Załącznik
do Uchwały nr 3347
Senatu Uniwersytetu w Białymstoku
z dnia 28 lutego 2024 roku

STUDY PROGRAMME
FIELD OF STUDY**: APPLIED CHEMISTRY**
effective from the academic year: 2024/2025

Part I. General information.

1. Name of the unit conducting the study: **Faculty of Chemistry**
2. Level of education: **second-cycle studies, Master studies**
3. Educational profile: **general academic**
4. A number of semesters: **4**
5. A total number of ECTS points required to complete the study: **90**
6. A total number of hours in the course required to complete the study: **1065**
7. The programme accepted at the meeting of the Faculty Board on: **18.01.2024**
8. Prevailing discipline whereby more than a half of learning outcomes will be acquired, and proportional (%) share of individual disciplines whereby learning outcomes specified in the study programme will be acquired:

Name of the prevailing discipline	Proportional (%) share of the prevailing discipline
Chemical sciences	**100%**
Total:	100 %

Part II. Learning outcomes.

Descriptor of second degree PRK (*Polish Qualifications Framework)* specifications	Learning outcome symbol	Learning outcome description
KNOWLEDGE, a graduate is familiar with and understands:		
P7S_WG	KP7_WG1	in-depth facts, objects, and phenomena covering advanced knowledge of chemistry
	KP7_WG2	methods and theories explaining complex relationships between facts, objects and phenomena, including advanced general knowledge in the field of chemical sciences at an in-depth level
	KP7_WG3	main trends in development and the latest achievements of chemical sciences influencing the improvement of instrumental and analytical methods for solving complex chemical problems
	KP7_WG4	computational techniques used in chemistry and specialized IT tools to solve typical chemical problems in greater detail

	KP7_WG5	advanced, specialized tools, methods, and modern measurement techniques used in chemical analysis, explains the theoretical basis of operation of measuring equipment used in chemical research
	KP7_WG6	current directions of development and the latest discoveries in chemistry
	KP7_WG7	occupational health and safety rules are needed when organizing an independent research station
P7S_WK	KP7_WK1	legal and ethical aspects related to the protection of intellectual property, industrial property and copyright as well as the need to manage intellectual property resources, can use patent information resources
	KP7_WK2	rules governing the free market, basic principles of creating and developing various forms of entrepreneurship, and technology transfer from science to the economy, including public and private sector entities
SKILLS, a graduate is able to:		
P7S_UW	KP7_UW1	plan and perform scientific chemical experiments
	KP7_UW2	select and apply methods and research tools used in chemistry adequately to the intended goals, including advanced measurement, laboratory, and IT techniques, and adapt them appropriately
	KP7_UW3	use professional literature, databases and other sources to obtain necessary information in the field of chemistry
	KP7_UW4	apply acquired chemical knowledge to analyze problems in chemistry and related fields
	KP7_UW5	present at an advanced level, verbally and in writing, the results of their research and present the results of scientific discoveries in the field of chemistry and related sciences
	KP7_UW6	use advanced information and communication techniques to present, in oral and written form, the results of experimental research, analyze data, perform critical analysis and indicate measurement errors, justify the purpose of the study and its significance compared to similar research
P7S_UK	KP7_UK1	prepare written works and appear in public in English or a foreign language, presenting specialized issues in the field of chemistry, justify your opinions, and conduct discussions

	KP7_UK2	communicate in the English or foreign language at level B2+ of the Common European Framework of Reference for Languages
P7S_UO	KP7_UO1	cooperate with other team members and take on the responsibilities of leading the team in planning and performing assigned tasks and complying with occupational health and safety rules
P7S_UU	KP7_UU1	plan their learning and career independently and motivate others to undertake such activities
	KP7_UU2	understand the limitations of one's knowledge and the need for lifelong learning and self-education
SOCIAL COMPETENCE, a graduate is prepared for:		
P7S_KK	KP7_KK1	systematic updating and verification of knowledge and a rational and critical approach to information obtained from various sources
	KP7_KK2	taking responsibility for undertaken experiments and scientific research
P7S_KO	KP7_KO1	works in a team, taking on various roles, verifies and respects the opinions of other team members, is responsible for the safety of his own and others' work
	KP7_KO2	thinking and acting in an entrepreneurial way
P7S_KR	KP7_KR1	acting by ethical principles in professional work and everyday life
	KP7_KR2	constantly expanding their professional competencies in the field of applied chemistry as well as language skills

Part III. Description of the process whereby learning outcomes are acquired.

Learning programmes for the courses or groups of courses.

A group of courses_1, a name of the group of courses: **subjects of general university education**

Learning outcome symbols: KP7_WK1, KP7_WK2, KP7_UK1, KP7_UK2, KP7_UO1, KP7_KK1, KP7_KO1

Learning programmes whereby learning outcomes assigned to the courses or group of courses are acquired.

The subjects of the general university education block include: Foreign language, Entrepreneurship, Subject in humanities or social sciences, Introduction to intellectual property management, Specialistic linguistic workshop.

The group of classes covers 110 hours, and 9 ECTS points have been assigned do it. The aim of education in the subjects included in this module is to provide knowledge and skills regarding the protection of intellectual property and the ability to speak a foreign language at the B2+ level. Moreover, the aim of education in this module is to provide knowledge and skills regarding entrepreneurship in the conditions

of globalization and the ability to speak a specialized (scientific) foreign language and subject in humanities or social sciences.

A group of courses_2, a name of the group of courses: **major subjects**
Learning outcome symbols: KP7_WG1-WG6, KP7_UW2, KP7_UW4, KP7_UW6, KP7_UO1, KP7_KK1, KP7_KR1, KP7_KR2
Learning programmes whereby learning outcomes assigned to the courses or group of courses are acquired.

Major subjects include: Inorganic & metalloorganic coordination chemistry, Advanced analytical chemistry, Advanced organic chemistry, Physical aspects of advanced techniques & processes, Molecular spectroscopy, Chromatography and electrophoresis, Sustainable chemistry and technology for the circular economy and Good laboratory practice.

This module covers 220 hours, and 22 ECTS points have been assigned do it.

The topic of the classes *Inorganic & metalloorganic coordination chemistry* will be focused on modern aspects of coordination chemistry, inorganic nanostructural materials, and selected aspects of metalloorganic catalysis.

The course *Advanced analytical chemistry* aims to give in-depth knowledge of analytical techniques and methods and their applications within, for example, food, pharmaceutics, and environmental analysis. Understand the range of application areas in which analytical chemistry and analytical instrumentation are applied. Furthermore, the course aims to enable students to develop their ability to use and optimize analytical methods and critically discuss and evaluate environmental sustainability and its relevance for society as a whole. The course covers topics related to experimental tools and techniques for different non-chromatographic separation techniques, such as different variants of extraction and microextraction, multivariate experimental design, various statistical tools, principles for green analytical chemistry, and new research within this field. Separation and particle characterization techniques will be discussed in automated monitoring and process analysis in various industrial, clinical, and environmental applications. Instrumentation, data processing, and chemometrics will be emphasized in each analytical technique discussed.

The course in *Advanced Organic Chemistry* provides in-depth and expanded knowledge in organic chemistry, focusing on the "5 pillars" of modern organic chemistry, isolation/analysis, and synthesis as two realms of research and interconnection with other sciences and technology. Topics include organic chemistry literature and databases, mechanistic and physical organic chemistry, stereochemistry and methods of molecular structure determination, organic synthesis concepts, and practice: retrosynthesis, tactics vs. strategy, PG, etc. The laboratories are intended to familiarize the student with modern reactions (e.g., coupling reactions, cycloaddition reactions, addition reactions to unsaturated carbonyl compounds, etc.) and techniques used in preparative organic chemistry, methods of identifying organic compounds, including spectroscopic techniques. During classes, the students improve the manual skills necessary for laboratory work, learn how to plan and observe experiments, draw

conclusions from them, and prepare results in writing. Additionally, these classes should teach students how to plan and organize their work time, solve problems independently, work in a group, and choose physicochemical methods for product analysis.

The topics of the classes *Physical aspects of advanced techniques & processes* include the description and application of physicochemical methods in quantitative analyses of bioactive substances, computational and statistical methods in physical chemistry, and physicochemical background of electrical charge accumulation and low energy conversion processes.

The course *Molecular spectroscopy* provides students with a solid understanding of the theoretical basis of spectroscopic methods and an understanding of how these methods provide information on molecular structure. Laboratory classes will teach students how to identify organic and inorganic compounds from the synergistic information afforded by a combination of infrared, Raman, ultraviolet, and nuclear magnetic resonance spectra.

The course *Chromatography and electrophoresis* aims to familiarize students with chromatographic and electrophoretic techniques and combined techniques used in chemical analysis. Students learn concepts, mechanisms, and technical solutions in liquid, gas, supercritical fluid chromatography, and coupled techniques. They will become acquainted with the chromatographic methods and procedures used today in chemical analysis.

The course *Sustainable chemistry and technology for the circular economy* will provide students with knowledge of the most common methods underlying green chemistry and their application to protect the environment and implement a circular system.

The lecture *Good laboratory practice* presents selected issues related to good laboratory practice (GLP), applicable rules, areas of its application, the legal basis of GLP in Poland and worldwide, and supervisory institutions. Standard operating procedures, validation of measurement procedures, measurement traceability, and internal and external laboratory quality control will be presented. The ISO 17025 standard, the conditions for obtaining accreditation by entities and the audit process, controlled elements of the quality management system, and the issuance of an accreditation certificate will be discussed. Systems supporting laboratory management, such as the LIMS system, will be presented.

A group of courses_3, a name of the group of courses: **elective subjects**
Learning outcome symbols: KP7_WG3, KP7_WG6
Learning programmes whereby learning outcomes assigned to the courses or group of courses are acquired.
As part of the group of elective courses, a monographic lecture is proposed, which will be consistent with new trends related to current knowledge in the Chemistry of materials and Chemical analysis specialization. Group_3 of classes is carried out within 15 hours, and 1 ECTS point has been assigned to it.

A group of courses_4, a name of the group of courses: **specialization subjects**
Learning outcome symbols: KP7_WG3-WG5, KP7_UW1, KP7_UO1
Learning programmes whereby learning outcomes assigned to the courses or group of courses are acquired.
The group of classes for specialization subjects (block of elective subjects from blocks I and II - specializations) covers 210 hours, and 21 ECTS points have been assigned to it.

The group of specialization subjects includes;

1) within specialization – **Chemistry materials** – Materials for energy storage, Advanced instrumental methods for material analysis, Chemistry of nanomaterials, Structural Chemistry, Polymers, Current methods in the chemistry of materials, Catalytic processing, Nanostructural materials in chemical analysis, and Conducting polymers.

Materials for energy storage - Characterization of the chemical composition and structure of electrode materials and electrolytes for energy storage. Discuss and compare the electrochemical properties of various energy storage materials, such as specific capacitance, energy density, charge-discharge rates, and cycle stability. Construction and principle of operation of energy storage devices. Techniques and methods for testing energy storage materials and devices.

Advanced instrumental methods for materials analysis - The course's main objective is knowledge about advanced instrumental techniques used in the chemical analysis of technologically important materials. Theoretical and practical aspects of selected instrumental methods of analysis will be discussed.

Chemistry of nanomaterials - Presentation of the historical outline of the development of nanotechnology, definitions of nanomaterials, and their diversification. Indication of selected features of nanomaterials that cause broad interest in these materials. Discussion of examples of synthesis procedures and characterization methods of nanomaterials..

Structural chemistry - The course aims to extend the basic knowledge of quantum mechanics and familiarize the student with methods of electronic structure calculations useful in solving real chemical problems.

Polymers - The course aims to provide basic information about methods of synthesis and modification of polymers, properties of the most common polymer materials, relationships between the structure and properties of macromolecules, and basic methods of analyzing polymers and learning about modern methods of controlled polymerization and new trends in the chemistry of macromolecular compounds. The laboratory aims to familiarize students with controlled radical polymerization methods. Students will learn how to perform polymerization of a selected monomer (e.g., styrene, butyl acrylate, acrylic acid, acrylonitrile, or *N*-isopropylacrylamide) in a controlled

fashion, how to isolate, purify, and characterize the obtained polymer using diverse techniques, e.g., 1H NMR, FT IR, UV-Vis, SEC, TGA, or DSC.

Current methods in the chemistry of materials – The laboratory classes offered during this course will familiarize students with modern methods most often used in the chemistry of materials.

Catalytic processes - The principle of catalysis, heterogeneous and homogeneous catalysis, type of catalysts, e.g., metal complex catalysts, organocatalysts, biocatalysts, and phase transfer catalysts—examples of the catalysis process for synthesizing fine chemicals, pharmaceuticals, functional materials, and petrochemicals.

Nanostructural materials in chemical analysis - The topics of the classes include the use of nanostructured materials for quantitative and qualitative determinations in bioanalysis. Particular attention will be paid to materials used in biosensors. Various methods of determining biosubstances and their use in medical diagnostics will also be discussed.

Conducting polymers - The course aims to expand students' knowledge about such type of materials, their structure, synthesis methods, properties, and potential practical applications. The laboratory is focused on the synthesis methods and studies of conducting polymer properties.

2) within specialization – **Chemical analysis –** Sampling and sample preparation, Atomic spectrometry, Process analysis in chemistry, Toxicological analysis, Methods for surface analysis, Current methods in chemical analysis, Bioanalysis, Ecoanalysis, and Environmental chemistry.

Sampling and sample preparation – The course aims to deepen knowledge regarding collecting, preparing, and storing samples before analysis. Students gain knowledge about sampling rules and methods for protection against changes during storage, primary sample preparation such as drying or filtration and dissolution/mineralization processes, isolation and enrichment of analytes using headspace techniques, types of sorbents used in solid phase extraction, modern extractants used in liquid-liquid extraction (ionic liquids, deep eutectic solvents, surface active compounds and supramolecular solvents) and miniaturized extraction methods (e.g. liquid-liquid microextraction, dispersive liquid-liquid microextraction, single drop microextraction, solid phase microextraction, micellar extraction). Issues will also concern membrane extraction, solventless sample preparation for analysis, drying, and purification of extracts, and analysis of obtained extracts using spectrophotometric and chromatographic methods with different kinds of detection (HPLC-UV, HPLC-CAD, GC-MS, LC-MS/MS).

Atomic spectrometry – This course covers the fundamental theory of atomic spectrometry techniques, including atomic absorption, emission and fluorescence, X-ray fluorescence spectrometry, and mass spectrometry. Students will learn about

components of spectrometers: light sources, systems of sample introduction to the atomizer/ion source (gaseous, liquid, and solid samples, including laser ablation), types of atomizers, excitation and ionization sources, monochromators, and detectors. Advanced topics like interference effects in atomic spectrometry and their elimination will also be explored. Students will learn about the strategy for selecting an analytical method to solve a specific problem. The methods will be compared regarding quantification limits, linearity ranges, selectivity, speed, and analysis cost. Using atomic spectrometry techniques, the laboratory is designed to improve students' knowledge, best practices, and troubleshooting skills. Students will perform inorganic analyses using atomic absorption spectrometry with flame (FAAS) or electrothermal (ETAAS) atomization and inductively coupled plasma mass spectrometry (ICP-MS).

Process analysis in chemistry – The course aims to familiarize students with an overview of the main methodologies for analytical flow measurements and examples of the use of flow monitoring systems in environmental and clinical analysis. Division and principle of operation of the main types of electrochemical sensors, their advantages, limitations, and application examples. Moreover, the course addresses issues concerning basic concepts and definitions in the field of photochemistry, kinetics of the photochemical reactions, and photochemical processes in various elements of the environment: water and air.

Toxicological analysis – Methods for testing the toxicity of environmental pollutants, food, drugs, and waste. Biomarkers in toxicological tests; Classic and alternative models/organisms in toxicological research. Exposure assessment and the concept of limit, threshold, toxic and lethal dose, definitions of limit exposure levels, and critical concentration. Factors determining toxicity (physical and chemical properties of poisons, chemical structure of the compound and toxicity, biological, genetic, individual, disease, environmental factors) of chemical substances. Criteria for assessing the toxicity of substances towards the ecosystem. Selected toxic effects of, e.g., psychoactive substances. Methods for testing the mutagenic and genotoxic properties of selected poisons.

Methods for surface analysis - The course aims to familiarize the students with the selected instrumental methods that can be used for materials surface analysis. Among others, microscopic methods like electron microscopy (TEM, SEM, or STEM) will be discussed in detail, as well as spectroscopic ones, e.g., FT-IR, UV-Vis-NIR, Raman spectroscopy, etc. regarding surface analysis. In addition, other methods can be included to supplement the received information, like porosimetry, DLS, surface wetting angle, etc. All methods allow the performance of different aspects of surface characteristics, which will be explained in examples.

Current methods in chemical analysis - The laboratory classes offered during this course will familiarize students with modern methods most often used in chemical analysis.

Bioanalysis - The lecture presents selected issues related to analyzing biological samples (physiological fluids, food, plant material), their preparation and analysis methods, bioavailability, and bioaccessibility of selected substances. Determination of biomarkers using the SPR method with application of biosensors, types of biosensors, and the detection systems used in them. Bioanalytics in a holistic approach (metallomics, metabolomics, proteomics). Research strategies used in metabolomics and metallomics.

Ecoanalysis - The lecture presents selected issues related to the analysis of environmental samples. The following topics will be discussed: air analytics (internal and atmospheric air quality, compound isolation, determination of VOC, BTEX, PAH); water and sewage analytics (drinking water quality - analysis and interpretation, water and sewage pollution indicators, new contaminants of surface water and sewage: drug residues, endocrine disrupting compounds and methods of their determination, sewage sludge testing); soil and plant analytics (soil and plant pollution, mobility and bioavailability of metals for plants, fractionation, hyperaccumulators, remediation and bioremediation). Laboratory classes will include exercises on determining selected pollutants, including residues of pesticides, personal hygiene products, or drugs in environmental samples (e.g., surface waters, groundwater, plants, soil) using modern analytical methods, including GC-MS, LC-MS/MS. Experiments are also planned to assess the effectiveness of selected modern water purification technologies (advanced oxidation, bioremediation, etc.) based on determining water pollution indicators.

Environmental chemistry - The course's aim will be to select issues related to the analysis of environmental samples, i.e., air analysis, water and sewage analysis, and soil and plant analysis. Modern analytical methods will be discussed during the classes and applied to laboratory exercises, including GC-MS and LC-MS /SM.

A group of courses_5, a name of the group of courses: **diploma module**
Learning outcome symbols: KP7_WG5, KP7_WG7, KP7_UW1, KP7_UW3-UW5, KP7_UK1, KP7_UU1, KP7_UU2, KP7_KK1, KP7_KK2, KP7_KR1, KP7_KR2
Learning programmes whereby learning outcomes assigned to the courses or group of courses are acquired.
As part of the diploma module, the student participates in specialization laboratory and master seminar classes for 510 hours, gaining 37 ECTS points.
The aim of education in this module is to become familiar with the measurement equipment at the Faculty of Chemistry and then to independently complete a master's thesis, including the stage of collecting literature, planning, performing experiments, developing the results, and presenting them in the context of a discussion with literature data in the master's thesis, and familiarizing the student with intellectual property protection issues. The aim of education within this module is also to deepen specialist knowledge within the selected specialization and professional field, and familiarize the student with contemporary trends in applied chemistry.

Methods of verification and assessment of learning outcomes achieved by a student during the entire study cycle.

Detailed methods of verifying and assessing the learning outcomes achieved by the student are included in the syllabuses for applicable subjects. The syllabus specifies the conditions for passing the course. The methods of verifying and assessing the learning outcomes achieved by the student include written exams, oral exams, written and oral colloquiums, presentations, written work, tests, projects, and reports. The instructor must inform students about the selected assessment form during the first lesson in a given subject. Students are also familiarized with subject syllabuses on a given topic during the first classes. Grades from all tests and exams are entered into the minutes in the USOS system.
The coherence of the subject-specific learning outcomes with the field-specific learning outcomes is confirmed by the learning outcomes matrices, which show that all field-specific learning outcomes will be obtained within the subjects in the study program.

Conditions of graduation and conferred professional title.

The condition for completing second-cycle studies (master's studies) and obtaining the professional title of master's degree is to get all learning outcomes assigned in the study program, at least 90 ECTS points, and to meet the requirements provided for in the study program, prepare a diploma (master's) thesis and pass the diploma examination (master's degree) (by Chapter XI of the Study Regulations, § 41, point 2, in force since June 26, 2019, adopted at the meeting of the UwB Senate on June 26, 2019 - annex to Resolution No. 2524 and 2527).

Explanation of the symbols:
P6, P7 – PRK (*Polish Qualifications Framework*) level (6 – first-cycle studies, 7 – second-cycle studies and long-cycle studies)
S – characteristics typical of the qualifications obtained in the higher education system

W – knowledge	G – depth and range
	K - context
U – skills	W- application of knowledge
	K – communicating
	O – work organization
	U – learning
K – social competence	K – critical evaluation
	O – responsibility
	R – professional role