MASTER'S PROGRAM: METROLOGY IN CHEMISTRY

1. General presentation of the program

Being science of measurements, the metrology is the basis of all activities aimed at establishing quantitative characteristics of objects and phenomena. It examines the most general principles in all types of measurements. By their nature, chemical analyses are a combination of sequential physical measurements. Obtaining reliable, metrologically traceable results with correctly estimated measurement uncertainty is practically impossible without knowledge and application of metrological principles and international regulatory requirements. In more general terms, their knowledge is necessary for a wide range of specialists working in the field of experimental sciences.

Prerequisites

The Master's program is intended for graduates of the educational and qualification degree "Bachelor" or "Master" in specialties from a professional field different from 4.2. Chemical Sciences.

2. Objectives of the Master's Program

To prepare personnel with broad-based training in the field of analytical chemistry and metrology, possessing specific knowledge, skills and potential for future self-learning. Such personnel are suitable for the needs of institutes and laboratories working in the field of chemical analysis, metrological control, environmental monitoring, quality control, scientific research, industrial production, etc.

3. General qualification and specialization of the program

The Master's program has been developed in accordance with the requirements for level 7 – Educational Qualification Degree "**Master**" within the National Qualification Framework of the Republic of Bulgaria. It is aimed, above all, at satisfying the needs of accredited analytical laboratories for competent personnel, with metrological training, allowing them to meet the requirements of international standards and quality systems.

4. Acquired knowledge, skills and competences according to the National Qualifications Framework

Students graduating from the Master's program "Metrology in Chemistry" are expected to acquire a wide range of theoretical knowledge, skills and competencies at a high level, including:

4.1 Knowledge (theoretical and/or factual)

- Basic aspects of metrology and analytical chemistry: terminology, nomenclature, conventions, units of measurement, metrological traceability, method validation, measurement uncertainty assessment, etc.
- The main types of measurements and calibration techniques.
- Principles and approaches applied in chemical analyses and measurements in various fields of science and practice.
- The most commonly used instrumental methods of analysis in practice: atomic and molecular spectroscopy, chromatography, electroanalytical methods, etc.
- Basic techniques for sampling and sample preparation, assessment of their contributions to measurement uncertainty.
- Mathematical training applicable to calibration, experimental data processing, quantitative assessment of metrological characteristics and solving various chemometric problems.

4.2. Skills

- Ability to apply the acquired knowledge to solve various problems related to analytical chemistry, quality control, metrological assurance of laboratories and production units.
- Ability to conduct chemical analyses using basic chemical and physical methods in accordance with international standards (e.g. ISO/IEC 17025).
- Competencies for obtaining, evaluating and interpreting data from chemical analyses.
- Abilities to develop, evaluate and implement good practices in analyses and measurements of different types.
- An extensive set of practical and cognitive skills and approaches necessary for understanding abstract problems and developing creative solutions.
- Skills for diagnosing problems arising in analytical laboratories, quality control laboratories and production units and finding appropriate solutions.
- Abilities to generate new knowledge and find opportunities for its practical application.

- Abilities for finding and scientifically arguing solutions to problems of an interdisciplinary nature.

4.3. Personal independence and responsibility

- Skills for building administrative and organizational structures and independently managing teams to solve complex problems in an unpredictable environment, with multiple interacting factors and variable opportunities.
- Creativity and innovation in project development.
- Abilities to initiate and organize activities requiring a high degree of coordination.

4.4. Cognitive skills

- Systematic and in-depth self-assessment of own abilities and identification of needs for new knowledge.
- Information management, work with primary and secondary information and "on-line" sources.
- Using a variety of methods and techniques to learn new information and skills for adaptation and implementation in practice.
- Abilities for conceptual and abstract thinking

4.5. Communicative and social competences

- Skills for clear and understandable presentation of own theses, formulation of problems and possible solutions to specialized and non-specialized audiences using a wide range of techniques and approaches.
- Development and presentation of reasoned views on social processes and practices and justifying proposals for their improvement or change.
- Abilities related to interpersonal relationships, working in an international environment, teamwork, customer relations etc.
- Communication skills, oral and written communication in English on topics of varying degrees of complexity.

4.6. Professional competencies

- Skills for obtaining, processing and interpreting specialized analytical information necessary for solving emerging problems.
- Competencies for integrating information from a wide range of sources in a new and relatively unfamiliar context.
- Skills for sound judgment and finding solutions in a complex environment of diverse interactions.
- Skills for initiating changes and managing development processes in complex conditions, readiness to analyze and solve important scientific, social and moral problems arising in the process of work or continuing education.
- Abilities for adequate behavior and interaction in a professional and/or specialized environment.
- Ability to solve problems by integrating complex sources of knowledge, in conditions of insufficient information and in a new, unfamiliar environment.

5. Areas of professional realization

Graduates of the professional qualification "Metrology in Chemistry", according to the acquired education, can find employment in the following areas:

- The program provides a good foundation for future doctoral studies in the field of analytical chemistry, as well as other experimental sciences, such as physics, physical chemistry, ecology, biochemistry, environmental chemistry, etc.
- Opportunity to work in analytical laboratories, including those accredited to various standards, serving all areas of industry, agriculture, healthcare, ecology, forensics, etc.
- Possibility to work at various levels in scientific research laboratories and institutes working in the fields of chemistry and other experimental sciences, physics, biology, ecology, etc.
- Opportunity to work in laboratories performing quality control, environmental control, etc.
- Opportunity to work in national and international metrological institutions, e.g. metrology institutes, laboratories for control and calibration of measuring instruments, accreditation institutions, etc.
- Opportunity for teaching work in higher education institutions and specialized educational institutions.

- Opportunity to work in companies trading in specialized chemical laboratory and industrial equipment.

6. CONTENT OF THE CURRICULUM

№	COURSE TITLE	Evaluation		ECTS Credits	Auditorial activities				Extracurricular activities
		semester	form		total	lectures	seminars	exercises	
	I. MANDATORY COURSES								
1	General and inorganic chemistry	I	exam	**10**	60	45		15	240
2	Organic chemistry	I	exam	**10**	60	45		15	240
3	Physicochemical analysis	I	exam	**6**	45	30		15	135
4	Elective course / group 1	I	exam	**4**	30	30			90
	Semester 1 / TOTAL:			**30**	**195**	**150**		**45**	**705**
5	Analytical chemistry	II	exam	**10**	60	45		15	240
6	Instrumental methods for analysis	II	exam	**10**	60	45		15	240
7	Theoretical chemistry	II	exam	**6**	45	30		15	135
8	Elective course / group 2	II	exam	**4**	30	30			90
	Semester 2 / TOTAL:			**30**	**195**	**150**		**45**	**705**
	Year 1 / TOTAL (hours of mandatory and elective courses)			**60**	**390**	**300**		**90**	**1410**
9	Fundamentals of metrology	III	exam	**6**	45	30		15	135
10	Methods for experimental data processing	III	exam	**6**	45	30		15	135
11	Metrology of the electrochemical measurements	III	exam	**6**	45	30		15	135

12	Metrology of the physical measurements	III	exam	**6**	45	30		15	135
13	Elective course / group 1	III	exam	**3**	30	15	15		60
14	Elective course / group 2	III	exam	**3**	30	15	15		60
	Semester 3 / TOTAL:			**30**	**240**	**150**	**30**	**60**	**660**
15	Quality control and assurance	IV	exam	**6**	45	30		15	135
16	Chemometrics	IV	exam	**6**	45	30		15	135
17	Elective course / group 3	IV	exam	**3**	30	15	15		60
18	Graduation			**15**					450
	Semester 4 / TOTAL:			**30**	**120**	**75**	**45**	**30**	**780**
	Year 2 / TOTAL (hours of mandatory and elective courses)			**60**	**360**	**225**	**45**	**90**	**1440**
	TOTAL (hours of mandatory and elective courses)			**120**	**750**	**525**	**45**	**180**	**2850**
	II. ELECTIVE COURSES								
Group 1									
1.	X-ray diffraction, nuclear magnetic resonance, mass spectrometry		exam	**4**	30	30			90
2.	Methods of analysis and control		exam	**4**	30	30			90
3.	Modern chromatographic methods		exam	**4**	30	30			90
	Total of the courses elected from the group			**4**	30	30			90
Group 2									
1.	Electrochemistry		exam	**4**	30	30			90

2.	Molecular spectroscopy		exam	**4**	30	30			90
3.	Solid state chemistry		exam	**4**	30	30			90
	Total of the courses elected from the group			**4**	30	30			90
Group 3									
1.	Reference materials	I	exam	**3**	30	15	15		60
2.	Validation of analytical methods	I	exam	**3**	30	15	15		60
3.	Metrological aspects in ecological studies	I	exam	**3**	30	15	15		60
	Total of the courses elected from the group	**I**		**3**	**30**	**15**	**15**		**60**
Group 4									
1.	Renewable energy sources and systems	I	exam	**3**	30	15	15		60
2.	Metrological aspects in sampling and sample preparation	I	exam	**3**	30	15	15		60
3.	Specialized software	I	exam	**3**	30	15	15		60
	Total number of the courses elected from the group	**I**		**3**	30	15	15		60
Group 5									
1.	Atomic emission spectroscopy	II	exam	**3**	30	15	15		60
2.	Chromatography	II	exam	**3**	30	15	15		60
3.	Electroanalytical methods	II	exam	**3**	30	15	15		60
	Total of the courses elected from the group	**II**		**3**	30	15	15		60

	Total of all courses elected from all groups			**17**	**150**	**105**	**45**		**360**

	III. OPTIONAL DISCIPLINES
	1. Every student may study any subject taught at the university, regardless of the faculty that organizes the training (in accordance with Art. 2, para. 5 of the Regulation on the State Requirements for Acquiring Higher Education, published in the State Gazette, No. 76, 2002).
	2. The elective subjects studied are reported in the student's diploma.
	IV. GRADUATION
	1. Diploma thesis or state exam.

Notes:

1. The organization of extracurricular employment of students in each discipline is determined by its curriculum.
2. The forms of monitoring student progress (current and final) are described in the curricula.
3. The list of elective subjects may be updated upon proposal of the Department Council, approved by the Faculty Council and ratified by the Academic Council.
4. If the student chooses to complete his studies with a thesis, he may receive a topic for development provided that he has an average grade of his studies to date of no less than very good (4.50). An exception can be made only for students who have participated with their own developments in scientific forums. The assignment of a topic and the determination of the scientific supervisor are made by decision of the Department Council.

7. GRADUATION

The studies may end with a written state exam or a thesis defense.

ANNOTATIONS OF COURSE SUBJECTS

MANDATORY COURSES

GENERAL AND INORGANIC CHEMISTRY

Semester: I

Weekly: 3 h lectures + 1 h exercises

ECTS credits: 10

Lecturers: Assoc. prof. Elitsa Chorbadzhijska, PhD

Form of final evaluation: written exam

Methodical guidance: Department: “Chemistry”, Faculty of Natural Sciences and Mathematics,e-mail: himia@swu.bg

Course status: mandatory

Annotation:

The lecture material sequentially examines the main issues of general chemistry such as: structure of the electron shell, atomic nucleus, periodic law and periodic table of elements, structure of molecules, structure of complex compounds, intermolecular interactions, chemical bonding in solids, valence of chemical elements, basic concepts in thermodynamics, chemical kinetics, chemical equilibrium, solubility of substances, theory of dilute solutions, electrolyte solutions, properties of chemical elements and their compounds.

Laboratory exercises consolidate the mastery of the lecture material by stimulating the student's independent chemical thinking. Laboratory exercises, chemical experiments build skills for working in a chemical laboratory. Problems related to safety techniques when working in a chemical laboratory, basic laboratory operations, separation and purification of substances, mixing and dilution of solutions, electronic balance in oxidation-reduction processes, basic chemical properties of simple substances and chemical compounds are examined.

Course objectives:

The main aims of the General and Inorganic Chemistry program are:

1. Acquisition of chemical knowledge in general and inorganic chemistry, based on knowledge related to the structure of matter, laws and regularities in nature.

2. Acquisition of dexterity and skill in performing chemical experiments in a specialized chemical laboratory in inorganic chemistry.

3. Development of chemical thinking and independent work with chemical literature.

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: General requirements for the MSc program Metrology in Chemistry. Basic knowledge of chemistry, physics and mathematics.

ORGANIC CHEMISTRY

Semester: I

Weekly: 3 h lectures + 1 h exercises

ECTS credits: 10

Lecturers: Assoc. prof. Maya Chochkova, PhD

Form of final evaluation: written exam

Methodical guidance: Department: "Chemistry", Faculty of Natural Sciences and Mathematics,e-mail: himia@swu.bg

Course status: mandatory

Annotation:

The lecture material covers the sections: modern concepts of the nature of chemical bonds in molecules of organic compounds, electronic effects in molecules of organic compounds, methods for establishing the structure and structure of organic compounds, reactivity of organic compounds, mechanisms of organic reactions. The classification, nomenclature and isomerism of organic compounds are considered; classes of hydrocarbons (saturated, unsaturated and aromatic hydrocarbons); halogen and hydroxyl derivatives of hydrocarbons; carbonyl derivatives of hydrocarbons, carboxylic acids, N-containing compounds and more important biologically active substances (carbohydrates, aminocarboxylic acids, peptides, etc.).

Practical classes in seminar and laboratory form illustrate the lecture material. Laboratory exercises include: methods for purification and isolation of organic compounds, functional analysis of organic compounds, synthesis of certain classes of organic compounds.

Course objectives:

The main targets of the Organic Chemistry course are:

1. To provide students with basic knowledge of the composition, structure, properties and methods for obtaining the most important classes of organic compounds.

2. To develop skills for experimental work in the field of organic chemistry.

3. To develop habits for the creative application of knowledge in the field of organic chemistry.

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: General requirements for the MSc program Metrology in Chemistry. Basic knowledge of chemistry, physics and mathematics..

PHYSICOCHEMICAL ANALYSIS

Semester: I

Weekly: 2 h lectures + 1 h exercises

ECTS credits: 6

Lecturers: Assoc. prof. Petranka Petrova, PhD

Form of final evaluation: written exam

Methodical guidance: Department: "Chemistry", Faculty of Natural Sciences and Mathematics,e-mail: himia@swu.bg

Course status: mandatory

Annotation:

The discipline Physicochemical Analysis covers the theoretical foundations and application of modern physicochemical methods of analysis. The main emphasis is placed on instrumental techniques and metrological aspects to ensure the accuracy, precision and reliability of analytical results. Spectral, electrochemical, chromatographic and other methods are

considered, as well as their application in various fields of chemistry, industry, ecology and scientific research.

Course objectives:

To introduce students to the theoretical principles of the main physicochemical methods of analysis (atomic and molecular spectroscopy, electroanalytical methods, gas and liquid chromatography).

To develop skills in working with modern analytical equipment.

To train students in the principles of validation of analytical methods, assessment of measurement uncertainty and quality control.

To provide knowledge on choosing an appropriate analytical method for a specific task, optimizing the conditions for analysis and processing of experimental data.

To form critical thinking in the interpretation of analytical results and making decisions based on them.

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: General requirements for the MSc program Metrology in Chemistry. Basic knowledge of chemistry, physical chemistry, physics and mathematics.

ANALYTICAL CHEMISTRY

Semester: II

Weekly: 3 h lectures + 1 h exercises

ECTS credits: 10

Lecturers: Assoc. prof. Petko Mandjukov, PhD

Form of final evaluation: written exam

Methodical guidance: Department: “Chemistry”, Faculty of Natural Sciences and Mathematics, e-mail: himia@swu.bg

Course status: mandatory

Annotation:

The course presents the theoretical foundations of analytical chemistry. Equilibria in solutions and heterogeneous systems are examined in detail: acid-base equilibria, complexation processes, formation and dissolution of sparingly soluble compounds, oxidation-reduction processes, as well as methods for assessing the influence of various external factors on the processes under consideration. On this basis, the theory of classical qualitative analysis - systematic wet analysis, the main methods for preliminary sample preparation, methods for detection, determination, separation and masking of components of the analyzed sample are examined.

Laboratory exercises introduce students to the analytical properties of cations and anions, as well as basic techniques for separation, concentration and masking, widely used in analytical chemistry.

Course objectives:

The main aims of the Analytical Chemistry program are:

1. To familiarize students with the theoretical foundations of analytical chemistry in qualitative and quantitative form.

2. To acquire practical knowledge, skills and abilities for working in specialized analytical laboratories.

3. To develop creative thinking and independently find appropriate solutions to analytical problems.

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: General requirements for the MSc program Metrology in Chemistry. Basic knowledge of chemistry, physics and mathematics.

INSTRUMENTAL METHODS FOR ANALYSIS

Semester: II

Weekly: 3 h lectures + 1 h exercises

ECTS credits: 10

Lecturers: Assoc. prof. Petko Mandjukov, PhD

Form of final evaluation: written exam

Methodical guidance: Department: "Chemistry", Faculty of Natural Sciences and Mathematics,e-mail: himia@swu.bg

Course status: mandatory

Annotation:

The course covers the main stages of analysis using instrumental methods. Absolute and relative methods, calibration and basic metrological characteristics of instrumental methods. Principles of the most commonly used atomic and molecular spectral methods of analysis. The physical foundations, possible practical applications, advantages and limitations of the considered instrumental analytical methods are discussed.

Course objectives:

The main objectives of the Instrumental Methods of Analysis program are:

1. To familiarize students with the capabilities of modern instrumental methods of analytical chemistry.

2. To acquire practical knowledge and skills for working with specialized analytical equipment.

3. To develop creative thinking and the ability to independently choose a method suitable for solving a given analytical problem and evaluate the results obtained.

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: General requirements for the MSc program Metrology in Chemistry. Basic knowledge of analytical chemistry, physics and mathematics.

THEORETICAL CHEMISTRY

Semester: II

Weekly: 2 h lectures + 1 h exercises

ECTS credits: 6

Lecturers: Assist. prof. Boyka Stoykova, PhD

Form of final evaluation: written exam

Methodical guidance: Department: "Chemistry", Faculty of Natural Sciences and Mathematics, e-mail: himia@swu.bg

Course status: mandatory

Annotation:

This course is designed for students who have not studied chemistry at the undergraduate level. In this course, students should become familiar with the theoretical foundations of chemistry.

It traces the development of ideas about the structure of atoms until reaching modern quantum-chemical ideas. Then, the basic concepts of quantum mechanics are presented. The spectral characteristics of atoms and molecules are studied and the basic concepts - ionization energy, electron affinity, electronegativity. On this basis, the concept of the types of chemical bonds - covalent, ionic, coordination - is built. Then, students are introduced to the types of intermolecular bonds. The last topics in this basic course include consideration of the energy spectrum of molecules and the theory of transition states.

Course aim:

The main objectives of the Theoretical Chemistry program are:

1. To familiarize students with the structure of the atom and the types of chemical bonds.

2. To familiarize students with the spectral characteristics of atoms and molecules.

3. To develop creative thinking and skills for independently finding appropriate solutions to analytical and metrological problems.

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: General requirements for the MSc program Metrology in Chemistry. Basic knowledge of general chemistry and mathematics.

FUNDAMENTALS OF METROLOGY

Semester: I

Weekly: 2 h lectures + 1 h exercises

ECTS credits: 6

Lecturers: Assoc. prof. Petko Mandjukov, PhD

Form of final evaluation: written exam

Methodical guidance: Department: "Chemistry", Faculty of Natural Sciences and Mathematics, e-mail: himia@swu.bg

Course status: mandatory

Annotation:

Metrology, being a science of measurements, is the base of all activities aimed to establishing quantitative characteristics of objects and phenomena. It examines the most general regularities in all types of measurements. Understanding the basic metrological principles is mandatory for a wide range of specialists working in the field of measurements, chemical analysis and, more generally, experimental sciences. The course treats issues of broad applicability in chemistry, clinical and pharmaceutical practice and in practically all experimental sciences and all areas of production.

Course aim:

The main objectives of the program **Fundamentals of Metrology** are:

1. To familiarize students with the basic concepts in metrology and the structure of national, regional and international metrological institutions.

2. To familiarize students with the methods for uncertainty assessment and the statistical apparatus necessary for these assessments.

3. To acquire knowledge and skills for verification and validation of analytical methods.

4. Skills for declaring and proving metrological traceability of analytical results

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: General requirements for the MSc program Metrology in Chemistry. Basic knowledge of analytical chemistry.

METHODS FOR EXPERIMENTAL DATA PROCESSING

Semester: I

Weekly: 2 h lectures + 1 h exercises

ECTS credits: 6

Lecturers: Prof. Stefan Stefanov, PhD

Form of final evaluation: written exam

Methodical guidance: Department: "Informatics", Faculty of Natural Sciences and Mathematics e-mail: informatics@swu.bg

Course status: mandatory

Annotation:

The curriculum considers interpolation as a way to approximate experimental data (tabulated functions): classical interpolation problem, Lagrange interpolation formula, interpolation error, divided differences and Newton's interpolation formula with divided differences, finite differences and finite difference interpolation formulas, interpolation with spline functions (linear and cubic splines), Hermite interpolation problem. Another basic classical approach to approximating tabulated functions is also considered - mean square approximations (least squares method). A place is also devoted to the topic of numerical differentiation as a variation of the data processing approach. It is also planned to study basic methods for numerical integration (approximate calculation of definite integrals using quadrature formulas) - Newton-Coates quadrature formulas, including composite quadrature formulas.

Course objectives:

The goal and main task of studying the discipline **Methods for Processing Experimental Data** is for students to acquire knowledge and skills for applying some basic methods of processing experimental data.

Students are also expected to be introduced to software products that implement some of the methods considered.

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: General requirements for the MSc program Metrology in Chemistry. Basic knowledge of mathematics.

METROLOGY OF ELECTROCHEMICAL MEASUREMENTS

Semester: I

Weekly: 2 h lectures + 1 h exercises

ECTS credits: 6

Lecturers: Assoc. prof. Elitsa Chorbadzhijska, PhD

Form of final evaluation: written exam

Methodical guidance: Department: "Chemistry", Faculty of Natural Sciences and Mathematics, e-mail: himia@swu.bg

Course status: mandatory

Annotation:

The electrochemical methods of analysis are based on electrochemical processes occurring on the electrodes or in the interelectrode space. The course Metrology of Electrochemical Measurements examines the metrological aspect of measuring electrochemical quantities (potential difference between electrodes, current strength, amount of electricity, electrical conductivity, etc.). Students are introduced to basic concepts of metrology and metrological control of electrochemical measurements, as well as basic metrological regulatory documents.

Course aim:

The main objectives of the program **Metrology of Electrochemical Measurements** are:

1. To familiarize students with the theoretical foundations and possible applications of modern electrochemical measurements.

2. To familiarize students with some basic European regulatory documents related to metrology and modern requirements for the organization and control of electrochemical results.

3. To acquire practical knowledge, skills and abilities for work in specialized electrochemical laboratories.

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: General requirements for the MSc program Metrology in Chemistry. Basic knowledge of physical chemistry.

METROLOGY OF PHYSICAL MEASUREMENTS

Semester: I

Weekly: 2 h lectures + 1 h exercises

ECTS credits: 6

Lecturers: Assoc. prof. Petko Mandjukov, PhD

Form of final evaluation: written exam

Methodical guidance: Department: "Chemistry", Faculty of Natural Sciences and Mathematics, e-mail: himia@swu.bg

Course status: mandatory

Annotation:

From a metrological point of view, chemical analyses can be considered as a combination of consecutive measurements of physical quantities. The course examines the metrological aspects of measuring basic physical quantities. Students are introduced to systems of measurement units, current definitions of SI, principles of metrological traceability, uncertainty assessments in physical measurements, calibration of measuring instruments, basic metrological regulatory documents, etc.

Course aim:

The main objectives of the **Metrology of Physical Measurements** program are:

1. To familiarize students with the definitions of the basic physical units of measurement, as well as with the methods for their implementation. To consider the evolution of units of measurement, determined by the desire to create precise, universal and "eternal" definitions.

2. To acquire knowledge and skills for performing precise physical measurements and correct estimates of measurement uncertainty and its components.

3. Skills for declaring and proving metrological traceability of measurement results.

4. To develop creative thinking and independently finding appropriate solutions to various problems related to various measurements and analytical practice.

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: General requirements for the MSc program Metrology in Chemistry. Basic knowledge of physics and metrology.

QUALITY CONTROL AND QUALITY ASSURANCE

Semester: I

Weekly: 2 h lectures + 1 h exercises

ECTS credits: 6

Lecturers: Assoc. prof. Petranka Petrova, PhD

Form of final evaluation: written exam

Methodical guidance: Department: "Chemistry", Faculty of Natural Sciences and Mathematics, e-mail: himia@swu.bg

Course status: mandatory

Annotation:

The course introduces students to a wide range of issues related to quality control and assurance in analytical laboratories. It covers methods for controlling deviations and uncertainty of measurement results, control charts, interlaboratory comparisons, proficiency testing, use of different types of reference materials, internal laboratory standards, stable

control samples, etc. The course content is in line with the requirements of the international standard ISO 17025:2017.

Course aim:

The main objectives of the **Quality Control and Quality Assurance** program are:

1. Introducing students to the methods of internal laboratory quality control: correct selection and adequate use of reference/certified reference materials, creation and interpretation of control charts, RT tests, etc.

2. Calibration and validation of analytical methods and individual procedures within a given method.

3. Skills for declaring and proving metrological traceability of the results of chemical analyses. Interlaboratory comparisons.

4. Developing creative thinking and independently finding appropriate solutions to various problems related to analytical practice.

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: Basic knowledge of analytical chemistry and metrology.

CHEMOMETRICS

Semester: I

Weekly: 2 h lectures + 1 h exercises

ECTS credits: 6

Lecturers: Assoc. prof. Petko Mandjukov, PhD

Form of final evaluation: written exam

Methodical guidance: Department: “Chemistry”, Faculty of Natural Sciences and Mathematics, e-mail: himia@swu.bg

Course status: mandatory

Annotation:

The course covers the main methods for statistical processing of analytical results: statistical criteria used for hypothesis testing in analytical chemistry, regression analysis, multiple linear regression and variance analysis are covered; classification and pattern recognition - cluster analysis (similarity criteria, agglomerative procedures); function optimization (methods for direct search for the extremum). The potential applications of the considered methods in analytical chemistry and in experimental data processing are discussed. The course provides information on modern metrological requirements for presenting the results of chemical analyses, as well as on methods for further data processing, allowing for obtaining additional information about the studied object or system.

Course aim:

The main tasks of the **Chemometrics** program are:

1. Introducing students in qualitative and quantitative form to basic methods for optimization and data processing in analytical chemistry and metrology.
2. Establishing a closer interdisciplinary connection with mathematics.
3. Developing creative thinking and abilities to independently find solutions to practical problems.

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: Basic knowledge of mathematics and analytical chemistry.

ELECTIVE COURSES

Group 1

X-RAY DIFFRACTION, NUCLEAR MAGNETIC RESONANCE, MASS SPECTROMETRY

Semester: I

Weekly: 2 h lectures

ECTS credits: 4

Lecturers: Prof. Boris Shivachev, PhD

Form of final evaluation: written exam

Methodical guidance: Department: "Chemistry", Faculty of Natural Sciences and Mathematics, e-mail: himia@swu.bg

Course status: elective

Annotation:

The course includes elements of the theory, basic principles and dependencies, specific techniques for analysis of some of the main and most important methods for analysis and determination of the structure of organic and biologically active compounds, such as NMR, Mass Spectrometry and X-ray structural analysis. The main characteristics of different classes of organic compounds when studied with the respective method are covered. The possibilities for comparative analysis are shown, as well as the advantages and disadvantages of studying specific compounds, taking into account the specificity of the method.

Course aim:

The main objectives of the course X-ray structural analysis, nuclear magnetic resonance, mass spectrometry are:

1. Introducing students to the basic principles and techniques of the specified methods for the analysis of chemical compounds.

2. Acquiring systematic knowledge and skills for identifying and characterizing the studied compounds and correct interpretation of the obtained results.

3. Developing creative thinking and the ability to independently choose approaches and methods when solving a given problem.

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: Basic knowledge of general chemistry and organic chemistry.

METHODS FOR ANALYSIS AND CONTROL

Semester: I

Weekly: 2 h lectures

ECTS credits: 4

Lecturers: Assoc. prof. Petko Mandjukov, PhD

Form of final evaluation: written exam

Methodical guidance: Department: "Chemistry", Faculty of Natural Sciences and Mathematics, e-mail: himia@swu.bg

Course status: elective

Annotation:

The course examines modern concepts in analytical chemistry, current problems and methods for their solution. The physical foundations, possible practical applications, advantages and limitations of instrumental analytical methods are discussed. Special attention is paid to the challenges to analytical chemistry posed by modern requirements for environmental control.

Course aim:

The main objectives of the course Methods of Analysis and Control are:

1. To familiarize students with the basic principles and techniques of analytical methods widely used in environmental monitoring and for solving a wide range of problems related to quality control.

2. To familiarize students with the basic techniques for sample preparation, preliminary concentration of the determined component and separation from interfering components.

3. To develop creative thinking and the ability to independently choose approaches and methods when solving a given problem.

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: Basic knowledge of general chemistry and analytical chemistry.

MODERN CHROMATOGRAPHIC METHODS

Semester: I

Weekly: 2 h lectures

ECTS credits: 4

Lecturers: Assoc. prof. Radoslav Chayrov, PhD

Form of final evaluation: written exam

Methodical guidance: Department: "Chemistry", Faculty of Natural Sciences and Mathematics, e-mail: himia@swu.bg

Course status: elective

Annotation:

The course presents the theoretical foundations of chromatographic methods for analysis and purification. The main characteristics necessary for the correct selection of analytical equipment, setup and the necessary materials/consumables for obtaining the most accurate result are examined. Students are introduced to the properties and basic separation and derivatization techniques widely used in high-performance liquid chromatography. Emphasis is placed on the importance and correct selection of the necessary components for the preparation of mobile phases suitable for the respective analysis, as well as their adjacent stationary phases.

Course aim:

The main tasks of the Chromatography Methods program are:

1. Introducing students to the application of chromatographic methods for qualitative and quantitative analysis;

2. Acquiring knowledge and skills for work in specialized analytical laboratories in sample preparation and analysis.

3. Developing engineering thinking and finding adequate solutions to problems that arise.

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: Basic knowledge of general, organic and analytical chemistry.

Group 2

ELECTROCHEMISTRY

Semester: II

Weekly: 2 h lectures

ECTS credits: 4

Lecturers: Assoc. prof. Elitsa Chorbadzhijska, PhD

Form of final evaluation: written exam

Methodical guidance: Department: "Chemistry", Faculty of Natural Sciences and Mathematics, e-mail: himia@swu.bg

Course status: elective

Annotation:

The curriculum for the discipline Electrochemistry includes 30 hours of lectures. The course expands and deepens basic knowledge of electrochemistry problems introduced in the mandatory courses on "General and Inorganic Chemistry" and "Physicochemical Analysis".

The lecture material examines issues related to "Basic Concepts and Functions in Electrochemical Thermodynamics" and "Electrochemical Kinetics and Practically Important Electrode Processes". Unlike other courses on electrochemistry, the proposed course does not include issues related to electrolyte dissociation and transfer processes in electrolyte solutions, since these issues are discussed in detail in the aforementioned courses on "General and Inorganic Chemistry" and "Physicochemical Analysis".

Course aim:

The main tasks of the Electrochemistry course are:

1. To present to students a modern lecture course in electrochemistry using a variety of modern teaching methods and tools.

2. Based on knowledge obtained from the disciplines "General and Inorganic Chemistr and "Physicochemical Analysis", to build new knowledge on basic issues of theoretical electrochemistry, as well as those for the most important electrochemical processes for practic

3. To form practical skills in students related to calculating and experimentally determi important electrochemical characteristics and dependencies.

4. To provoke the active participation of students in the learning process through solving problem cases, preparing course papers and other forms.**Teaching methods:** lectures, exercises and extracurricular work

Prerequisites: Basic knowledge of general chemistry, physical chemistry and mathematics.

MOLECULAR SPECTROSCOPY

Semester: II

Weekly: 2 h lectures

ECTS credits: 4

Lecturers: Assoc. prof. Petranka Petrova, PhD

Form of final evaluation: written exam

Methodical guidance: Department: "Chemistry", Faculty of Natural Sciences and Mathematics, e-mail: himia@swu.bg

Course status: elective

Annotation:

The curriculum for the discipline Molecular Spectroscopy includes 30 hours of lectures. The main goal of the course is to familiarize students with the basic principles of the theory of electronic, vibrational (IR-, Raman) spectra and the influence of various factors on the corresponding spectral characteristics. The techniques and equipment of UV-VIS, IR- and Raman spectral analysis are considered, as well as their joint application for the characterization of chemical compounds. The possibilities and application of the corresponding methods are shown by considering specific examples.

Course aim:

The main objectives of the Molecular Spectral Analysis course are:

1. To familiarize students with the basic principles and techniques of UV- and IR-Raman spectroscopy for the analysis of chemical compounds.

2. To acquire systematic knowledge and skills for the identification and characterization of the studied compounds using spectral methods and correct interpretation of the obtained results.

3. To develop creative thinking and the ability to independently choose approaches and methods when solving a given problem.

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: Basic knowledge of organic and analytical chemistry.

SOLID STATE CHEMISTRY

Semester: II

Weekly: 2 h lectures

ECTS credits: 4

Lecturers: Assoc. prof. Elitsa Chorbadzhijska, PhD

Form of final evaluation: written exam

Methodical guidance: Department: "Chemistry", Faculty of Natural Sciences and Mathematics, e-mail: himia@swu.bg

Course status: elective

Annotation:

The curriculum for the discipline **Solid State Chemistry** includes lectures.

The lecture material examines contemporary problems of inorganic materials science. The program directs the attention of master's students to contemporary inorganic materials and the clarification of the synthesis - structure - property relationship. The lecture material is divided into sections: materials cycle, preparative methods for obtaining solids, direct reactions with solids, crystallization, synthesis of solid-phase materials by transport reactions in the gas phase, intercalation syntheses, ion-exchange syntheses, physical and chemical methods for obtaining thin layers, new forms of carbon and molecular metals.

Course aim:

The objective of the program is to obtain a broad-based preparation in solid state chemistry, providing a basis for contemporary inorganic materials science.

The main objectives of the Solid State Chemistry program are:

1. Obtaining broad-based training for chemistry students in the field of inorganic materials science through studying the elective course Solid State Chemistry in the Master's degree in Chemistry and Ecology.

2. Mastering the basic methods for obtaining solids and understanding the synthesis - structure - property relationship for obtaining modern materials.

3. Acquiring dexterity and skills for performing chemical experiments in solid state chemistry.

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: Basic knowledge of general and inorganic chemistry, organic chemistry, analytical chemistry, instrumental methods of analysis, physics and informatics.

Group 3

REFERENCE MATERIALS

Semester: III

Weekly: 1 h lectures + 1 h exercises

ECTS credits: 3

L**ecturers:** Assoc. prof. Petranka Petrova, PhD

Form of final evaluation: written exam

Methodical guidance: Department: "Chemistry", Faculty of Natural Sciences and Mathematics, e-mail: himia@swu.bg

Course status: elective

Annotation:

The different types of reference materials, methods for their preparation and characterization are discussed; the international standards regulating the production and use of reference materials. Particular attention is paid to the role of different types of reference materials in controlling and assuring the quality of analytical results, ensuring metrological traceability of

results and possible applications in empirical approaches for estimating measurement uncertainty, etc.

Course aim:

The aim of the course is to provide students with the information necessary for adequate selection and competent application of reference materials to solve various analytical and metrological problems.

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: Basic knowledge of analytical chemistry and metrology.

VALIDATION OF ANALYTICAL METHODS

Semester: III

Weekly: 1 h lectures + 1 h exercises

ECTS credits: 3

Lecturers: Assoc. prof. Elitsa Chorbadzhijska, PhD

Form of final evaluation: written exam

Methodical guidance: Department: "Chemistry", Faculty of Natural Sciences and Mathematics, e-mail: himia@swu.bg

Course status: elective

Annotation:

The course introduces the basic concepts, subject, tasks and the need for validation of analytical methods. The analytical parameters to be validated, the method of their determination and calculation are presented. Laboratory exercises introduce students to the development and validation of analytical methods.

Course aim:

The main objectives of the **Validation of Analytical Methods** program are:

1. To familiarize students with the theoretical foundations, definitions used in the validation of an analytical method.

2. To acquire practical knowledge, skills and abilities for working in analytical laboratories, developing new analytical methods and performing validation.

3. To develop creative thinking, selection of analytical parameters for validation according to the method used and its applicability.

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: Basic knowledge of analytical chemistry.

METROLOGICAL ASPECTS IN ECOLOGICAL STUDIES

Semester: III

Weekly: 1 h lectures + 1 h exercises

ECTS credits: 3

Lecturers: Assoc. prof. Petko Mandjukov, PhD; Ava Amideina, PhD student
Form of final evaluation: written exam

Methodical guidance: Department: "Chemistry", Faculty of Natural Sciences and Mathematics, e-mail: himia@swu.bg

Course status: elective

Annotation:

Analyses related to the environmental research are some of the most complex and pose a wide range of metrological problems that must be resolved to obtain reliable and correct results. These problems are related to the assessment of measurement uncertainty, including the components due to sampling, sample preparation, calibration, etc.; assessment of LOD and LOQ; determination of target measurement uncertainty; selection and use of reference materials for quality control; validation of the analytical method and its individual stages; ensuring metrological traceability of results, etc.

Course aim:

The main objectives of the program **Metrological Aspects in Environmental Research** are:

1. Familiarizing students with the basic strategies for monitoring various environmental objects.

2. Familiarizing students with quality control methods for analyzing environmental objects.

3. Familiarizing students with approaches to assessing measurement uncertainty due to the different stages of analysis.

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: General requirements for the MSc program Metrology in Chemistry. Basic knowledge of analytical chemistry.

Group 4

RENEWABLE ENERGY SOURCES AND SYSTEMS

Semester: III

Weekly: 1 h lectures + 1 h exercises

ECTS credits: 3

Lecturers: Assoc. prof. Elitsa Chorbadzhijska, PhD

Form of final evaluation: written exam

Methodical guidance: Department: "Chemistry", Faculty of Natural Sciences and Mathematics, e-mail: himia@swu.bg

Course status: elective

Annotation:

The lecture material addresses key issues in renewable energy sources (RES) such as: sustainable "green" energy from renewable sources, solar radiation and solar spectrum, solar energy and solar systems, wind energy and wind generators, energy from small hydro systems, bioenergy, biomass and biofuels, geothermal energy and systems, hydrogen energy, energy

storage from RES, energy efficiency of RES systems, environmental monitoring with RES systems and good practices in the use of RES.

The seminar exercises support the assimilation of the lecture material. They include classes on "green" electricity from a photovoltaic generator (connected to the energy grid and autonomous), obtaining bioethanol and its combustion, ecological fuels obtained through energy from RES, water purification for drinking and technical purposes with energy from RES and efficient use of energy from RES. Students have the opportunity to visit the "Union of Ecological Energy Producers - Bulgaria" in Blagoevgrad to learn about the problems of green energy and the RES sector as a share in the country's energy mix.

Course aim:

The main tasks of the Renewable Energy Sources and Systems program are:

1. Acquisition of knowledge about renewable energy sources, systems and energy mix with the participation of "green" energy.

2. Acquisition of dexterity and skills for performing chemical experiments in a specialized chemical laboratory at the Institute of Chemical Engineering and Technology of Southwestern University for RES.

3. Development of chemical thinking and independent work in the field of ecological energy from RES and systems.

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: General requirements for the MSc program Metrology in Chemistry. Basic knowledge of physical chemistry.

METROLOGICAL ASPECTS IN SAMPLING AND SAMPLE PREPARATION

Semester: III

Weekly: 1 h lectures + 1 h exercises

ECTS credits: 3

Lecturers: assoc. prof. Petko Mandjukov, PhD

Form of final evaluation: written exam

Methodical guidance: Department: "Chemistry", Faculty of Natural Sciences and Mathematics, e-mail: himia@swu.bg

Course status: elective

Annotation:

Sampling and sample preparation are stages of the analytical process that are critical for obtaining correct results. These stages account for the largest share of the time for the entire analytical study, as well as the largest contribution to the measurement uncertainty of the final result. The latest version of the international standard ISO/IEC 17025:2017 (reviewed and confirmed in 2023) sets new requirements for assessing the contributions to the measurement uncertainty of each stage of the analytical study.

Course aim:

The main objectives of the program **Metrological Aspects of Sampling and Sample Preparation** are:

1. To familiarize students with the basic strategies for sampling from different objects.

2. To familiarize students with modern methods of sample preparation.

3. To familiarize students with the approaches to assessing the measurement uncertainty due to sampling and sample preparation.

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: Basic knowledge of analytical chemistry, metrology and mathematics.

SPECIALIZED SOFTWARE

Semester: III

Weekly: 1 h lectures + 1 h exercises

ECTS credits: 3

Lecturers: Assoc. prof. Elena Karashtranova, PhD

Form of final evaluation: written exam

Methodical guidance: Department: "Informatics", Faculty of Natural Sciences and Mathematics e-mail: informatics@swu.bg

Course status: elective

Annotation:

The **Specialized Software** course introduces students to the capabilities of specialized statistical packages for processing experimental data and their application in practice. The course includes basic principles for modeling empirical data and the capabilities of modern technologies for their implementation (MS EXCEL, SPSS AND STATISTICA, etc.).

Course aim:

The main tasks of the **Specialized Software** program are:

1. To familiarize students with theoretical knowledge of modern applied programs, as well as the specifics of their use.

2. To acquire knowledge and skills for creating correct statistical models and develop skills for their application.

3. To familiarize students with modern technologies for statistical data analysis.

4. To prepare students for their future research work.

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: Basic knowledge of mathematics and some skills in informatics.

Group 5

ATOMIC EMISSION SPECTROSCOPY

Semester: IV

ECTS credits: 3

Weekly: 1 h lectures + 1 h exercises

Lecturers: Assoc. prof. Petranka Petrova, PhD

Form of final evaluation: written exam

Methodical guidance: Department: "Chemistry", Faculty of Natural Sciences and Mathematics, e-mail: himia@swu.bg

Course status: elective

Annotation:

The course examines basic concepts and principles of atomic emission spectroscopy – principle scheme, intensity of spectral lines, spectral and non-spectral interferences, as well as statistical processing of analytical results. The main metrological characteristics of the analytical method are discussed – detection limits and determination limits, accuracy, precision, linear dynamic concentration range and selectivity.

Laboratory exercises introduce students to the stages through which a real analysis goes – sampling, sample preparation, instrumental determination and processing of the analysis results.

Course aim:

The main tasks of the program in Atomic Emission Spectroscopy are:

1. To introduce students to the basic principles of atomic emission analysis;

2. Acquisition of knowledge and skills for work in specialized analytical laboratories;

3. Interpretation of analytical results, development of creative thinking and ability to independently conduct the analysis.

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: Basic knowledge of analytical chemistry and physics.

CHROMATOGRAPHY

Semester: IV

Weekly: 1 h lectures + 1 h exercises

ECTS credits: 3

Lecturers: Assoc. prof. Radoslav Chairov, PhD

Form of final evaluation: written exam

Methodical guidance: Department: "Chemistry", Faculty of Natural Sciences and Mathematics, e-mail: himia@swu.bg

Course status: elective

Annotation:

The **Chromatography** course includes lectures mainly related to thin-layer and column variants.

The course presents the theoretical foundations of chromatographic methods for analysis and purification. The main characteristics necessary for the correct selection of analytical equipment, setup and the necessary materials/consumables for obtaining the most accurate result are examined. Students are introduced to the properties and basic techniques for separation and derivatization applied in practice. The emphasis is on the importance and correct selection of the necessary components for the preparation of mobile phases suitable for the respective analysis, as well as their adjacent stationary phases.

Course aim:

The main tasks of the **Chromatography** program are:

1. Introducing students to the application of chromatographic methods for qualitative and quantitative analysis;

2. Acquiring knowledge and skills for work in specialized analytical laboratories in sample preparation and analysis.

3. Developing engineering thinking and finding adequate solutions to problems that arise.

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: General requirements for the MSc program Metrology in Chemistry. Basic knowledge of analytical chemistry.

ELECTROANALYTICAL METHODS

Semester: IV

Weekly: 1 h lectures + 1 h exercises

ECTS credits: 3

Lecturers: Assoc. prof. Elitsa Chorbadzhijska, PhD

Form of final evaluation: written exam

Methodical guidance: Department: "Chemistry", Faculty of Natural Sciences and Mathematics, e-mail: himia@swu.bg

Course status: elective

Annotation:

Electrochemistry provides some of the most sensitive, relatively fast and informative analytical techniques. Electroanalytical methods such as linear and cyclic voltammetry, chronoamperometry, impedance potentiometry, etc. can not only determine traces of a given electrochemically active analyte, but these methods also provide useful information about its physical and chemical properties.

Course aim:

The main objectives of the **Electroanalytical Methods** program are:

1. To familiarize students with the theoretical foundations and possible applications of m electroanalytical methods.

2. To acquire practical knowledge, skills and abilities for work in specialized analytical laborat

3. To develop creative thinking and independently find appropriate solutions to various anal problems.

Teaching methods: lectures, exercises and extracurricular work

Prerequisites: General requirements for the MSc program Metrology in Chemistry. Basic knowledge of analytical chemistry.