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Study programme

Chemical Engineering and Technology

first degree study

The profile of studing: general academic

PRK VI

1. Basic information about the course

The name of the field of study	**Chemical Engineering and Technology**
The level of study	**first degree study**
The profile of studing	**general academic**

The name of the core discipline, in which more than half of the learning outcomes are obtained together with the percentage share of the number of ECTS credits for the core discipline in the total number of ECTS credits required to complete studies in the course of study.

The name of the core discipline	Share
chemical engineering	**74 %**

Names of other disciplines together with the percentage share of the number of ECTS credits for other disciplines in the total number of ECTS credits required to complete a course of study. PRS7

	Share
chemical sciences	**26 %**

Number of semesters	full time study: **7**
Number of ECTS credit points required to complete the studies	**210**
Total number of class hours	full time study: **2850**
Recruitment requirements	Requirements annually determined by the Senate of Rzeszów University of Technology
After graduation, the graduate obtains a professional title	Bachelor of Science (BSc)
Graduate's profile, employment opportunities	Graduates have a systematic, theoretically based general knowledge of the basic branches of chemistry as well as knowledge and engineering skills in the field of material engineering, process engineering, and chemical technology. They know modern technologies for the production of various chemical products, including ceramic, composite, and polymer engineering materials. The degree holders can use modern methods, techniques, and tools for structure identification, qualitative and quantitative analysis, and assessment of the properties of raw materials and products. Graduates have the structured knowledge required to understand, design, and supervise technological processes using a variety of experimental, computational, and simulation methods and techniques. They analyse the functioning of devices and technical systems used in these processes and indicate the possibilities of technology development. Degree holders are familiar with current trends in technology and chemical engineering. They know new technological solutions according to the principles of sustainable development, including use of technologies using natural and renewable resources, planning new pro-ecological technological solutions, waste management, and in particular the use of appropriate recycling technologies. Graduates have knowledge of a general foreign language at the B2 proficiency level of the European System of the Description of Language Education of the Council of Europe. They have instilled the habits of lifelong learning and is prepared to undertake second-cycle or postgraduate studies. Interdisciplinary technical education allows graduates to take up professional work in the chemical, pharmaceutical, cosmetics, polymer processing and food industries, as well as biotechnology, energy and environmental protection. Working as engineers, technologists and designers, graduates are sought-after engineering and managerial staff for almost all branches of the processing industry. They are also valued employees of industrial research and development laboratories as well as design studios and offices.

2. Learning outcomes

Symbol	Contents	References to PRK
K_W01	has basic knowledge of mathematics and physics necessary to understand and describe chemical and physical processes and phenomena, as well as to solve simple engineering tasks	**P6S_WG**
K_W02	has systematic, theoretically based knowledge of inorganic, organic, and physical chemistry required to understand, interpret, and describe phenomena and processes related to chemical technology and engineering	**P6S_WG**
K_W03	has a structured general knowledge of chemical and instrumental methods of quantitative and qualitative analysis of chemical compounds	**P6S_WG**
K_W04	has basic knowledge in the field of materials science, mechanical engineering and the principles of engineering constructions, allowing to understand the construction and selection criteria of apparatuses and devices used in the chemical industry	**P6S_WG**
K_W05	has structured knowledge covering key issues in the field of thermodynamics, physical and chemical fundamentals of unit operations, heat transfer processes, mass and momentum required to understand, supervise, and design chemical engineering operations and processes	**P6S_WG**

K_W06	knows mechanical processes typical for chemical engineering, describes selected technological solutions, has knowledge related to the selection of equipment, and knows the principles of their operation, understands the importance of basic mechanical processes and indicates their possible application	**P6S_WG**
K_W07	has basic knowledge of fluid mechanics and knows tools that use numerical methods to analyze flow phenomena, enabling their better understanding and optimization of existing solutions	**P6S_WG**
K_W08	has knowledge of raw materials, products, and processes used in the chemical industry and has an orientation in the current directions of development of technology and chemical engineering, including in the field of closed-loop technology	**P6S_WG**
K_W09	knows and describes technological solutions used in environmentally friendly, modern industrial technologies, i.e. waste-free, zero-emission technologies, using renewable raw materials or biotechnological processes	**P6S_WG**
K_W10	has structured and theoretically based knowledge about the properties, methods of production and processing of ceramic, composite, and polymer engineering materials, including materials for biomedical applications	**P6S_WG**
K_W11	knows and describes the basic methods, techniques, tools and materials used in solving typical engineering tasks related to chemical technology and engineering	**P6S_WG**
K_W12	has general knowledge necessary to understand the social, economic, legal and other non-technical conditions of engineering activity	**P6S_WK**
K_U01	has the ability to search, understand, analyze, and creatively use information from literature, databases, standards, and other sources, is able to draw appropriate conclusions, and formulate their own opinions	**P6S_UW**
K_U02	has language skills in the field of technical sciences in accordance with the requirements set out for level B2 of the Common European Framework of Reference for Languages	**P6S_UK**
K_U03	uses computer programmes for engineering calculations, data processing, analysis, and graphical presentation, and uses software supporting design, simulation, modelling, and other engineering tasks	**P6S_UW**
K_U04	plans and conducts experimental research using appropriate tools and techniques and documents the results of the experiments performed, interprets the results, and presents the effects of the research	**P6S_UW**
K_U05	uses mathematical knowledge and IT skills to solve simple engineering tasks, performs calculations, interprets the obtained results, and draws correct conclusions	**P6S_UW**
K_U06	evaluates the suitability and selects the method of analysis, laboratory technique, and engineering solution for the implementation of specific engineering tasks of varying degrees of difficulty	**P6S_UW**
K_U07	uses appropriate methods and techniques to identify the structure, qualitative and quantitative analysis, evaluate the properties of raw materials and products, and to control the course of processes	**P6S_UW**
K_U08	is able to prepare and present an oral presentation devoted to the results of the implementation of an engineering task and prepares a well-documented study related to the issues studied within the field of study	**P6S_UK**
K_U09	understands and is able to explain the phenomena occurring during processes and unit operations, is able to analyze, and optimize technological processes, is able to select raw materials and appropriate technologies for the implementation of these processes	**P6S_UW**
K_U10	designs basic apparatuses, processes, and unit operations taking into account engineering principles and is able to verify the operation of a simple chemical industry installation or laboratory stand	**P6S_UW**
K_U11	performs a critical analysis of the functioning of existing technical solutions, in particular systems, processes, services, devices, and facilities, for the needs of specific industrial processes and operations, assesses the suitability and possibility of using new technologies, research methods and technological solutions	**P6S_UW**
K_U12	analyzes and selects solutions conducive to economical use of materials, reduction of energy consumption and emissions, recovery of valuable by-products, and minimization of problems with waste disposal	**P6S_UW**
K_U13	assesses the risks associated with the implementation of chemical processes, observes the relevant health, and safety regulations and applies the principles of proper waste management	**P6S_UW**
K_U14	when formulating and solving engineering tasks, is able to integrate the acquired knowledge in the field of chemistry, chemical and process engineering, chemical technology and apply a systemic approach, also taking into account non-technical aspects, including environmental, organizational, economic and legal aspects	**P6S_UW**
K_U15	is able to plan and organize own work and work in a team realizing a common task	**P6S_UO**
K_U16	has the ability to self-educate, improve professional competences, and supplement knowledge throughout his professional life	**P6S_UU**
K_K01	understands the need to update their knowledge and improve their qualifications and knows the possibilities of developing professional and interpersonal competencies	**P6S_KK**
K_K02	is responsible for his own work and the consequences of his decisions; is able to comply with the rules of working in a group in various roles; is responsible for jointly implemented tasks, and is able to act in a creative and entrepreneurial way	**P6S_KO** **P6S_KR**
K_K03	is able to correctly define priorities for the implementation of tasks defined by him or others and ensure their timely completion	**P6S_KR**
K_K04	is able to correctly identify and resolve dilemmas related to the performance of the engineering profession, including: behaving in a professional manner, observing the rules of professional ethics, and personal culture	**P6S_KR**
K_K05	understands the need to formulate and provide the public with information and opinions on the achievements of chemistry, engineering, and chemical technology, as well as other aspects of the activity of a chemical engineer and makes efforts to provide such information and opinions in a commonly understandable way	**P6S_KO** **P6S_KR**

The description of learning outcomes includes learning outcomes referred to in the Act of 22 December 2015 on the Integrated Qualification System and takes into account universal characteristics of the first degree cycle specified in this Act and the characteristics of the second degree cycle specified in the regulations issued on the basis of Article 7, section 3 of this Act..

Detailed information about:

1. the relationship between learning outcomes and modular learning outcomes;
2. key learning outcomes in terms of knowledge, skills and social competences, demonstrating their relation to the discipline / disciplines to which the course is assigned;
3. the development of learning outcomes at the level of classes or group of classes, in particular related to the scientific activity conducted at the university;
4. learning outcomes in terms of knowledge, skills and social competences leading to the acquisition of engineering competences, in the case of study programmes on completion of which the student is awarded a professional title of engineer / Master of Engineering;

can be found in the Module Activity Sheets, available on the website of the faculty. Module Activity Sheets are integral part of the study programme.

3. List of classes, parameters of the study program, methods of verification of learning outcomes and program content

3.1 Common subjects for the field of study, independent of the students' choice

Semester	Org.Unit	name of the subject	Lecture	Class	Laboratory	Project/ Seminar	Sum of hours	ECTS	Exam	Mand.
1	CN	General and inorganic chemistry	30	30	15	0	75	7	T	
1	CI	Physics	30	30	0	0	60	5	N	
1	DJ	Foreign language	0	30	0	0	30	2	N	
1	FM	Mathematics I	30	30	0	0	60	6	T	
1	CI	Technical mechanics	15	30	0	0	45	4	N	
1	CM	Fundamentals of materials science	15	15	0	0	30	2	N	
1	ZF	Elective subject 1.1	15	15	0	0	30	2	N	
1	ZO	Elective subject 1.2	30	0	0	0	30	2	N	
1	DL	Physical education	0	30	0	0	30	0	N	
2	CN	General and inorganic chemistry	30	30	30	0	90	7	T	
2	DJ	Foreign language	0	30	0	0	30	2	N	
2	CI	Computer engineering graphics (CAD)	15	0	0	45	60	4	N	
2	CI	Machines theory	15	0	0	15	30	2	N	
2	FM	Mathematics II	30	30	0	0	60	6	T	
2	CI	Engineering calculation software	0	0	30	15	45	3	N	
2	ZH	Elective subject 2.1	30	0	0	0	30	2	N	
2	CB	Statistics and elaboration of results	15	0	15	0	30	2	N	
2	CB	Information technology	0	0	30	0	30	2	N	
2	DL	Physical education	0	30	0	0	30	0	N	
3	CN	Analytical chemistry	15	15	15	0	45	3	N	
3	CF	Physical chemistry	45	30	45	0	120	9	T	
3	CD	Organic chemistry	30	30	30	0	90	7	T	
3	DJ	Foreign language	0	30	0	0	30	2	N	
3	CI	Fluid mechanics	30	0	30	0	60	4	N	
3	CI	Mechanical processes in chemical engineering	30	0	30	15	75	5	N	
4	CD	Organic chemistry	30	30	45	0	105	8	T	
4	CS	Polymer chemistry	15	0	0	0	15	1	N	
4	DJ	Foreign language	0	30	0	0	30	3	T	
4	CM	Ceramic materials	15	0	15	0	30	2	N	
4	CK	Engineering materials	15	0	30	0	45	3	N	
4	CI	CFD modeling of flows	0	0	0	30	30	2	N	
4	CI	Fundamentals of engineering calculations	15	0	15	0	30	2	N	
4	CI	Fundamentals of heat and mass transfer	30	0	30	15	75	5	T	
4	CI	Engineering thermodinamics	30	0	30	0	60	4	N	
5	CF	Instrumental analysis	30	0	30	0	60	4	N	
5	CI	Diffusion separation processes	30	0	45	15	90	6	T	
5	CS	Biomaterials engineering	30	0	30	0	60	4	N	
5	CM	Industrial organic chemistry	30	0	60	0	90	6	T	
5	CF	Chemical sensors	15	0	0	0	15	1	N	
5	CM	Inorganic technology	15	0	30	0	45	3	N	
6	CI	Computer aided process design	15	0	0	30	45	3	N	
6	CM	Modern physicochemical methods in the analysis of organic and inorganic materials	15	0	15	0	30	2	N	
6	CM	Carbochemical and petrochemical processes	30	0	15	0	45	3	T	
6	CK	Recycling of polymeric materials	15	0	15	0	30	2	N	
6	CN	Advanced methods of instrumental analysis	15	0	30	0	45	3	N	
7	CX	Diploma laboratory	0	0	150	0	150	10	N	
7	CN	Environmental protection in chemical technology	15	0	0	0	15	1	N	
7	CX	Diploma thesis	0	0	0	0	0	8	N	
7	CX	Professional practice	0	0	0	0	0	4	N	
7	CI	Chemical reactors	30	0	30	0	60	4	N	
7	CX	Diploma seminar	0	15	0	0	15	1	N	

Note that not being granted credits from the modules marked with a red flag makes it impossible to make an entry for the next semester (even if the total number of ECTS credits is lower than the permissible debt), these are modules continued in the next semester or modules in which failure to achieve all assumed learning outcomes does not allow one to continue studies in the modules included in the next semester's study programme

3.2 List of thematic blocks

- Engineering of Polymeric Materials
- Sustainable Chemical Technologies

3.2.1. Thematic block: Engineering of Polymeric Materials

Subjects implemented after the selection of the thematic block

Semester	Org.Unit	name of the subject	Lecture	Class	Laboratory	Project/ Seminar	Sum of hours	ECTS	Exam	Mand.
5	CM	Fundamentals of polymer physicochemistry	15	0	30	0	45	3	N	
5	CK	Fundamentals of rheology	15	0	30	0	45	3	N	
6	CX	Modern polymer technologies	15	0	30	0	45	3	N	
6	CX	Smart polymers	15	0	15	0	30	2	N	
6	CK	Shape and processing design of polymer components	15	0	0	15	30	2	N	
6	CS	Polymer technology	30	0	30	0	60	4	N	
6	CK	Processing technology of polymer materials	30	0	60	0	90	6	T	
7	CS	Polymer protective coatings	15	0	30	0	45	2	N	

List of additionally subjects of choice within the study program, both in the field of subjects common to the field of study and the thematic blocks, including foreign languages.

Semester	Org.Unit	name of the subject	Lecture	Class	Laboratory	Project/ Seminar	Sum of hours	ECTS	Exam	Mand.
1	DJ	French (A)	0	30	0	0	30	2	N	
1	DJ	French (B)	0	30	0	0	30	2	N	
1	DJ	German (A)	0	30	0	0	30	2	N	
1	DJ	German (B)	0	30	0	0	30	2	N	
1	ZF	Elective subject 1.1 - Finance in project management	15	15	0	0	30	2	N	
1	ZF	Elective subject 1.1 - Accounting and finance in business	15	15	0	0	30	2	N	
1	ZO	Elective subject 1.2 - Introduction to economic activity	30	0	0	0	30	2	N	
1	ZO	Elective subject 1.2 - Fundamentals of management	30	0	0	0	30	2	N	
2	DJ	French (A)	0	30	0	0	30	2	N	
2	DJ	French (B)	0	30	0	0	30	2	N	
2	DJ	German (A)	0	30	0	0	30	2	N	
2	DJ	German (B)	0	30	0	0	30	2	N	
2	ZH	Elective subject 2.1 - Psychological aspects in professional work	30	0	0	0	30	2	N	
2	ZH	Elective subject 2.1 - Social psychology	30	0	0	0	30	2	N	
3	DJ	French (A)	0	30	0	0	30	2	N	
3	DJ	French (B)	0	30	0	0	30	2	N	
3	DJ	German (A)	0	30	0	0	30	2	N	
3	DJ	German (B)	0	30	0	0	30	2	N	
4	DJ	French (A)	0	30	0	0	30	3	T	
4	DJ	French (B)	0	30	0	0	30	3	T	
4	DJ	German (A)	0	30	0	0	30	3	T	
4	DJ	German (B)	0	30	0	0	30	3	T	

Parameters of the study program

The total number of ECTS credits that a student must obtain in the course of classes conducted with direct participation of academic teachers or other persons conducting classes.	129 ECTS
The total number of ECTS credits allocated to classes related to scientific activity conducted at the university in a given discipline or disciplines to which the course of study is assigned.	134 ECTS
The total number of ECTS credits required to be obtained by a student in the humanities or social sciences for the courses of study assigned to disciplines within the fields of study other than the humanities or social sciences respectively.	6 ECTS
The total number of ECTS credits allocated to elective courses.	63 ECTS
Total number of ECTS credits allocated to work placements, internships (if the study program includes work placements or internships).	4 ECTS
Hours of apprenticeships, internships (if the study program provides for internships or apprenticeships).	120 h.
The total number of ECTS points that a student must obtain as part of a foreign language course.	9 ECTS
Number of hours of physical education classes.	60 h.

Verification methods of learning outcomes

Detailed rules and methods for the verification and assessment of learning outcomes that allow all learning outcomes to be verified and assessed are described in the Module Activity Sheets. Within the framework of a programme, verification of learning outcomes is carried out in particular by means of the following methods: written, exam part practical, exam part oral, written pass, pass a part practical, oral pass, essay, colloquium, written test, observation of performance, portfolio, project presentation, written report, oral report, project report, written test. Detailed information about the verification of learning outcomes achieved by students can be found in the Module Activity Sheets on the website of the faculty. Parameters of selected methods of verification of learning outcomes are presented in the table below.

Number of classes where the exam is required	13
Number of classes where a written exam is required	13
Number of classes where an oral exam is required	0
Number of hours devoted to the written exam	28
Number of hours devoted to oral exam	0
Estimated number of hours students should spend preparing for exams and credits	477
Number of classes which result in a pass without an exam	46
Number of hours to be completed in writing	63
Oral number of hours to complete	3
Estimated number of hours that students should spend on preparing for credits during semesters during classes (no final credits)	161
Number of classes in which the verification of the achieved learning outcomes is carried out on the basis of observation of performance (laboratories)	34
Number of laboratories where the achieved learning outcomes are checked on the basis of tests during the semester	29
Estimated number of hours students should spend in preparing for laboratory tests	234
Number of project classes in which the learning outcomes achieved are checked on the basis of a project presentation, a written report, a written report, an oral report or a project report	9
Estimated number of hours students should spend on design / documentation / report preparation and preparation for presentation	114
Number of lecture classes that require separate credit in writing or orally, regardless of the requirements of other forms of classes in this module	25
Estimated number of hours students should spend in preparing for lecture tests	175

3.2.2. Thematic block: Sustainable Chemical Technologies

Subjects implemented after the selection of the thematic block

Semester	Org.Unit	name of the subject	Lecture	Class	Laboratory	Project/ Seminar	Sum of hours	ECTS	Exam	Mand.
5	CN	Elements of biotechnology	15	0	15	0	30	2	N	
5	CN	Corrosion protection	15	0	15	0	30	2	N	
5	CF	Electrochemical technologies	15	0	15	0	30	2	N	
6	CS	Biodegradable polymer products	15	0	30	0	45	3	N	
6	CB	Protein biotechnology	15	0	30	0	45	3	N	
6	CF	Electrochemical energy sources	15	0	30	0	45	3	N	
6	CX	Molecular modeling	15	0	30	15	60	4	N	
6	CX	Material technologies in medicine	30	0	30	0	60	4	T	
7	CS	Ecological materials	15	0	30	0	45	2	N	

List of additionally subjects of choice within the study program, both in the field of subjects common to the field of study and the thematic blocks, including foreign languages.

Semester	Org.Unit	name of the subject	Lecture	Class	Laboratory	Project/ Seminar	Sum of hours	ECTS	Exam	Mand.
1	DJ	French (A)	0	30	0	0	30	2	N	
1	DJ	French (B)	0	30	0	0	30	2	N	
1	DJ	German (A)	0	30	0	0	30	2	N	
1	DJ	German (B)	0	30	0	0	30	2	N	
1	ZF	Elective subject 1.1 - Finance in project management	15	15	0	0	30	2	N	
1	ZF	Elective subject 1.1 - Accounting and finance in business	15	15	0	0	30	2	N	
1	ZO	Elective subject 1.2 - Introduction to economic activity	30	0	0	0	30	2	N	
1	ZO	Elective subject 1.2 - Fundamentals of management	30	0	0	0	30	2	N	
2	DJ	French (A)	0	30	0	0	30	2	N	
2	DJ	French (B)	0	30	0	0	30	2	N	
2	DJ	German (A)	0	30	0	0	30	2	N	
2	DJ	German (B)	0	30	0	0	30	2	N	
2	ZH	Elective subject 2.1 - Psychological aspects in professional work	30	0	0	0	30	2	N	
2	ZH	Elective subject 2.1 - Social psychology	30	0	0	0	30	2	N	
3	DJ	French (A)	0	30	0	0	30	2	N	
3	DJ	French (B)	0	30	0	0	30	2	N	
3	DJ	German (A)	0	30	0	0	30	2	N	
3	DJ	German (B)	0	30	0	0	30	2	N	
4	DJ	French (A)	0	30	0	0	30	3	T	
4	DJ	French (B)	0	30	0	0	30	3	T	
4	DJ	German (A)	0	30	0	0	30	3	T	

4	DJ	German (B)	0	30	0	0	30	3	T	

Parameters of the study program

The total number of ECTS credits that a student must obtain in the course of classes conducted with direct participation of academic teachers or other persons conducting classes.	130 ECTS
The total number of ECTS credits allocated to classes related to scientific activity conducted at the university in a given discipline or disciplines to which the course of study is assigned.	137 ECTS
The total number of ECTS credits required to be obtained by a student in the humanities or social sciences for the courses of study assigned to disciplines within the fields of study other than the humanities or social sciences respectively.	6 ECTS
The total number of ECTS credits allocated to elective courses.	63 ECTS
Total number of ECTS credits allocated to work placements, internships (if the study program includes work placements or internships).	4 ECTS
Hours of apprenticeships, internships (if the study program provides for internships or apprenticeships).	120 h.
The total number of ECTS points that a student must obtain as part of a foreign language course.	9 ECTS
Number of hours of physical education classes.	60 h.

Verification methods of learning outcomes

Detailed rules and methods for the verification and assessment of learning outcomes that allow all learning outcomes to be verified and assessed are described in the Module Activity Sheets. Within the framework of a programme, verification of learning outcomes is carried out in particular by means of the following methods: written, exam part practical, exam part oral, written pass, pass a part practical, oral pass, essay, colloquium, written test, observation of performance, portfolio, project presentation, written report, oral report, project report, written test. Detailed information about the verification of learning outcomes achieved by students can be found in the Module Activity Sheets on the website of the faculty. Parameters of selected methods of verification of learning outcomes are presented in the table below.

Number of classes where the exam is required	13
Number of classes where a written exam is required	13
Number of classes where an oral exam is required	0
Number of hours devoted to the written exam	28
Number of hours devoted to oral exam	0
Estimated number of hours students should spend preparing for exams and credits	476
Number of classes which result in a pass without an exam	47
Number of hours to be completed in writing	69
Oral number of hours to complete	3
Estimated number of hours that students should spend on preparing for credits during semesters during classes (no final credits)	161
Number of classes in which the verification of the achieved learning outcomes is carried out on the basis of observation of performance (laboratories)	36
Number of laboratories where the achieved learning outcomes are checked on the basis of tests during the semester	30
Estimated number of hours students should spend in preparing for laboratory tests	210
Number of project classes in which the learning outcomes achieved are checked on the basis of a project presentation, a written report, a written report, an oral report or a project report	9
Estimated number of hours students should spend on design / documentation / report preparation and preparation for presentation	134
Number of lecture classes that require separate credit in writing or orally, regardless of the requirements of other forms of classes in this module	27
Estimated number of hours students should spend in preparing for lecture tests	202

3.3 Programme content

Programme content (educational content) is consistent with the learning outcomes and takes into account, in particular, the current state of knowledge and research methodology in the discipline or disciplines to which the course of study is assigned, as well as the results of scientific activity in this discipline or disciplines. A detailed description of the program content is available in the Module Activity Sheets on the website of the faculty.

Advanced methods of instrumental analysis	K_W03, K_K02, K_K03
• Structural analysis of selected chemical compounds using mass spectrometry with soft ionization • Qualitative and quantitative analysis of biomolecules by laser mass spectrometry • The optimization of the chromatographic analysis parameters. An assessment of the resolution, efficiency and selectivity under different GC analysis conditions. • An analyte indication and quantitative analysis in tea extract samples with the use of solid-phase extraction (SPE) and liquid chromatography technique (HPLC). • A quantitative analysis of ethanol in alcoholic beverage samples with the use of single drop microextraction (SDME) and gas chromatography technique (GC). • A study of the matrix effect on an analysis accuracy and precision. A quantitative analysis of limenene in a plant-based material sample with the use of extrapolation method of the calibration with the aim of minimise the matrix effect impact.	
Analytical chemistry	K_W03, K_U04, K_U06, K_U07, K_U15, K_K02, K_K03
• Division of analytical chemistry, scale, accuracy and precision of the methods. General scheme of quantitative analysis. Analytical errors, statistical evaluation of results. Methods of separation and concentration. Division and characteristics of chemical analysis methods. Contemporary theories of acids and bases, protolytic solvents, equilibrium constants. solubility and solubility product. Theoretical bases of volumetric analysis: acid-base, oxidation-reduction and complexation titrations, . Precipitation analysis, effects accompanying solid product separation. Chemical calculations in the field of volumetric and gravimetric methods. • Acid-base titration. Preparation of NaOH solution. Adjustment of NaOH titre. • Oxidation-reduction titration. Preparation and adjustment of KMNO4 solution titre. Testing analysis: determination of Fe2+ content. • Complexation	

titration. Preparation of EDTA solution. Testing analysis: determination of Ca(II) or Mg(II) content. • Calculations in analytical analysis.	
Biodegradable polymer products	K_W08, K_W09, K_U04, K_U06, K_U07, K_U09, K_U11, K_U15, K_K02, K_K03
• The properties of the polymers (molecular weight, the degree of the polymerization, the degree of polydyspersion, Tg, the degree of crosslinking). Types of polymers in terms of their chemical and supermolecular structure and physicmechanical properties • Types of biodegradable polymers: natural polymers, polymers with bonds susceptible to hydrolysis, blends of biodegradable and non-degradable polymers. • Factors affecting the biodegradation of the polymer (structure of the polymer, morphology, molecular weight). Decision tree for evaluating biodegradability of plastics. Polymer modification to facilitate biodegradation (creation of the „weak points ” by the insertion of functional groups, copolimerization, implantation of metal salts). Mechanisms of biodegradation. • Technologies for obtaining biodegradable polymers - classic, by bacterial fermentation, from petrochemical raw materials and renewable sources • Application of biodegradable polymers. The development of biodegradable polymers. • Polymer biodegradation - mechanisms and estimation techniques. Tests and standards for research. • Preparation and characterization of carboxymethyl cellulose. Preparation of a biodegradable poly (vinyl alcohol) - starch composition. Enzymatic degradation of starch. Biodegradation tests in water, soil, simulated composting conditions.	
Biomaterials engineering	K_W10, K_W11, K_U04, K_U06, K_U07, K_U15, K_K02, K_K03
• Biomaterials - concepts, classification, biocompatibility, bioactivity, chemical corrosion, fatigue corrosion, pitting, fretting. • Preparation and characterization of synthetic polymers for use as biomaterials (polyvinyl alcohol (PVA), polylactic acid (PLA), copolymers of L-lactic and glycolic acids (PLGA), silicones, PMMA, polyurethanes, poly(esteramides), polyanhydrides, polyphosphazenes). • Types and properties of natural polymers used as biomaterials (proteins and poly(amino acids), polysaccharides). • The use of polymers in various fields of biomedical engineering: tissue fusion materials, dressing materials, materials used in surgery, orthopedics, cardiac surgery, dentistry and prosthetics, in controlled drug delivery systems • Polymeric biomaterials research methods. Testing and introducing biomaterials for use and marketing, legislative issues regarding biomaterials and medical devices. • Ceramic biomaterials - introduction. Classification of ceramic biomaterials. Outline of ceramic biomaterials technology • Alumina in bone surgery and dentals. Manufacturing of alumina biomaterials.. Manufacturing and properties of hydroxyapatite. • Methods for the preparation and properties of porous ceramic biomaterials • Technology and properties of carbon biomaterials . Technology and properties of metallic biomaterials . Technology and properties of the composite biomaterials • Manufacturing and testing the properties of selected polymeric materials: biocompatible polyurethane elastomers; preparation of hydrogel from poly(vinyl alcohol) and evaluation of its selected properties; assessment of technological properties of selected biomaterials • Preparation and characterization of selected ceramic biomaterials.	
Carbochemical and petrochemical processes	K_W08, K_U04, K_U06, K_U07, K_U09, K_U11, K_U12, K_U13, K_U15, K_K02, K_K03
• The raw materials for the carbochemical and petrochemical industry - general information. • Coal and lignite and its processing. Coking and coal tar processing. Coal gasification and liquefaction. • Natural gas processing. • Crude oil distillation and thermal and catalytic processing of petroleum products including catalytic cracking and reforming, olefin and aromatics production. Fuel production. • Production of acetylene and syngas, hydrogen. • Crude oil distillation. Examination of selected physicochemical properties of fuels and oils, examination of fuel composition	
Ceramic materials	K_W08, K_W10, K_U04, K_U06, K_U07, K_U09, K_U11, K_U15, K_K02, K_K03
• The definition and application of ceramic materials, ceramic materials division. Manufacture of ceramic materials: Prepare the raw materials, molding, sintering, final treatment. Traditional ceramics materials for example plastic porcelain. Materials with special ceramics: oxides, carbides and nitrides as engineering plastics. Porous ceramic materials. Glass, ceramic and glass-ceramic materials. Ceramic composites. Ceramic-metal composites. The use of ceramic materials in the industry and medicine • Laboratory exercises: - Grain analysis of ceramic powders, - Determination of water absorption, apparent density and total and openporosity of ceramics, - Forming ceramic materials by pressing	
CFD modeling of flows	K_W07, K_W11, K_U03, K_U10, K_U16, K_K02, K_K03
• Work in sketchpad mod. 2D modeling. Simplifying and repairing of geometry. Parametrization of geometry. • Mesh generation in Ansys Meshing software. Kinds of calculation meshes. Meshing algorithms. Control of quality and size of mesh. Methodology of mesh generation for CFD analysis. • Basics of Fluent Software. Determination of flow model. Determination of boundary conditions. Solver options. • Analysis and interpretation of results.	
Chemical reactors	K_W04, K_W05, K_U05, K_K02, K_K03
• Kinetics of chemical reactions. Reaction rate vs. concentration and temperature. Calculating the composition of the reaction mixture. • Chemical reactors - material balance. Periodic reactor. Methods of analysis of kinetic data. Simple and complex reactions in a batch reactor. • Continous stirred tank reactor. Cascade of reactors. Plug-flow reactor. Semi-continous reactor. Plug-flow with recycling of flux. • Comparison of reactors for simple reactions. Comparison of reactors for complex reactions.	
Chemical sensors	K_W08, K_W11, K_U16, K_K01
• Classification of chemical sensors. Theoretical basics of chemical recognition. • Electrochemical sensors - potentiometric, amperometric and conductometric sensors. • Optical sensor, physics of optical fibers, optical fiber sensors – design, operation and examples. • Mass sensors, basics of piezo- and pyroelectricity, chemical layers of mass sensors. • Thermal sensors - pyroelectric sensors, gas catalytic sensors. • Applications of chemical sensors in industrial analytical control, clinical chemistry and environment protection. Prospects of development of chemical sensors.	
Computer aided process design	K_W08, K_W11, K_U03, K_U05, K_U06, K_U10, K_U11, K_U15, K_U16, K_K02, K_K03
• Introduction to methods of designing integrated systems technology. Characteristics of simulation software and simulation strategy. Definitions and calculations organization. Basic rules for the selection of thermodynamic models. • Introduction to simulation calculations of technological processes (flow of information, analysis of degrees of freedom, the models selected processes, classification of simulation methods, numerical computation, useful options - design specifications, sensitivity analysis. The calculation of the physicochemical properties of the solutions. • Selection rules and parameters of the processes, apparatuses, the selection of the reactor and the reaction parameters, the separation process - the base. The calculation of chemical reactions and reactors. Calculation of the heat exchangers. • Criteria for evaluation of the project - "pure" chemical technology. Hierarchical method, an example application. Basics of simultaneous methods. Calculation of separators with two liquid phases. • Design Heuristics. The calculation of basic unit operations and analysis of the results (flash calculations, distillation, extractive distillation, absorption). • Systems design process - the base, the scope of the initial project, the organization of the design process, the evaluation criteria the technological system, basic system design strategies. Calculation of pipeline networks and their elements. The calculation of the basic operations of fluid transport (pumps, compressor, expander, valves). • The use of sensitivity analysis as a tool for selection of parameters of the apparatus. • Optimization calculations of the distillation columns.	
Computer engineering graphics (CAD)	K_W04, K_W11, K_U03, K_U05, K_K02, K_K03

• Technical letter • Rectangular projections, axonometric views, views and sections. • Technical charts. • Rules for dimensioning. • Tolerance of dimensions, shape and position. • Determination of surface roughness. • Connections of the machines: separable and inseparable. • Assembly drawings. • Standardized graphical symbols and devices used in the processes of chemical technology. • Preliminary information, start AutoCAD and basic settings. • Creating a drawing template and drawing styles. • Exercises for features and commands of AutoCAD. • Examples of application AutoCAD specific functions. • Constraints - parametric drawing in AutoCAD • Creating technical drawings - projection and dimensioning of a complex geometric solids. • Drawing preparation and printing from the layout level. • Making production and assembly drawings of machines parts. • Reading the technical documentation.	
Corrosion protection	K_W08, K_W11, K_U04, K_U06, K_U07, K_U09, K_U11, K_U15, K_K02, K_K03
• The structure of metals and alloys. Polycrystalline structure and grain boundary. Iron, carbon steel and alloy steels. Phase diagram of Fe-C system. Effervescing steel, killed steel and semi-killed steel. Carbon steel and its transformation during cooling. Heat treatment and hardening of steel. Austenite and martensite. Chrome steel, low, medium and high-alloy steel. Other stainless and heat-proof steels. The structure and properties of selected metals of technical interest (Al, Mg, Cu, Ni, Cr, Ti, Mo and their alloys). Thermodynamics and stability of metals. Potential-pH dependences and diagrams (Pourbaix approach). Oxygen and hydrogen lines. The potential-pH diagrams for metals and systems of technological interest. Stress corrosion and cracking. Intercrystalline (intergranular) corrosion. • Electrochemistry of corrosion. Metal-solution interface. The origin of electrode potential. Standard potential system. Other non-thermodynamic systems of electrode potentials (galvanic series). Charge transfer reactions and redox couples as the origin of the instability of metals. The electron-sink (anodic) and electron-source (cathodic) areas in corrosion process. Evans's diagrams. Polarization curves as an example of current-potential dependences. Kinetic parameters of corrosion rate. Oxygen depolarization corrosion, oxygen reduction. Hydrogen depolarization corrosion, the parameters influencing the rate of corrosion. Hydrogen ion reduction mechanisms. Hydrogen brittleness of steel. The inner and outer factors influencing the rate of corrosion. The origin of factors of instability of metal surface. The state of surface, structure of metal and metal short circuited cells and heterocells in metals and alloys. Cathodic and anodic metallic coatings on metals as a source of galvanic couples. Illustration of typical forms of corrosion. Metal replacement (immersion plating). • High temperature and gaseous corrosion of metals and alloys. Thermodynamics of the process. Oxide layers and their properties. The influence of temperature and gaseous atmosphere on the kinetics of the corrosion process. The influence of temperature and atmosphere composition on the kinetics of oxide layers formation. Diffusion in the oxide layers. The Pilling-Bedford dependence. Mechanical properties and corrosion resistance of steel at high temperatures. Gaseous corrosion protection. Heat-proof alloys and coatings on metals. Corrosion of non-metallic and pseudo-metal materials: graphite, concrete and reinforced concrete including corrosion of reinforcement, ceramics, plastics, rubber, wood. • Corrosion protection methods. Metallic coatings: Zn, Ni, Cr, Al, Sn and others. Inorganic coatings: chemical conversion coatings: chromate, phosphate, chemical oxide coatings. Anodic treatment of metals. Organic coatings: paints and varnishes, lacquers and backing enamels. Bituminous coatings. Rubber coatings. Inhibitors and passivators. Fundamentals and application of cathodic and anodic protection of metals. Metallic protectors (sacrificial anodes), their theory and application. Laboratory and field corrosion tests.	
Diffusion separation processes	K_W05, K_W08, K_W11, K_U04, K_U05, K_U06, K_U09, K_U10, K_U11, K_K02, K_K03
• Absorption. Characteristics of the process. The equilibrium of gas - liquid. The mass balance of the process and the operating line. Methods of mass exchanger high calculation.Hydrodynamic diameter of the apparatus. Apparatus. Distillation and rectification. Liquid - vapor equilibrium for two-and multi-component systems . Simple distillation. Steam distillation. Adjustment of the two-component batch and continuous : the balance sheets, operating lines, minimum and maximum reflux, determination of the number of theoretical plates - graphical and analytical methods. Rectification of multicomponent mixtures. Design issues: the selection of the type of apparatus, the characteristics of the shelves and their efficiency, mass transfer coefficients , packed columns. Laboratory: Five laboratory exercises related to the topic of the course Projects : Students perform project of the the mass exchanger fluid - fluid system : the rectification column and/or absorber.	
Diploma laboratory	K_W03, K_W08, K_W11, K_U01, K_U04, K_U06, K_U07, K_U09, K_U15, K_K02, K_K03
• Drawing up a plan for the experimental part of the diploma thesis. Realization tests/analyzes related to the experimental part of the diploma thesis. Working out the results. Drawing conclusions from the conducted research/analyzes.	
Diploma seminar	K_W11, K_U01, K_U03, K_U08, K_K05
• Discussion of the principles of writing a diploma thesis and preparing a multimedia presentation. Cyclic meetings with students to present the results of their research and discussion with the participation of students and the moderator after the presentation of the results.	
Diploma thesis	K_W08, K_W11, K_U01, K_U03, K_U04, K_U08, K_U11, K_U14, K_U15, K_K02, K_K04, K_K05
• Collection and analysis of subject literature related to the topic of work. Developing the concept and method of solving the research problem raised in the subject of the diploma thesis, as well as developing a work implementation plan. The solution of the research problem raised in the subject of the diploma thesis. Development of the obtained results of the solution and their critical analysis. Preparation of final conclusions. • Preparation of the master thesis • Master thesis defense	
Ecological materials	K_W08, K_W09, K_U04, K_U06, K_U07, K_U09, K_U11, K_U12, K_U15, K_K02, K_K03
• Raw materials (natural, recycled, renewable, waste) used to produce environmentally friendly materials • Technologies of production of selected pro-ecological materials • in terms of giving them pro-ecological properties • Optimization of materials in terms of resource use • Modern trends in the development of environmentally friendly materials • 1. Obtaining of emission-free coatings-forming products 2. Obtaining of epoxy composites based on natural fillers 3. Synthesis of alkyd lacquer based on vegetable oils 4. Polyurethane foams based on natural raw materials 5. Synthesis of biobased polyester resin	
Electrochemical energy sources	K_W08, K_W09, K_U04, K_U06, K_U07, K_U09, K_U11, K_U12, K_U15, K_K02, K_K03
• Primary and secondary energy sources. Chemical and electrochemical energy sources. • Classification of electrochemical cells. Basic thermodynamics and kinetics of electrochemical energy conversion. Primary electrochemical cells. Zinc-carbon batteries. Magnesium and aluminum batteries. Alkaline-manganese dioxide. Mercuric oxide batteries. Silver oxide batteries. Zinc/air batteries. Lithium batteries. Solid-electrolyte batteries. • Secondary elechtrochemical cells. Classification of secondary batteries. Lead-acid battery. Iron electrode batteries. Nickel-cadmium batteries. Nickel-metal hydride batteries. Nickel-zinc batteries. Nickel-hydrogen batteries. Silver oxide batteries. Rechargable lithium batteries. Lithium-ion batteries. Other rechargable batteries. • Fuel cells. Classification of fuel cells. Alkaline Fuel Cell (AFC). Phosphoric Acid Fuel Cell (PAFC) Molten Carbonate Fuel Cell (MCFC) Solid Oxide Fuel Cell (SOFC) Proton-exchange Membrane Fuel Cell (PEMFC) Direct Methanol Fuel Cell (DMFC) • Leclanche cell. Investigation of polymer electrolyte fuel cell. Electrochemical hydrogen generation. Hydrogen as a secondary energy source. Discharge curve of electrochemical cell..	
Electrochemical technologies	K_W08, K_W09, K_U04, K_U06, K_U07, K_U09, K_U11, K_U12, K_U15, K_K02, K_K03
• Electrolysis process - general definitions. Area of electro-chemical engineering. Industrial electrochemical processes of inorganic compounds. Chloralkali industry processes. Electrolytic production of aluminium and magnesium. Hydrometallurgical processes. Electrochemical production of zinc. Electrolytic refining of copper. Industrial electrochemical processes of organic compounds. Electrohydro - dimerization of acetonitrile. Electrolytic production of sebacic acid. Electrochemical production of	

aromatic aldehydes. Application of electrochemical methods in waste recycling. Principles of electroplating processer. Batteries and fuel – cells. • Electroreffining of copper. Galvanic cells. Characteystic of charging and discharging of the cell. Electrolytic manganese dioxide. Electrochemical oxidation of aniline.	
Elements of biotechnology	K_W09, K_U04, K_U06, K_U07, K_U09, K_U11, K_U15, K_K02, K_K03
• Metabolites - structures, applications, biological function • Application of microorganisms in environmental protection. Biosorption, environmental bioremediation and toxic waste biodegradation • Principles of fermentation (ethanol, lactatic acid). Technology of food production: beer, cheese, and others. Industrial application of the lactic acid fermentation products. Methods of prediction and control of industrial fermentation process. • Technology of antibiotics production (penicillin, cephalosporin, tetracyclin,aminoglicosides, clavulinic acid and its analogs). Methods of microorganisms immobilization. Biotrasformation. Biosynthesis of aminoacids, organic acids and vitamins. • Bio-fuels and technologies applied in the production of bio-ethanol, bio-diesel, bio-hydrogen and saturated hydrocarbons.Metal biosorption. Microbially enhanced oil recovery. Biopolymers-structure, properties and biosynthesis. • Application of biocatalysts, immobilisation of biocatalysts, production via biotransformation and fermentation	
Engineering calculation software	K_W11, K_U03, K_U05, K_U10, K_U16, K_K02, K_K03
• Application of MS Excel to discretize functions, create simple and advanced plot charts, perform array operations, simple statistical analysis, operations with macros and to solve chemical problems and model simple chemical processes using solver tool. • Application of Origin Lab software to prepare professional 2D and 3D charts, to perform statistical processing of experimental data, to estimate parameters for equation describing experimental data, to perform differentiation and integration of discrete functions • Application of Matlab and/or Maple programs for arithmetic calculations, algebraic transformations, solution of linear and nonlinear equations, inequalities and systems of equations, symbolic and numerical function integration and differentiation, matrix algebra, solving differential equations, graphing functions of one and two variables. Introduction to Programming in Matlab and/or Maple. Creation of simple programs for solving selected mathematical problems. • Application of ChemSketch software to create and edit chemical structures	
Engineering materials	K_W08, K_W10, K_U04, K_U06, K_U07, K_U09, K_U11, K_U15, K_K02, K_K03
• Introduction to materials science • Polymer materials and composites • Mechanical properties of polymer composite materials. • Flammability of construction materials • Methods of reducing the flammability of construction materials • Selection of materials • Determination of strength properties of fiber composites. in static tension. Obtaining plastic products by casting and determining properties of finished products. Determination of rheological properties of polymer compositions. Grain size analysis of powders Water absorption, real and apparent density and porosity of ceramic materials. Determination of rheological properties of polymer compositions.	
Engineering thermodinamics	K_W05, K_U05, K_K02, K_K03
• Equations of state of fluids, thermodynamic functions, characteristic processes for non-ideal liquids, thermodynamics of cooling and heating cycles. Equations of state for real solutions, thermodynamic functions for real solutions. Basics of equilibrium in multiphase systems, fugativity, activity, methods of calculation. Phase equilibrium for systems liquid-liquid, liquid-vapor, liquid-solid.	
Environmental protection in chemical technology	K_W09, K_U12, K_U16
• Definitions i fundamental phrases. Environment, environment protection, ecology, ecological impact, system, ecosystem, paradigm, civilization. Theory of systems. Reductionism versus holistic approach in reality description an understanding. Soft and hard technologies. • Ecological equilibrium. Elements of ecological equilibrium of Earth. Energy balance of Earth. Cycles of chemicals in the environment. Circulation of matter (H2O, CO2, N2, O2 , heavy metals) and energy. Populations and their features. Agglomeration process, dissipative structures. Agriculture and ecology. Contamination caused by farm plant and animal production. Soil components and their transformation. Degradation and protection of soils. Biological sewage and waste water purification. Importance of fuels and energy in agriculture economy. • Chemical inorganic and organic toxic substances in the environment and their biological effects. Classification and systematics of contaminants. Environmental persistent organic pollutants, dispersion, bioaccumulation, toxicology (dysfunction of enzymes and biosynnthesis of haem, anaesthesia, modification of DNA) and pseudohormonal activity. Ecological and ethical aspects of chemical production. Tobacco smoke as environmental pollution. • Level of toxic metals in air, soil and food as an indicator of environmental quality. Systemic approach to calculation and conversion of various expressions defining concentrations and their units for applications in ecology, analytical chemistry and medicine. • Energy production and ecology in XXI age. Ecological valuation and economy of applied energy sources. Renewable sources of energy. Biomass and bio-fuels. Soft technologies rising up on the basis of solar energy as wind, solar collectors, heat pumps etc. Solar economy and possibility of solar age. Thermal and photovoltaic technology applications of solar energy. The passage to the Solar Age and its political, legislative and tax limitations. Geothermic energy as a large scale energy source of growing importance. • Waste in human and nature technologies. Waste management. Hazardous waste. Municipal waste management in the commune. Review of municipal waste disposal methods. Waste combustion. Car transport and environmental impact, current solutions. • Current ecological problems. The current ecological problems of Poland and UE. Look over of environment friendly technologies and biological methods of environment protection. Environment legislation in Poland and UE. The problem of taxes. The formulation of non-formal laws governing the ecological market.	
Fluid mechanics	K_W07, K_U04, K_U06, K_U09, K_K02, K_K03
• Suplementary information from mathematics. Vector operations, Operator of gradient, divergence rotation. Integration along curves. Surface, volume integrals. Ordinal differential equations, sets of differential equations, method of integration. Partial differential equations, Furrier method of solution, method of Laplace transform. Ideal and real fluids, forces acting in fluids. Fluid statics, equilibrium conditions, Pascal, Euler, Archimedes laws. Fluid kinematics. Analytical methods of fluid kinetic. Continuity equation, Euler equation of motion. Laminar and turbulent flow. Boundary layer. General and differential momentum and mass balances. Navier-Stokes equation. Selected analytical solution of Navier-Stokes equation. Theory of turbulence-elements. Elements of rheology. Flow through porous media. Dimensionless analysis: Rayleigh method, Buckingham theorem, method of differential equations.	
Fundamentals of engineering calculations	K_W11, K_U05, K_K01
• Balanced quantities and extensive and intensive quantities. Consistency of the system of units of physical quantities, conversion of units. • General mass balance equation in systems without and with reaction under steady-state and transient conditions. Examples of mass balance application. • Concept of energy and ways of energy transfer. Energy balance in closed and open systems without and with chemical reaction. Examples of energy balancing in chemical engineering processes. • Mass Balances for multiple unit systems and systems with recycle.	
Fundamentals of heat and mass transfer	K_W05, K_U05, K_U10, K_K02, K_K03
• Energy transport. Steady and unsteady heat conduction. First Fourier low and its application. Differential energy balance, method of solution of energy balance equation. Heat convection, heat transfer, Newton equation, overall heat transfer. Energy transport by radiation. Energy transport by convection and radiation. Basics rules of heat exchanger designing. Mass transport. Steady and unsteady diffusion. First and second Fick law. Maxwell-Stefan equations for multicomponent diffusion. Differential mass balance. Exemplary analytical solution of mass balance equation. Estimation of diffusion coefficients. Mass convection, single-phase, two-phase mass transfer. Basics rules of mass exchanger designing. Theoretical one stage exchanger, multi stage exchanger, exchanger with continuous phase contact. Axial dispersion.	
Fundamentals of materials science	K_W02, K_U06, K_K01

• Introduction, definition of material, classification of materials in terms of arrangement, -crystals and glasses. The basic terms of crystallography: (space lattice, crystal axis, unit cell, space points, lines and planes). • Bravais lattices. Symbols of crystal nodes. Symbols of crystallographic directions. Symbols of lattice planes . Planes belt . Symmetry of crystals and their combinations.. • Classification of the crystals based on the chemical bonding: ionic crystals, covalent crystals, metal crystals , molecular crystals , crystals with mixed bonds . Effect of chemical bonding and crystalline structure on the material properties • Close-packed structures . Octahedral and tetrahedral gaps . The main structures of elements and chemical compounds . Allotropy and polymorphism. • Real crystals. Point defects . Dislocations . Surface defects . Single crystals and polycrystals • Classes: Lattice points, lattice directions and lattice planes, Points spaces, planes spaces and angles between planes Volume and crystallographic density of an unit cell. Atom radius and ion radius. Octahedral and tetrahedral holes. Symmetry of crystals. Dense crystallographic structures. Real crystals.	
Fundamentals of polymer physicochemistry	K_W10, K_W11, K_U04, K_U06, K_U07, K_U15, K_K02, K_K03
• Introduction, basic definitions, classification of polymers. • Structure of macromolecules. Intramolecular interactions in polymers. • Molecular weights of polymers. Methods of determination of molecular weights. • Types of polyreaction and the distribution of degrees of polymerization • Copolymers and crosslinking systems • Condensed state of polymer. Crystalline and amorphous state of polymers. • Polymer solutions and alloys. • Rubber elasticity. • Liquid crystallinity in polymers. • Specialty polymer. • 1. Determination of degree of crystallinity of poly(ethylene terephthalate) by means of density measurements and by differential scanning calorimetry DSC. 2. Determination of molecular weight of selected polymers by viscosity (viscosimetric) method. 3. Investigation of physical and chemical properties of polymers by gel permeation chromatography GPC – molecular mass and distribution of molecular mass. 4. Determination of the size of macroparticles in polymer solutions and dispersions using the dynamic light scattering (DLS) technique. 5. Determination of reaction order (in relation to the initiator) of block polymerization of styrene. 6. Analysis of free radical copolymerization kinetics and determination of reactivity coefficients for the styrene-acrylonitrile system.	
Fundamentals of rheology	K_W10, K_W11, K_U04, K_U06, K_U07, K_U15, K_K02, K_K03
• Fundamental definitions in rheology: stress, deformation, kinematics of deformation. • Rheological equation of state, rigid substance, liquid substance. • Definition of viscoelasticity of polymers, mechanical models. • Viscosity of polymer during flow. Rheological properties of alloys and solutions of polymers. • Practical application of rheology: isothermal flow and nonisothermal flow through channels with different sections; polymer flow in single-screw extruder and double-screw extruder (isothermal, adiabatic and polytropic regime). • Determination of flow curves of polymer melts by using plastometer. Analysis of the flowing of thixotropic liquids. Determination of glass transition temperatures of polymers by using Höppler consistometer. Determination of the heat resistance of selected thermoplastics. Determination of the hardness of plastics. Determination of the processing properties of rubber compounds by using wulcameter.	
General and inorganic chemistry	K_W02, K_U04, K_U06, K_U15, K_K02, K_K03
• Structure of the atom. Basic chemical concepts and laws. The abundance of matter. Stoichiometry of a chemical compound and chemical reaction. Electron structure and properties of elements in the periodic table. Metals and non-metals. Chemical bonds and geometry of molecules. Covalent and ionic bonds. Valency and oxidation state of the elements. Valence bond theory. Theory of molecular orbitals. States of matter and phase transformations. The gaseous state. Equations of state of a gas. Solid state and its structures. Liquids. Mixtures and expression of their composition. Electrochemical processes and corrosion. Reaction kinetics and chemical equilibrium. • Fundamentals of chemical calculations: basic chemical concepts and laws. Concentrations of solutions: ways of expressing concentrations, converting concentrations, diluting solutions, mixing solutions. Electrolytic dissociation of strong electrolytes: Activity, activity coefficient, ionic strength of a solution. Gas laws. Determining of empirical and molecular formulas. Stoichiometry of chemical reaction. Reaction yield. Redox reactions. Fundamentals of chemical reaction kinetics. Chemical equilibria: equilibrium constants, Le Châtelier's principle. • Basic laboratory operations and handling of typical equipment. Synthesis of inorganic compounds. Classification of inorganic compounds. Types of chemical reactions. • Classification of inorganic compounds and their nomenclature. Strong and weak electrolyte solutions. The ion-product constant of water, pH and pOH. Theories of acids and bases. Hydrolysis of salts. Buffer solutions. Precipitation-dissolution of solids: solubility product. Systematics of elements groups in the periodic table. Occurrence, properties and formation of selected elements and inorganic compounds. Transition elements and some aspects of coordination chemistry. • Electrolytic dissociation of weak electrolytes. Ionic product of water, pH and pOH. Constant and degree of dissociation. Buffer solutions. Hydrolysis, constant and degree of hydrolysis. Solubility product. • Electrolytes. Buffer solutions. Hydrolysis. Precipitation, dissolution and digestion of precipitates. Oxidation and reduction reactions. Complex compounds.	
Industrial organic chemistry	K_W08, K_U04, K_U06, K_U07, K_U09, K_U10, K_U11, K_U13, K_U15, K_K02, K_K03
• Introduction. Synthesis involving carbon monoxide. Preparation of methanol, acetic acid, ojavascript:NDLG('DIALOGKARTY','dialog_karty','tresciksz t;17503;id=194942;','save')xo aldehydes. Fischer-Tropsch synthesis. • Halogenation processes. Production of chloromethanes, vinyl chloride and chlorobenzene as well as propylene oxide and epichlorohydrin by chlorine methods. • Alkylation processes. Production of ethylbenzene and cumene, and N, O, S and Al alkylation products. • Hydrogenation and dehydrogenation. Production of formaldehyde, styrene, cyclohexane, aniline, diaminebenzene and toluenediamine. • Oxidation. Production of ethylene and propylene oxides, adipic and terephthalic acids, phthalic and maleic anhydrides, phenol and acetone as well as hydrogen peroxide. • Addition and condensation processes, including preparation of Bisphenol A, caprolactame, 2-ethyhexanol. • Hydration and esterification processes. Production of ethanol and ethylene oxide, esters of acetic and phthalic acids. • Nitration processes. Preparation nitrobenzene, dinitrobenzene and dinitrotoluene toluene. • Sulfonation processes • Syntheses of the selected organic chemicals, e.g. cyclohexanone oxime and caprolactam, adipic acid, dibutyl phthalate, methacrylate.	
Information technology	K_W11, K_U03, K_U05, K_K02, K_K03
• The Windows operating system. Searching for information on the Internet. Internet-based education. • Text editor, presentation editor, diagram editor - development of laboratory data. Preparing of a presentation. • Chemical structure editors. • Elaboration of a web page. • Getting to know the C++ programming environment. Creation a sample program to acquaint the structures, data types and the main control instructions in C++. Preparation of the own program project and algorithm develop. Implementing the program using elements of object-oriented programming. Running and testing the computer program. Developing of the program documentation. Acceptation of the student work.	
Inorganic technology	K_W08, K_U04, K_U06, K_U07, K_U09, K_U11, K_U12, K_U13, K_U15, K_K02, K_K03
• Production of potable and technological water • Technology of industrial gases • Technology of nitrogen compounds • Technology of sulphur and sulphur compounds • Soda industries • Technology of phosphorus and its compounds • Industrial electrochemistry • Production of sulphur from ore mineral • Study on slacking quicklime • Extraction of potassium chloride from ore mineral • Digestion of phosphoric ore mineral • caustification of soda	
Instrumental analysis	K_W03, K_W11, K_U04, K_U06, K_U07, K_U15, K_K02, K_K03
• Analysis of compounds by spectroscopic methods. Atomic Emission Spectroscopy - basics of the method, methods of atomic excitation of samples, applications. Atomic absorption spectroscopy. Molecular spectroscopy in ultraviolet and visible light. Infrared spectroscopy. Techniques for recording spectra, methods of quantitative and qualitative analysis. Fundamentals of nuclear magnetic resonance spectroscopy. Quantitative and structural analysis based on NMR spectra. Fundamentals of mass spectroscopy. Interpretation and analytical applications of mass spectra of organic compounds. Chromatographic separation	

methods - basics and classification of chromatographic methods. Mechanisms of retention. Parameters of retention. Theoretical basis of separation. Separation efficiency. Definition and determination of resolution, efficiency, selectivity. Types of liquid chromatography techniques - adsorption chromatography, partition chromatography, ion chromatography, gel chromatography. Selection of chromatographic process conditions - principles of stationary and mobile phase selection. High Performance Liquid Chromatography and High Performance Thin Layer Chromatography HPTLC, isocratic and gradient elution techniques. Gas Chromatography. Shelf and kinetic theory - band broadening and column efficiency. Chromatographic methods of qualitative and quantitative analysis. Potentiometry. Construction, principle of operation and applications of selected ion-selective electrodes. Conductometry and its analytical applications. Voltammetric methods - voltammetry with linearly varying potential LSV, cyclic CV. Quantitative and qualitative analysis. Selected applications in laboratory and industrial analytics, criteria for the selection of instrumental methods. • 1. Gas Chromatography. Identification of components in a mixture of hydrocarbons. Quantitative determination of the substance content in a multi-component mixture. 2.Liquid chromatography. Determination of caffeine using liquid chromatography. 3. Mass spectrometry. Analysis of the composition of the mixture of hydrocarbons using gas chromatography coupled with mass spectrometry. 4. Analysis of the structure of organic compounds by IR spectroscopy. Basic rules for the interpretation of IR spectra. Methods of sample preparation in IR spectroscopy. 5. Determination of the parameters of the absorption band and the molar absorption coefficient. Quantitative determination of the content of picric acid in the test sample. 6. Analysis of 1H-NMR spectra. 7. Determination of the content of elements in solutions by atomic absorption spectroscopy (AAS). 8.Quantitative determination of paracetamol content by cyclic voltammetry. 9. Determination of weak acid concentration by conductometric titration.	
Machines theory	K_W04, K_W11, K_U03, K_U10, K_K02, K_K03
• General rules of designing and construction of chemical apparatus • Pressure Equipment Directive and related harmonized standards and laws • Basic constructive materials used in construction of chemical apparatus: steels and iron-base alloys, other metallic materials, plastics, glass and ceramics, wood. Criteria and rules of constructive material selection. • Machines review and basic machine parts of general purpose: joints, shafts and axles, bearings, couplings,gears and drives together with their calculation and selection rules • Basic chemical apparatus parts: bodies (shells), heads, connector pipes, openings, vessel accessories, pipelines and their parts, seals and valves together with their calculation and selection rules	
Material technologies in medicine	K_W07, K_W08, K_W10, K_U04, K_U06, K_U09, K_U11, K_U15, K_K02, K_K03
• Principles of technology including materials technology. • Metalic materials (austenic steels, tytanium and its alloys, cobalt alloys, chromium alloys and othar metals) • Polymer materials - technologies of synthesis and processing • Technology of biodegradable polymers • Biomimetics. Tissue engineering. • Nanomaterials (magnetic nanoparticles, colloidal gold and silver) as well as other selected technologies for medical purposes • Ceramic and composite materials used in medicine. Dental composites • Hydrogels as modern drug formulation • Bone cements • Production of magnetic nanoparticles • Manufactoring capsules • Qualitative examination of textile products • Applications of biomaterials - production of equipment and elements of medical apparatus as well as prostheses, implants, implantable elements, dressings, use in controlled drug release and drug transfer, etc.. Modern innovative technologies for processing materials dedicated to medical applications. Basic problems of biomaterials engineering. • Obtaining polymer composites dedicated to applications in medicine. Obtaining test fittings (3D printing on an innovative printer, injection of elements), printing of selected implants. Sterilization of materials. Examination of the functional properties of the elements.	
Mathematics I	K_W01, K_U05, K_K03
• Elements of mathematical logic and set theory. Basic properties functions of one real variable, polynomials, Horner's scheme, rational functions and other elementary functions, arc functions. • Sequences of numbers: monotonicity and boundedness of sequences, limit of a sequence, theorems about existence of a limit, Napierian base and its applications. Series of numbers: properties of series of numbers, tests for convergence of series, tests for divergence of series. Limit and continuity of function of real variable: definitions of limit, counting properties of limits of functions, notion of continuity of a function. Asymptotes of a function. • Differential calculus of function of one real variable: notion of derivative of function, derivatives of higher order, derivatives of basic elementary functions, derivative of composite function, De l'Hospital's theorem, mean value theorems, investigation of monotonicity and determination of extrema of functions, convex and concave functions, points of inflexion of graph of function, investigation of the behavior and systematic procedure in graphing of function. • Integral calculus of function of one real variable: notions of primitive function and indefinite integral, integration by parts and by substitution, integration of rational functions, integration of irrational functions, integration of trigonometric functions. Notion of definite integral, applications of definite integrals, improper integrals.	
Mathematics II	K_W01, K_U05, K_K03
• Algebraic structures: group, ring, field. The set of complex numbers: canonical and polar form of a complex number, de Moivre's formula, calculation of power and root of complex numbers. • Matrices: definition, operations on matrixes and its properties, square matrices, determinant and its properties, inverse matrix, rank of a matrix. Systems of linear equations: Kronecker-Capelli's theorem, Cramer's systems. • Ordinary differential equations: notions of general solution and particular solution, initial-value problem, ordinary differential equations of first-order (separable, homogeneous respect to x and y, linear, Bernoulli's), ordinary differential equations of second-order (reducible to equations of first-order, linear equations). • Elements of calculus of vectors and analytic geometry: vectors, operations on vectors and its properties, scalar product of vectors and its properties, vector product and triple scalar product of vectors, equations of a plane and of a straight line in the space. • Basic properties of function of several variables: limit and continuity of functions of several variables, partial derivatives and directional derivative, extrema of functions of several variables. Elements of field theory: scalar and vector fields, gradient, divergence, rotation, potential of vector field. Double and triple integrals - basic concepts. • Tests based on the materials covered during lectures and exercises.	
Mechanical processes in chemical engineering	K_W04, K_W06, K_W11, K_U04, K_U06, K_U07, K_U09, K_U10, K_U11, K_U15, K_K02, K_K03
• Classification of unit operations and process apparatus. Introduction to design and intensification of unit operations. • Intensification of flow processes in simple systems: flow parameters; the effect of flow turbulence on efficiency and cost of processes. • Transport of liquids and gases. Rotodynamic and positive displacement (piston) pumps. Suction and pumping heights. Pumps characteristics. Pumps systems. • Rotodynamic and positive displacement (piston) pumps. Gas compressors. Special pumps and comprssors. Vacuum pumps. • Introduction to fluid flow in complex systems. Dispersed phase characteristics. Comminution of solids and apparatus. Phase contacting methods: in fixed bed, fluidization and pneumatic conveying. • Introduction to mechanical phase separation methods: drag force and falling velocity. • Phase separation methods: sedimentation, filtration, flotation, filtration and centrifuge separation, dust removal. Thickeners for preconcentration, classifiers, filters and centrifugal separators, dust separators.	
Modern physicochemical methods in the analysis of organic and inorganic materials	K_W03, K_W11, K_U04, K_U06, K_U07, K_U11, K_U15, K_K02, K_K03
• Methods of thermal analysis (DSC, TM-DSC, TGA, TMA, DMA, etc.) and and their practical application. • Methods of characterization of flammability. Testing of heat resistance and assessment of the strength of materials during long-term heating. Test methods for aging resistance and chemical resistance. • Determination of strength properties (static and dynamic) of materials • Research methods using electromagnetic radiation: light scattering, X-ray methods (SAXS, WAXS), and neutron scattering. Application of synchrotron radiation. • Microscopic methods: optical and electron microscopy. Scanning probe microscopy. • Thermal analysis of plastics – determination of glass transition temperature and degree of crystallinity by DSC. The analysis of the reactivity of the epoxy resins by differential scanning calorimetry (DSC). Dynamic mechanical analysis DMA of selected polymer materials. X-ray and microscopic analysis of samples of organic and inorganic materials (degree of crystallinity, polymorphism). • Learning computer software used to operate the equipments used during laboratory lessons and	

to interpret obtained results.	
Modern polymer technologies	K_W08, K_W09, K_W10, K_U04, K_U06, K_U07, K_U09, K_U11, K_U15, K_K02, K_K03
• Basic concepts of polymers and polymerization.. Modification of polymers as a method of obtaining new materials. Types of modifications - chemical modification, e.g. by copolymerization. Methods of conducting physical modification. Modification of polymers in the direction of changing selected properties, e.g. hydrophobicity, heat resistance, photostability, flame resistance. Hydrophilic polymers. Interpolymer complexes. Trends in polymer modification. Application of polymer modifications in various fields of economy. Inorganic - organic polymers - polyphosphazenes, polysilanes, polysilazanes, polyborazenes. Conductive polymers - polycarbines, polyacetylene. Supramolecular polymers - charge transfer complexes, inclusion complexes, dendrimers, supramolecular recognition, self-assembly of matter, topological polymers - polycatenanes, polyrotaxanes and polycalixarenes, polymers with a molecular trace. • Obtaining polymeric materials using selected modern modification techniques. Synthesis and characterization of the selected polymers.	
Molecular modeling	K_W11, K_U03, K_U05, K_U06, K_U15, K_K02, K_K03
• Fundamentals of molecular quantum mechanics, ab initio methods, semi-empirical methods, methods using DFT density functionals. Optimization of particle geometry. Modeling of quantities characterizing physicochemical properties of systems. • Application of molecular modeling methods and conformational analysis in the study of reactivity of chemical systems: study of thermodynamics and transition states of reactions. Study of structure-activity relationships. • Sources of the experimental structural information and the consequences of the data quality used in simulations. Structure of the selected databases and search metodology. Molecular basis of the receptor-ligand interactions. • Modeling of quantities characterizing physicochemical properties of chemical systems. Modeling of a chemical reaction (thermodynamics, transition states). Calculation of QSAR descriptors. Study of the dependence of the structure of organic compounds on their activity, e.g. the relationship between the number of functional groups and redox potentials, modeling of UV, IR and NMR spectra. • Optimization of the structure of the molecule. Conformational analysis of chemical compounds. Simulation of the ligand-receptor interactions. • Complete, computer assisted simulation and analysis of selected chemical compounds and their interactions.	
Organic chemistry	K_W02, K_U04, K_U06, K_U15, K_K02, K_K03
• Basis of chemical nomenclature. Saturated and unsaturated hydrocarbons (alkene, alkadiene and alkyne). • Aromatic hydrocarbons – derivatives of benzene. Halogen derivatives of hydrocarbons (including carbene and metalorganic compounds). Alcohols and phenols. Ethers and oxiranes. Aldehyde and ketones (aldol condensation and Beckmann rearrangement). Monocarboxylic acids, derivatives of carboxylic acid (halogens, anhydrides, amides). Esters (soap, fats, ester condensation). Comparison of properties of monocarboxylic acids with their derivatives and policarboxylic acids. Elements of organic synthesis. Nitrogen organic compounds: nitro compounds, amines, azo- and diazocompounds, isocyanates, aminoacids, peptides, proteins. • Synthesis and characterization of selected organic compounds. • Structure and isomerism of organic compounds. Efects of electronic displacements versus explanation of properties of organic compounds. Classification of organic compounds. Type of organic reactions and kinds of mechanisms. Chemical individuals. • Basis of chemical nomenclature. • Saturated and unsaturated hydrocarbons (alkene, alkadiene and alkyne). • Techniques and methods relayed to separation and purification of organic compounds and determination of basic physical properties.	
Physical chemistry	K_W02, K_U04, K_U06, K_U15, K_K02, K_K03
• The theory of perfect gases. Equations of state. Dalton’s law and Amagat's law. The theories of real gases. The kinetic theory of perfect gases. Chemical thermodynamics. System. Surroundings. Work. Heat. Cyclic processes. Reversible processes. Isothermal reversible expansion of a gas. The first law of thermodynamics. Internal energy. Enthalpy. Heat capacity of gases, liquids and solids. Thermochemistry. Enthalpy of formation of compounds. Heat of solubility. Bond energy. The temperature dependence of reaction rate on temperature. The second and the third law of thermodynamics. Spontaneous transformations. Carnot cycle. Entropy. Entropy changes in reversible and irreversible processes. Entropy of mixing. Gibbs energy. Helmholtz energy. Differentials and derivatives of thermodynamic functions. The influence of pressure and temperature on free energy. Thermodynamic criteria of spontaneity of processes. Partial molar quantities. Chemical potential. Interatomic and intermolecular interactions. Viscosity and surface tension of liquids. Phase equilibria and diagrams. Three-component systems. Phase rule. Clapeyron equation. Clausius-Clapeyron equation. Vapor pressures over ideal solutions. Vapor pressures over real solutions. Solubilities of gases and liquids. Thermodynamics of ideal solutions. Activity. Activity coefficient. Boiling temperature – composition diagrams of two-component solutions. Azeotropes. Colligative properties. Colloidal solutions, micelles. Chemical equilibrium. A thermodynamic equilibrium constant. Chemical equilibrium in gas phase. Gibbs energy function. The influence of pressure and temperature on chemical equilibrium. Chemical kinetics. The rate and the order of reaction. Zero, first, second, third and fraction order reactions. Determination of reaction order and rate constant. Dependence of reaction rate and reaction rate constant on temperature. Arrhenius theory and transition state theory. Complex reactions. Basics of the kinetics of enzymatic reactions. Basics of katalysis Adsorption. Adsorption theories. Langmuir, Freundlich and BET equation. Electrolyte solutions. Debye-Hückel theory. Activity of electrolyte solutions. Specific and molar conductance of strong and weak electrolytes. Transport numbers. Ionic mobility. Thermodynamics of electrolyte solutions. Electrochemistry. Semicells and electrochemical cells. Electrode potential. Chemical reactions in semicells. Nernst equation. Electromotive force of electrochemical cells. Thermodynamics of electrochemical cell. Elements of symmetry of chemical molecules. Elements of quantum mechanics, the structure of atoms, and the structure of molecules. • Physicochemical calculation connected with the theory of perfect and real gases, chemical thermodynamics, phase equilibria, colligative properties of solutions. Physicochemical calculations connected with chemical equilibrium, chemical kinetics of simple, complex and enzymatic reactions, adsorption, theory of electrolyte solutions, ionic conductance and electrodics. • Determination of evaporation enthalpy of a high-boiling liquid. Determination of phase equilibrium in a three-component system. Determination of boiling temperature – composition diagram for chloroform – acetone system. Determination of reaction order and rate. Adsorption isotherm. Determination of limiting molar conductivity of an electrolyte solution. Determination of dissociation constant of a weak acid. Determination of a critical micelle concentration. Determination of ΔG, ΔH, and ΔS of a chemical reaction. Determination of colligative properties of non – electrolyte solutions.	
Physical education	K_U15, K_K01, K_K02
• Acquainting with the rules of participation in classes and the conditions for obtaining a pass. Discussion of the principles of safe use of sports facilities and equipment and safety rules in force during the course. • Acquainting with the rules of participation in classes and credit conditions. Discussion of swimming pool conditions and safety rules applicable during exercise in the aquatic environment. • Implementation of various sets of warm-up exercises and exercises focused on developing the student's basic motor skills. • Initial adaptation to the aquatic environment: - face dipping, eye opening and orientation under the surface of the water, - mastery of breathing in the aquatic environment, familiarization with the buoyancy of water, - control of lying on the breast and back, - plays and games in water. Warm-up exercises, preparing for exercises in water. Learning how to behave in water in difficult and unusual situations: choking, shrinkage, sinking, etc. • Shaping general physical fitness, motor coordination, endurance, flexibility, speed through individual selection of sports activities (eg: football, volleyball, basketball, table tennis) or recreational physical activity (eg: badminton, gym exercises). • Learning backstroke style: lying on the back, slipping, correct leg work with a board on the hips and without a board, proper work of the arms. Improvement of proper coordination of lower and upper limbs. Learning free style: slipping on the chest, proper leg work combined with breathing, exercise with a board and without a board. Learning the proper work of the arms (swimming with a proper body with a proper breath and exhalation). Learning how to coordinate the work of lower and upper limbs with the determination of proper breathing. Learning breaststroke style: proper work of legs with a board and without boards on the chest and on the back, correct work of arms in a classic style. Coordination of lower and upper limbs and breathing in a classic style. Learning to jump on the legs and on the head. • Physical fitness test: Multistage 20 m Shuttle Run (Beep test). • Fitness test: a 25-meter swimming trial chosen by the student. • Shaping general physical fitness, motor coordination, endurance, flexibility, speed through individual selection of sports activities (eg: football, volleyball, basketball, table tennis) or recreational physical activity	

(eg: badminton, gym exercises).	
Physics	K_W01, K_U14, K_K01
• Physical quantity and physical unit. Dimensional analysis. Functions of one and many variables. Scalar and vector quantities. Derivatives in physics. Coordinate systems. • Kinematics, dynamics, work, energy, power. • Dynamics and kinematics of circular motion, harmonic motion. • Elements of fluid mechanics. Introduction to thermodynamics: principles of thermodynamics, ideal gas transformations, entropy. • Introduction to electromagnetism: electrostatics, electric current, magnetism, electromagnetic induction, Maxwell's equations. • Introduction to modern physics - elements of quantum mechanics, wave-particle duality of light and matter.	
Polymer chemistry	K_W02, K_W10, K_U16, K_K01
• Introductory remarks; classification of polymers; examples of polymer types; nomenclature. Historical outline of polymer industry and the polymers produced in the largest quantity. Thermodynamic and kinetic conditions of polymerization processes. Structure of macromolecules vs. physical properties of polymers. Condensation polymers. Mechanism of polymerization. Main types of commercial condensation polymers. Radical polymerization. Large scale polymers produced by radical polymerization. Ionic polymerization of unsaturated monomers. Copolymerization. Copolymers produced on industrial scale. Oxirane polymerization. Commercial polymers produced by ring-opening oxirane polymerization. Polymer structure. Coordination polymerization. Polyolefins. Natural polymers. Biopolymers.	
Polymer protective coatings	K_W08, K_W09, K_W10, K_U04, K_U06, K_U07, K_U09, K_U11, K_U15, K_K02, K_K03
• Natural and synthetic polymers used for the production of protective coatings (polyvinyl, acrylic, polyurethanes, epoxy resins, polyester resins, polysiloxanes, phenolic, aminoplastics, polyolefins). • Auxiliary substances used in the production of protective coatings (catalysts, siccatives, pigments, substances regulating flow, facilitating outgassing, aiding application, matting agents, improving selected properties, e.g. impact strength, UV resistance, giving specific properties, e.g. antibacterial, anticorrosive, antistatic, self-cleaning ability) • Technology of production and application of various types of coating-forming products used for the manufacturing of protective coatings (water-based, solvent-based, high-solid, solvent-free, powder) • Techniques of preparing various types of substrates for applying protective coatings • Techniques of applying protective coatings • Aging and stabilization of polymer protective coatings. • Designing protective protection systems in relation to exploitation conditions • Methods for evaluation of the quality of coating-forming products and protective coatings • 1. Protective coatings made of modified alkyd resin. 2. Protective coatings made of thermosetting powder coatings. 3. Protective coatings of high-solid paints. 4. Protective coatings made of water-soluble vinyl-acrylic paints. 5. Evaluation of selected properties of coating-film forming products and protective coatings (e.g. viscosity, dry mass content, flow, hiding power) and coatings obtained from them (thickness, degree of drying, hydrophobicity, oleophobicity, chemical resistance, thickness, gloss, impact strength, flexibility, cupping, hardness, scratch and abrasion resistance, adhesion to the substrate).	
Polymer technology	K_W08, K_W10, K_U04, K_U06, K_U07, K_U09, K_U11, K_U13, K_U15, K_K02, K_K03
• Some historical aspects of the polymer manufacturing on industrial scale. Radical polymerization and condensation polymerization. Thermodynamic and kinetic issues important for polymerization processes at the industrial-scale Industrial methods for production of the polymers: polymerization in gas phase, in bulk, suspension and emulsion polymerization, electrochemical, radiation, plasma and solution polymerization. Coordination polymerization in solution and in fluid phase. Apparatus and technological schemes of selected polymerization processes of olefins, polystyrene and PVC. Ecological issues in those processes. Polymerization of dienes. Rubber industry. Polymers containing fluorine that are performed at the industrial-scale. Polyacrylates. Polyacrylonitrile. Poly(oxymethylene). Aliphatic and aromatic polyethers. Manufacturing technologies of polyurethane products. Aliphatic and aromatic polyamides. Polysiloxanes. Polycarbonates. Epoxy resins. Novel polymeric materials. • Synthesis of polymers using various polycondensation and polymerization techniques, including emulsion, suspension, solvent and bulk polymerization. Preparation of polyurethane foams.	
Processing technology of polymer materials	K_W06, K_W08, K_W10, K_U04, K_U06, K_U07, K_U09, K_U11, K_U15, K_K02, K_K03
• Auxiliaries for plastics processing. Preparation of plastics for processing. Forming treatment. Extrusion and related technologies. Injection and related technologies. Application, spraying. Dipping Coating. Lamination. Pressing and pressing. Rolling and calendering. Foaming Sintering. Finishing of plastics. Secondary molding. Joining and bending. Surface treatment of products: dyeing, printing, metallization. Chip processing. Improving the surface. Design: Basic tools used in plastics processing Injection molds for thermoplastics. Application of CAD CAM software in the design. Laboratory: Investigation of the influence of compression molding parameters of thermosetting molds on the properties of moldings. Setting up the thermoplastic injection process. Study of the effect of injection molding parameters of thermoplastics on the strength properties of moldings. Examination of extrusion performance of plastic profiles. Study of the effect of extrusion blowing parameters on the properties of polyolefin films. Polyester-glass composites (laminates). Metal bonding. Determining the optimum rolling time of the rubber blends. Study on the effect of selected parameters on the strength of seams welded from polymeric films. Processing of polychlorovinyl pastes. Galvanic metallization of plastics 11. Production of plastic products by casting method 12.Termoforming	
Professional practice	K_W08, K_W09, K_W11, K_U04, K_U06, K_U11, K_U12, K_U13, K_U14, K_U15, K_K04, K_K05
• Training on safety work and anti fire regulations in plant/company/institution. Extending of knowledge gained on university in practical way. Introducing to work of plant/company/institution and with their internal procedures. Preparation to job in future.	
Protein biotechnology	K_W09, K_U04, K_U06, K_U07, K_U09, K_U15, K_K02, K_K03
• Structure and function of proteins with special emphasis on enzymes and immunoglobulins • Basic techniques for analysis of biomolecules/biomacromolecules: isolation techniques, electrophoretic techniques, chromatographic techniques, immunochemical techniques • Enzyme catalysis, outline of enzyme reaction kinetics and influence of factors on enzyme activity, use of enzymes in industry	
Recycling of polymeric materials	K_W06, K_W08, K_W09, K_U04, K_U06, K_U07, K_U09, K_U11, K_U12, K_U15, K_K02, K_K03
• Principles of polymer waste management in European Union countries. Biodegradable plastics. Recykling material and raw materials of plastics. Utilization of polymer waste by energy recovery (combustion).	
Shape and processing design of polymer components	K_W04, K_W08, K_W10, K_W11, K_U03, K_U05, K_U06, K_U07, K_U10, K_K02, K_K03
• Principles of plastic product design - technology of fittings. System of computer aided design (CAD) of plastic products. Application of Rapid prototyping technology in product design. Selected computerized simulation systems for selected plastic processing processes. Application of CAD / CAE systems in processing design.	
Smart polymers	K_W08, K_W10, K_W11, K_U04, K_U06, K_U07, K_U09, K_U15, K_K02, K_K03
• The concept of smart polymers. Synthesis and construction of polymers sensitive to stimuli such as temperature, pH, moisture, light radiation, magnetic field, electric field, solvent. Self-healing polymers. Shape memory polymers. Liquid crystalline polymers. Biopolymers. Application possibilities and analytical methods used for the characterization of smart polymers. • Synthesis of a modified stimuli-sensitive polymer. Characterization of liquid crystalline epoxy monomer. Synthesis of liquid crystalline epoxy network and investigations of their properties.	

Statistics and elaboration of results	K_W11, K_U03, K_U05, K_U16, K_K03
• LIMS (Laboratory Information Management System) – selected problems. • Experimental database. Rejection outliers in data. Selective use of data. • Exploratory data analysis of the analytical measurements, descriptive statistics, cross-sectional data, normality tests, statistical graphs. The frequency distribution of a variable. • Statistical hypothesis testing. Parametric and non-parametric tests. • Multiple regression. Study of correlation between variables. • One-way and multiple analysis of variance. Discriminant analysis, factor analysis and principal components analysis. • Fitting the observed variable distribution to a theoretical distribution. • Management of Statistica program data. Parameters of variable distribution. Descriptive statistics. • Study of empirical variable distribution. Statistical inference- nonparametric tests. • Statistical inference- parametric tests. • Analysis of Variance. • Analysis of the relationship between variables: linear and non-linear regression.	
Technical mechanics	K_W04, K_W11, K_U05, K_U06, K_K01
• Basic terms and concepts of mechanics. • Flat, convergent arrangement of forces. • Moment of force. • Reduction and equilibrium of planar systems forces converging and arbitrary. • The sliding and rolling friction. • The center of gravity. • The moment of inertia. • Basic terms and concepts of the strength of materials. • Mechanical properties of construction materials. • Basic cases of stress: compressive, tensile, shear, torsion, bending, buckling, complex strength.	
Elective subject 1.1 - Accounting and finance in business	K_W12, K_U14, K_K01
• Introduction to the module. Basic issues in accounting and finance. • The nature of accounting, the users and usefulness of financial information. • The financial statements: the balance sheet, the profit and loss account, the cash flow statement - their essence and basic elements. • Accounting, finance and businesses decisions.	
Elective subject 1.1 - Finance in project management	K_W12, K_U14, K_K01
• Introduction to the module. Basic issues in project financial management. • Principles of creating the project budget, the cost analysis essential for the project implementation. • Managing the financial liquidity in the project (cash flows), establishing sources of the project financing. • Methods of assessing the profitability of projects.	
Elective subject 1.2 - Fundamentals of management	K_W12, K_U14, K_K01
• Management as an academic discipline • Company and its environment as an object of management • Management features • Conterporary management problems. • State security management, internal and external security, ecological safety, microbiological safety, management of state security structures.	
Elective subject 1.2 - Introduction to economic activity	K_W12, K_U14, K_K01
• The essence of enterprise and entrepreneurship. Enterprise as a unit conducting economic activity. Enterprise as a system. Attributes of a modern enterprise. The interdisciplinary nature of the company. Models of active and reactive behavior of enterprises on the market. Rules of enterprising "karaoke". Sales as a manifestation of entrepreneurship. Controversial advertising as an expression of entrepreneurial activity. Enterprise models: economic, financial, production, organizational, cybernetic, socio-psychological, legal, ethical, ecological. The process of strengthening the company on the market - diagnosis, forecast, selection, development plan, fundraising. Indicators of setting individual goals of entrepreneurial activities. Socio-cultural conditions of entrepreneurship. Alternative theories of the enterprise. Concepts of creating and functioning of enterprises in a changing environment. Characteristics of entrepreneurs. Characteristics of an entrepreneurial man. Features of the entity positively and negatively affecting entrepreneurial activities. Business planning process - focus on the idea, goals and strategies, operational decisions.	
Elective subject 2.1 - Psychological aspects in professional work	K_W12, K_U14, K_K01
• Introduction to the problems of psychology and work psychology • Cognitive functioning. The place of emotions in effective work • Personality - Big Five theory, self-image, self-esteem and knowledge about yourself and others • Factors affecting the efficiency of communication, conflict management methods • Social relations (social impact) - a group phenomenon and efficiency at work. • Stres at work and coping with stress • Problems of assessment and decision-making	
Elective subject 2.1 - Social psychology	K_W12, K_U14, K_K01
• Subject and scope of social psychology, social context in psychology • The basic social motives of human action • Personality - self-image, self-esteem and getting to know himself and others • Human knowledge about the social world, social beliefs • Social cognition, understanding and assessment of social situations. Social perception • Attitudes and change of attitudes • Social groups and group phenomena, social impact • Leadership and power. Styles of management, motivation • Interpersonal communication. Conflicts and conflict solving • Social and political conflicts. Possibilities of solving them • Social relations. Prosocial activity and aggresion • Intergroup relations. Stereotypes, prejudices, discrimination	
French (A)	K_W12, K_U02, K_K01
• Interrogative pronouns (simple and complex inversion). • Trip around Paris; short advertisements - writing. • Describing events with the use of le passé composé tense. • Vocabulary related to describing the past. • Similarities and differences between Polish and French educational systems. Interpreting figures. • Presenting the university and the field of study. • Describing your last holidays - the use of l'imparfait and le passé composé tenses. • Direct object pronouns in various tenses and moods. • Indirect object pronouns in various tenses and moods. • Living in the city and in the country - advantages and disadvantages; comparatives and superlatives. • Real estate ads analysis; le conditionnel présent mood. • Possessive pronouns. • Hypothesizing and giving opinions; impersonal verb forms. • Describing things; the place of an adjective in a sentence. • Relative pronouns. • Vocabulary related to shopping; negotiating the price. • House chores; sharing duties with the family members. • Favourite dish - preparing a questionnaire; written comments on its results. • Outfits for various occassions; family celebrations. • "Dont" relative pronoun. • Giving personal opinion. • Means of transport - comparison. • A biography of a famous person; le plus-que –parfait tense. • The role of fashion in people's lives - presenting opinions. • Direct and indirect object pronouns COD/COI in the past tense. • The use of past participle with the subject and direct object. • Reported speech - positive sentences. • Car accident - expressing reasons. • Relationships within neighbourhood - describing people. • Hypotheses about text characters. • Sharing a flat - expressing personal opinions. • The „gérondif" mood as a way to express simultaneity, manner, reason. • Entertainment ans free time activities. • Reported questions. • Complex relative pronouns. • Presenting the selected French region. • Active and passive voice. • A film review. • Newspaper article - the use of the passive voice. • Job advertisement, CV, cover letter - documents analysis. • Vocabulary and expressions used in administrative correspondence - writing a cover letter. • A job interview. • Students' work, socializing and building a network of contacts. • The „subjonctif" mood - introduction. • Describing work experience. • Internet as the most popular medium. • Future tenses: le futur proche/ le futur simple; conditional „si+présent+futur simple". • Plans for the future. • Conditional « si+ imparfait+conditionnel présent ». • Expressing wishes. • Adverbs - the place in the sentence. • Private letter and reply to a private letter.	
French (B)	K_W12, K_U02, K_K01
• Describing and reporting events in the past tense. • Paris - the center of fashion. • Pronouns COD/COI in various tenses. • Modern and dying professions. • A famous fashion designer - presentation. • Demonstrative and possessive substatival pronouns. • Simple and complex relative pronouns. • Jeans - a universal timeless outfit. • Complaints and solving problems, giving advice. • Expressing reason and result. • The „subjonctif" mood - expressing purpose. • Traffic regulations - obligations and prohibitions. • Reported questions. • Choosing profession, justyfiyng. • Expressing the reason. • Living in homeland and abroad, giving arguments. • National symbols of Poland and France. • „Le passé simple - literary tense". • Comparisons - various living styles, the comparative of irregular adjectives. • Real estate market in France and in Poland. • Expressing acquiescence. • Emigration and mobility, expressing opinions. • „Le savoir-vivre" - good manners. • What is proper and improper - similarities and differences concerning Polish and French customs. • Negatives - summary. • Expressing prohibition. • Expressing hypothesis. • Passive voice in a newspaper article. • Climate changes - vocabulary related to ecology. • People's	

eco-friendly habits. • Plans for the future - time expressions. • Pensioners nowadays and in the past; changes in perceiving elderly people. • Setting up a company - development plans. • Inventions which revolutionized people's lives. • Expressing hypothesis and condition. • Eco-firendly solutions for the city, region and country. • Ideal friend; superlatives. • Modern idols. • Presenting the favourite character. • Passions in our lives. • Tense concordance in a short story. • Globalisation, positive and negative consequences. • Verb patterns with an infinitive. • Expressing disagreement towards proposals. • The art of giving arguments in a presentation. • A mobile phone: hell or paradise? • Where does Europe end? - information about the European Union. • Verbs useful for giving arguments. • Arguments cohesion - coherence linkers. • Sentence transformations - expressing coherence. • Higher education - facts and expectations. • Presenting a selected company.	
German (A)	K_W12, K_U02, K_K01
• Friendship, meetings, people relationships, relations. Declension - type 'n'. • Describing a person, introductions, characteristics of types of behaviour, features of character. • Presenting one's characteristic. Noun formation. • Reder's magazine - class reunions and locating classmates by Internet. Working with a text. • Occupation and work, workplace, presenting one's flaws and strengths. • Talking about the past. Past tense (Präteritum) of regular, irregular and mixed nouns. • Report concerning the internship done. Presenting opinions regarding an employee. • Conditions and forms of work. Requirements and competences. • Working with a video material. Conducted activities and working conditions. • Presenting one's plans and professional plans. • Living conditions, an interview with a real estate agent. Relative pronouns and relative clauses. • Analysis of offers and notices, explaining abbrevations. Adverbials of time. • Living in Germany: informational text, statistics, graphs. • Customer service, phone conversations. Language reactions based on a given situation. • Oral and written complaint. Sentences with „obwohl” and „trotzdem” • Writing a formal letter with a set of fixed phrases. • Inviting to a company promotional meeting - working with a text. • Computerisation of everyday life. Functions of devices/appliances used nowadays and in the future. • Visions of technological progress of the future. Futur I tense. • Using electronic devices in private and professional life - presentation. • Working with a video material - history and development of an enterprise, features of products and their distribution. • Formal and informal invitation. Conditional conjunction "falls". • Business meeting. Rules of participating in a meal and different professional and social situations. • Holiday plans, expressing wishes and intentions. Verbs: 'sollen'. • Media, Germany's press market. • Characteristics of a given magazine - presentation. • Shopping, slecting products, reacting to suggestions and propositions. Sentences with 'zu' before an infinitive. • Conversation between a client and consultant. Typical expressions. • Conversations between a client and consultant. Using typical professional expressions. Setting up a company and customer acquistion. • Choosing a profession. Determining one's own skills and abilities. Causative clauses. • Social competences and career choice test. Employment profiles. Time clauses with 'bevor' and 'während' conjunctions. • Describing personality and aptitudes, expressing opinions and presenting test results. • Miniproject - professional predispositions, weak and strong sides of a candidate, talking with a careers adviser. • Working with a video material - history and development of Hueber publishing house, as well as its products. • Working conditions and concept of an employee-friendly enterprise. Gradation and declension of an adjective. • European Union - employment opportunities in EU countries, its history, as well as inner labour market and main institutions. • Smoking prohibitions in a work place - formulating arguments in favour and against, expressing opinions. Imperative. • Presentation structure, template, typical expressions. • Conditions determining good employment and company's attractiveness. • Wasted chances and opportunities. Unreal clauses in the past. • Reporting experienced failures - a radio audition. Conditional clauses - Konjunktiv II. • Helpline - describing a given situation. 'Wäre / hätte' structures + Partizip II. • Describing controversial events - discussion and commentary. • Expressing disappointment and reacting to it - writing an e-mail, working with a text published on a blog. • Everyday situations that make you happy. Plusquamperfekt tense. • Expressing emotions - language means. • Summarizing the previous year and positive events. Time clauses with 'nachdem'. • Working with a video material - 'Our piece of happiness'. Family history. Important life areas, experiencing success and satisfaction. • Parties, celebrations, events happening in a workplace. • Beginnings of a career. Speed-dating. Employers' expectations. • Comparison of holidays and events. Written invitations for different occassions. • Writing an e-mail and letters - components. Writing invitations.	
German (B)	K_W12, K_U02, K_K01
• New communication media. Establishing new contacts: Speed-dating. • Describing one's language skills - working with a video material. Declension of an adjective after definite, indefinite and no article. • Media competences, ability to creatively use internet assets in foreign language learning. Time adverbs. • Bisness meetings in a new environment, forms of greeting and introduction. • Strategies of learning language for special purposes. • Private and business meetings. Modal particles. • Planning and organizing official events. • Spoken and written invitations, establishing the date of the meeting. Rektion of the verb. Adverbial pronouns in questions and answers. • Working with a video material - 'Oktoberfest'. • Planning and preparation of a presentation. • Business lunch. Quiz about etiquette. • Features of a good presentation. • Preparing product presentation. • Planning a holiday, travel bureau's offers. Assumptions - 'werden + wohl' verbs + infinitive. • Accommodation - hotel rating, opinions on internet sites. Relative sentences, relative pronouns. • Public transport in German speaking countries. • Future vehicles and travels. Future tense 'Futur I'. • Working with a video material - dream travels. • Organizing a conference, choosing a hotel, business mail. • Flat market, different forms of accommodation. Complex nouns. • Living community, student's house. Looking for a flat - advertisements. Time prepositions. • A student room, flat appliances, description of functions of furniture and items of every day use. • Switching flats during holiday. Word order. • Multi generation house. • Office and its equipment, positive rapport. • Living business community, pros and cons. • Presenting a profession - working with a video material. • Ideal work place. Conditionals. • Job advertisements, writing a cv. • Different ways of job searching. Advice and tips for job applicants. Sentences with 'damit' and 'um...zu'. • Job applications, talking about your education and work experience. • Small-talk, expressing opinion about one's job - pros and cons. • Famous composers, a biography note. Negative sentences. • Music genres, music instruments, music bands. • Festivals and concerts in German speaking countries. A schedule of musical events. • Planning a shared evening, inviting to a concert, writing a private email. • 'Rammstein' band - presenting a band. Providing argument support one's choice. Sentences with „denn”, „weil”, „nämlich”, „deshalb“. • German rock music - working with a video material. • Creating a presentation about German rock music. • Board games, tele shows. Rules of favourite games. Passive voice. • E-commerce, internet shops. • Psychology of selling, interpreting the behaviour of the customer. Passive voice with modal verbs. • Consumers' typical behaviour during shopping. Identification of different behaviour. • Online shopping discussion - pros and cons. • Vocabulary related to finances. • Acquisition of new skills, upgrading one's qualifications, various course offers and certificates. Noun's genitive. • Advanced ways of information searching, remote ways of providing education, education platforms. • Facilities found in a moder language lab. Prepositions of place. • Education system in Germany - a discussion forum. • Technical occupations, handling and description of technical equipment, manuals. Prepositions with dative and accusative. • Malfunctions and technical faults. Imperative. • Complaints - exchaning emails.	

4. Student work placement and internship

The main objective of professional practice is to acquire practical skills that complement and deepen the knowledge acquired by the student in the course of didactic classes at the university. The implementation of internships creates an opportunity to confirm and develop the student\"s professional competences within the selected field of study and/or specialization, get acquainted with advanced technical solutions as well as obtain specialist knowledge and the ability to use it in practice, participate in the implementation of specific projects and solve real problems. The opportunity to learn about the specifics of the company\"s operation as well as to shape the attitudes desired by employers and coworkers (proper organization of work, conscientiousness, and responsibility for entrusted tasks).

Professional practice is treated as a separate education module and is subject to crediting. The organization of professional practice is defined in the Rector\"s Ordinance on the principles of organizing practice for students of the Rzeszow University of Technology. Students wishing to broaden their professional experience can also do additional internships at any time. Additional internships may be carried out during the summer break.

The number of student work placements and internships is presented in Chapter 3 and may vary in different variants of the study plan for a given course Chemical Engineering and Technology.