biomaterials. (5) Is able to independently perform material tests using advanced techniques, and is able to analyze and interpret the obtained results. The expected learning outcomes are in line with the current needs of the sector of design, production and processing of modern materials used in various industries. The learning outcomes are tailored in such a way that the graduate is ready to start working in companies dealing with quality control and characterization of manufactured/processed modern organic materials, liquid crystals, nanomaterials, biomaterials and polymeric materials.

2.6. The total number of ECTS points that a student must obtain in classes requiring direct participation of academic teachers or other persons conducting classes and students (enter the sum of ECTS points for subjects / groups of classes marked with the BU[1] code)

68,4 ECTS

2.7. Total number of ECTS points, which student has to obtain from basic sciences classes

Number of ECTS points for obligatory subjects	4
Number of ECTS points for optional subjects	0
Total number of ECTS points	**4**

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
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2.8. Total number of ECTS points, which student has to obtain from practical classes, including project and laboratory classes (enter total number of ECTS points for subjects/group of classes denoted with code P)

Number of ECTS points for obligatory subjects	38
Number of ECTS points for optional subjects	32
Total number of ECTS points	**70**

2.9. Minimum number of ECTS points, which student has to obtain doing education blocks offered as part of University-wide classes or other main field of study (enter number of ECTS points for subjects/group of classes denoted with code O)

8 ECTS points

2.10. Total number of ECTS points, which student may obtain doing optional blocks (min. 30% of total number of ECTS points)

41 ECTS points

3. Description of the process leading to learning outcomes acquisition:

Verification and assessment of learning outcomes with reference to courses or groups of courses throughout the entire education cycle takes place in relation to the information contained in the subject cards (syllabuses).

The student acquires knowledge and skills by participating in theoretical and practical classes, which are largely based on the results of scientific research conducted by academic teachers - course tutors conducting classes with students. The basis of teaching and learning process are laboratory, seminar and project courses. Education in the field of studies is conducted in accordance with the principle of increasing the complexity of theoretical and practical tasks set for students. Modern teaching methods are implemented in the teaching practice, thanks to which the students' activity during the classes increases. Theoretical courses in the form of lectures and seminars are supplemented with project and laboratory classes, which include, among others: computer modelling and design, as well as conducting scientific research. The program is complemented by humanities and foreign language courses. The course (study programme) ends with a master thesis preparation and its defence checking the student's theoretical knowledge.

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

4. List of education blocks:

4.1. List of obligatory blocks:

4.1.1 List of general education blocks

4.1.1.1 ***Liberal-managerial subjects*** **block** *(min. ..... ECTS points):*

No.	Subject group of classes code	Name of Subject group of classes (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of Subject group of courses	Way[3] of crediting	Subject group of classes			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University-wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
		Total																	

4.1.1.2 ***Foreign languages*** **block** *(min. ..... ECTS points):*

No.	Subject group of classes code	Name of Subject group of classes (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of Subject group of courses	Way[3] of crediting	Subject group of classes			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University-wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
		Total																	

4.1.1.3 ***Sporting classes*** **block** *(0 ECTS points):*

No.	Subject group of classescode	Name of Subject group of classes (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of Subject group of courses	Way[3] of crediting	Subject group of classes			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University-wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
		Total																	

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

4.1.1.4 *Information technologies* block *(min. .... ECTS points):*

No.	Subject group of classes code	Name of Subject group of classes (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of Subject group of courses	Way[3] of crediting	Subject group of classes			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University -wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
		Total																	

Altogether for general education blocks

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Total number of ECTS points for DN classes[5]	Number of ECTS points for BU classes[1]
lec	cl	lab	pr	sem					

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

4.1.2 List of basic sciences blocks

4.1.2.1 *Mathematics* block

No.	Subject group of classescode	Name of Subject group of classes (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of Subject group of courses	Way[3] of crediting	Subject group of classes			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University-wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1	W03ANB-SM2007L	Mathematical methods in planning and analysis of experiment			2			K2Aan_W05 K2Aan_W10 K2Aan_W17 K2Aan_U06 K2Aan_U08 K2Aan_U12	30	50	2		1,4	T	Z			P	PD
		Total			**2**				**30**	**50**	**2**		**1,4**					**2**	

4.1.2.2 *Physics* block

No.	Subject group of classes code	Name of Subject group of classes (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of Subject group of courses	Way[3] of crediting	Subject group of classes			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University-wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
		Total																	

4.1.2.3 *Chemistry* block

No.	Subject group of classes code	Name of Subject group of classess (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of Subject group of courses	Way[3] of crediting	Subject group of classes			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University-wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1	W03ANB-SM2002W	Modern spectroscopy	2					K2Aan_W07 K2Aan_W08	30	50	2	2	1,3	T/Z	**E**		DN		PD
		Total	**2**						**30**	**50**	**2**	**2**	**1,3**		**1**				

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

Altogether for basic sciences blocks:

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Total number of ECTS points for DN classes[5]	Number of ECTS points for BU classes[1]
lec	cl	lab	pr	sem					
2		**2**			**60**	**100**	**4**	**2**	**2,7**

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

4.1.3 List of the main field of study blocks

4.1.3.1 *Obligatory main field of study* blocks

No.	Subject group of classes code	Name of Subject group of classes (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of Subject group of courses	Way[3] of crediting	Subject group of classes			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University-wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1	W03W03-SM2018L	Informatics for engineers			2			K2Aan_U12 K2Aan_W17	30	50	2		1,4	T	Z			P	K
2	W03W03-SM2007W	Biotechnology with introduction to industrial microbiology	2					K2Aan_W01 K2Aan_W18	30	50	2	2	1,3	T/Z	Z		DN		K
3	W03W03-SM2019P	Biotechnology with introduction to industrial microbiology				1		K2Aan_U03 K2Aan_U08 K2Aan_U10	15	50	2	2	0,75	T/Z	Z		DN	P	K
4	W03W03-SM2025P	Basics of technical drawing				2		K2Aan_U12	30	50	2		1,5	T	Z			P	K
5	W03W03-SM2026W	Technical safety in industry	1					K2Aan_W14	15	25	1		0,65	T/Z	Z				K
6	W03W03-SM2026L	Technical safety in industry			1			K2Aan_U04	15	25	1		0,7	T	Z			P	K
7	W03W03-SM2027W	Material recovery and recycling	2					K2Aan_W02 K2Aan_W18	30	50	2	2	1,3	T/Z	Z		DN		K
8	W03W03-SM2028W	Fundamentals of chemical and process engineering	2					K2Aan_W17 K2Aan_W18	30	50	2		1,3	T/Z	**E**				K
9	W03W03-SM2028P	Fundamentals of chemical and process engineering				2		K2Aan_U08 K2Aan_U12	30	50	2		1,5	T/Z	Z			P	K
10	W03W03-SM2029W	Bioreactors	2					K2Aan_W18	30	50	2	2	1,3	T/Z	**E**		DN		K
11	W03W03-SM2029L	Bioreactors			2			K2Aan_U02 K2Aan_U04 K2Aan_U12	30	50	2	2	1,4	T	Z		DN	P	K
12	W03W03-SM2003W	Introduction to materials science and engineering	2					K2Aan_W01 K2Aan_W18 K2Aan_W06 K2Aan_W02	30	50	2		1,3	T/Z	Z				K
13	W03W03-SM2030W	Fundamentals of chemical technology design	2					K2Aan_W05 K2Aan_W17	30	75	3		1,3	T/Z	**E**				K
14	W03W03-SM2030P	Fundamentals of chemical technology design				2		K2Aan_U12	30	50	2		1,5	T/Z	Z			P	K
15	W03W03-SM2025W	Separation and purification of products	1					K2Aan_W18	15	25	1	1	0,65	T/Z	Z		DN		K

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

16	W03W03-SM2025L	Separation and purification of products			2			K2Aan_U02 K2Aan_U04	30	50	2	2	1,4	T	Z		DN	P	K
17	W03ANB-SM2006W	Liquid crystals for photonics	2					K2Aan_W03 K2Aan_W15	30	75	3	3	1,3	T/Z	**E**		DN		K
18	W03ANB-SM2006L	Liquid crystals for photonics.			1			K2Aan_W03 K2Aan_U04 K2Aan_U11 K2Aan_U14	15	25	1	1	0,7	T	Z		DN	P	K
19	W03ANB-SM2005W	Modern polymers	2					K2Aan_W01 K2Aan_W15 K2Aan_W18	30	50	2		1,3	T/Z	Z				K
20	W03ANB-SM2004W	Bioorganic chemistry	2					K2Aan_W13 K2Aan_W14 K2Aan_W15	30	75	3	3	1,3	T/Z	**E**		DN		K
21	W03ANB-SM2003W	Biophotonics	1					K2Aan_W07 K2Aan_W13	15	50	2		0,65	T/Z	Z				K
22	W03ANB-SM2003S	Biophotonics.					2	K2Aan_W07 K2Aan_U05 K2Aan_U06 K2Aan_U08	30	50	2		1,4	T/Z	Z			P	K
23	W03ANB-SM2001W	Fluorescence spectroscopy and bioimaging	2					K2Aan_W07 K2Aan_W13	30	75	3	3	1,3	T/Z	Z		DN		K
24	W03ANB-SM2001C	Fluorescence spectroscopy and bioimaging.		1				K2Aan_U12 K2Aan_U17 K2Aan_U16	15	25	1	1	0,7	T/Z	Z		DN	P	K
25	W03ANB-SM2014W	Advanced functional materials	2					K2Aan_W02 K2Aan_W04 K2Aan_W06 K2Aan_W12 K2Aan_W16 K2Aan_W18	30	50	2	2	1,3	T/Z	**E**		DN		K
26	W03ANB-SM2014S	Advanced functional materials.					2	K2Aan_W12 K2Aan_W15 K2Aan_U05 K2Aan_U06 K2Aan_U08 K2Aan_K07	30	50	2	2	1,4	T/Z	Z		DN	P	K
27	W03ANB-SM2013W	Advanced research methods in the engineering of materials	2					K2Aan_W07 K2Aan_W14	30	50	2	2	1,3	T/Z	**E**		DN		K
28	W03ANB-SM2013C	Advanced research methods in the engineering of materials		1				K2Aan_W14 K2Aan_U02	15	25	1	1	0,7	T/Z	Z		DN	P	K

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

								K2Aan_U11 K2Aan_K08											
29	W03ANB-SM2013L	Advanced research methods in the engineering of materials			1			K2Aan_W14 K2Aan_U02 K2Aan_U13 K2Aan_U16 K2Aan_K08	15	50	2	2	0,7	T	Z		DN	P	K
30	W03ANB-SM2012W	Organic electronics	1					K2Aan_W07 K2Aan_W13	15	25	1	1	0,65	T/Z	Z		DN		K
31	W03ANB-SM2012S	Organic electronics.					1	K2Aan_W13 K2Aan_W15 K2Aan_U05 K2Aan_U06 K2Aan_U08	15	25	1	1	0,7	T/Z	Z		DN	P	K
32	W03ANB-SM2011W	Nanomaterials	2					K2Aan_W06 K2Aan_W13 K2Aan_W18	30	50	2	2	1,3	T/Z	**E**		DN		K
33	W03ANB-SM2011S	Nanomaterials.					1	K2Aan_W13 K2Aan_W15 K2Aan_U05 K2Aan_U06 K2Aan_U08 K2Aan_K07	15	25	1	1	0,7	T/Z	Z		DN	P	K
34	W03ANB-SM2010W	Nanoscale physics	2					K2Aan_W04 K2Aan_W06 K2Aan_W12	30	50	2	2	1,3	T/Z	Z		DN		K
35	W03ANB-SM2010L	Nanoscale physics.			1			K2Aan_W12 K2Aan_U04 K2Aan_U09 K2Aan_U13 K2Aan_U16 K2Aan_K05	15	50	2	2	0,7	T	Z		DN	P	K
36	W03ANB-SM2009L	Nonlinear optics for Chemists.			1			K2Aan_W07 K2Aan_U04	15	50	2	2	0,7	T	Z		DN	P	K
37	W03ANB-SM2008W	Laser and microscopic techniques in materials analysis	2					K2Aan_W02 K2Aan_W04 K2Aan_W12 K2Aan_W15	30	50	2	2	1,3	T/Z	Z		DN		K
38	W03ANB-SM2014L	Advanced functional materials..			6			K2Aan_W04 K2Aan_W12 K2Aan_U01 K2Aan_U04	90	150	6	6	4,2	T	Z		DN	P	K

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

								K2Aan_U09 K2Aan_U10 K2Aan_U12 K2Aan_U13 K2Aan_U15 K2Aan_U16 K2Aan_U17										
		Total	**34**	**2**	**17**	**7**	**6**		**990**	**1875**	**75**	**52**	**44,85**		**8**			**36**	

Altogether (for main field of study blocks):

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Total number of ECTS points for DN classes[5]	Number of ECTS points for BU classes[1]
lec	cl	lab	pr	sem					
34	**2**	**17**	**7**	**6**	**990**	**1875**	**75**	**52**	**44,85**

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

4.2 List of optional blocks

4.2.1 List of general education blocks

4.2.1.1 Liberal-managerial subjects blocks *(min. 5 ECTS points):*

No.	Subject group of classes code	Name of Subject group of classes (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of Subject group of courses	Way[3] of crediting	Subject group of classes			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University-wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1	W03-SM2002BH	Managerial course I	1					K2Aan_K02 K2Aan_K03 K2Aan_K07	15	60	2		0,65	T/Z	Z	O			KO
2	W03-SM2001BH	Managerial course II	2					K2Aan_W11 K2Aan_K02 K2Aan_K03 K2Aan_K07	30	90	3		1,3	T/Z	Z	O			KO
		Total	**3**						**45**	**150**	**5**		**1,95**						

4.2.1.2 ***Foreign languages*** **block** *(min. 3. ECTS points):*

No.	Subject group of classes code	Name of Subject group of classes (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of Subject group of courses	Way[3] of crediting	Subject group of classes			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University-wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1	SJO-SM0003	Foreign language II		3				K2Aan_U07 K2Aan_U10 K2Aan_K01 K2Aan_K04	45	60	2		1,8	T/Z	Z	O		P	KO
2	SJO-SM0004	Foreign language I		1				K2Aan_U07 K2Aan_U10 K2Aan_K01 K2Aan_K04	15	30	1		0,6	T/Z	Z	O		P	KO
		Total		**4**					**60**	**90**	**3**		**2,4**					**3**	

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

Altogether for general education blocks:

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Total number of ECTS points for DN classes[5]	Number of ECTS points for BU classes[1]
lec	cl	lab	pr	sem					
3	**4**				**105**	**240**	**8**		**4,35**

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

4.2.2 List of basic sciences blocks

4.2.2.1 *Mathematics* block *(min. .... ECTS points):*

No.	Subject group of classes code	Name of Subject group of classes (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of Subject group of courses	Way[3] of crediting	Subject group of classes			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University -wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
		Total																	

4.2.2.2 *Physics* block *(min. .... ECTS points):*

No.	Subject group of classes code	Name of Subject group of classes (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of Subject group of courses	Way[3] of crediting	Subject group of classes			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University -wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
		Total																	

4.2.2.3 *Chemistry* block *(min. .... ECTS points):*

No.	Subject group of classes code	Name of Subject group of classes (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of Subject group of courses	Way[3] of crediting	Subject group of classes			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University -wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
		Total																	

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

Altogether for general basics sciences blocks:

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Total number of ECTS points for DN classes[5]	Number of ECTS points for BU classes[1]
lec	cl	lab	pr	sem					

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

4.2.3 List of the main field of study blocks

4.2.3.1 *Diploma profile* block *(min. 29 ECTS points):*

No.	Subject group of classes code	Name of Subject group of classes (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of Subject group of courses	Way[3] of crediting	Subject group of classes			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University -wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1	W03W03-SM2053S	Graduation proseminar					1	K2Aan_U08 K2Aan_U15 K2Aan_K01 K2Aan_K07	15	25	1	1	0,7	T/Z	Z		DN	P	K
2	W03W03-SM2054D	Graduate laboratory I			4			K2Aan_U03 K2Aan_U04 K2Aan_U09 K2Aan_K01 K2Aan_K05 K2Aan_K07	60	150	6	6	3	T	Z		DN	P	K
3	W03W03-SM2055D	Graduate laboratory II			14			K2Aan_U03 K2Aan_U04 K2Aan_U09 K2Aan_U10 K2Aan_U13 K2Aan_K01 K2Aan_K05 K2Aan_K07	210	500	20	20	9,5	T	Z		DN	P	K
4	W03W03-SM2056S	Graduation seminar					1	K2Aan_U05 K2Aan_U08 K2Aan_K01 K2Aan_K06 K2Aan_K07 K2Aan_K08	15	50	2	2	0,7	T/Z	Z		DN	P	K
		Total			**18**		**2**		**300**	**725**	**29**	**29**	**13,9**					**29**	

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

4.2.3.2 *Optional courses* block

No.	Subject group of classes code	Name of Subject group of classes (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of Subject group of courses	Way[3] of crediting	Subject group of classes			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University -wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1	W03ANB-SM20BW	Elective course*	4					K2Aan_W16 K2Aan_K08	60	100	4		2,6	T/Z	Z				K
		Total	**4**						**60**	**100**	**4**		**2,6**						

List of elective course*

No.	Subject group of classes code	Name of Subject group of classes (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of Subject group of courses	Way[3] of crediting	Subject group of classes			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University -wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1	W03ANB-SM2101w	Nonlinear optics for Chemists.	2						30	50	2		1,3	T/Z	Z				K
2	W03ANB-SM2102w	Biomaterials	2						30	50	2		1,3	T/Z	Z				K
3	W03ANB-SM2103w	Metallic materials	2						30	50	2		1,3	T/Z	Z				K
4	W03ANB-SM2104w	Basics molecular dynamics	2						30	50	2		1,3	T/Z	Z				K

Altogether for (main field of study) blocks:

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Total number of ECTS points for DN classes[5]	Number of ECTS points for BU classes[1]
lec	cl	lab	pr	sem					
4		**18**		**2**	**360**	**825**	**33**	**29**	**16,5**

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

4.3 Training block - concerning principles of training crediting – attachment no.

Not applicable

Opinion of the Advisory Faculty Council concerning the rules of crediting training block

Name of training			
Number of ECTS points	**Number of ECTS points for BU[1] classes**	**Training crediting mode**	**Code**

Training duration	Training objective

4.4 „Diploma dissertation" block

Type of diploma dissertation	~~Licencjat / inżynier /~~ magister / magister inżynier*	
Number of diploma dissertation semesters	**Number of ECTS points**	**Code**
3	**29**	W03W03-SM2053S W03W03-SM2054D W03W03-SM2055D W03W03-SM2056S
Character of diploma dissertation		
Thesis of the second cycle (master) should have traits of scientific, experimental or theoretical, with a primary or practical. Work should lead to new results of original research or technical and technological solutions, and its presentation in the form of written work should include the results and show the knowledge and skills of the author, including but not limited to:(1)The ability to formulate objectives and research questions; (2)Ability to use literature and other sources of knowledge ;(3)The ability to plan and carry out research and other activities to achieve its objectives and problems; (4)Ability to correctly interpret the results; (5)Ability to use precise and clear language and the proper matching of the images presented to illustrate the problem.		
Number of BU[1] ECTS points	**13,9**	

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

5. Ways of verifying assumed learning outcomes

Form of classes	Ways of verifying assumed learning outcomes
lecture	e.g. examination, progress/final test
class	e.g. progress/final test
laboratory	e.g. pretest, report from laboratory
project	e.g. project defence
seminar	e.g. participation in discussion, topic presentation, essay
diploma dissertation	prepared diploma dissertation

6. Range of diploma examination

1. Chemistry and physical chemistry of nano- and bio- materials
2. Methods of design of nano- and bio-materials
3. Engineering of nano- and bio-materials - selected issues

7. Requirements concerning deadlines for crediting subject/groups of subject for all courses in particular blocks

Each course should be passed in accordance with the study plan. If it is necessary to repeat a course, it should be completed in the next semester in which it is offered.

***T/Z** Remote form of classes requires Dean's approved, but cannot exceed 75 % of ECTS points.
T/Z option is accepted only for lectures, exercises and seminars

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

8. Plan of studies (attachment no.4)

Approved by faculty student government legislative body:

.....	.....
Date	name and surname, signature of student representative

.....	.....
Date	Dean’s signature

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

Zał. nr 4 do ZW 78/2023
Attachment no. 3 to Program of Studies

PLAN OF STUDIES

FACULTY: **Chemistry**

MAIN FIELD OF STUDY: **ADVANCED NANO AND BIOMATERIALS - MONABIPHOT**

EDUCATION LEVEL: **second-level studies (4-semester)**

FORM OF STUDIES: **full-time studies**

PROFILE: **general academic**

SPECIALIZATION: **----------**

LANGUAGE OF STUDY: **English**

In effect since **2024/2025**

Plan of studies structure (optionally)

1) in ECTS point layout

(space for scheme of plan)

2) in hourly layout

(space for scheme of plan)

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

2nd LEVEL STUDIES (MASTER LEVEL STUDIES) 4 sem
Field of study: Advanced Nano and Biomaterials-MONABIPHOT

Obligatory subjects
Optional subjects

Sem.	I	II	III	IV
Godz.	**28h/ 30ECTS/ 3E**	**25h / 30ECTS / 3E**	**25h / 30ECTS / 3E**	**23h / 30ECTS**
28	Informatics for engineers 2l (2ECTS)			
27				
26	Biotechnology with introduction to industrial microbiology 2w+1p (2+2) ECTS			
25		Fluorescence spectroscopy and bioimaging 2w + 1c (3 + 1 ECTS)	Elective courses 2w (2 ECTS)	
24				
23	Basics of technical drawing 2p (2 ECTS)		Laser and microscopic techniques in materials analysis 2w (2 ECTS)	Elective courses 2w (2 ECTS)
22		Modern spectroscopy **E** 2w (2 ECTS)		
21	Technical safety in industry 1w +1l (1+1) ECTS		Nonlinear Optics for Chemists 1l (2 ECTS)	Advanced functional materials 6l (6 ECTS)
20		Biophotonics 1w + 2s (2 + 2 ECTS)	Nanoscale physics 2w + 1l (2+2 ECTS)	
19	Material recovery and recycling 2w (2 ECTS)			
18				
17	Fundamentals of chemical and process engineering **E**	Bioorganic chemistry **E** 2w (3 ECTS)	Nanomaterials **E** 2w + 1s (2 +1 ECTS)	
16				
15	2w+2p	Modern polymers 2w (2 ECTS)		Graduate laboratory II 14l (20 ECTS)
14	(2+2) ECTS		Organic electronics 1w + 1s (1+1 ECTS)	
13	Bioreactors **E**	Liquid crystals for photonics **E** 2w + 1l (3 + 1 ECTS)		
12	2w+2l		Advanced research methods in the engineering of materials **E** 2w + 1c + 1l (2 + 1 + 2 ECTS)	
11	(2+2) ECTS			
10		Mathematical methods in planning and analysis of experiment 2l (2 ECTS)		
9	Introduction to materials science and engineering 2w (2 ECTS)			
8		Managerial course II 2w (3 ECTS)	Advanced functional materials **E** 2w + 2s (2 + 2 ECTS)	
7	Fundamentals of chemical technology design 2w +2p **E**			
6	(3+2 ECTS)	Managerial course I 1w (2 ECTS)		
5		Foreign language II 3c (2 ECTS)		
4			Graduate laboratory I 4l (6 ECTS)	
3	Separation and purification of products 1w+2l (1+2) ECTS			
2		Foreign language I 1c (1 ECTS)		
1		Graduation proseminar 1s (1 ECTS)		Graduation seminar 1s (2 ECTS)
Sem.	**I**	**II**	**III**	**IV**

1. Set of obligatory and optional subjects and groups of classes in semestral arrangement

Semester 1

Obligatory subjects / groups of classes Number of ECTS points 30

No.	Subject / groups of classescode	Name of subject / groups of classes (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of subject / groups of classes	Way[3] of crediting	Subject / groups of classes			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University -wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1	W03W03-SM2018L	Informatics for engineers			2			K2Aan_U12 K2Aan_W17	30	50	2		1,4	T	Z			P	K
2	W03W03-SM2007W	Biotechnology with introduction to industrial microbiology	2					K2Aan_W01 K2Aan_W18	30	50	2	2	1,3	T/Z	Z		DN		K
3	W03W03-SM2019P	Biotechnology with introduction to industrial microbiology				1		K2Aan_U03 K2Aan_U08 K2Aan_U10	15	50	2	2	0,75	T/Z	Z		DN	P	K
4	W03W03-SM2025P	Basics of technical drawing				2		K2Aan_U12	30	50	2		1,5	T	Z			P	K
5	W03W03-SM2026W	Technical safety in industry	1					K2Aan_W14	15	25	1		0,65	T/Z	Z				K
6	W03W03-SM2026L	Technical safety in industry			1			K2Aan_U04	15	25	1		0,7	T	Z			P	K
7	W03W03-SM2027W	Material recovery and recycling	2					K2Aan_W02 K2Aan_W18	30	50	2	2	1,3	T/Z	Z		DN		K
8	W03W03-SM2028W	Fundamentals of chemical and process engineering	2					K2Aan_W17 K2Aan_W18	30	50	2		1,3	T/Z	**E**				K
9	W03W03-SM2028P	Fundamentals of chemical and process engineering				2		K2Aan_U08 K2Aan_U12	30	50	2		1,5	T/Z	Z			P	K
10	W03W03-SM2029W	Bioreactors	2					K2Aan_W18	30	50	2	2	1,3	T/Z	**E**		DN		K
11	W03W03-SM2029L	Bioreactors			2			K2Aan_U02 K2Aan_U04 K2Aan_U12	30	50	2	2	1,4	T	Z		DN	P	K
12	W03W03-SM2003W	Introduction to materials science and engineering	2					K2Aan_W01 K2Aan_W18 K2Aan_W06 K2Aan_W02	30	50	2		1,3	T/Z	Z				K
13	W03W03-SM2030W	Fundamentals of chemical technology design	2					K2Aan_W05 K2Aan_W17	30	75	3		1,3	T/Z	**E**				K
14	W03W03-SM2030P	Fundamentals of chemical technology design				2		K2Aan_U12	30	50	2		1,5	T/Z	Z			P	K

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

15	W03W03-SM2025W	Separation and purification of products	1					K2Aan_W18	15	25	1	1	0,65	T/Z	Z		DN		K
16	W03W03-SM2025L	Separation and purification of products			2			K2Aan_U02 K2Aan_U04	30	50	2	2	1,4	T	Z		DN	P	K
		Total	**14**		**7**	**7**			**420**	**750**	**30**	**13**	**19,25**		**3**			**15**	

Altogether in semester

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Total number of ECTS points for DN classes[5]	Number of ECTS points for BU classes[1]
lec	cl	lab	pr	sem					
14		**7**	**7**		**420**	**750**	**30**	**13**	**19,25**

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

Semester 2

Obligatory subjects / groups of classes Number of ECTS points 21

No.	Subject / groups of classescode	Name of subject / groups of classes (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of subject / groups of classes	Way[3] of crediting	Subject / groups of classes			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University -wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1	W03ANB-SM2007L	Mathematical methods in planning and analysis of experiment			2			K2Aan_W05 K2Aan_W10 K2Aan_W17 K2Aan_U06 K2Aan_U08 K2Aan_U12	30	50	2		1,4	T	Z			P	PD
2	W03ANB-SM2006W	Liquid crystals for photonics	2					K2Aan_W03 K2Aan_W15	30	75	3	3	1,3	T/Z	**E**		DN		K
3	W03ANB-SM2006L	Liquid crystals for photonics.			1			K2Aan_W03 K2Aan_U04 K2Aan_U11 K2Aan_U14	15	25	1	1	0,7	T	Z		DN	P	K
4	W03ANB-SM2005W	Modern polymers	2					K2Aan_W01 K2Aan_W15 K2Aan_W18	30	50	2		1,3	T/Z	Z				K
5	W03ANB-SM2004W	Bioorganic chemistry	2					K2Aan_W13 K2Aan_W14 K2Aan_W15	30	75	3	3	1,3	T/Z	**E**		DN		K
6	W03ANB-SM2003W	Biophotonics	1					K2Aan_W07 K2Aan_W13	15	50	2		0,65	T/Z	Z				K
7	W03ANB-SM2003S	Biophotonics.					2	K2Aan_W07 K2Aan_U05 K2Aan_U06 K2Aan_U08	30	50	2		1,4	T/Z	Z			P	K
8	W03ANB-SM2002W	Modern spectroscopy	2					K2Aan_W07 K2Aan_W08	30	50	2	2	1,3	T/Z	**E**		DN		PD
9	W03ANB-SM2001W	Fluorescence spectroscopy and bioimaging	2					K2Aan_W07 K2Aan_W13	30	75	3	3	1,3	T/Z	Z		DN		K

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

10	W03ANB-SM2001C	Fluorescence spectroscopy and bioimaging.		1				K2Aan_U12 K2Aan_U16 K2Aan_U17	15	25	1	1	0,7	T/Z	Z		DN	P	K
		Total	**11**	**1**	**3**		**2**		**255**	**525**	**21**	**13**	**11,35**		**3**			**6**	

Optional subjects / groups of classes 9 ECTS points

No.	Subject / groups of classescode	Name of subject / groups of classes (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of subject / groups of classes	Way[3] of crediting	Subject / groups of classes			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University -wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1	W03-SM2002BH	Managerial course I	1					K2Aan_K02 K2Aan_K03 K2Aan_K07	15	60	2		0,65	T/Z	Z	O			KO
2	W03-SM2001BH	Managerial course II	2					K2aan_W11 K2Aan_K02 K2Aan_K03 K2Aan_K07	30	90	3		1,3	T/Z	Z	O			KO
3	SJO-SM0003	Foreign language II		3				K2Aan_U07 K2Aan_U10 K2Aan_K01 K2Aan_K04	45	60	2		1,8	T/Z	Z	O		P	KO
4	SJO-SM0004	Foreign language I		1				K2Aan_U07 K2Aan_U10 K2Aan_K01 K2Aan_K04	15	30	1		0,6	T/Z	Z	O		P	KO
5	W03W03-SM2053S	Graduation proseminar					1	K2Aan_U08 K2Aan_U15 K2Aan_K01 K2Aan_K07	15	25	1	1	0,7	T/Z	Z		DN	P	K
		Total	**3**	**4**			**1**		**120**	**265**	**9**	**1**	**5,05**					**4**	

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

Altogether in semester

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Total number of ECTS points for DN classes[5]	Number of ECTS points for BU classes[1]
lec	cl	lab	pr	sem					
14	**5**	**3**		**3**	**375**	**790**	**30**	**14**	**16,4**

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

Semester 3

Obligatory subjects / groups of classes Number of ECTS points 22

No.	Subject / groups of classescode	Name of subject / groups of classes (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of subject / groups of classes	Way[3] of crediting	Subject / groups of classes			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University-wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1	W03ANB-SM2014W	Advanced functional materials	2					K2Aan_W02 K2Aan_W04 K2Aan_W06 K2Aan_W12 K2Aan_W16 K2Aan_W18	30	50	2	2	1,3	T/Z	**E**		DN		K
2	W03ANB-SM2014S	Advanced functional materials.					2	K2Aan_W12 K2Aan_W15 K2Aan_U05 K2Aan_U06 K2Aan_U08 K2Aan_K07	30	50	2	2	1,4	T/Z	Z		DN	P	K
3	W03ANB-SM2013W	Advanced research methods in the engineering of materials	2					K2Aan_W07 K2Aan_W14	30	50	2	2	1,3	T/Z	**E**		DN		K
4	W03ANB-SM2013C	Advanced research methods in the engineering of materials		1				K2Aan_W14 K2Aan_U02 K2Aan_U11 K2Aan_K08	15	25	1	1	0,7	T/Z	Z		DN	P	K
5	W03ANB-SM2013L	Advanced research methods in the engineering of materials			1			K2Aan_W14 K2Aan_U02 K2Aan_U13 K2Aan_U16 K2Aan_K08	15	50	2	2	0,7	T	Z		DN	P	K
6	W03ANB-SM2012W	Organic electronics	1					K2Aan_W07 K2Aan_W13	15	25	1	1	0,65	T/Z	Z		DN		K
7	W03ANB-SM2012S	Organic electronics.					1	K2Aan_W13 K2Aan_W15 K2Aan_U05	15	25	1	1	0,7	T/Z	Z		DN	P	K

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

								K2Aan_U06 K2Aan_U08										
8	W03ANB-SM2011W	Nanomaterials	2					K2Aan_W06 K2Aan_W13	30	50	2	2	1,3	T/Z	**E**		DN		K
9	W03ANB-SM2011S	Nanomaterials.					1	K2Aan_W13 K2Aan_W15 K2Aan_U05 K2Aan_U06 K2Aan_U08 K2Aan_K07	15	25	1	1	0,7	T/Z	Z		DN	P	K
10	W03ANB-SM2010W	Nanoscale physics	2					K2Aan_W04 K2Aan_W06 K2Aan_W12	30	50	2	2	1,3	T/Z	Z		DN		K
11	W03ANB-SM2010L	Nanoscale physics.			1			K2Aan_W12 K2Aan_U04 K2Aan_U09 K2Aan_U13 K2Aan_U16 K2Aan_K05	15	50	2	2	0,7	T	Z		DN	P	K
12	W03ANB-SM2009L	Nonlinear optics for Chemists.			1			K2Aan_W07 K2Aan_U04	15	50	2	2	0,7	T	Z		DN	P	K
13	W03ANB-SM2008W	Laser and microscopic techniques in materials analysis	2					K2Aan_W02 K2Aan_W04 K2Aan_W12 K2Aan_W15	30	50	2	2	1,3	T/Z	Z		DN		K
		Total	**11**	**1**	**3**		**4**		**285**	**550**	**22**	**22**	**12,75**					**11**	

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

Optional subjects / groups of classes 8 ECTS points

No.	Subject / groups of classescode	Name of subject / groups of classes (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of subject / groups of classes	Way[3] of crediting	Subject / groups of classes			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University -wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1	W03ANB-SM20BW	Elective course*	2					K2Aan_W16 K2Aan_K08	30	50	2		1,3	T/Z	Z				K
2	W03W03-SM2054D	Graduate laboratory I			4			K2Aan_U03 K2Aan_U04 K2Aan_U09 K2Aan_K01 K2Aan_K05 K2Aan_K07	60	150	6	6	3	T	Z		DN	P	K
		Total	**2**		**4**				**90**	**200**	**8**	**6**	**4,3**					**6**	

Altogether in semester

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Total number of ECTS points for DN classes[5]	Number of ECTS points for BU classes[1]
lec	cl	lab	pr	sem					
13	**1**	**7**		**4**	**375**	**750**	**30**	**28**	**17,05**

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

Semester 4

Obligatory subjects / groups of classes Number of ECTS points 6

No.	Subject / groups of classescode	Name of subject / groups of classes (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of subject / groups of classes	Way[3] of crediting	Subject / groups of classes			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University -wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1	W03ANB-SM2014L	Advanced functional materials..			6			K2Aan_W04 K2Aan_W12 K2Aan_U01 K2Aan_U04 K2Aan_U09 K2Aan_U10 K2Aan_U12 K2Aan_U13 K2Aan_U15 K2Aan_U16 K2Aan_U17	90	150	6	6	4,2	T	Z		DN	P	K
		Total			**6**				**90**	**150**	**6**	**6**	**4,2**					**6**	

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

Optional subjects / groups of classes 24 ECTS points

No.	Subject / groups of classescode	Name of subject / groups of classes (denote group of courses with symbol **GK**)	Weekly number of hours					Learning effect symbol	Number of hours		Number of ECTS points			Form[2] of subject / groups of classes	Way[3] of crediting	Subject / groups of classes			
			lec	cl	lab	pr	sem		ZZU	CNPS	Total	DN[5] classes	BU[1] classes			University -wide[4]	Concerning scientific activities[5]	Practical[6]	Type[7]
1	W03ANB-SM20BW	Elective course*	2					K2Aan_W16 K2Aan_K08	30	50	2		1,3	T/Z	Z				K
2	W03W03-SM2055D	Graduate laboratory II			14			K2Aan_U03 K2Aan_U04 K2Aan_U09 K2Aan_U10 K2Aan_U13 K2Aan_K01 K2Aan_K05 K2Aan_K07	210	500	20	20	9,5	T	Z		DN	P	K
3	W03W03-SM2056S	Graduation seminar					1	K2Aan_U05 K2Aan_U08 K2Aan_K01 K2Aan_K06 K2Aan_K07 K2Aan_K08	15	50	2	2	0,7	T/Z	Z		DN	P	K
		Total	**2**		**14**		**1**		**255**	**600**	**24**	**22**	**11,5**					**22**	

Altogether in semester

Total number of hours					Total number of ZZU hours	Total number of CNPS hours	Total number of ECTS points	Total number of ECTS points for DN classes[5]	Number of ECTS points for BU classes[1]
lec	cl	lab	pr	sem					
2		**20**		**1**	**345**	**750**	**30**	**28**	**15,7**

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

2. Set of examinations in semestral arrangement

Subject / groups of classescode	Names of subjects / groups of classesending with examination	Semester
W03W03-SM2028W	Fundamentals of chemical and process engineering	**1**
W03W03-SM2029W	Bioreactors	
W03W03-SM2030W	Fundamentals of chemical technology design	
W03ANB-SM2006W	Liquid crystals for photonics	**2**
W03ANB-SM2004W	Bioorganic chemistry	
W03ANB-SM2002W	Modern spectroscopy	
W03ANB-SM2014W	Advanced functional materials	**3**
W03ANB-SM2013W	Advanced research methods in the engineering of materials	
W03ANB-SM2006W	Nanomaterials	

3. Numbers of allowable deficit of ECTS points after particular semesters

Semester	Allowable deficit of ECTS points after semester
1	15
2	15
3	15
4	0

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

Opinion of student government legislative body

.....	.....
Date	Name and surname, signature of student representative

.....	.....
Date	Dean’s signature

[1]BU – number of ECTS points assigned to hours of classes requiring direct participation of academic teachers and other persons conducting classes
[2]Traditional – enter T, remote – enter Z
[3]Exam – enter E, crediting – enter Z. For the group of classes – after the letter E or Z - enter in brackets the final subject form (lec, cl, lab, pr, sem)
[4]University-wide subject /group of classes – enter O
[5]DN - number of ECTS points assigned to the classes related to the University's academic activity in the discipline/disciplines to which the main field of study is assigned
[6]Practical subject / group of classes – enter P. For the group of classes – in brackets enter the number of ECTS points assigned to practical courses
[7]KO – general education courses, PD – basic sciences courses, K – main field of study courses, S – specialization courses

KARTY PRZEDMIOTÓW

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

SUBJECT CARD

Name of subject in Polish Zaawansowane Materiały Funkcjonalne
Name of subject in English Advanced Functional Materials
Main field of study (if applicable): Advanced Nano and Biomaterials - MONABIPHOT
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code W03ANB-SM2014W, W03ANB-SM2014L, W03ANB-SM2014S
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		90		30
Number of hours of total student workload (CNPS)	50		150		50
Form of crediting (Examination / crediting with grade)	Exam		crediting with grade		crediting with grade
For group of courses mark (X) final course					
Number of ECTS points	2		6		2
including number of ECTS points for practical classes (P)			6		2
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1,3		4,2		1,4

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. General knowledge of mathematics, physics and chemistry

SUBJECT OBJECTIVES

C1 Extending knowledge about materials used in modern materials engineering.
C2 Acquisition of experience in independent development and presentation of the state of knowledge on the basis of scientific publications
C3 Getting to know measurement methods of advanced materials

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:
PEU_W01 has general knowledge in the field of research carried out in modern material engineering
PEU_W02 has knowledge about the synthesis, properties and research of photorefractive materials
PEU_W03 has knowledge about the synthesis, properties and research of photochromic materials

PEU_W04 has knowledge about the synthesis, properties and research of thermo-, electro- and solvatochromes
PEU_W05 has knowledge about the production, properties and testing of organic and inorganic semiconductors
PEU_W06 has knowledge about the synthesis, properties and research of compounds based on coal
PEU_W07 has knowledge about the synthesis, properties and research of energy storage materials
PEU_W08 has knowledge about the production and testing of optical fibers and photonic crystals
PEU_W09 has knowledge about modern materials used in medicine
PEU_W10 has knowledge about the synthesis, properties and research of metamaterials
PEU_W11 has knowledge about the synthesis, properties and research of magnetic and ferroelectric materials
PEU_W12 has knowledge about the properties and research of superconductors
PEU_W13 has knowledge about the synthesis, properties and testing of porous materials
PEU_W14 has knowledge about the synthesis, properties and research of ceramic materials
PEU_W15 has knowledge about the synthesis, properties and studies of luminescent dyes

relating to skills:
PEU_U01 student is able to independently develop and present the state of knowledge on the basis of scientific publications
PEU_U02 student is able to independently perform material tests with advanced techniques
PEU_U03 student is able to analyze and interpret the obtained results

relating to social competences:
PEU_K01 The student can use scientific literature, accessing source materials and viewing them

PEU_K02 student is ready to critically evaluate his/her knowledge and received content

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1	Modern materials science	2
Lec 2	Photorefractive materials	2
Lec 3	Photochromic materials	2
Lec 4	Thermoplastic materials, electronic and solvatochromic	2
Lec 5	Organic and inorganic semiconductors	2
Lec 6	Carbon materials	2
Lec 7	Materials for energy storage	2
Lec 8	Fiber optics and photonic crystals	2
Lec 9	Materials in medicine	2
Lec 10	Metamaterials	2
Lec 11	Magnetic and ferroelectric materials	2

Lec 12	Superconductors	2
Lec 13	Porous materials	2
Lec 14	Ceramic materials	2
Lec 15	Luminescent dyes	2
	Total hours	30

Classes		**Number of hours**
Cl 1		
Cl 2		
Cl 3		
Cl 4		
..		
	Total hours	

Laboratory		**Number of hours**
Lab 1	BHP training. The way the laboratory is run. Locations and their discussion. Requirements for course credits.	6
Lab 2	The luminescent properties of organic dyes	6
Lab 3	Methods for determining the thickness of nanolayers	6
Lab 4	Nanomaterials - size effects	6
Lab 5	OFET - fabrication and characteristics	6
Lab 6	OLED - fabrication and characteristics	6
Lab 7	Characteristics of liquid crystals	6
Lab 8	Measurement of phototropic properties of liquid crystals	6
Lab 9	Two-dimensional thermo-optic analysis	6
Lab 10	Quantum efficiency, comparative method	6
Lab 11	Photochemical synthesis of nanostructured silver suspensions	6
Lab 12	Chemical synthesis of nanostructured gold suspensions	6
Lab 13	Fabrication of nanolayers	6
Lab 14	Repetition of the material	6
Lab 15	Repetition of the material, checking knowledge and passing the course	6
	Total hours	90

Project		**Number of hours**
Proj 1		
Proj 2		
Proj 3		
Proj 4		
…		
	Total hours	

Seminar		Number of hours
Semin 1	Student presentations on topic Lec 1	2
Semin 2	Student presentations on topic Lec 2	2
Semin 3	Student presentations on topic Lec 3	2
Semin 4	Student presentations on topic Lec 4	2
Semin 5	Student presentations on topic Lec 5	2
Semin 6	Student presentations on topic Lec 6	2
Semin 7	Student presentations on topic Lec 7	2
Semin 8	Student presentations on topic Lec 8	2
Semin 9	Student presentations on topic Lec 9	2
Semin 10	Student presentations on topic Lec 10	2
Semin 11	Student presentations on topic Lec 11	2
Semin 12	Student presentations on topic Lec 12	2
Semin 13	Student presentations on topic Lec 13	2
Semin 14	Student presentations on topic Lec 14	2
Semin 15	Student presentations on topic Lec 15	2
	Total hours	30

TEACHING TOOLS USED
N1. Lecture with multimedia presentation and lecture using the board N2. Performing tasks in the laboratory N3. Problem discussion N4. The tests check (short essays) - used on laboratory N5. Reports from exercises laboratory

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement
F1 (laboratory)	PEU_U02	quizes

F2 (laboratory)	PEU_U03	reports
P (lecture)	PEU_W01 - PEU_W015	final exam
P (laboratory) = (F1+F2)/2		
P (seminar)	PEU_U01, PEU_U03, PEU_K01- PEU_K02	evaluation of multimedia presentation

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Original articles from Web of Science
[2] Internet source

SECONDARY LITERATURE:

[1] Internal instructions for individual laboratory classes

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

Prof. Jaroslaw Mysliwiec, jaroslaw.mysliwiec@pwr.edu.pl

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

SUBJECT CARD

Name of subject in Polish *Zaawansowane metody badawcze w inżynierii materiałów*
Name of subject in English Advanced research methods in the engineering of materials
Main field of study (if applicable): *Chemistry and engineering of materials*
Specialization (if applicable): Advanced Nano and Biomaterials - MONABIPHOT
Profile: *academic*
Level and form of studies: *2nd level, full-time*
Kind of subject: *obligatory*
Subject code W03ANB-SM2013W, W03ANB-SM2013C, W03ANB-SM2013L
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	15	15		
Number of hours of total student workload (CNPS)	50	25	50		
Form of crediting (Examination / crediting with grade)	Exam	Crediting with grade	Crediting with grade		
For group of courses mark (X) final course					
Number of ECTS points	2	1	2		
including number of ECTS points for practical classes (P)		1	2		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1,3	0,7	0,7		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge about the structure of the atom and chemical bonds.
2. Basic knowledge about the structure of popular engineering materials.
3. Basics of electrochemistry, the concept of electrochemical potential, the phenomenon of electrochemical corrosion.
4. Basics of the interaction of solids with different types of radiation. Principles of spectroscopic techniques.

SUBJECT OBJECTIVES

C1. Understanding the importance of solid surface in nanotechnology.
C2. To acquaint students with modern and advanced techniques of surface research, morphology and structure of engineering materials.
C3. Ability to choose an appropriate method of determining: surface composition, surface topography, adhesion and hardness to the material being tested.

C4. Understanding the interaction of the surface of the material with the corrosive environment.
C5. Ability to apply standards in making measurements and their statistical treatment.

SUBJECT EDUCATIONAL EFFECTS

related to knowledge:

PEU_W01 Student has elementary theoretical knowledge about XPS / AES methods and equipment working in ultra high vacuum.

PEU_W02 The student has a basic knowledge of the research possibilities of determining the surface chemical composition by XPS and AES.

PEU_W03 Student ma podstawową wiedzę o mikroskopii elektronowej (SEM) oraz mikroanalizie rentgenowskiej (EDS), a także o systemie orientacji i detekcji faz na podstawie dyfrakcji elektronów wstecznie rozproszonych (EBSD).

PEU_W04 The student has a basic knowledge of the method of determining the mechanical properties of materials based on the measurements of microhardness and adhesion, as well as on the method of determining geometric parameters of the surface.

PEU_W05 The student has a basic knowledge of the types of electrochemical corrosion and laboratory techniques for testing the corrosion resistance of materials. The student has a basic knowledge of electrochemical impedance spectroscopy (EIS).

PEU_W06 The student knows the basics of impedance spectroscopy to determine the material properties of dielectric materials.

PEU_W07 The student knows the basics of structural analysis by X-ray diffraction (XRD) in the analysis of metals, their alloys and ceramics.

related to skills:

PEU_U01 Student is able to characterize qualitatively and quantitatively the tested surface of a solid material.

PEU_U02 The student is able to perform basic operations on XPS spectra and use the XPS and AES databases for the purpose of qualitative interpretation of XPS, AES spectra.

PEU_U03 The student is able to select the parameters of the scanning microscope (SEM), microanalysis (EDS) and the EDS and EBSD databases that are appropriate for the material being studied.

PEU_U04 The student is able to perform a DC polarization measurement and is able to determine the basic electrical quantities that characterize the corrosion process.

PEU_U05 The student can perform the measurement using the EIS technique, analyze and interpret the simplest impedance spectrum, propose an electric substitute circuit.

PEU_U06 Student is able to determine the basic properties of dielectric material using impedance spectroscopy.

PEU_U07 The student can interpret the XRD diffractogram.

PEU_U08 Student based on available standards can interpret the type of damage of the coating during scratch-test adhesion measurements.

PEU_U09 The student is able to register the surface profile of the tested material and determine on its basis the most important geometric parameters of the tested surface.

PEU_U10 The student is able to measure the thickness of the coating / thin layer and interpret the dependence of the penetration depth on the applied force during microhardness measurement.

related to social competences:

PEU_K01 The student is ready to apply the acquired knowledge to solve research problems.

PEU_K02 The student understands the need to use expert knowledge when interpreting the obtained research results.

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1	XPS, AES - basic concepts: surface, spectroscopic and X-ray notation. Photoelectric process - primary and secondary emission.	2
Lec 2	X-ray photoelectron spectroscopy (XPS / ESCA). “Depth” in XPS / AES analyzes. Spectrum and its components. Stages of the analytical process. Auger electron spectroscopy (AES). Basic instrumentation (UHV, energy analyzer, photon source, ion gun, manipulator).	2
Lec 3	Practical applications of electron spectroscopy in materials engineering. Examples of spectra (XPS / AES) and their interpretation: in microelectronics, ceramics, catalysis, semiconductor and polymer materials, metallurgy, and corrosion of materials.	2
Lec 4	Basic polarization techniques for testing the corrosion resistance of materials. Measuring systems. Interpretation of current-voltage characteristics.	2
Lec 5	Electrochemical impedance spectroscopy (EIS). Impedance and methods of its presentation, basic concepts, available measurement techniques, spectra and their analysis, electrical equivalent models in the study of corrosion processes.	2
Lec 6	The profilometric methods for determining the surface topography of coatings and thin films.	2
Lec7	Determining the thickness of coatings and thin layers. Available non-destructive measurement techniques.	2
Lec8	Determination of microhardness of coatings and layers.	2
Lec9	Determination of adhesion of coatings and layers.	2
Lec10	Impedance spectroscopy of dielectric materials.	2
Lec11	Basics of electron microscopy (SEM) and X-ray microanalysis (EDS). Basic instrumentation (electron and X-ray detectors, vacuum system, preparations used in electron microscopy).	2
Lec12	Application of SEM, EDS and EBSD in material engineering. Examples of SEM images, spectra and chemical composition of EDS and crystallographic orientation maps (EBSD). Basics of spectra interpretation.	2
Lec13	Application of SEM / PFIB and TEM techniques in the analysis of the structure of coatings and thin films. Sample preparation. Contemporary analytical capabilities.	2

Lec14	Structural investigations of metals and their alloys as well as ceramic materials by X-ray diffraction (XRD).	2
Lec15	The use of GC-MS in determination of organic compounds.	2
	Total hours	30

Classes		**Number of hours**
Cl 1	Organizational matters.	1
Cl 2	Data treatment and analysis of linear polarization resistance characteristics. Determination of electrochemical parameters from polarization curves.	2
Cl 3	Interpretation of impedance spectra from EIS measurements. Proposing of physical models and electric equivalent circuits. Calculation of the values of elements of the electric equivalent circuit by non-linear least squares method.	2
Cl 4	Familiarization with software for interpreting XPS and AES spectra on the basis of real experimental spectra. Electron spectra: qualitative and quantitative interpretations. Acquisition of low- and high-resolution spectra.	2
Cl 5	Identification of spectral components. Quantitative calculations of elemental surface composition. Elimination of spectral by-products, methods for determining the background line. Calibration of spectra.	2
Cl 6	Calculating the average mean free electron path (IMFP) based on available models. Calculating the thickness of passive / oxide layers based on selected models.	2
Cl 7	Determination of dielectric properties of ceramics by dielectric impedance spectroscopy. Spectra processing and interpretation.	2
Cl 8	GC-MS technique. Analysis of chromatograms for organic compounds.	2
	Total hours	15

Laboratory		**Number of hours**
Lab 1	Organizational matters. Health and safety training.	1
Lab 2	Determination of the corrosion rate using linear polarization resistance and polarization curves.	2
Lab 3	EIS spectroscopic measurements of the corrosion process of selected metals and alloys.	2
Lab 4	Measurement of surface roughness by contact profilometry method. Profile registration and determination of basic geometric parameters of the surface based on the standard.	2
Lab 5	Measurements of coating thickness by means of magnetic induction and Eddy current methods.	2
Lab 6	Measurements of microhardness of coatings and thin films. Oliver and Pharr method. Statistical analysis of results. Testing of adhesion and resistance to scratch of metal coatings using the scratch-test method. Microscopic evaluation of the scratch track based on the standard.	2
Lab 7	Analysis of the surface morphology of the material by means of scanning electron microscopy (SEM). Secondary electron and back scattered electron imaging.	2

Lab 8	Quantitative analysis based on X-ray microanalysis (EDS) as well as map analysis of crystallographic orientation (EBSD) of ceramics, metals and semiconductors.	2
	Total hours	15

TEACHING TOOLS USED

N1. Multimedia presentation - thematic lecture.
N2. Practical exercises in the laboratory.
N3. Presentation / demonstration.
N4. Computer.
N5. Use of available scientific literature (Web of Science, Scopus), NIST database.
N6. The use of SpecLab, XPSPeak, Quases, Gamry, Nova, SAI, CSM, Bruker, FEI, TEAM, Origin software.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement
F1 = P1 (classes)	PEU_W01- PEU_W07, PEU_U01- PEU_U10, PEU_K01-K02	Grade from the tests
F1 (laboratory)	PEU_W01- PEU_W07, PEU_U01- PEU_U10, PEU_K01-K02	Grade from the reports
F2 (laboratory)	PEU_W01- PEU_W07, PEU_U01- PEU_U10, PEU_K01 -K02	Grade from the tests
P (laboratory) Arithmetic average of F1 and F2 forming grades		
P (lecture)	PEU_W01- PEU_W07	Final exam

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] XPSPeak41 Manual.
[2] An Introducing to Surface Analysis by XPS and AES; J.F. Watts, J. Wolstenholme, John Wiley&Sons Ltd., 2003.
[3] Electrochemical Impedance Spectroscopy; Mark E. Orazem, Bernard Tribollet, John Wiley & Sons Ltd., 2011.
[4] Scanning Electron Microscopy and X-Ray Microanalysis 4th ed., Goldstein, J.I., Newbury, D.E., Michael, J.R., Ritchie, N.W.M., Scott, J.H.J., Joy, D.C., 2018.
[5] K. Nitsch, Zastosowanie spektroskopii impedancyjnej w badaniach materiałów elektronicznych, Oficyna Wydawnicza PWr, 1999.
[6] B. D. Cullity and S. R. Stock, Elements of X-ray Diffraction, Pearson, 2001.

SECONDARY LITERATURE:

[1] http://www.casaxps.com/ebooks/ebooks.htm

[2] Oliver W.C., Pharr G.M. *„An improved technique for determining hardness and elastic modulus using load and displacement sensing indentation experiments”*. Journal of Materials Research. Vol. 7, No. 6 (1992): pp. 1564÷1583.
[3] https://www.gamry.com/application-notes/EIS/basics-of-electrochemical-impedance-spectroscopy/
[4] https://www.bruker.com/products/surface-and-dimensional-analysis/stylus-profilometers/dektak-xt/learn-more.html
[5] https://blog.phenom-world.com/
[6] https://www.ameteksi.com/products/materials-testing-systems/1296a-dielectric-interface
[7] https://www.fei.com/products/sem/quanta-sem/

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

DSc. Eng. Juliusz Winiarski, Assoc. Prof., juliusz.winiarski@pwr.edu.pl

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

SUBJECT CARD

Name of subject in Polish **Chemia Bioorganiczna**
Name of subject in English **Bioorganic Chemistry**
Main field of study (if applicable): Advanced Nano and Biomaterials - MONABIPHOT
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level
Kind of subject: obligatory
Subject code W03ANB-SM2004W
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30				
Number of hours of total student workload (CNPS)	75				
Form of crediting (Examination)	x				
For group of courses mark (X) final course					
Number of ECTS points	3				
including number of ECTS points for practical classes (P)					
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1,3				

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. knowledge of the basics of organic chemistry and biochemistry
2. knowledge of the basics of chromatographic and spectroscopic methods
3. possession of practical skills related to the application of laboratory techniques of organic chemistry from the range of courses provided in the curriculum of the first-degree program
4. knowledge of the English language

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SUBJECT OBJECTIVES

C1. To familiarize students with the issues of bioorganic chemistry.
C2. To familiarize students with the issues of mimetics of biochemical processes.
C3. To acquaint students with the issues of molecular receptors.
C4. To familiarize students with the structure, properties and use of various groups of compounds used in bioorganic chemistry.
C5. To acquaint students with the practical possibilities of using particular groups of compounds as enzyme mimetics and molecular receptors.
C6, To acquaint students with the methods of obtaining macrocyclic receptors

C7. To acquaint students with scientific literature and literature examples

SUBJECT EDUCATIONAL EFFECTS

In terms of knowledge:

PEU_W01 - knows what is bioorganic chemistry and knows the scope of its application.

PEU_W02 - knows the properties of individual groups of compounds applicable in bioorganic chemistry

PEU_W03 - knows the application of discussed, individual groups of compounds in bioorganic chemistry

PEU_W04 - knows the basic methods of obtaining macromolecular compounds

PEU_W05 - knows the types of intermolecular interactions and which compounds participate in the formation of individual interactions

PEU_W06 - knows what supramolecular chemistry is, knows the different types and can give examples of the application of supramolecular complexes

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1	Presentation of the general characteristics of the subject	2
Lec 2	Mimetics of peptides and proteins	2
Lec 3	Mimetics of DNA and RNA nucleic acids	2
Lec 4	Structure, properties and applications of cyclodextrins	2
Lec 5	Structure, properties and application of dendrimers	2
Lec 6	Structure, properties and applications of calixarenes	2
Lec 7	Structure, properties and applications of cyclophanes	2
Lec 8	Structure, properties and applications of crown ethers and cyclic polyamines	2
Lec 9	Enzyme mimetics - molecular printing of polymers	2
Lec 10	Micellar catalysis, liposomes, fatty acid mimetics	2
Lec 11	Structure, properties and applications of porphyrins	2
Lec 12	Carbohydrates and their derivatives	2
Lec 13	Receptors for compounds having diol groups	2
Lec 14	Application of allotropic carbon groupings in bioorganic chemistry	2
Lec 15	Structure, properties and applications of rotaxanes and catenanes	2

	Total hours	30
Classes		**Number of hours**
Cl 1		
Cl 2		
Cl 3		
Cl 4		
..		
	Total hours	
Laboratory		**Number of hours**
Lab 1		
Lab 2		
Lab 3		
Lab 4		
Lab 5		
…		
	Total hours	
Project		**Number of hours**
Proj 1		
Proj 2		
Proj 3		
Proj 4		
…		
	Total hours	
Seminar		**Number of hours**
Semin 1		
Semin 2		
Semin 3		
…		
	Total hours	

TEACHING TOOLS USED
N1. Informative and problem-oriented lecture using multimedia presentation N2. Consultation N3. Student's own work

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement
F1	PEU_W01 - PEU_W06	Examination in oral form - presentation
F2		
F3		
P		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Jerry L. Atwood, Comprehensive Supramolecular Chemistry, Elsevier LTD 2017
[2] Marcel Van de Voorde, Nanoscience and Nanotechnology, De Gruyter 2018
[3] Czasopisma naukowe

Aktualne książki z zakresu chemii bioorganicznej, nanotechnologii i chemii supramolekularnej

SECONDARY LITERATURE:

Current books on bioorganic chemistry, nanotechnology and supramolecular chemistry

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

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Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

SUBJECT CARD

Name of subject in Polish Biofotonika
Name of subject in English Biophotonics
Main field of study (if applicable): Advanced Nano and Biomaterials - MONABIPHOT
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code W03ANB-SM2003W, W03ANB-SM2003S
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15	20	30		30
Number of hours of total student workload (CNPS)	30				30
Form of crediting (Examination / crediting with grade)	C				C
For group of courses mark (X) final course					
Number of ECTS points	2				2
including number of ECTS points for practical classes (P)					2
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	0,65				1,4

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. General chemistry
2. Basics of physics
3. Basics of biology at high school level

SUBJECT OBJECTIVES

C1 Obtaining additional knowledge in the field of synthesis, characterization and application of materials for biophotonics
C2 Knowledge about modern biophotonics
C3 Obtaining additional knowledge about materials used in biophotics
C4 To familiarize the student with modern biophotonics
C5 Knowledge about the development and limitations of biophotonics

SUBJECT EDUCATIONAL EFFECTS

In terms of knowledge:
Person who passed the subject:

PEU_W01 – Has structured, theoretically based general knowledge covering key issues in the field of biophotonics
PEU_W02 – Knows new methods of synthesizing materials for biophotonics
PEU_W03- Knows modern methods of material characterization for biophotonics
PEU_W04- Knows the basic methods of functionalization of materials for biophotonics
PEU_W05 - Understands and is able to explain descriptions in biophotonics
PEU_W06- Knows and understands selected applications of materials for biophotonics
PEU_W07- Knows and understands the prospects and threats related to the synthesis and application of materials for biophotonics
PEU_W08 – Knows modern methods of dynamic phototherapy
PEU_W09 – Has knowledge of the toxicity of nanobiomaterials
PEU_W10- Knows the applications of DNA in biophotics
PEU_W11 – Knows new methods of biosynthesis of nanomaterials
PEU_W12 – Knows popular biopolymers and their applications
PEU_W13 – Has knowledge about photonic biocrystals

In terms of skills:
Person who passed the subject:
PEU_U01 – Is able to name and define biophotics. Knows the latest literature on biophotonics. Searches for information in the field of biophotonics from available sources.
PEU_U02 - Knows modern imaging methods
PEU_U03- Is able to name and define advanced equipment used in biophotics
PEU_U04- Has language skills in the field of biophotonics.
PEU_U05- Is able to name and define biophotonic materials.
PEU_U06- Has language skills in the field of biophotonics.
PEU_U07- is able to critically analyze the prospects for the use of biophotonics
PEU_U08 - Is able to name and define new biomaterials
PEU_U09- Knows the latest literature on biophotonics
PEU_U10 – Knows various applications of photodynamic therapy
PEU_U11 – Can give an example of a biosensor
PEU_U12 – Knows biobased materials for photonics and materials engineering
PEU_U13 - Is able to define photonic biocrystals
PEU_U14 – Knows the 3-D printing technique for biomaterials

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1	**Fundamentals of light-matter interactions.**	2
Lec 2	**Principles of Lasers, Current Laser Technology and Nonlinear Optics**	2
Lec 3	**Bioimaging – principles, techniques and applications**	2
Lec 4	**Principles of biosensors**	2
Lec 5	**Plasmonic nanoparticles for cancer detection and treatment**	2
Lec 6	**Light activated therapy – photodynamic therapy**	2
Lec 7	**Photonics biocrystals**	2

Lec8	**Biocompatible materials for photonics – 3-D printing of new biomaterials.**	1

Seminar		**Number of hours**
Semin 1	**Bioimaging**	2
Semin 2	**Bioimaging in therapies**	2
Semin 3	**Biosensors**	2
Semin 4	**Biosensors in practice**	2
Semin 5	**Plasmonic nanoparticles for cancer detection and treatment**	4
Semin 6	**Photodynamic therapy**	2
Semin 7	**Antibacterial photodynamic therpy**	2
Semin 8	**Photonics crystals in nature**	4
Semin 9	**Advances in 3-D printing for medicine**	4
Semin 10	**Biomaterials for photonics**	4
Semin 11	**Nonlinear bioimaging**	2
	Total hours	30

TEACHING TOOLS USED
N1. N1 Multimedia lectures N2 Workshop seminars N3 Own work – preparation of a presentation/paper N2. N3.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement
F1 - lecture	PEU-W1 to W13	Presentation /lecture
F1 (wykład)		
F1 = P1 (seminarium)	PEU-W1 do W13, PEU-U1 do U14	Presentation

P

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] [1] M. Jurgen, T. Mayerh€ofer, and J Popp Handbook of biophotonics, Wiley 2013

SECONDARY LITERATURE:

[1] Paras N. Prasad, Nanophotonics, Wiley-Interscience, 2004
[2] Paras N. Prasad, Introduction to Biophotonics, 2004
[3] Challa Kumar, Nanomaterials for Medical Diagnosis and Therapy, Wiley, 2007
[4] Yoon Yeo, Nanoparticulate drug delivery systems : strategies, technologies, and applications, Wiley, 2013

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Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

SUBJECT CARD

Name of subject in Polish Spektroskopia fluorescencyjna i bioobrazowanie
Name of subject in English Fluorescence spectroscopy and bioimaging
Main field of study (if applicable): Advanced Nano and Biomaterials - MONABIPHOT
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code W03ANB-SM2001W, W03ANB-SM2001C
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	15			
Number of hours of total student workload (CNPS)	75	25			
Form of crediting (Examination / crediting with grade)	Crediting with grade	Crediting with grade			
For group of courses mark (X) final course					
Number of ECTS points	3	1			
including number of ECTS points for practical classes (P)		1			
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1,3	0,7			

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. General knowledge about biochemistry and chemistry
2. Skills in basic chemistry/biochemistry calculations

SUBJECT OBJECTIVES

C1 To provide an advanced understanding of the core principles and selected topics of biological chemistry and their experimental basis
C2 To enable students to acquire knowledge and understanding of selected aspects of fluorescence spectroscopy and bio-imaging in context of proteins visualization. This will be pursued by means of lecture series and wet laboratory classes.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 student knows the principles of chemical biology, cancer biology, and the role of proteolytic enzymes in health and disease

PEU_W02 student knows modern technologies for the proteins visualization in biological samples with emphasis on the detection of proteolytic enzymes using activity based probes

PEU_W03 student knows and understands the principles of the spectrofluorometric plate readers, confocal microscopy and mass cytometry

relating to skills:

PEU_U01 student can apply the principles of various biochemical techniques to visualize proteins in biological samples using spectrofluorimeter, LC-MS, fluorescence microscopy, infrared bio-imaging system and mass cytometry

PEU_U02 student is able to analyze and critically evaluate the results obtained by using aforementioned techniques and systems

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1	Basis of biological chemistry	2
Lec 2	Introduction to cell and molecular biology	2
Lec 3	Introduction to proteomics	2
Lec 4	Biochemical techniques in life sciences	2
Lec 5	Proteomic techniques in life sciences	2
Lec 6	Lifestyle diseases: the biology of cancer	2
Lec 7	Lifestyle diseases: the biology of diabetes	2
Lec 8	Proteomic techniques for the visualization of enzymes activtiy	2
Lec 9	Fluorescent techniques for the visualization of enzymes activtiy	2
Lec 10	Fluorescence microscopy as a tool for proteins visualization	2
Lec 11	Flow cytometry as a tool for diseases diagnosis	2
Lec 12	The principles of mass cytometry	2
Lec 13	The principles of imaging mass cytometry (IMC)	2
Lec 14	The application of mass cytometry and IMC for multiparametric bio-imaging	2
Lec 15	Final exam	2
	Total hours	30

	Classes	**Number of hours**
Cl 1	Introduction to enzyme kinetics (principles, methods, calculations)	2
Cl 2	Introduction to proteomics (principles, methods, calculations)	2
Cl 3	Detection of peptides hydrolysis by mass spectrometry techniques	2

Cl 4	Detection of enzymes activity with chemical probes and proteomics	2
C1 5	Detection of enzymes activity with fluorescent probes and antibodies	2
C1 6	Application of mass spectrometry in clinical proteomics	2
C1 7	Application of mass cytometry in clinical proteomics	2
C1 8	Final remarks	1
	Total hours	15

Laboratory		**Number of hours**
Lab 1		
Lab 2		
Lab 3		
Lab 4		
Lab 5		
…		
	Total hours	

Project		**Number of hours**
Proj 1		
Proj 2		
Proj 3		
Proj 4		
…		
	Total hours	

Seminar		**Number of hours**
Semin 1		
Semin 2		
Semin 3		
…		
	Total hours	

TEACHING TOOLS USED

N1. PowerPoint presentations (for lectures and classes)
N2. Scientific literature
N3. Data generated from experiments performed on spectrofluorimeters, fluorescence scanners, confocal microscopes, mass cytometers and imaging mass cytometers
N4. Other teaching tools will include: laboratory demonstrations, guest lecturers, online simulations, case studies and group projects.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement
P (for lecure)	PEU_W01-W03	test
F1 (for classes)	PEU_U01-U02	Students' activtiy during classes
F2 (for classes)	PEU_U01-U02	The quality of group project and other tasks

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] **Principles and Techniques of Biochemistry and Molecular Biology**, by Keith Wilson and John Walker, *Cambridge University Press*

[2] **Principles of Fluorescence Spectroscopy,** by Joseph R. Lakowicz, *Springer*

[3] **Proteomics: Principles, Techniques, and Analysis** Syrawood Publishin House, Peter Wyatt

[4] High-Dimensional Single Cell Analysis: Mass Cytometry, Multi-parametric Flow Cytometry and Bioinformatic Techniques, by Harris G. Fienberg and Garry P. Nolan, *Springer*

SECONDARY LITERATURE:

[1] **Biochemistry: The Chemical Reactions of Living Cells**, by David Metzler, *Elsevier*

[2] **Introduction to Cancer Biology** by Robin Hesketh, *Cambridge University Press*

[3] **Handbook of Proteolytic Enzymes,** by Neil D. Rawlings and Guy S. Salvesen, *Elsevier*

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

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Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

SUBJECT CARD

Name of subject in Polish Techniki laserowe i mikroskopowe
Name of subject in English Laser and microscopy techniques
Main field of study (if applicable): Advanced Nano and Biomaterials MONABIPHOT
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code W03ANB-SM2008W
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30				
Number of hours of total student workload (CNPS)	50				
Form of crediting (Examination / crediting with grade)	Crediting with grade				
For group of courses mark (X) final course					
Number of ECTS points	2				
including number of ECTS points for practical classes (P)					
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1,3				

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basics of physics
2. Basics of spectroscopy
3. Basics of chemistry
4. Basics of biology

SUBJECT OBJECTIVES

C1 Knowledge of basic issues in the field of microscopy
C2 To familiarize the student with modern microscopic techniques
C3 Teaching the selection of appropriate microscopic techniques for specific materials

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:
PEU_W01 – Knows the basics of optical microscopy
PEU_W02 – Knows fluorescence microscopy methods

PEU_W03- Knows fluorescence lifetime microscopy methods
PEU_W04- Knows multiphoton microscopy methods
PEU_W05- Knows the basics of electron microscopy
PEU_W06- Knows scanning probe microscopy techniques (AFM, STM)
PEU_W07- Knows near-field microscopy techniques
PEU_W08 - Knows the latest microscopic methods of imaging below the diffraction limit

PROGRAMME CONTENT		
Lecture		**Number of hours**
Lec 1	Basics of light microscopy (basic elements of microscope, concept of microscope resolution, bright field, dark field, polarizing microscopy, etc.)	2
Lec 2	Basic concepts of fluorescence and confocal microscopy (fluorescence microscopy, autofluorescence, fluorescent labels, confocal microscopy)	2
Lec 3	Fluorescence microscopy methods and lifetime microscopy (FRAP, FRET, TIRF, FLIM techniques)	2
Lec 4	Multiphoton microscopy (multiphoton fluorescence, second and third harmonic generation (SHG, THG), microscopy	2
Lec 5	Electron microscopy (scanning electron microscopy SEM, transmission electron microscopy TEM)	2
Lec 6	Atomic force microscopy and other microscopic techniques with a scanning probe (AFM atomic force microscope, STM scanning tunneling microscope)	2
Lec 7	Near-field microscopy (NSOM scanning near-field microscopy methods)	2
Lec 8	Electron microscopy in practice	2
Lec 9	Scanning microscopy in practice	2
Lec 10	Super-resolution microscopy methods (STED, GSD techniques, STORM statistical microscopy, PALM)	2
Lec 11	Atomic force microscopy in practice	2
Lec 12	Practical examples of microscopy applications and techniques	2
Lec 13	Practical examples of microscopy applications and techniques	2
Lec 14	Practical examples of microscopy applications and techniques	2
Lec 15	Final evaluation of the work	2
	Total hours	30

TEACHING TOOLS USED
N1. Multimedia lectures N2. Own work - independent studies and preparation of a report/presentation

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement

F1	PEU_W01-08	Colloquium
F2	PEU_W01-08	Evaluation of the report/speech
P=(F1+F2)/2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Peter W. Hawkes, John C. H. Spence "Handbook of Microscopy" Springer, 2019
[2] A. Barbacki i in. „Mikroskopia elektronowa" Wydawnictwo Politechniki Poznańskiej, 2007
[3] M. Kopaczyńska „Mikroskopia sił atomowych (AFM) - biomedyczne zastosowanie pomiarów w nanoskali" Oficyna Wydawnicza Politechniki Wrocławskiej, 2010
[4] http://www.microscopyu.com/
[5] http://zeiss-campus.magnet.fsu.edu/

SECONDARY LITERATURE:

[1] M. Sauer, J. Hofkens, J. Enderlein "Handbook of fluorescence spectroscopy and imaging: from single molecules to ensembles." Wiley 2011
[2] H. Tanke, B. Herman, "Fluorescence Microscopy" Taylor & Francis Group, 2006
[3] B. R. Masters, P. T. C. So "Handbook of Biomedical Nonlinear Optical Microscopy" Oxford University Press 2008
[4] P. Eaton, P. West "Atomic force microscopy", Oxford University Press, 2011
[5] C. J. Chen "Introduction to scanning tunneling microscopy" Oxford University Press 2008
[6] L. Novotny, B. Hecht "Principles of Nano-Optics" Cambridge University Press 2012

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

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Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

SUBJECT CARD

Name of subject in Polish Ciekłe kryształy dla fotoniki
Name of subject in English LIQUID CRYSTALS for PHOTONICS
Main field of study (if applicable): Advanced Nano and Biomaterials MONABIPHOT
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code W03ANB-SM2006W, W03ANB-SM2006L

Group of courses No

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		15		
Number of hours of total student workload (CNPS)	75		50		
Form of crediting (Examination / crediting with grade)	egzamin		Crediting with grade		
For group of courses mark (X) final course					
Number of ECTS points	3		1		
including number of ECTS points for practical classes (P)			1		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1,3		0,7		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. General physics,
2. General chemistry

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SUBJECT OBJECTIVES

C1 To provide students with a general knowledge of chemical structure, interactions and physics of liquid crystals.
C2 To provide students with a knowledge about physicochemical properties of various mesophases: nematics, smectics, and chiral nematics including chiral ferroelectric LCs.
C3 To provide students with deep understanding of LCs optics
C4 To provide students with a knowledge related to applications of liquid crystals in display technologies, optical filtering, spatial light modulators.

C5 To provide students with contemporary photonic devices based on liquid crystals.

SUBJECT EDUCATIONAL EFFECTS

PEU_W01 - Student knows the principles of classification of liquid crystals in view of their structure, symmetry, origin of mesophase and macroscopic organization in bulk.

PEU_W02 - Student understands the liquid crystallinity and physical consequences of this state

PEU_W03 – Student understands in depth optical and dielectric properties of liquid crystals

PEU_W04 – Student knows and is able to identify various mesophases used for different functions like information displaying, processing and dynamic storage.

PEU_W05 - Student understands the advanced technologies of liquid crystal panels fabrication. He knows and understands the functioning of LC in photonics and knows the advantages and limits of these materials.

related to skills:

PEU_U01 – Student is able to make LC panels and characterize their optical properties.

PROGRAMME CONTENT

Lectures		**Number of hours**
Lec 1	Brief introduction to liquid crystalline state. Calamitic and discotic liquid crystals and its chemical structures. Polymorphism. Thermotropic liquid crystals.	2
Lec 2	Systematics of liquid crystals: nematics and smectics, cholesterics and their main properties.	2
Lec 3	Physicochemical properties of liquid crystals. Sequence of phases, phase transitions, textures, defects, viscosity.	2
Lec 4	Order parameter and anisotropy of electric and magnetic susceptibilities, Interaction of LC with electric field, Freedericksz effect, elastic constants K_{11}, K_{22} and K_{33}.	2
Lec 5	Dielectric, optic, elastic, hydrodynamic and thermal methods used for characterization of LCs in their various phases. Polarizing light studies of LCs.	2
Lec 6	Optical properties of liquid crystals. Refractive indices, birefringence, light scattering and light propagation, molecular dichroism).	2

Lec 7	The most important applications of liquid crystals and polymeric liquid crystals - liquid crystal displays and spatial light modulators.	2
Lec 8	Structure and properties of lyotropic liquid crystals. Kraft's plot. Amphiphilic molecules, micelles, mono- and bilayers, biological membranes.	2
Lec 9	Molecular engineering of LCs. Ferroelectric, ferrielectric and antiferroelectric LCs. Blue phases in LCs.	2
Lec 10	Polymeric liquid crystals, polymer dispersed liquid crystals and their applications.	2
Lec 11	Introduction of models of nematic LC description. Phenomenological approach. Free energy and theory of Maier and Saupe.	2
Lec 12	Optical properties of LCs. Mie light scattering.	2
Lec 13	Nonlinear optical phenomena in liquid crystals. Mechanism of giant optical nonlinearity. Laser induced molecular reorientations. Laser-induced dye-assisted molecular reorientations (Janossy effect).	2
Lec 14	Second harmonic generation, stationary degenerate wave mixing, optical phase conjugation, self-modulations effects, soliton formation, light amplification and optical limiting.	2
Lec 15	Review of applications of LCs in display technology and spatial light modulators. Electrically addressed spatial light modulators (SLM) for telecommunications. Real-time holography and use of SLM for optical manipulation of nanoscopic objects "optical tweezers". Tuning of liquid crystals in waveguides and photonic crystals.	2
	Total hours	30

Laboratory		**Number of hours**
Lab 1	Preparation of the LC panel	5
Lab 2	Microscopic studies of LC samples	5
Lab 3	Thermal evaluation of LC samples	5
	Total hours	15

TEACHING TOOLS USED
N1. Lecture with use of multimedia presentation. N2. Lecture with elements of discussion of problems

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement
P1 (lecture)	PEU_W01 PEU_W02 PEU_W03 PEU_W04 PEU_W05	Written test. Evaluation of test max. 100 pts 3.0 if 50-60 % pts 3.5 if 61-70 % pts 4.0 if 71-80 % pts 4.5 if 81-90% pts 5.0 if 91-95% pts 5.5 if 96-100 % pts
P1 (laboratory)	PEU_U01	Evaluation of a single report of performed measurements

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Displeje ciekłokrystaliczne – fizyka, technologia, zastosowanie, PWN, Warszawa (1993)
[2] Handbook of Liquid Crystals, D. Demus, J. Goodby, G.W. Gray, H.W. Dpiess, V. Vill, vols. 1-3, Wiely-VCH (1998)
[3] I.C. Khoo, Liquid Crystals, Physical Properties and Nonlinear optical Phenomena, J. Wiley, New York (1995)
[4] L.M. Blinov, V.G. Chigrinov, Electrooptic Effects in Liquid Crystal Materials, Springer (1996)
[5] P. Yeh, C. Gu, Optics of Liquid Crystals, Wiley Intersicence Publication, J. Wiley and Sons, New York (1999)

SECONDARY LITERATURE:

[1] Original scientific articles available through electronic literature database of Main Library of WUST
[2] Materials Today - scientific journal

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Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

SUBJECT CARD

Name of subject in Polish METODY MATEMATYCZNE W PLANOWANIU I ANALIZIE EKSPERYMENTU

Name of subject in English MATHEMATICAL METHODS IN PLANNING AND ANALYSIS OF EXPERIMENT

Main field of study (if applicable): Advanced Nano and Biomaterials - MONABIPHOT

Specialization (if applicable):

Profile: academic

Level and form of studies: 2nd level, full-time

Kind of subject: obligatory

Subject code W03ANB-SM2007L

Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)			30		
Number of hours of total student workload (CNPS)			60		
Form of crediting (Examination / crediting with grade)					
For group of courses mark (X) final course					
Number of ECTS points			2		
including number of ECTS points for practical classes (P)			2		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)			1,4		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. General physics
2. General chemistry

SUBJECT OBJECTIVES

C1 The aim of the subject is to familiarize students with the experimental data analysis
C2 Familiarizing the student with the methods of data analysis
C3 Acquiring the ability to carry out the data analysis process

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 Has basic knowledge of selecting and fitting a mathematical model to experimental data.

PEU_W02 Obtains knowledge about authorized inference methods.

PEU_W03 Has knowledge of the chemical and physical characteristics of materials and their impact on their functional properties

relating to skills:

PEU_U01 Is able to calculate the electrical, optical, magnetic and mechanical properties of polymers using a computer program.

PEU_U02 Is able to conduct literature research on a specific scientific and research problem. Has basic skills in planning and conducting scientific research.

PEU_U03 Is able to conduct scientific experiments, develop and interpret their results and relate them to appropriate theories or scientific hypotheses. Is able to determine directions for further learning and implement the self-education process. Is able to apply the principles of safe work in a chemical laboratory.

PROGRAMME CONTENT

	Laboratory	**Number of hours**
Lab 1	Planning experiments	2
Lab 2	Selection of experimental methods	2
Lab 3	Computer data analysis - Origin, ImageJ	2
Lab 4	Computer data analysis - Python	2
Lab 5	Descriptive statistics	2
Lab 6	Statistical hypotheses	2
Lab 7	The use of a statistical description	2
Lab 8	Integral methods	2
Lab 9	Differential methods	2
Lab 10	Signal filtration	2
Lab 11	Image analysis - part 1	2
Lab 12	Image analysis - part 2	2
Lab 13	Image analysis - part 3	2
Lab 14	Review of experimental methods	2
Lab 15	Review of experimental methods	2
	Sum of hours	30

TEACHING TOOLS USED

N1. Performing tasks in the laboratory
N2. Computer / computer program / programming

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during semester), P –	Learning outcomes code	Way of evaluating learning outcomes achievement

concluding (at semester end)		
P	PEU_W01-W03, PEU_U01-U03	Project evaluation from analysis of experimental data

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Alistair Croll, Benjamin Yoskovitz, „Lean Analytics: Use Data to Build a Better Startup Faster", "O'Reilly Media, Inc.", 2013

[2] Viktor Mayer-Schönberger, "Big Data : a Revolution that Will Transform how We Live, Work, and Think", Mariner Books, Houghton Mifflin Harcourt, 2013

[3] Wes McKinney, "Python for Data Analysis: Data Wrangling with Pandas, NumPy, and Ipython", O'Reilly Media, Incorporated, 2017

SECONDARY LITERATURE:

[1] Original scientific articles available through electronic literature database of Main Library of WUST

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

Konrad Cyprych, PhD, e-mail: konrad.cyprych@pwr.edu.pl

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

SUBJECT CARD

Name of subject in Polish Nowoczesne polimery
Name of subject in English Modern polymers
Main field of study (if applicable): Advanced Nano and Biomaterials - MONABIPHOT
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code W03ANB-SM2005W

Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30				
Number of hours of total student workload (CNPS)	50				
Form of crediting (Examination / crediting with grade)	Zaliczenie na ocenę				
For group of courses mark (X) final course					
Number of ECTS points	2				
including number of ECTS points for practical classes (P)					
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1,3				

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.Basic knowledge of organic chemistry
2.Basic knowledge of either polymer chemistry or material science

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SUBJECT OBJECTIVES

C1 To provide students with basic knowledge of polymers structure.
C2 To provide students with knowledge of main polymerization mechanisms and techniques as well as chosen methods of chemical modification of macromolecules.
C3 To acquaint students with the most important groups of modern polymers and methods of their fabrication

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 student knows the principles of polymer syntheses, relationships between type of polymerization and properties of the final product

PEU_W02 student knows the methods of polymer modification and knows how to give the desired properties to the polymers

…

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1	Program of lecture – basic polymers' features, differences from low molecular compounds, definitions.	2
Lec 2	Methods of polymer syntheses – relationship between polymerization and properties of final product	2
Lec 3	Suspension polymerization and modification of polymers' morphology; introduction of polymers to modern organic and analytical chemistry; Solid Phase Synthesis (SPS)	2
Lec 4	Chemical modifications leading to polymeric scavengers and carriers for catalysts	2
Lec 5	Syntheses of High Internal Phase Polymers and related multi-phase polymeric materials	2
Lec 6	Obtaining of thermosensitive polymers displaying Lower Critical Solubility Temperature (properties and applications)	2
Lec 7	Fabrication of semi-synthetic materials. Bio-based polymers revisited (a return to Nature)	2
Lec 8	Polymeric carriers for enzymes	2
Lec 9	Hydrogels syntheses and modifications. and their applications	2
Lec 10	Other methods of polymers' synthesis - plasma modification – superhydrophobic polymers	2
Lec 11	Making of 'smart" fibrous polymers – modern superhydrophobic, modern conducting materials. Electrospinning of multifunctional composite fibers	2
Lec 12	Making of conducting polymers - electropolymerization (poly(acetylenes), poli(pyrroles), poly (tiophenes)	2
Lec 13	Ionic polymers – ionophores; ion-exchangers and their synthesis, modern ion-exchangers and coordinating resins	2
Lec 14	Polymeric analogues of Ionic Liquids – synthesis and applications	2
Lec 15	Synthesis of self-healing polymers	2
	Total hours	30

	Classes	**Number of hours**
Cl 1		
Cl 2		
Cl 3		
Cl 4		
..		

	Total hours	
Laboratory		**Number of hours**
Lab 1		
Lab 2		
Lab 3		
Project		**Number of hours**
Proj 1		
Proj 2		
Proj 3		
Proj 4		
…		
	Total hours	
Seminar		**Number of hours**
Semin 1		
Semin 2		
Semin 3		
…		
	Total hours	

TEACHING TOOLS USED
N1. PowerPoint presentations N2. Scientific literature (is also included on each subject slide)

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement
F=P	PEU_W01-W02	test

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] M. Chanda, S.K. Roy, "Industrial Polymers, Specialty Polymers, and Their Applications", Boca Raton etc., CRC Press/Taylor & Francis Group, 2009.
[2] F. Mohammad (Ed), "Specialty Polymers: Materials And Applications", I. K. International Pvt Ltd, Anshan Ltd, Tunbridge Wells, 2007.
[3] papers from the scientific journals provided by the lecturer

SECONDARY LITERATURE:

[1] R. Barbucci (Ed.), "Hydrogels. Biological Properties and Applications", Springer-Verlag Italia, Milan 2009.
[2] R.M. Ottenbrite, K. Park, T. Okano (Eds.), "Biomedical Applications of Hydrogels Handbook", Springer Science & Business Media New York, 2010.

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Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

SUBJECT CARD

Name of subject in Polish ……Zaawansowana spektroskopia…….
Name of subject in English ……Modern Spectroscopy…….
Main field of study (if applicable): …Chemistry…….
Specialization (if applicable): …… Advanced Nano and Biomaterials - MONABIPHOT
Profile: academic ~~/ practical~~*
Level and form of studies: - 2nd level, full-time
Kind of subject: obligatory
Subject code W03ANB-SM2002W
Group of courses - NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30				
Number of hours of total student workload (CNPS)	50				
Form of crediting (Examination / crediting with grade)	crediting with grade				
For group of courses mark (X) final course					
Number of ECTS points	2				
including number of ECTS points for practical classes (P)					
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1,3				

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. General chemistry
2. Fundamentals of physics
3. Fundamentals of physical chemistry

SUBJECT OBJECTIVES

C1 To provide students with a general knowledge on the modern spectroscopy
C2 To provide students with a knowledge on spectroscopic setups and techniques
C3 To provide students with a trends in materials characterization using spectroscopic techniques

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:
P7U_W01student knows the basic definitions of spectroscopy, especially optical spectroscopy
P7U_W02 student knows the light sources applied in spectroscopy
P7U_W03 student knows the modern setups applied in spectroscopic measurements

P7U_W04 student knows the time-resolved spectroscopies and techniques such as TCSPC
P7U_W05 student knows advanced time-resolved spectroscopies and techniques such as pump-probe
P7U_W06 student knows the selected aspects of nonlinear optical spectroscopy
P7U_W07 student knows the spectroscopic techniques such as Hyper-Rayleigh
P7U_W08 student knows the Hyper-Raman spectroscopy
P7U_W09 student knows the infrared spectroscopies
P7U_W10 student knows new techniques such as CARS and SERS
P7U_W11 student knows techniques of Raman and IR microspectroscopy
P7U_W12 student knows techniques of chiral materials investigations
P7U_W13 student knows new modulation spectroscopy techniques
P7U_W14 student knows new trends in spectroscopy

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1	**Introduction to modern spectroscopy.** Definitions.	2
Lec 2	**Light sources in laser spectroscopy.**	2
Lec 3	**Modern spectroscopy setups.**	2
Lec 4	**Time-resolved techniques part 1.** Techniques like TCSPC.	2
Lec 5	**Time-resolved techniques part 2.** Techniques like pump-probe.	2
Lec 6	**Nonlinear spectroscopy part 1.** Multiphoton absorption**,** z-scan technique, saturable absorption spectroscopy.	2
Lec 7	**Nonlinear spectroscopy part 2.** Hyper-Rayleigh spectroscopy.	2
Lec 8	**Nonlinear spectroscopy part 3.** Hyper-Raman spectroscopy.	2
Lec 9	**Modern infra-red spectroscopy.** Ultrafast spectroscopy, 2D-IR	2
Lec 10	**Raman scattering spectroscopy**. Resonant spectroscopy, micro-Raman, SERS, CARS	2
Lec 11	**Raman and IR imaging techniques.**	2
Lec 12	**Chiral spectroscopy – circular dichroism.**	2
Lec 13	**Modulation spectroscopy.** Examples of light-, magnetic field, electric field stimulated spectroscopies.	2
Lec 14	**New trends in modern spectroscopy.**	2
Lec 15	**Colloquium**	2

TEACHING TOOLS USED

N1. Multimedia presentation
N2. Discussions during the lectures

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement

P	P7U_W1-W14	test

PRIMARY LITERATURE:

[1] H.Abramczyk, Spektroskopia laserowa, skrypt PWr, 2011

[2] W. Demtröder, Spektroskopia laserowa. Wydawn. Naukowe PWN, 1993

ADDITIONAL LITERATURE:

[3] A. Corney, Atomic and laser spectroscopy. Oxford Classic Texts in the Physical Sciences, 2006

[4] S. Svanberg, Atomic and Molecular Spectroscopy. Springer, 2004

[5] J.M. Hollas, Modern Spectroscopy, 2004

[6] Joseph R. Lakowicz, Principles of Fluorescence Spectroscopy , Springer, 2006

[7] Max Diem, Introduction to Modern Vibrational Spectroscopy Wiley, 1993

Michael D. Fayer ed., Ultrafast Infrared Vibrational Spectroscopy, CRC press 2013.

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Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

SUBJECT CARD

Name of subject in Polish Nanomateriały
Name of subject in English Nanomaterials
Main field of study (if applicable): Advanced Nano and Biomaterials - MONABIPHOT
Specialization (if applicable): ……..
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code W03ANB-SM2011W, W03ANB-SM2011S
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30				15
Number of hours of total student workload (CNPS)	50				25
Form of crediting (Examination / crediting with grade)					
For group of courses mark (X) final course					
Number of ECTS points	2				1
including number of ECTS points for practical classes (P)					1
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1,3				0,7

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. General chemistry
2. Basics of physics
3. Basics of biology

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SUBJECT OBJECTIVES

C1 To provide students with a general knowledge on the synthesis of nanomaterials
C2 To provide students with a general knowledge on the chemical and physical properties of nanomaterials
C3 To provide students with a general knowledge on the applications of nanomaterials
C4 To provide students with a general knowledge on the challenges and dangers of the applications of nanomaterials

SUBJECT EDUCATIONAL EFFECTS

related to knowledge:
PEU_W01student knows the differences in the properties of nanomaterials and bulk materials

PEU_W02 student knows the methods of the synthesis of nanomaterials
PEU_W03 student knows the lithographic techniques used to produce nanomaterials
PEU_W04 student knows methods of characterization of nanomaterials – structural investigations and optical spectroscopies and microscopies of a single nanoparticle, nanomanipulation
PEU_W05 student knows the properties and applications of plasmonic nanomaterials
PEU_W06 student knows the properties and applications of metal nanoparticles
PEU_W07 student knows the properties and applications of quantum dots
PEU_W08 student knows the properties and applications of carbon nanomaterials
PEU_W09 student knows the properties and applications of lanthanide-doped nanomaterials
PEU_W10 student knows the properties and applications of 2D nanomaterials
PEU_W11 student knows the properties and applications of nanofibers and composite nanomaterials
PEU_W12 student knows the processes in self-assembly of nanomaterials
PEU_W13 student knows the methods of bioconjugation and functionalization of nanomaterials
PEU_W14 student knows and understands the dangers of the applications of nanomaterials

related to skills:
PEU_U01 - Can name and define concepts in the field of nanomaterials and search for information on nanomaterials from available sources.
PEU_U02- Can name methods of synthesis of colloidal nanomaterials.
PEU_U03- Can name and compare the physical methods of synthesis of nanomaterials.
PEU_U04- Has language skills in the field of nanoparticle characterization methods.
PEU_U05- Is able to recognize, name and define plasmonic nanomaterials
PEU_U06- Is able to recognize, name and define metal nanoparticles
PEU_U07- Can recognize, name and define properties and applications of quantum dots
PEU_U08- Is able to recognize, name and define properties and applications of carbon nanomaterials
PEU_U09- Can recognize, name and define properties and applications of 2D nanomaterials
PEU_U10 - Is able to recognize, name and define properties and applications of nanoparticles with lanthanides
PEU_U11 - Is able to recognize, name and define properties and applications of nanofibers and nanocomposites
PEU_U12 - Can name and define methods for self-assembly of nanoparticles
PEU_U13 - Can name methods of nanoparticles functionalization
PEU_U14 - Can identify the dangers and prospects of nanomaterials applications

related to social competences:
PEU_K01 student is ready to critically evaluate his/her knowledge and received content

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1	Introduction to nanomaterials, definitions, nanomaterials vs. bulk materials, general methods of nanomaterials preparation	2
Lec 2	Synthesis of nanomaterials, colloidal nanoparticles	2
Lec 3	Physical techniques for nanomaterials preparation	2

Lec 4	Characterization of nanomaterials – structural investigations and optical spectroscopies and microscopies of a single nanoparticle	2
Lec 5	Plasmonic nanoparticles: synthesis, properties and applications	2
Lec 6	Metal nanoparticles: nanoclusters, heterostructures	2
Lec 7	Quantum dots: synthesis, properties, applications	2
Lec 8	Carbon nanomaterials: synthesis, properties, applications	2
Lec 9	2D nanomaterials (TMD, graphene etc.)	2
Lec 10	Lanthanide-doped nanomaterials: synthesis, properties, applications	2
Lec 11	Biology-inspired nanomaterials	2
Lec 12	Self-assembly of nanoparticles	2
Lec 13	Functionalization of nanomaterials, bioconjugation	2
Lec 14	Perspectives, challenges and dangers in the applications of nanomaterials. Nanotoxicology.	2
Lec 15	Exam	2
	Total hours	30

Seminar		**Number of hours**
Semin 1	Introduction to presentation of nanomaterials and recent discoveries in nanotechnology	2
Semin 2	Presentations of students on nanomaterials	2
Semin 3	Presentations of students on nanomaterials	2
Semin 4	Presentations of students on nanomaterials	2
Semin 5	Presentations of students on nanomaterials	2
Semin 6	Presentations of students on nanomaterials	2
Semin 7	Evaluation	1
	Total hours	15

TEACHING TOOLS USED
N1. Multimedia presentation N2. Discussion during lectures and seminars

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement
P1 (lecture)	PEU W01-14	exam
P2 (seminar)	PEU U01-14	student presentation

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE: [1] Paras N. Prasad, Nanophotonics, Wiley-Interscience, 2004 [2] K. D. Sattler, Handbook of nanophysics, CRC Press, 2011 [3] Paras N. Prasad, Introduction to Nanomedicine and Nanobioengineering, Wiley, 2012 [4] C. Louis, O. Pluchery, Gold Nanoparticles for physics, chemistry and biology, Imperial College Press 2012 [5] Challa S. S. R. Kumar, Biofunctionalization of Nanomaterials. Wiley 2005
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dr hab. inż. Joanna Olesiak-Bańska, prof. PWr (joanna.olesiak@pwr.edu.pl)

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

SUBJECT CARD

Name of subject in Polish Fizyka w nanoskali
Name of subject in English Nanoscale physics

Main field of study (if applicable): Advanced Nano and Biomaterials - MONABIPHOT

Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code W03ANB-SM2010W, W03ANB-SM2010L
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		15		
Number of hours of total student workload (CNPS)	50		50		
Form of crediting (Examination / crediting with grade)	crediting with grade		crediting with grade		
For group of courses mark (X) final course					
Number of ECTS points	2		2		
including number of ECTS points for practical classes (P)			2		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1,3		0,7		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Fundamentals of optical spectroscopy.
2. Fundamentals of solid state physics.

SUBJECT OBJECTIVES

C1 To provide students with a general knowledge on physical phenomena occurring in inorganic nanostructures of various types.

C2 To provide students with a general knowledge on modern manufacturing techniques of various nanomaterials.

C3 To provide students with a general knowledge on modern applications of inorganic nanostructures.

C4 To provide students with a general knowledge on experimental techniques used for inorganic nanostructures investigations.

C5 To provide student with a ability to work in group at solving different experimental as well theoretical problems occurring during the laboratories.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 student knows the principles of different experimental techniques used for inorganic nanostructures analysis.

PEU_W02 student knows modern theories/technologies/ related with semiconducting nanomaterials.

PEU_W03 student knows and understands the principles of the experimental methods used in nanostructures investigations.

relating to skills:

PEU_U01 student can apply the principles of different experimental techniques to analyze semiconducting nanomaterials.

PEU_U02 student is able to analyze and critically evaluate experimental results obtained for spectroscopic data obtained for semiconducting nanomaterials.

relating to social competences:

PEU_K01 student understands the need to inform the public about the need to achieve the goals of sustainable development in technologies for the production of new materials, energy and environmental protection.

PEU_K02 student is able to work in a group, performing various roles including group leader.

PEU_K03 student is aware of the social role of the engineer.

PEU_K04 student is ready to critically evaluate his/her knowledge and received content.

PROGRAMME CONTENT

Lecture		Number of hours
Lec 1	Introduction to nanotechnology, nanostructures and discussion on the main civilization problems and market demands which stimulate nanotechnology development and defines new challenges for engineers.	2
Lec 2	Basic concepts of solid state physics and solid state spectroscopy	2
Lec 3-4	Basic concepts of physics of nanostructures: Excitons, Plasmons, Polaritons, Plextitons. Crystal vs. Quantum Box - electron energy diagrams, energy band-off sets, density of states, optical properties.	4
Lec 5	Basic concepts of physics and chemistry of inorganic nanostructures. Size effects, shape effects, surface effects.	2
Lec 6	Optical properties of nanocrystals: electron confinement, dielectric confinement, phonon confinement, core-shell structures, nanocrystals in matrix.	2

Lec 7	Methods of nanostructures growth: Chemical Vapor Deposition and Physical Vapor Deposition methods.	2
Lec 8-9	Methods of nanostructures growth: wet chemistry methods.	4
Lec 10-11	Nanocrystals applications in biology and medicine.	4
Lec 12-13	Nanocrystals applications in optoelectronics.	4
Lec 14	Main experimental methods used for nanostructures investigations. Setups, hands-on and deep theoretical insight. Photoluminescence, Photoluminescence Decay, Photoluminescence Excitation, Absorbance, Raman Spectroscopy.	2
Lec 15	Advanced experimental methods used for nanostructures investigations. Single nanocrystals spectroscopy. Super-resolution imaging.	2
….		
	Total hours	30

Classes		**Number of hours**
Cl 1		
Cl 2		
Cl 3		
Cl 4		
..		
	Total hours	

Laboratory		**Number of hours**
Lab 1	Introduction. Safety. Setups description.	2
Lab 2	Photoluminescence Decay of semiconducting nanostructures & Photoluminescence of up-converting nanostructures.	5
Lab 3	Photoluminescence Excitation of semiconducting nanostructures.	3
Lab 4	Absorbance of semiconducting nanostructures	5
	Total hours	15

Project		**Number of hours**
Proj 1		
Proj 2		
Proj 3		
Proj 4		
…		
	Total hours	

Seminar		Number of hours
Semin 1		
Semin 2		
Semin 3		
…		
	Total hours	

TEACHING TOOLS USED
N1. Multimedia presentation N2. Lectures N3. Hands-on experiments discussed during lectures. N4. Scientific reports.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement
P1 (lecture)	PEU W01-03	test
P2 (seminar)	PEU U01-02, PEU K01-04	student presentation

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] *Nanoscale Materials in Chemistry*, Second Edition, Edited by Kenneth J. Klabunde and Ryan M. Richards, 2009 by John Wiley & Sons, Inc.

[2] *Nanocrystals-Synthesis, Properties and Applications - Series: Springer Series in Materials Science*, Vol. 95, **Rao**, C.N.R., **Thomas**, P. John, **Kulkarni,** G.U. 2007

[3] *Semiconductor Nanocrystal Quantum Dots: Synthesis, Assembly, Spectroscopy and Applications*, Andrey L. Rogach, Springer 2008

[4] *Colloids and Colloid Assemblies: Synthesis, Modification, Organization and Utilization of Colloid Particles*, Frank Caruso, John Wiley & Sons 2006

[5] *Highlights in Colloid Science*, Dimo Platikanov, Dotchi Exerowa, John Wiley & Sons 2009

[6] *Colloid Science: Principles, Methods and Applications*, Terence Cosgrove, John Wiley & Sons 2010.

[7] *Functional Coatings: By Polymer Microencapsulation*, Swapan Kumar Ghosh, John Wiley & Sons 2006.

[8] *Nano-Surface Chemistry*, Morton Rosoff, Taylor & Francis, 2001.

[9] *Colloid Chemistry II*, Markus Antonietti, Springer 2003.

[10] *Applied Colloid and Surface Chemistry*, Richard Pashley, Marilyn Karaman, John Wiley & Sons 2005

[11] *Surface Chemistry*, A. Goel, Discovery Publishing House 2006.

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Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

SUBJECT CARD

Name of subject in Polish Optyka nieliniowa dla Chemików
Name of subject in English Nonlinear Optics for Chemists
Main field of study (if applicable): Advanced Nano and Biomaterials - MONABIPHOT
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: laboratory-obligatory / lecture-optional
Subject code W03ANB-SM21010W, W03ANB-SM2009L
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		15		
Number of hours of total student workload (CNPS)	50		50		
Form of crediting (Examination / crediting with grade)	Crediting with grade		Crediting with grade		
For group of courses mark (X) final course					
Number of ECTS points	2		2		
including number of ECTS points for practical classes (P)			2		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1,3		0,7		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. General physics,
2. General Chemistry

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SUBJECT OBJECTIVES

C1 To provide students with general knowledge about the fundamentals of the theory of nonlinear light interaction with matter.
C2 To provide students with knowledge about main nonlinear optical phenomena.
C3 To provide students with knowledge about the main methods of study of matter using laser beams of short pulses and strong power.
C4 To inform students about the application of nonlinear optics achievements in science and technology.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 – Student has systematized knowledge within the physical basis of optical field interaction with matter.

PEU_W02 - Students can understand the physics of nonlinear light interaction with matter at the microscopic and macroscopic levels

PEU_W03 - Student knows and recognizes nonlinear optical phenomena of second and third-order

PEU_W04 - Student knows and understands measurement methods used to evaluate nonlinear optical properties of optical materials

relating to skills:

PEU_U01 – Student has the ability to propose optical material for fulfilling desired functionality of second and third nonlinear optical type.

PEU_U02 – Student has the ability to design measurement setup to measure fundamental nonlinear optical properties of a material

PEU_U03 Student is able to perform chosen experiments in the field of nonlinear optics

relating to social competences:

PEU_K01 – The student is able to do research and overview of scientific literature

PEU_K02 – The student has a knowledge of the importance and role of light in contemporary life and of materials interacting with light in a nonlinear fashion for the production of economical and useful devices for mankind

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1	Introduction to optics – light.	2
Lec 2	Basics of the light-matter interactions.	2
Lec 3	Harmonic oscillator approximation – linear effects.	2
Lec 4	Nonlinear optical medium, polarization, nonlinear optical susceptibilities.	2
Lec 5	Units, notation and conservation rules in nonlinear optics.	2
Lec 6	Phenomenological description of nonlinear optics phenomena. The most important second-order phenomena.	2
Lec 7	Phenomenological description of nonlinear optics phenomena. The most important third-order phenomena.	2
Lec 8	Detailed description of the second harmonic generation phenomenon.	2
Lec 9	Generation of sum and difference frequencies. Wave mixing processes.	2
Lec 10	Nonlinear refractive index, Kerr media	2
Lec 11	Generation of supercontinuum, solitons, and ultra-short pulses.	2
Lec 12	Nonlinear light absorption and emission – selection rules in nonlinear optics.	2
Lec 13	Modern materials for nonlinear optics.	2
Lec 14	Evaluation test of students' knowledge.	2

Lec 15	Second evaluation test of students' knowledge.	2
	Total hours	30

Laboratory		**Number of hours**
Lab 1	Linear electrooptic effect – Pockels effect	3
Lab 2	Optical Kerr effect	3
Lab 3	Second harmonic generation	3
Lab 4	Degenerate two-wave mixing	3
Lab 5	Optical phase conjugation	3
	Total hours	15

TEACHING TOOLS USED

N1. Lecture with use of multimedia presentation.
N2. Laboratory of nonlinear optics – group work

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement
P1 (lecture)	PEU_W01 PEU_W02 PEU_W03 PEU_W04 PEU_W05	Written test. Evaluation of test max. 100 pts 3.0 if 50-60 % pts 3.5 if 61-70 % pts 4.0 if 71-80 % pts 4.5 if 81-90% pts 5.0 if 91-95% pts 5.5 if 96-100 % pts
P1 (laboratory)	PEU_U01-PEU_U03, PEU-K01_PEU-K02	Evaluation of a single report of performed measurements

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] B.E. A. Saleh, M. C. Teich, Fundamentals of Photonics, Wiley, New York, 1999
[2] P. N. Prasad, Nanophotonics, Wiley-Interscience, New Jersey, 2004
[3] Pavel Chmela,"Wprowadzenie do optyki nieliniowej", PWN, Warszawa 1987
[4] A. Yariv, P.Yeh," Optical waves in crystals", Wiley 1984
[5] F. Kaczmarek, „Wstęp do fizyki laserów", PWN, Warszawa 1986
[6] S. Kielich, "Molekularna optyka nieliniowa", PWN Warszawa, 1977

SECONDARY LITERATURE:

[1] Photonics journal
[2] Original scientific articles available through the electronic literature database of the Main Library of WUST

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

Dr inż. Paweł Karpiński (pawel.karpinski@pwr.edu.pl) and/or dr hab. inż. Lech Sznitko (lech.sznitko@pwr.edu.pl)

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of CHEMISTRY

SUBJECT CARD

Name of subject in English: **Organic Electronics**
Main field of study (if applicable): **Advanced Nano and Biomaterials - MONABIPHOT**
Specialization (if applicable):
Profile: **academic**
Level and form of studies: **2nd level, full-time**
Kind of subject: **obligatory**
Subject code: **W03ANB-SM2012W, W03ANB-SM2012S**
Group of courses: **NO**

	Lecture	**Classes**	**Laboratory**	**Project**	**Seminar**
Number of hours of organized classes in University (ZZU)	**15**				**15**
Number of hours of total student workload (CNPS)	**25**				**25**
Form of crediting	**crediting with grade**	crediting with grade	crediting with grade	crediting with grade	**crediting with grade**
For group of courses mark (X) final course					
Number of ECTS points	**1**				**1**
including number of ECTS points for practical (P) classes					**1**
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	**0,65**				**0,7**

*delete as applicable

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Elemental mathematics: Analysis I and II, algebra
2. Elemental physics: Physics I and II
3. Fundamentals of physical chemistry

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SUBJECT OBJECTIVES

To provide students with a general knowledge of:
C1 Mechanism of electrical conductivity in organic materials
C2 Principles of operation of organic electronic devices
C3 Organic electronic materials and fabrication technologies
C4 Measurement methods used in characterization of organic electronic devices

C5 To gain experience in elaboration and presentation of state of the art knowledge, based on scientific publications

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:
PEU_W01 - student knows the types and basic properties of typical organic electronic materials.

PEU_W02 - student knows the basics of the description of conductivity and electronic excitation in organic materials
PEU_W03 - student knows the principles of operation of diodes, transistors and photovoltaic devices.
PEU_W04 - student knows the methods of fabrication and characterization of organic electronic devices

relating to skills:
PEU_U01 student is able to interpret, elaborate and present a range of actual knowledge based on original scientific literature

related to social competences:

PROGRAMME CONTENT		
Lectures		**Number of hours**
Lec 1	Types and properties of materials used in organic electronics: crystals, polymers, molecules	2
Lec 2	Basic description of phenomena occurring during absorption and emission of radiation	2
Lec 3	Basic description of electrical conductivity in organic materials	2
Lec 4	Fabrication methods: vacuum, solution-based, Langmuir-Blodgett	2
Lec 5	Light emitting diodes - principles of operation and materials	2
Lec 6	Photovoltaic devices - principles of operation and materials	2
Lec 7	Field effect transistors - principles of operation and materials	2
Lec 8	Electronic devices built from single molecules, memories, optoelectronic devices	1
	Total hours	**15**
Seminar		**Number of hours**
Proj 1 - Proj 7	Student presentations on a selected topic from the field of organic electronics elaborated on the basis of original scientific reports	15
	Total hours	**15**

TEACHING TOOLS USED
N1. Lecture: traditional lecture or multimedial presentation N2. Seminar: students presentations

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F – forming (during semester), P – concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1	PEU_W01 - PEU_W04	Written essay on the given topic
F2	PEU_U01	Oral presentation
P= (F1+F2)/2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Köhler, A. and Bässler, H. (2015). Front Matter. In Electronic Processes in Organic Semiconductors (eds A. Köhler and H. Bässler).

SECONDARY LITERATURE:

[1] Jan Godlewski (2008). Wstęp Do Elektroniki Molekularnej.

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

dr inż. Krzysztof Janus, Krzysztof.janus@pwr.edu.pl

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

SUBJECT CARD

Name of subject in Polish: Praca dyplomowa I
Name of subject in English: Graduate laboratory I
Main field of study (if applicable):
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code W03W03-SM1054D, W03W03-SM2054D
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)			60		
Number of hours of total student workload (CNPS)			150		
Form of crediting (Examination / crediting with grade)			crediting with grade		
For group of courses mark (X) final course					
Number of ECTS points			6		
including number of ECTS points for practical classes (P)			6		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)			3		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.
2.

SUBJECT OBJECTIVES

C1 Developing the ability to select and analyze sources of knowledge, including scientific literature
C2 Developing the ability to create a written study on the topic of the diploma thesis
C3 Expanding the skills of planning and conducting scientific work

SUBJECT EDUCATIONAL EFFECTS

In relation to knowledge:

PEU_W01 – knows the types of sources of scientific and professional knowledge,
PEU_W02 – has in-depth knowledge of the topic of the diploma thesis

In relation to skills:

PEU_U01 – is able to collect information useful for learning about a specific issue and preparing for the completion of a diploma thesis
PEU_U02 – is able to critically analyze the collected information in a form written on a selected scientific or practical issue.
PEU_U03 – (optional) is able to plan and carry out experiments/design work as well as develop the results and draw conclusions from their achievements and plan further work

In relation to social competences:

PEU_K01 – is ready to critically evaluate knowledge obtained from various sources
PEU_K02 – is ready to comply with the principles of professional ethics and respect copyrights

PROGRAMME CONTENT

	Laboratory	**Number of hours**
Lab 1-Lab15	Individual student work on a selected topic according to the schedule agreed with the diploma thesis supervisor	60
	Total hours	60

TEACHING TOOLS USED

N1. consultations

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement
P	PEU_W01 – PEU_W02 PEU_U01 –PEU_U03 PEU_K01 – PEU_K02	assessment of student work based on progress in completing the diploma thesis

PRIMARY AND SECONDARY LITERATURE

Scientific and professional literature indicated by the course tutor and/or found by the student.

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

Supervisors of individual diploma thesis topics
Subject card preparation:
Piotr Rutkowski, piotr.rutkowski@pwr.edu.pl

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

SUBJECT CARD

Name of subject in Polish: Praca dyplomowa II
Name of subject in English: Graduate laboratory II
Main field of study (if applicable):
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code W03W03-SM1055D, W03W03-SM2055D
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)			210		
Number of hours of total student workload (CNPS)			500		
Form of crediting (Examination / crediting with grade)			crediting with grade		
For group of courses mark (X) final course					
Number of ECTS points			20		
including number of ECTS points for practical classes (P)			20		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)			9,5		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.

SUBJECT OBJECTIVES

C1 implementation of a research project
C2 written preparation of the diploma thesis

SUBJECT EDUCATIONAL EFFECTS

In relation to knowledge:
PEU_W01 – knows the types of sources of scientific and professional knowledge
PEU_W02 – has advanced knowledge of the topic of the diploma thesis

In relation to skills:
PEU_U01– is able to carry out experiments / develop a project in accordance with the developed work plan

PEU_U02 – is able to compare information obtained from sources of knowledge with the results of research, verify the results of own research, draw conclusions and plan further work
PEU_U03 – is able to develop the results of his/her work on a selected topic and present them in the form of a diploma thesis

In relation to social competences:
PEU_K01 – is ready to critically evaluate the obtained results of research work on a selected topic
PEU_K02 – is ready to comply with the principles of professional ethics and respect copyrights

PROGRAMME CONTENT

	Laboratory	**Number of hours**
Lab 1-Lab15	Individual student work on a selected topic according to the schedule agreed with the diploma thesis supervisor	210
	Total hours	210

TEACHING TOOLS USED

N1. consultations

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement
P	PEU_W01 – PEU_W02 PEU_U01 – PEU_U03 PEU_K01 – PEU_K02	assessment of student work based on progress in completing the diploma thesis

PRIMARY AND SECONDARY LITERATURE

Scientific and professional literature indicated by the course tutor and/or found by the student.

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

Supervisors of individual diploma thesis topics
Subject card preparation:
Piotr Rutkowski, piotr.rutkowski@pwr.edu.pl

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

SUBJECT CARD

Name of subject in Polish: Proseminarium
Name of subject in English: Graduation proseminar
Main field of study (if applicable):
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code W03W03-SM1053S, W03W03-SM2053S
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)					15
Number of hours of total student workload (CNPS)					25
Form of crediting (Examination / crediting with grade)					crediting with grade
For group of courses mark (X) final course					
Number of ECTS points					1
including number of ECTS points for practical classes (P)					1
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)					0,7

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.
2.
3.

\

SUBJECT OBJECTIVES

C1
C2

SUBJECT EDUCATIONAL EFFECTS

In relation to knowledge:
PEU_W01 – has knowledge of research topics related to the studied field of study conducted in organizational units of the Faculty of Chemistry

In relation to skills:

PEU_U01 – can take an active part in discussions on scientific topics

In relation to social competences:
PEU_K01 – is aware of the need to improve their competences in the field of research within the field of study

PROGRAMME CONTENT

	Seminar	**Number of hours**
Semin 1-15	Discussion of the topics of diploma theses by employees of the Faculty's units conducting research related to the field of study; Presentation of research and analytical laboratories in the Faculty's units; Discussion of the rules for selecting the topics of diploma theses and the rules for implementing/passing the "Diploma Thesis" courses	15
	Total hours	15

TEACHING TOOLS USED

N1. Presentation
N2. Discussion
N3. Consultations

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement
P	PEU_W01 PEU_U01 PEU_K01	Attendance at classes, participation in discussions - assessed by the people conducting the classes

PRIMARY AND SECONDARY LITERATURE

N/A

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

Chairman of the study program committee

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

SUBJECT CARD

Name of subject in Polish: Przedmiot kierunkowy wybieralny
Name of subject in English: Elective course
Main field of study (if applicable):
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: elective
Subject code …….
Group of courses NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30				
Number of hours of total student workload (CNPS)	25				
Form of crediting (Examination / crediting with grade)	Zaliczenie na ocenę				
For group of courses mark (X) final course					
Number of ECTS points	2				
including number of ECTS points for practical classes (P)					
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1,3				

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.
2.
3.

SUBJECT OBJECTIVES

C1 Familiarizing the student with advanced issues in the field of chemical sciences (including biotechnology) and/or materials engineering and/or chemical engineering (including chemical technology)

SUBJECT EDUCATIONAL EFFECTS

In relation to knowledge:
PEU_W01 – Knows and is able to describe the basic phenomena and processes occurring in the life cycle of devices, objects and technical systems.

PEU_W02 – has in-depth knowledge of development trends and new achievements in the field of chemical engineering and technology and related sciences

In relation to social competences:

PEU_K01 – is ready to critically evaluate the knowledge acquired and the content received

PEU_K02 – is aware of the role of a technical university graduate and the need to maintain the ethos of the engineering profession

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec 1-Lec 15	To familiarize students with advanced concepts, theories describing phenomena, operations and processes occurring in living and inanimate systems, as well as with the latest trends in chemical sciences, chemical engineering and related sciences. Issues presented in an elective subject, depending on the field studied, may include, among others: - adsorbents in environmental protection and industry - alternative and renewable energy sources, renewable raw materials in industry, recycling technologies - technical security - medical and pharmaceutical chemistry - chemistry of coordination compounds - chemistry of fragrance compounds - physical chemistry of chemical processes and products - chemistry, engineering and technology of materials (polymer, carbon, ceramic, metallic) and composites - technologies of dispersed systems - catalysts and catalysis in industry - instrumental methods in chemistry - physicochemical description of simple and complex systems - from the borderline of biology and medicine, describing the biological and biochemical basis of the functioning of organisms, including chemical and biochemical processes at the cellular and molecular level - industrial aspects of biotechnology - recycling of precious metals - issues of technological process and quality management, principles of investing and operating chemical technologies - modern chemical technologies - biotechnology development trends - basics of spectroscopic methods, - bioelectrochemical systems - issues related to sustainable development - characteristics of the biotechnology and chemical industry in Poland and in the world	30
	Total hours	30

TEACHING TOOLS USED

N1. Presentation

N2. Discussion

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement
P	PEU_W01- PEU_W02 PEU_K01- PEU_K02	Writing test (to pass minimum 50% of points)

PRIMARY AND SECONDARY LITERATURE
[1] Literature is provided during the first classes by the teachers of the elective subject
SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Chairman of study program committee

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of Chemistry

SUBJECT CARD

Name of subject in Polish: Seminarium dyplomowe
Name of subject in English: Graduation seminar
Main field of study (if applicable):
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level, full-time
Kind of subject: obligatory
Subject code: **W03W03-SM1056S, W03W03-SM2056S**
Group of courses: NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)					15
Number of hours of total student workload (CNPS)					50
Form of crediting (Examination / crediting with grade)					crediting with grade
For group of courses mark (X) final course					
Number of ECTS points					2
including number of ECTS points for practical classes (P)					2
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)					0,7

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

n/a

SUBJECT OBJECTIVES

C1 development of students' social competences in presenting the results of their diploma thesis, initiating discussions and actively participating in them

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:
PEU_W01 – has in-depth knowledge of the topic of the diploma thesis
relating to skills:

PEU_U01 – is able to collect and verify information necessary to learn about the selected research topic
PEU_U02 – is able to draw conclusions from the results of one's own research in relation to literature sources
PEU_U03 – is able to publicly present the results of his research and defend them during public discussion
PEU_U04 – is able to transfer knowledge to others
relating to social competences:
PEU_K01 – is aware of the importance of knowledge, including its critical analysis
PEU_K02 – is ready to deepen knowledge and skills, and, if necessary, use the help of experts

PROGRAMME CONTENT		
Seminar		**Number of hours**
Se 1	Discussion of the diploma process in the field of study	1
Se 2 – Se 15	Presenting a multimedia presentation and participating in the discussion	14
	Total hours	15

TEACHING TOOLS USED
N1. Presentation N2. Discussion N3. Consultations

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement
P	PEU_W01 PEU_U01 –PEU_U04 PEU_K01 – PEU_K02	assessment based on the presentation and activity in discussions

PRIMARY AND SECONDARY LITERATURE
N/A
SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)
Chairman of the program committee for the relevant field of study Card preparation: Piotr Rutkowski, piotr.rutkowski@pwr.edu.pl

KARTY PRZEDMIOTÓW – SEMESTR UZUPEŁNIAJĄCY – STUDIA 4-SEMESTRALNE

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY OF CHEMISTRY

SUBJECT CARD

Name of subject in Polish: Podstawy grafiki inżynierskiej
Name of subject in English: Basics of technical drawing
Main field of study (if applicable): all fields
Specialization (if applicable):
Profile: academic
Level and form of studies: 1st level, 2nd level – supplementary semester, full-time
Kind of subject: obligatory
Subject code: W03W03-SM2025P
Group of courses: NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)				30	
Number of hours of total student workload (CNPS)				50	
Form of crediting				crediting with grade	
For group of courses mark (X) final course					
Number of ECTS points				2	
including number of ECTS points for practical (P) classes				2	
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)				1.4	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of computers

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SUBJECT OBJECTIVES

C1 Familiarisation with the technical drawing conventions.
C2 Learning to read and making a design drawing.
C3 Working knowledge of using the computer aided design software in making and modifying the technical documentation.

SUBJECT EDUCATIONAL EFFECTS

Related to skills:

PEU_U01 – understands the conventions of technical drawing and the role of standardisation on technical drafting.

PEU_U02 – can project the planar and three-dimensional objects in views.
PEU_U03 – possesses skills at representation and dimensioning of existing and proposing objects according to technical drawing conventions.
PEU_U04 – has the sufficient knowledge of reading the design drawings and chemical plant diagrams.
PEU_U05 – has the working knowledge of using computer aided design applications in making the technical documentation.

PROGRAMME CONTENT		
Project		**Number of hours**
Pr 1	Organising class. Familiarisation with the safety rules in the computer room. Teaching tools and conditions of course completion. Standardisation of technical drawing. Searching for standard exercises.	2
Pr 2	Introduction to CAD application. The user interface, workspace, drawing area, creating and modifying of objects in AutoCAD. Setting the desired AutoCAD operating parameters. Creating a drawing based on the coordinates of points.	2
Pr 3	Introduction to CAD application. Creation and organisation of 2D objects. Drawing objects in AutoCAD: line, polyline, arc, circle, ellipse, rectangle, polygon.	2
Pr 4	Introduction to CAD application. Selection and modifications of objects in AutoCAD: move, copy, rotate, mirror, scale, trim, extend, break, fillet, chamfer, explode, offset.	2
Pr 5	Principles of technical drawing (types of drawings, sheet formats, drawing plates, types and thickness of drawing lines, technical writing). Auto CAD: the creation of inscriptions, managing layers, printing technical documentation.	2
Pr 6-7	Representation of planar and spatial objects in projections (axonometric, orthographic and central projection). Dimensioning the drawings.	4
Pr 8-10	Representation of the interior details of an object. Cross-sections of objects: straight cross-section, half-section, cross-section with several intersecting planes, laying, local cross-section, cross-section and partial view. Dimensioning the drawings.	6
Pr11	Graphical symbols and diagrams in technical drawing. Chemical apparatus. Chemical installation diagrams. Test I	2
Pr12	Dimensioning of threaded joints and selected non-separable joints. Drawing simplifications. Dimensioning the drawings continued.	2
Pr13	Principles of preparing working and assembly drawings. Dimensional tolerances and fits of structural components, deviations in shape and position. Determination of the geometrical structure of surfaces.	2
Pr14	Graphical representation of intersecting objects. Sections of solids by planes and lines.	2
Pr15	Test II. Course acceptance.	2
	Total hours	30

TEACHING TOOLS USED

N1. Multimedia presentations N2. Using of AutoCAD software

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F – forming (during semester), P – concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1	PEU_U01-PEU_U02	test I
F2	PEU_U03-PEU_U05	test II
F3-F8	PEU_U02-PEU_U05	drawings made in AutoCAD
P=[(F1+F2)/2+(F3+F4+...+F8)/6]/2 3,0 if 3,00 ≤ P < 3,25 3,5 if 3,25 ≤ P < 3,75 4,0 if 3,75 ≤ P < 4,25 4,5 if 4,25 ≤ P < 4,75 5,0 if 4,75 ≤ P < 5,25 5,5 if 5,25 ≤ P		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] B.Bielefeld, I.Skiba, Basics Technical Drawing, Birkhäuser 2013.
[2] K.Rathnam, A First Course in Engineering Drawing, Springer Singapore Pte. Limited 2017
[3] J.Leach, S.Lockhart, AutoCAD 2022 Instructor: A Student Guide for In-depth Coverage of Autocad's Commands and Features, SDC Publications, 2021

SECONDARY LITERATURE:

[1] C.Simmons, N.Phelps, Manual of Engineering Drawing: Technical Product Specification and Documentation to British and International Standards, Oxford: Elsevier Science & Technology 2012.
[2] A.Congdon-Fuller, A.Ramirez, D.Smith, Technical Drawing 101 with AutoCAD 2022, SDC Publications, 2021.
[3] A.Bhatt, AutoCAD 2022 Beginners Guide, CADFolks 2021.

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

dr hab. inż. Izabela Polowczyk, izabela.polowczyk@pwr.edu.pl
dr inż. Mateusz Kruszelnicki, mateusz.kruszelnicki@pwr.edu.pl

Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY OF CHEMISTRY

SUBJECT CARD

Name of subject in Polish: Bioreaktory
Name of subject in English: Bioreactors
Main field of study (if applicable): all fields of 2nd level study
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level - supplementary semester, full-time
Kind of subject: obligatory
Subject code: W03W03-SM2029W, W03W03-SM2029L
Group of courses: NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30		
Number of hours of total student workload (CNPS)	50		50		
Form of crediting	Exam		crediting with grade		
For group of courses mark (X) final course					
Number of ECTS points	2		2		
including number of ECTS points for practical (P) classes			2		
including number of ECTS points for direct teacher-student contact (BU) classes	1,3		1,4		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Passed course - Basics of chemical engineering
2. Basic knowledge of biochemistry, enzymology and microbiology

SUBJECT OBJECTIVES

C1. Learning how to balance microbiological changes
C2. Learning the description of the kinetics of enzymatic reactions and microbiological changes
C3. Presentation of the mathematical description of particular types of bioreactors
C4. Obtaining knowledge about the properties and purpose of particular types of bioreactors
C5. Learning methods for the selection of bioreactors

SUBJECT EDUCATIONAL EFFECTS

related to knowledge:

PEU_W01 – student has knowledge of the use of various types of biocatalysts and is able to describe the processes with their participation
PEU_W02 – student knows and understands the basics of construction and the essence of the operation of the equipment used to carry out enzymatic and microbiological processes in the laboratory and industrial scale.
PEU_W03 – student knows the methods of enzyme immobilization and is able to describe the process with their participation mathematically
PEU_W04 – student has knowledge about membrane bioreactors.

related to skills:

PEU_U01 – student is able to develop the results and is able to present them in the form of a written study or oral presentation, using terminology suitable for bioreactor engineering.
PEU_U02 – student is can determine the activity of biomolecules.
PEU_U03 – student has the ability to experimentally determine the kinetics of enzymatic reactions and microbiological changes and the parameters of different types of bioreactors.

PROGRAMME CONTENT

Lectures		Number of hours
Lec 1	Introduction to the issue of bioreactor engineering.	2
Lec 2	Kinetics of chemical reaction.	2
Lec 3	Methods of determining the parameters of the kinetic equation.	2
Lec 4	Kinetic equations in enzymatic catalysis. Substrate and product inhibition.	2
Lec 5	Kinetic equations for multi-substrate kinetics. Inactivation of enzymes.	2
Lec 6	Immobilization of enzymes.	2
Lec 7	Catalytic catalysis with mass transfer.	2
Lec 8	Kinetics of microbial growth. Construction of a stirred microbial bioreactor.	2
Lec 9	Mixing in a bioreactor.	2
Lec 10	Material balance of the bioreactor. Batch reactor.	2
Lec 11	Continuous reactor. Time of residence.	2
Lec 12	Biofilm.	2
Lec 13	Cascade of reactors.	2
Lec 14	Microbiological membrane reactor.	2
Lec 15	Reactor with a catalytic membrane.	2
		30
Laboratory (2nd level of studies)		
La1 La2 La3	The way of conducting and passing exercises. Anti-plagiarism policy. Microbiological reactor - study of the kinetics of yeast growth and determination of the parameters of the Monod equation.	10
La4	Research on the kinetics of a chemical reaction in a batch reactor	4
La5 La6	Enzymatic processes in a batch reactor: determination of kinetic parameters. Laboratory combined with calculations of parameters of equations using linear and non-linear regression in a computer laboratory.	8
La7	Distribution of residence time in a stirred tank reactor and a column reactor.	4
La8	Flow reactors: glucose isomerization in a packed bed column	4
		30

TEACHING TOOLS USED
N1. Lecture with multimedia presentation N2. Laboratory

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation (F – forming (during semester), P – concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
F1 (lecture)	PEU_W01 - PEU_W04	Final exam (max. 10 points)
P(lecture) = F1 9.5 - 10 pkt. + bdb 9.0 – 9.4 pkt. bdb 8.0 – 8.9 pkt. + db 7.0 – 7.9 pkt. db 6.0 – 6.9 pkt. + dst 5.0 – 5.9 pkt. dst		
F1 – F6 (**laboratory**)	PEU_U1 – PEU_04	Points for each exercise – test + report (max. 5 points for each)
P (laboratory) = (F1+F2+F3+F4+F5+F6) P = 3.0 if sum in the range 60-67,9% 3.5 if sum in the range 68-75,9% 4.0 if sum in the range 76-83,9%		

4.5 if sum in the range 84-89,9%
5.0 if sum in the range 90-98%
5.5 if sum in the range >98%

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] S.Ledakowicz – Inżynieria biochemiczna, WNT, 2011
[2] J. Bałdyga: Obliczenia w inżynierii bioreaktorów, Oficyna Wyd. Pol. Warszawskiej, 1996
[3] E.Klimiuk, K.Lossow, M.Bulińska – Kinetyka reakcji i modelowanie reaktorów biochemicznych w procesach oczyszczania ścieków, ART, 1995
[4] K.Szewczyk – Bilansowanie i kinetyka procesów biochemicznych, Wyd. PW, 1993

SECONDARY LITERATURE:

[1] J.E. Bailey, D.F/ Ollis: Biochemical Engineering Fundamentals, McGraw-Hill, 1986
[2] A. Trusek-Hołownia: Membrane Bioreactors - Models for Bioprocess Design, Desalination Publications, 2011

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

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FACULTY OF CHEMISTRY

SUBJECT CARD

Name in English	Biotechnology with introduction to industrial microbiology
Name in Polish	Biotechnologia z elementami mikrobiologii przemysłowej
Specialization (if applicable)	
Profile:	academic
Level and form of studies:	2nd level – supplementary semester /full-time
Kind of subject	obligatory
Subject code	W03W03-SM2007W, W03W03-SM2019P
Group of courses	NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30			15	
Number of hours of total student workload (CNPS)	50			50	
Form of crediting	crediting with grade			crediting with grade	
For group of courses mark (X) final course					
Number of ECTS points	2			2	
including number of ECTS points for practical (P) classes				2	
including number of ECTS points for direct teacher-student contact (BU) classes	1,3			0,75	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1.

SUBJECT OBJECTIVES

C1 Cognoscence of structure and functions of basic cells structures
C2 Cognoscence of fundamentals of gaining energy and nitritienst requirmenst of living cells
C3 Cognoscense of possibilities of application of living systems in biotechnology and industrial mmicrobiology - fundamentals

SUBJECT EDUCATIONAL EFFECTS

related to knowledge:

PEU_W01 – Student knows the structures and functions of macromolecules building living cells
PEU_W02 – Student knows the basics about cells metabolism
PEU_W03 – Student knows the basic methods of introduction of living systems into the industrial technology

Related to skills

PEU_U01 – Students can apply the principles of biotechnology to prepare the presentation on defined subject from the area of modern biotechnology

PROGRAMME CONTENT		
Form of classes - lecture		Number of hours
Lec 1	Fundamentals: proteins – general structure and functions	2
Lec 2	Fundamentals: proteins – general structure and functions	2
Lec 3	Fundamentals: – enzymes – classification and mode of action	2
Lec 4	Fundamentals: – enzymes – classification and mode of action	2
Lec 5	Fundamentals: – redox cycle in living cells	2
Lec 6	Fundamentals: – energy gaining cycle in living cells	2
Lec 7	Fundamentals: – nutrition requirements of microbes (bacteria and fungi)	2
Lec 8	Fundamentals: – basics of microbiological techniques	2
Lec 9	Fundamentals: – basics of microbiological techniques	2
Lec 10	Fundamentals: – methodology of scaling of microbial processes	2
Lec 11	Fundamentals: – methodology of scaling of microbial processes	2
Lec 12	Industrial processes with microbes - examples	2
Lec 13	Industrial processes with microbes - examples	2
Lec 14	Subjects repetitions. Final colloquium – I attempt.	2
Lec 15	Subjects repetitions. Final colloquium – II attempt.	2
	Total hours	**30**

Project		**Number of hours**
Proj 1	Students presentation of novel trends in industrial microbiology	15

TEACHING TOOLS USED	
N1	Lecture – multimedia presentation
N2	Project – multimedial presentation

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation F – forming (during semester), P – concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
P - lecture	PEK_W01- PEK_W03	Colloquium
P-project	PEK_U01	Grading of individual presenattion

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

„ Modern Industrial Microbiology and Biotechnology**”** Second Edition**,** Okafor Nduka**;** 2018**,** ISBN13

(EAN): 9781138550186

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Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY OF CHEMISTRY

SUBJECT CARD

Name of subject in Polish **Podstawy inżynierii chemicznej i procesowej**
Name of subject in English **Fundamentals of chemical and process engineering**
Main field of study (if applicable): **all fields of 2nd level studies**
Specialization (if applicable):
Profile: **academic**
Level and form of studies: **2nd level, supplementary semester (full-time)**
Kind of subject: **obligatory**
Subject code W03W03-SM2028W, W03W03-SM2028P
Group of courses **NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30			30	
Number of hours of total student workload (CNPS)	50			50	
Form of crediting (Examination / crediting with grade)	Examination			Crediting with grade	
For group of courses mark (X) final course					
Number of ECTS points	2			2	
including number of ECTS points for practical classes (P)				2	
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	1.3			1.5	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic principles of chemical engineering.
2. Basic principles of chemical technology.

SUBJECT OBJECTIVES

C1 Providing the students with the rules of production process design.
C2 Acquiring fundamental knowledge about design procedures and use of this knowledge for solving problems and engineering tasks concerning momentum, heat and mass transfer processes.
C3 Providing the students with the rules of elaboration of production process course in designed plant, rules of general process scheme elaboration, mass and heat balances elaboration, principles of technological-equipment scheme elaboration.
C4 Providing the students with the rules of process apparatuses and equipment selection, with design rules of basic process equipment for momentum, heat and mass transfer processes, selection rules of control and measurement instruments.
C5 Acquiring the fundamental knowledge about calculation methods (design algorithms) of basic equipment in processes and unit operations of momentum, heat and mass transfer processes.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:
PEU_W01 – knows the design rules of production process, knows the rules of elaboration of process project of the industrial plant,
PEU_W02 – knows the design procedures and can apply them for solving the problems and engineering tasks in momentum, heat and mass transfer processes,

PEU_W03 – can elaborate the production process course, elaborate general and technological-equipment schemes, make mass and energy balances for the designed process,
PEU_W04 – can design the basic, simple process equipment used in processes and unit operations of momentum, heat and mass transfer.

relating to skills:
PEU_U01 – can determine productability / economic capacity of batch or continuous plant,
PEU_U02 – can formulate design problems and solve engineering tasks in processes and unit operations of momentum, heat and mass transfer in production processes, including: flow resistances in the apparatuses, balancing the mass and heat streams, process kinetics, characteristics of pipelines, pump selection, sedimentation, filtration, heat transfer and heat exchangers, mass transfer and mass exchangers (e.g. absorption, adsorption, extraction, crystallization), batch and continuous stirred reactors,
PEU_U03 – can make general scheme of production process, propose technological-equipment scheme,
PEU_U04 – can select and design basic process equipment used in processes and unit operations of momentum, heat and mass exchange.

relating to social competences:
PEU_K01 – can cooperate in a design and laboratory group,
PEU_K02 – can present the results of the work.

PROGRAMME CONTENT

	Lecture	**Number of hours**
Lec1	Stages of new technology elaboration. Technical-economical assumptions, process design, technical design.	2
Lec2	Design procedures. Rules of the process project elaboration. Design assumptions. Productability / economic capacity of batch or continuous plant.	2
Lec3	Processes and unit operations of momentum transfer. Hydrodynamics, pumps, sedimentation, filtration, mixing and mixers.	2
Lec4	Processes and unit operations of heat transfer. Conduction and heat transfer, interphase heat transfer, heat exchangers.	2
Lec5	Processes and unit operations of mass transfer. Absorption, adsorption, extraction, distillation – mass exchangers.	2
Lec6	Processes and unit operations of mass transfer (continuation). Crystallization, crystallizers, stirred chemical reactors.	2
Lec7	Production process course. Process data, general scheme of production process. Raw materials, products, wastes, environment protection.	2
Lec8	Material and energetic balances. Indicators of raw materials and energy consumption.	2
Lec9	Selection of process equipment and apparatuses. Selection of constructional materials.	2
Lec10	Technological-equipment scheme of the designed production process. Selection of measurement and control instruments.	2
Lec11	Process equipment requiring individual design. Design algorithms of basic equipment for momentum transfer processes.	2
Lec12	Process equipment requiring individual design. Design algorithms of basic equipment for heat transfer processes.	2
Lec13	Process equipment requiring individual design. Design algorithms of basic equipment for mass transfer processes.	2
Lec14	Design of batch or continuous stirred chemical reactors.	2

Lec15	Technical safety of the plant. Rules of investment costs and exploitation costs estimation.	2
	Total hours	**30**
Project		**Number of hours**
Proj1	Calculation of productability / economic capacity of continuous and batch plants.	2
Proj2, Proj3	Calculations in selected unit operations of momentum transfer: flows in pipeline system and process equipment, sedimentation, filtration, mixing.	4
Proj4	Calculations in selected unit operations of heat transfer: conduction, heat transfer, interphase heat transfer.	2
Proj5, Proj6	Calculations in selected unit operations of mass transfer: absorption, adsorption, extraction, distillation, crystallization, stirred tank chemical reactors.	4
Proj7	Material balances for exemplary production processes, calculation of raw materials consumption indicators.	2
Proj8	Energy balances for exemplary production processes, calculation of energy consumption indicators.	2
Proj9	Elaboration of general scheme of production process, technological-equipment scheme of industrial plant.	2
Proj10	Design of flow tank, pump selection.	2
Proj11	Design of heat exchanger.	2
Proj12	Design of mixer.	2
Proj13	Design of batch and continuous stirred reactor.	2
Proj14	Design of continuous crystallizer with internal circulation of suspension.	2
Proj15	Credit test.	2
	Total hours	**30**

TEACHING TOOLS USED

N1. Lecture with multimedia presentation.
N2. Solving of engineering and design problems.
N3. Project consultations.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement
P (lecture)	PEU_W01 – PEU_W04	Examination.
P2 (project)	PEU_U01 – PEU_U04	Crediting with grade.

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] J. Ciborowski: *Podstawy inżynierii chemicznej*, WNT, Warszawa, 1982.
[2] J. Pikoń: *Aparatura chemiczna*, PWN, Warszawa, 1978.
[3] D.W. Green, R.H. Perry (red.): *Perry's chemical engineers' handbook*, 8th ed., McGraw–Hill, 2007.
[4] S. Kucharski, J. Głowiński: *Podstawy obliczeń projektowych w inżynierii chemicznej*, OWPWr, Wrocław, 2000.
[5] Pr. zbiorowa: *Zadania projektowe z inżynierii procesowej*, OWPW, Warszawa, 1986.

SECONDARY LITERATURE:

[1] Himmelblau: *Basic principles and calculation in chemical engineering*, N. Y., 1986.
[2] G.I. Wells, L.M. Rose: *The art of chemical process design*, Elsevier, 1986.
[3] W.D. Seider: *Process design principles*, J.W.&S., 1999.
[4] U. Bröckel, W. Meier, G. Wagner (red.): Product design and engineering. Vol. 1: *Basics and technologies*, Vol. 2: *Rawmaterials, additives and application*, Wiley, 2007.

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Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY OF CHEMISTRY

SUBJECT CARD

Name of subject in Polish: Podstawy projektowania w technologii chemicznej
Name of subject in English: Fundamentals of chemical technology design
Main field of study (if applicable): all Faculty of Chemistry
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level – supplementary semester, full-time
Kind of subject: obligatory
Subject code: W03W03-SM2030W, W03W03-SM2030P
Group of courses: NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30			30	
Number of hours of total student workload (CNPS)	75			50	
Form of crediting	crediting with grade, exam (2nd level in english)			crediting with grade	
For group of courses mark (X) final course					
Number of ECTS points	3			2	
including number of ECTS points for practical (P) classes				2	
including number of ECTS points for direct teacher-student contact (BU) classes	1,3			1,5	

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of general chemistry: properties of substances, stoichiometry
2. Knowledge of physical chemistry: thermodynamics, kinetics
3. Knowledge of mathematics: differentiation, integration, differential equations

SUBJECT OBJECTIVES

C1 To familiarize with basic concepts and laws in the field of chemical technology
C2 To familiarize with material and thermal balances of the process.
C3 To familiarize with physicochemical properties of substances and methods of their evaluation
C4 To teach methods of engineering calculations of chemical processes
C5 Use of Excel spreadsheet and professional software to create simple projects and simulations

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:
PEU_W01 – knows basic technological principles
PEU_W02 - knows principles of preparing material and energy balances
PEU_W03 - knows methods to estimate physicochemical properties of a studied substance
PEU_W04 - knows basics of composition and temperature of a reacting system calculations
relating to skills:
PEU_U01 – can reach data sources about properties of a studied substance
PEU_U02 - can make simple material and energy balances and analyze them
PEU_U03 - can perform simple engineering calculations
PEU_U04 - can use professional computer software for simple engineering calculations and simulation of selected processes

PROGRAMME CONTENT

Lectures		Number of hours
Lec1	Basic terminology: technological process, chemical method concept, technological method concept. Discussion of technological principles: the principle of the best use of raw materials, the principle of the best use of energy, the principle of the best use of equipment, the principle of technological moderation. Unit operations.	2
Lec2	Material balance of the chemical process: the principle of mass conservation, the principle of atoms conservation, the principle of energy conservation. Analysis of material balance of steady-state processes. Material balance of systems with chemical reaction. The degree of conversion in the stoichiometric and non-stoichiometric mixture of reagents. Process efficiency. Process diagram, stream diagram simulation. Computer programs used to simulate chemical processes.	2
Lec3	Energy balance. Basic concepts: system state variables, system state. Principle of energy conservation, energy components of systems: internal energy, work, heat, enthalpy. Calculation of enthalpy changes. Enthalpy of reaction. The influence of temperature and pressure on the enthalpy of the reaction.	2
Lec4	Ideal gas: the equation of state, properties. Compressibility factor. Compression and expansion work . Polytropic transformation. Classification of chemical processes, types of balance sheets.	2
Lec5	Properties of chemical substances. Sources of technological information - databases. Condensed phases. Estimation of physicochemical properties: density, viscosity, critical parameters. Thermodynamic properties. Critical state of matter.	2
Lec6	Real gas. Deviations from the ideal state. Compressibility factor for real gases. Equations of real gas state. Acentric coefficient. Mixtures of real gases.	2
Lec7	Factor of gas and liquid activity. Definition of volatility and volatility coefficient. Equations for calculating volatility coefficient. Liquid activity factor. LewisRandal's rule. Phase equilibria. Functions of deviation from the ideal state.	2
Lec8	Chemical reaction. Stoichiometry; concentration, degree of conversion relative to a concentration and molar stream (change in volume). Direction of reaction; elimination of component reactions as part of the chemical process concept. Composition calculation (reaction run to the end).	2
Lec9	Composition in a state of equilibrium. Equilibrium constant. Temperature dependence of the equilibrium constant. Reactions with a change in the number of moles; pressure influence; technological treatments (excess reagent, reduction of concentration - examples). Calculation of equilibrium composition based on selected examples.	2
Lec10	Kinetic equation. Rate of an elementary reaction; concentration dependence. Irreversible and reversible elementary reactions; solving appropriate differential equations. Reaction rate constant. Change of composition over time. Rate of real reaction; full kinetic model, simplified descriptions. An approximation of the state of equilibrium and an approximation of the stationary state. Examples of complex reactions. Use of experimental data.	2
Lec11	Tank reactor. Periodic work system; perfect mixing, volume dependency on the degree of conversion and reaction time. Flow system; equation of component continuity, perfect mixing, steady state, design equation of a continuous-stirred tank reactor, conventional reaction time.	2

Lec12	Plug flow reactor. Design equation for a piston type system in a steady state. Comparison of volume and degree of conversion in continuous reactors: tank and tubular.	2
Lec13	Estimation of composition and temperature in the studied system. Heat balance. Examples. Adiabatic reaction.	2
Lec14	Written credit I	2
Lec15	Written credit II	2
	Total hours	**30**
Project		**Number of hours**
Pr1	Introduction. Basics of the used computer software. Principles of a material balance creation without chemical reaction.	2
Pr2	Simulation of selected processes - material balance without chemical reaction, process limitation.	2
Pr3	Simulation of selected processes - material balance, returned stream. Project I.	2
Pr4	Principles of material balance of processes with chemical reactions.	2
Pr5	Simulation of selected processes - material balance with parallel reactions. Project II.	2
Pr6	Projects and material overview.	2
Pr7	Written credit I.	2
Pr8	Analysis of the chemical process with regards to reaction kinetics - elementary reactions, calculations of concentrations of selected reagents, time necessary to achieve the state of equilibrium in studied systems.	2
Pr9	Analysis of the chemical process with regards to reaction kinetics - complex reactions, estimation of reaction order and kinetic parameters on the basis of experimental data.	2
Pr10	Volumetric gas properties determined from third degree real gas state equations. Project III.	2
Pr11	Volumetric gas properties determined from the Lee-Kesler real gas state equation.	2
Pr12	Functions of deviation from the ideal state: free energy, enthalpy, free enthalpy, entropy, volatility. Project IV.	2
Pr13	Influence of pressure and temperature on an equilibrium reaction process.	2
Pr14	Projects overview. Written credit II.	2
Pr15	Written credit - second term.	2
	Total hours	**30**

TEACHING TOOLS USED

N1. Lecture with multimedia presentation
N2. Excel spreadsheet
N3. Polymath computer software
N4. Computer software for simulation of chemical processes (ChemCAD or Aspen Plus)

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming (during semester), P –	Learning outcomes number	Way of evaluating learning outcomes achievement

concluding (at semester end)		
P (lecture)	PEU_W01 – PEU_W03	Written credits I and II, exam
F1 (project)	PEU_U01 – PEU_U04	Written credit I
F2 (project)	PEU_U01 – PEU_U04	Written credit II
P (project) = (F1 + F2) / 2		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] S. Kucharski, J. Głowiński, Podstawy obliczeń projektowych w technologii chemicznej, 3 wyd., Oficyna Wyd. PWr, Wrocław 2010

[2] J. Szarawara, J. Piotrowski, Podstawy teoretyczne technologii chemicznej, WNT, Warszawa 2010

SECONDARY LITERATURE:

[1] R.C. Reid, J.M. Prausnitz, B.E. Poling, The properties of gases and Liquids, 4th ed., Mcgraw-Hill, New York 1987

[2] Praca zbiorowa, Przykłady i zadania do przedmiotu Podstawy technologii chemicznej, Oficyna Wyd. PWr, Wrocław 1991

[3] W. Ufnalski, Wprowadzenie do termodynamiki chemicznej, Oficyna Wyd. PW, Warszawa 2004

[4] H.S. Fogler, Elements of Chemical Reaction Engineering, Fourth Ed., Prentice Hall PTR, New Jersey, 2005.

[5] D. M. Himmelblau, J. B. Riggs, Basic Principles and Calculations in Chemical Engineering, Seventh Ed., Prentice Hall PTR, New Jersey, 2004.

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Zał. nr 5 do ZW 78/2023

Attachment no. 4. to the Program of Studies

FACULTY of CHEMISTRY

SUBJECT CARD

Name of subject in Polish *Informatyka dla inżynierów*
Name of subject in English *Informatics for engineers*
Main field of study (if applicable): …….
Specialization (if applicable): ……..
Profile: academic / ~~practical~~*
Level and form of studies: ~~1st~~/ 2nd level, ~~uniform magister studies~~*, full-time / ~~part-time~~*
Kind of subject: obligatory / ~~optional / university-wide~~*
Subject code W03W03-SM2018L
Group of courses ~~YES~~ / NO*

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)			30		
Number of hours of total student workload (CNPS)			50		
Form of crediting (Examination / crediting with grade)			crediting with grade		
For group of courses mark (X) final course					
Number of ECTS points			2		
including number of ECTS points for practical classes (P)			2		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)			1,4		

*delete as not necessary

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of general chemistry, linear algebra, mathematical analysis;
2. Basic knowledge of computer science;
3. Specialized English.

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SUBJECT OBJECTIVES

C1 Introducing main chemical, biological and bibliographic databases.
C2 Teaching about basic formats used in chemical and bioinformatic databases.
C3 Introducing software used for drawing and visualization of chemical structures and macromolecules.
C4 Teaching students the basics of the scripting language.
C5 Teaching students the skills allowing the automation of computational tasks.

SUBJECT EDUCATIONAL EFFECTS

relating to skills:
PEU_U01 – ability to search chemical and bibliographic databases and biological sequences databases;
PEU_U02 – ability to use chemical structures visualization tools;
PEU_U03 – ability to select appropriate methods and tools for the studied problem;
PEU_U04 – ability to develop an algorithm;

PEU_U05 – ability to use a scripting language to automate computational tasks and solve simple numerical problems.

PROGRAMME CONTENT

Laboratory		Number of hours
Lab 1	**Introductory classes**: the program of laboratory classes, organization and rules of the computer lab, grading rules. Introduction of basic tools and software used during the course.	2h
Lab 2 & Lab 3	**Scientific databases**: introduction to the selected chemical, scientific and bibliographic databases (e.g. Reaxys, ChemSpider, CSD, PDB, Scopus, WoS, NCBI), data organization and presentation, search options. The importance of obtaining scientific information from reputable and verified sources will be discussed.	4h
Lab 4	**Data formats and visualization of molecule structures:** introduction to data formats used in chemical and structural databases and the formats used for biological sequences. Practical exercises on searching for information in chemical databases. Practical examples of the use of visualization software and tools used for building of molecular structures.	2h
Lab 5	Individual Project I	2h
Lab 6	**Introduction to Python**. Introduction of numerical data types and arithmetic operators. The first scripts - working with numerical data and using arithmetic operators. Introduction of interactive Python.	2h
Lab 7	**Basic data types**. Overview of basic data types: numbers and strings. Writing scripts that use data provided by the user. Practical examples of using Help.	2h
Lab 8	**Conditional statement**. Overview of the principles of creating conditional statements and creating a group of statements. Practical examples e.g. calculating factorials, printing a multiplication table.	2h
Lab 9	**Advanced data types** - lists, tuples, dictionaries. Creating lists, tuples and dictionaries as well as introduction of their operators and methods. Writing scripts using these data types. Programming test I.	2h
Lab 10	**While loop**. Overview of the principles of creating loops controlled by a logical condition together with practical examples.	2h
Lab 11	**Modules**. The rules of importing modules and their use in practice (math and random module). Practical exercises with a while loop.	2h
Lab 12	**For loop**. Overview of the principles of creating a counter controlled loop. Programming test II.	2h
Lab 13	**Counter controlled loop**. Practical examples of scripts using counter-controlled loops, exercises with complex instructions and loop control statements.	2h
Lab 14	**Text Files**. Overview of processing of text files. Exercises using biological sequences.	2h
Lab 15	Programming test III. Repetition of tests I and II. Discussion of Individual Project.	2h
	Total hours	30h

TEACHING TOOLS USED

N1. Lecture/presentation
N2. Scripts writing
N3. Practical usage of databases
N4. Practical usage of software
N5. Solving the exercises

N6. Preparation of reports

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming during semester), P – concluding (at semester end)	Learning outcomes code	Way of evaluating learning outcomes achievement
F1	PEU_U01-PEU_U03	Report from the Individual Project I
F2	PEU_U03-PEU_U05	Programming test I
F3	PEU_U03-PEU_U05	Programming test II
F4	PEU_U03-PEU_U05	Programming test III
P = (F1 + F2 + F3 + F4)/4		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Python 3 documentation: https://docs.python.org/3/
[2] Python Crash Course, 3rd Ed.: A Hands-On, Project-Based Introduction to Programming, Matthes E., No Starch Press, 2023
[3] Python Programming: An Introduction to Computer Science, Zelle J. Ingram short title, 2016

SECONDARY LITERATURE:

[1] Python Programming for Beginners, Robbins P., 2023

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

Renata Grzywa, PhD, renata.grzywa@pwr.edu.pl

FACULTY OF CHEMISTRY

SUBJECT CARD

Name of subject in Polish: Wprowadzenie do nauki o materiałach i inżynierii materiałowej
Name of subject in English: Introduction to material science and engineering
Main field of study (if applicable):
Specialization (if applicable):
Profile: academic
Level and form of studies: 2nd level – supplementary semester, full-time
Kind of subject: obligatory
Subject code: W03W03-SM2003W
Group of courses: NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30				
Number of hours of total student workload (CNPS)	50				
Form of crediting	crediting with grade				
For group of courses mark final course with (X)					
Number of ECTS points	2				
including number of ECTS points for practical (P) classes					
including number of ECTS points for direct teacher-student contact (BU) classes	1,3				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Basic knowledge of the structure of matter.
2. Fundamentals of physics, mechanics, electronics, chemistry and physical chemistry.
3. Basic knowledge about the structure of popular engineering materials.
4. Communicative English skills.

SUBJECT OBJECTIVES

C1 To familiarize students with the basic relationships between the structure of the material and its properties.
C2 To familiarize students with the principles of selection of materials for various applications.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 The student has basic knowledge about the structure of popular construction materials.
PEU_W02 The student understands the impact of structure defects on the potential properties of materials.
PEU_W03 The student understands the impact of diffusion on the properties of construction materials.
PEU_W04 The student has basic knowledge about the mechanical properties of materials and the generation of damage.
PEU_W05 Student understands the impact of heat treatment on the properties of metals and alloys.
PEU_W06 The student knows the basic electrical and magnetic properties of materials.
PEU_W07 The student knows the basic optical and thermal properties of materials.
PEU_W08 The student knows the selected methods of fabrication of materials.
PEU_W09 The student understands the concept of composite materials and knows their example applications.
PEU_W10 The student knows the concept of corrosion, its impact on the degradation of materials and how to prevent it.

PROGRAM CONTENT		
Lectures		**Number of hours**
Lec 1	Atomic structure of solids. Bonding in solids.	2
Lec 2	Structures of metals, ceramics and polymers.	2
Lec 3	Defects in solids. Diffusion phenomena.	2
Lec 4	Mechanical properties of materials.	2
Lec 5	Deformation and strengthening of materials.	2
Lec 6	Failure of materials.	2
Lec 7	*I test*	2
Lec 8	Phase diagrams and phase transformations.	2
Lec 9	Electrical and magnetic properties of materials.	2
Lec 10	Optical and thermal properties of materials.	2
Lec 11	Synthesis, fabrication and processing of materials.	2
Lec 12	Composites materials.	2
Lec 13	Corrosion and degradation of materials.	2
Lec 14	*II test*	2
Lec 15	*Correction of test I and/or test II*	2
	Total hours	**30**

TEACHING TOOLS USED

N1. Lecture - multimedia presentation + solving simple calculation tasks.
N2. Discussion with students.
N3. E-books and databases.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming (during semester), P – concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
F1	PEU_W01 – PEU_W04	Test with multiple-choice answers. About 20 questions, including one descriptive one.
F2	PEU_W05 – PEU_W10	Test with multiple-choice answers. About 20 questions, including one descriptive one.

P – concluding grade, which consists of the total number of points obtained from both tests, with the obligatory obtaining about half of the points from each partial test. Grade scale according to the following scheme (% of points = grade):
46-55 = dst

56-65 = dst+
66-75 = db
76-85 = db+
>86 = bdb

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Ashby M.F., Materiały inżynierskie. 1. Właściwości i zastosowania, W N-T, Warszawa, 1997.
[2] Ashby M.F., Materiały inżynierskie. 2. Kształtowanie struktury i właściwości, dobór materiałów, WNT, Warszawa, 1998.
[3] Ashby M.F., Shercliff H., Cebon D., Materials: engineering, science, processing and design, Elsevier: Butterworth-Heinemann, Amsterdam, 2007.
[4] Askeland D.R., Phule P. P., The Science and Engineering of Materials, Thomas Brooks/Cole, 2003.
[5] Callister W. D. Jr, Materials science and engineering, John Wiley & Sons, New York, 1990.

SECONDARY LITERATURE:

[1] Blicharski M., Wstęp do inżynierii materiałowej, Wyd. N-T, Warszawa 2003 (i wcześniejsze).
[2] Dobrzański L. A., Podstawy nauki o materiałach i metaloznawstwo, Wyd. N-T, Gliwice-Warszawa, 2002.
[3] Wyatt O. H., Wprowadzenie do inżynierii materiałowej, Wyd. N-T, Warszawa, 1978.
[4] Przybyłowicz K., Przybyłowicz J., Materiałoznawstwo w pytaniach i odpowiedziach, Wyd. N-T, Warszawa, 2004.
[5] Ciszewski A., Radomski T., Szummer A, Materiałoznawstwo, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa, 1998.
[6] Blicharski M., Inżynieria materiałowa – stal, WNT, Warszawa, 2004.

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

Dr hab. inż. Juliusz Winiarski, juliusz.winiarski@pwr.edu.pl
Department of Advanced Material Technologies

FACULTY OF CHEMISTRY

SUBJECT CARD

Name of subject in Polish	Odzysk i recykling materiałów
Name of subject in English	Material recovery and recycling
Main field of study (if applicable):	all field 2nd level
Specialization (if applicable):	
Profile:	academic
Level and form of studies:	2nd level – supplementary semester, full-time
Kind of subject:	obligatory
Subject code	W03W03-SM2027W
Group of courses	NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30				
Number of hours of total student workload (CNPS)	50				
Form of crediting	crediting with grade				
For group of courses mark (X) final course					
Number of ECTS points	2				
including number of ECTS points for practical (P) classes					
including number of ECTS points for direct teacher-student contact (BU) classes	1,3				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. General Chemistry

\SUBJECT OBJECTIVES

C1 To familiarize students with the basic terminology of waste
C2 To familiarize students with the structure and systems of waste collection.
C3 To familiarize students with the basic methods of waste management.
C4 Awakening of environmental awareness.

SUBJECT EDUCATIONAL EFFECTS

In the field of knowledge:

A person who has passed the examination:
PEU_W01 – Student knows the basic terminology associated with waste management.
PEU_W02 – Student has a basic knowledge about the symbols and designations used to label the materials for recycling.
PEU_W03 – Student has a basic knowledge of the collection and distribution systems of waste materials.
PEU_W04 – Knows the basic legal conditions for recycled materials.
…

PROGRAMME CONTENT

	Lectures	**Number of hours**
Lec1	**Selective collection systems.** The division, the definition and sources of municipal waste and hazardous waste. Principles of waste management, basic definitions related to waste management. Logistics, waste recycling, its advantages and disadvantages, problems. Examples.	2
Lec2	**Classification, labeling materials.** The overall breakdown of characters and graphic symbols used to mark the packaging, recycling signs, signs indicating the	2

	proper waste handling.	
Lec3	**Waste management in Poland, part 1: Material Recycling** - definition, elements of the system, the barriers in the recycling process, the criteria for suitability for recycling.	2
Lec4	**Waste management in Poland, part 2: Material recycling** - European standards (applicable in Poland), heavy metals in the raw materials from recycling, recycling of paper and cardboard, recycling of glass packaging, metal packaging recycling, recycling of timber packaging and multimaterial packaging.	2
Lec5	**Waste management in Poland, part 3: Material recycling** - recycling of plastic packaging.	2
Lec6	**Waste management in Poland, part 4 Feedstock recycling** - definition, criteria for suitability for recycling of raw materials, disadvantages, advantages. Thermal and solvolytic processes used in the recycling of raw materials, examples.	2
Lec7	**Biological treatment part 1: Composting**. The legal basis, advantages and disadvantages, the criteria for the use of composting, limitations and conditions of composting, discuss progress and process parameters (pH, temperature, microorganisms).	2
Lec8	**Biological treatment, part 2: Methane fermentation.** Definition, classification, advantages, disadvantages, differences between composting and fermentation, fermentation steps, the most important parameters and microorganisms involved in the fermentation process. Fermentation methods one and two-stage, advantages and disadvantages. The substrates and products.	2
Lec9	**Incineration of waste**. Basic problems of waste incineration plants, safety, advantages and disadvantages.	1
Lec10	**Hazardous waste, part 1** - Definition, classification, origin. Methods of dealing with pharmaceuticals, batteries, fluorescent lamps, mercury-containing waste, appliances containing freon, electronics.	2
Lec11	**Hazardous waste, part 2** – Legislation. Disposal of used oils. Proceedings of vehicles spent product.	2
Lec12	**Analysis of the life cycle of consumables**. For selected examples – production, operation, recovery (home appliances, AGD).	2
Lec13	**Waste management in selected countries.**	2
Lec14	**Efforts to improve the situation in the field of waste management.** Shares information and education, legal, collection and transport, recovery, disposal.	2
Lec15	**Ethical problems related to the production and consumption.**	2
Lec 16	**Course credit**	1
	Total hours	30

TEACHING TOOLS USED

N1. Multimedia presentation
N2. Discourse

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming (during semester), P – concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
P1 (lecture)	PEU_W01-PEU_W04,	test

PRIMARY AND SECONDARY LITERATURE

BASIC LITERATURE:

[1] Systemy recyklingu odpadów opakowaniowych w asPEUcie wymagań ochrony środowiska / Hanna Żakowska, Wydawnictwo Akademii Ekonomicznej, 2008
[2] Odpady komunalne: zbiórka, recykling, unieszkodliwianie odpadów komunalnych i komunalnopodobnych, Wydawnictwo Politechniki Krakowskiej, 2005
[3] Procesy logistyczne w gospodarce odpadami / Józef Bendkowski, Maria Wengierek, Wydawnictwo Politechniki Śląskiej, 2002

SUPPLEMENTARY LITERATURE:

[4] Odzysk ciepła w procesie termicznej utylizacji odpadów medycznych / Janusz Wojciech Bujak, oficyna Wyd.Politechniki Wrocławskiej, 2010
[5] Wybrane zagadnienia recyklingu samochodów, Jerzy Osiński, Piotr Żach, Wydawnictwa Komunikacji i Łączności, 2006

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

Dr inż. Konrad Szustakiewicz, konrad.szustakiewicz@pwr.edu.pl

FACULTY OF CHEMISTRY

SUBJECT CARD

Name of subject in Polish	Techniki separacji i oczyszczania produktów
Name of subject in English:	Separation and purification of products
Main field of study (if applicable):	BIOTECHNOLOGY
Specialization (if applicable):	
Profile:	academic
Level and form of studies:	1st level, 2nd level – supplementary semester, full-time
Kind of subject:	obligatory
Subject code:	W03W03-SM2025W, W03W03-SM2025L
Group of courses:	NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30		
Number of hours of total student workload (CNPS)	25		50		
Form of crediting	crediting with grade		crediting with grade		
For group of courses mark (X) final course					
Number of ECTS points	1		2		
including number of ECTS points for practical (P) classes			2		
including number of ECTS points for direct teacher-student contact (BU) classes	1,3		1,4		

***PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Knowledge of such courses as chemical engineering, microbiology, biochemistry.
2. Ability to manually operate laboratory equipment such as spectrophotometer, analytical balance, automatic pipettes.
3. The ability to create diagrams for different types of functions (by computer), determining the function equation.

SUBJECT OBJECTIVES

C1 Getting familiar with the composition (homo- and heterogeneous systems) and the approach to the separation of post-reaction streams.
C2 Understanding the basics of using processes for the separation of heterogeneous systems.
C3 Learning the basics of diffusion processes application.
C4 Getting familiar with basic membrane techniques.
C5 Understanding the principles of multi-stage separation process designing.

SUBJECT EDUCATIONAL EFFECTS

related to knowledge:

PEU_W01 student knows and understands the basics of construction and the clue of the operation performed on apparatus components in processes conducted in both: laboratory and industrial scale, used for separating bioproducts and wastewater treatment.
PEU_W02 student has basic knowledge of separation techniques of heterogeneous and homogeneous systems.
PEU_W03 student knows the basic equations, which describe the kinetics of a given process.
PEU_W04 student has knowledge enabling him to select a given process (or cascade of processes) for a given application.

related to skills:

PEU_U01 student is able to carry out an experiment on laboratory scale equipment, develop the obtained

	results and present them in the form of a written report.
PEU_U02	student is able to purify biomolecules using a given separation method. He can measure the concentrations of the test ingredient and determine the degree of purification.
PEU_U03	student can assess profits of a given separation method for a given application and apply known equations to describe its kinetics.

PROGRAMME CONTENT

Lectures		**Number of hours**
Lec 1	Introduction to the separation of bioproducts. Division of methods.	2
Lec 2	Filtration - the fundamentals of the process, apparatus, application.	2
Lec 3	Division of suspensions. Sedimentation - the fundamentals of the process, apparatus, application.	2
Lec 4	Filtration - the basics of the process, types of partitions.	2
Lec 5	Filtration - apparatus, application.	2
Lec 6	Micro, ultrafiltration - the idea of membrane processes, apparatus, application.	2
Lec 7	Filtration and sediment centrifuge. Emulsions - structure, formation and disintegration.	2
Lec 8	Flotation - the fundamentals of the process, apparatus, application.	2
Lec 9	Introduction to diffusion processes. Extraction in a liquid-liquid system - the basics of the process, description of kinetics.	2
Lec 10	Extraction in a liquid-liquid system - apparatus. Solid–liquid extraction - the basics of the process, application	2
Lec 11	Classic and membrane distillation - the basics of the process, application.	2
Lec 12	Sorption - the basics of the process, description of kinetics, application.	2
Lec 13	Pervaporation - the basics of the process, description of kinetics, application apparatus.	2
Lec 14	Crystallization - process conditions, apparatus. Co-crystallization - the idea of the process, application.	2
Lec 15	Passing test	2
	Number of hours	**30**
Laboratory		**Number of hours**
Lab 1	Adsorption - determination and mathematical description of the adsorption rate and equilibrium state.	6
Lab 2	Extraction - determination of extraction kinetics and division coefficient in a batch system extraction (mixing); determination of working effectiveness in continuous system extraction (extraction column).	6
Lab 3	Flotation - determination of the enrichment and recovery factors gained during separation process.	6
Lab 4	Vacuum filtration - measuring the variability of the filtrate stream in time, description of the process with determination of compressibility index of the filter cake and determination of the liquid purification degree.	6
Lab 5	Sedimentation - determination of the sinking velocity of suspensions with different solid content. Distillation - determination of the composition of the distillate during periodic distillation duration, determination of the total alcohol mass obtained in the fermentation bottle subjected to distillation, process balance.	6

	Number of hours	**30**

TEACHING TOOLS USED

N1. Lecture
N2. Performing the experiment
N3. Description of results using computer graphics programs
N4. Consultations

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming (during semester), P – concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1(lecture)	PEU_W01 - PEU_W04	Written test for maximum 10 points.
P (lecture) = F1= 10 pkt. 9.5 - 10 pkt. + bdb 9.0 – 9.4 pkt. bdb 8.0 – 8.9 pkt. + db 7.0 – 7.9 pkt. db 6.0 – 6.9 pkt. + dst 5.0 - 5.9 pkt. dst		
F1-F5 (Laboratory classes)	PEU_U1 – PEU_03, PEU_K01 - PEU_K03	Points for each classes - quiz + report (max 5 points for each lab)
P (laboratory) = (F1 + F2 + F3 + F4 + F5 + F6) P = 3.0 if the sum of points is in the range of 60-67.9% 3.5 if the sum of points is in the range of 68-75.9% 4.0 if the sum of points is in the range of 76-83.9% 4.5 if the sum of points is in the range of 84-89.9% 5.0 if the sum of points is in the range of 90-98% 5.5 if the sum of points is> 98%		
F3		
P		

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] R. Gawroński- Procesy oczyszczania cieczy- Oficyna Wydawnicza Politechniki Warszawskiej, W-wa 1996
[2] Pod redakcją P. Lewickiego- Inżynieria procesowa i aparatura przemysłu spożywczegoWyd. Naukowo-Techniczne, W-wa 1999
[3] E. Pijanowski, M. Dłużewski – Ogólna technologia żywności – Wyd. NaukowoTechniczne, W-wa 1997
[4] R. Rautenbach – Procesy membranowe, Wyd. Naukowo-Techniczne, W-wa 1996

SUPPLEMENTARY LITERATURE:

[5] W.W. Blanch, D.S. Clark – Biochemical Eng.- rozdz.6, NY 1996
[6] P. Better, E. Cussler – Bioseparations-downstream processing for biotechnology – Wiley&Sons Publication 1988

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

ANNA TRUSEK, anna.trusek@pwr.edu.pl

FACULTY OF CHEMISTRY

SUBJECT CARD

Name in Polish	Bezpieczeństwo techniczne w przemyśle
Name in English	Technical safety in industry
Main field of study (if applicable):	Chemical Technology, Chemical and Process Engineering,Chemistry, Chemical and Process Engineering, Biotechnology
Level and form of studies:	2nd level – supplementary semester, full-time
Kind of subject:	obligatory
Subject code	W03W03-SM2026W, W03W03-SM2026L
Group of courses	NO

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	15		15		
Number of hours of total student workload (CNPS)	25		25		
Form of crediting	crediting with grade		crediting with grade		
For group of courses mark final course with (X)					
Number of ECTS points	1		1		
including number of ECTS points for practical (P) classes			1		
including number of ECTS points for direct teacher-student contact (BK) classes	0,65		0,7		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of chemistry on the secondary school level
2. Fundamental knowledge on the chemical safety
3. Skill in computer operation

SUBJECT OBJECTIVES

C1 To familiarize students with the basics of technical safety
C2 National and European law regulations related to the technical safety
C3 Learning algorithms for analysis of industrial installations hazards
C4 Teach students of the health risk assessment associated with industrial failures
C5 Familiarizing students with examples of spreading chemical pollution and with the methodology of calculations of spreading the contaminants in the environment

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEU_W01 - familiar with basic concepts and definitions of technical safety
PEU_W02 - can specify the basic legislative acts governing the national and European technical safety rules
PEU_W03 – knows the common elements of industrial operational and emergency response
PEU_W04 – familiar with the main provisions of environmental law, Seveso III directive and of the Convention on the transboundary effects of industrial accidents
PEU_W05 – able to apply methods of risk analysis to identify possible failure in industrial installations
PEU_W06 – knows how to describe the basic methods of analysis of the health risks in areas contaminated as a result of industrial accidents

relating to skills:

PEU_U01 – can use the databases in order to classify plants in terms of the risks involved
PEU_U02 – knows how to carry out an analysis of the hazards in simple industrial installations
PEU_U03 – can suggest remedial measures in the event of an industrial accident in simple chemical installations

PEU_U04 – can perform simple calculations of exposure to the contamination of the environment after the failure of industrial plant PEU_U05 – can use the tools to model the spreading of chemical contamination		
PROGRAM CONTENT		
Lectures		**Number of hours**
Lec 1	**Basic concepts.** The subject of technical safety, safety perception, the essence of enterprise security, basic definitions, security scopes, importance of safety as a guarantee of the existence of an entity, the risk and examples of threats to the elements of the environment. Risks for the environment. The state of insecurity, its social and economic effects. Types of security. Examples of technical failures, the analysis of the causes and effects.	2
Lec 2	**Safety-related items.** Safety features versus general security companies. Organisation and management, skills, specificity of manufacturing technology, infrastructure condition, emergency planning, internal reviews and analysis of accidents, development of safe work, organisation of operational service posts, striving for as few nuisance work. Analysis of the causes of industrial accidents. Characteristics of chemical companies, dangers, hazardous chemical substances.	2
Lec 3	**Polish and the European legislation**. Environmental law, Directive 67/548/EEC. Groups of substances and preparations considered dangerous. Explosive substances (E) oxidizing (O), extremely flammable (F+), flammable (F), flammable (R10), very toxic (T+), toxic (T), harmful (Xn), corrosive (C), irritant (Xi), sensitizing (R42 and/or R43), carcinogenic (karc..), mutagenic (Muta.), toxic to reproduction (Repr.), which are dangerous for the environment (N or/and R52, R53, R59), European Council Directive 96/82/EC, the Convention on the transboundary effects of industrial accidents, environmental law, Seveso-enterprises, non-Seveso enterprises, criteria.	2
Lec 4	**Toxic industrial agents, industrial accidents, severe crashes, industrial contamination.** Process safety. Functional safety, safety assessment map. A comprehensive evaluation of the installation process in the various phases of the realisation of the investment.	2
Lec 5	**Risk assessment methods.** Identification of potential threats. HAZard and OPerability Study (hazard and operability study), its goals, importance, specialty risks. Keywords, main and auxiliary keywords, installations, design objectives, deviations from design intent, hazards, parameter, operational problems, the experts, the process, pairs of keywords in hazards analysis.	2
Lec 6	**Examples of HAZOP analysis.** Chemical process, the analysis of installation nodes, HAZOP team of experts, the structure of the team, the team of experts work scheme, the development of HAZOP report, deviation, deviation result, the security, the action. Certification of persons carrying out safety circuits, design and service.	2
Lec 7	**The principles of contamination assessment** resulted from the industrial accidents, toxicity, carcinogenicity, principles for the risks evaluation in areas contaminated as a result of industrial accidents. Exposure-transmission path-receptor relationship. Elements of the risk assessment procedures, hazard identification, exposure assessment, dose-response identification, risk assessment, uncertainty analysis. Health risk, the risk quotient, the risk index.	2
Lec 8	Elimination of the effects of industrial accidents, environment remediation methods for the areas contaminated as a result of industrial accidents, examples. Summary. Knowledge check.	1
	Total hours	**15**

Laboratory		Number of hours
Lab 1	Determination of the limits of flammability and explosion of chemical substances	2
Lab 2	Determination of the effects related to the influence of toxic vapours of volatile substances resulting from industrial accidents	2
Lab 3	Analysis of explosive substances emissions and risks associated with their spread in the environment	2
Lab 4	Calculation of the level limits of toxic substances during outflow from a tank, taking into account different topography and atmospheric conditions	2
Lab 5	Analysis of risks related to the emission of toxic substances during the free evaporation from the open tank	2
Lab 6	Liquefied gas discharge from a pipeline. Hazard analysis and prevention consultation and the development of exercises.	2
Lab 7	Calculation of the migration limits of dangerous substances and their concentrations in areas with dense infrastructure	2
Lab 8	Consultations and development of laboratory reports.	1
	Total hours	**15**

TEACHING TOOLS USED

N1. Software EFFECTS 9 to calculate the potential risks arising from industrial accidents
N2. ALOHA software to calculate the effects of emissions of hazardous substances into the environment
N3. Multimedia presentations
N4. The laboratory test stand

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT

Evaluation (F – forming (during semester), P – concluding (at semester end)	Learning outcomes number	Way of evaluating learning outcomes achievement
P (lecture)	PEU_W01 – PEU_W06	final test
F (laboratory)	PEU_U01 – PEU_U05,	reports from the laboratory excercises

P1 (laboratory) = (F1+F2+F3+F4+F5+F6)/6

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] M.Ryng, Bezpieczenstwo techniczne w przemsle chemicznym , WNT Warszawa 1985
[2] Praca zbiorowa, Zapobieganie stratom w przemyśle, Pol. Łódzka, Łódź 1999
[3] W. Pihowicz, Inżynieria bezpieczeństwa technicznego, Problematyka podstawowa, WNT 2009

SECONDARY LITERATURE:

[1] Granice palności zgodnie z normą PN-EN 720-2, wskaźniki wybuchowości zgodnie z normą PN-EN26184-2, temperatury zapłonu w tyglu Clevelanda i Pensky'ego Martnsa
[2] Wydawnictwo Ministerstwa Przemysłu Chemicznego pt. "Niebezpieczne materiały chemiczne - charakterystyka, zagrożenia, ratownictwo" - Biuro Wydawnicze "Chemia" Warszawa 1989r.

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

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