Possibilities for realization

Students accomplished "Metrology in Chemistry" master degree study might found realization in following fields:

1. The program provides good basis for future PhD study in field of analytical chemistry as well as in all other branches of chemistry and other experimental sciences e.g. physics, biology, ecology, environmental chemistry etc.
2. Opportunity for work in all types of analytical laboratories: industrial, environmental, clinical and public health, etc.
3. Opportunity for work at different levels in scientific institutes working in field of chemistry and other experimental sciences e.g. physics, biology, ecology etc.
4. Opportunity for work in industrial, ecological, public health etc. laboratories performing quality control / quality assurance activities.
5. Opportunity for work in national and international metrological institutions e.g. institutes of metrology, laboratories for equipment test and calibration, accreditation bodies etc.
6. Opportunities for teaching work in universities and specialized educational institutions.
7. Opportunity for work in trade companies distributing specialized chemical laboratory and industrial equipment.

Learning outcomes of the curriculum

Outcomes: Subject Knowledge

Students become conversant with the following main aspects of chemistry:

a) Major aspects of analytical chemical and metrological terminology, nomenclature, conventions and units
b) The major types of measurement and calibration techniques and their main characteristics
c) The principles and procedures used in chemical analysis and characterization of chemical compounds
d) The principal instrumental techniques, including atomic and molecular spectroscopy, chromatography, analytical electrochemistry.
e) The principal techniques of sampling and sample preparation
f) Mathematical methods in measurement data evaluation

Outcomes: Abilities and Skills.

These are divided into three broad categories:

1. ***Chemistry-related cognitive abilities and competences, i.e. abilities and competences relating to intellectual tasks, including problem solving;***

1.1 Ability to demonstrate knowledge and understanding of essential facts, concepts, principles and theories relating to the subject areas identified above
1.2 Ability to apply such knowledge and understanding to the solution of qualitative and quantitative problems of a familiar nature.
1.3 Competences in the evaluation, interpretation and synthesis of information and data in chemical measurement field.
1.4 Ability to recognize and implement good measurement science and practice.
1.5 Competences in presenting scientific material and arguments in writing and orally, to an informed audience.
1.6 Computational and data-processing skills, relating to chemical measurement information and data.

2. ***Chemistry-related practical skills***

2.1 Carry out chemical measurements using the most common chemical and physical methods according to ISO 17025
2.2 Carry out sampling and sample preparation
2.3 Evaluate the analytical data, calculate results and estimate their reliability (uncertainty)
2.4 Develop and validate methods of measurement
2.5 Establish traceability of chemical measurement results
2.6 Use of appropriate software for evaluating the analytical data, calculating results and estimating their reliability (uncertainty)

3. ***Generic competences that may be developed in the context of chemistry and are of a general nature and applicable in many other contexts.***

3.1 The capacity to apply knowledge in practice, in particular measurement problem solving competences, relating to both qualitative and quantitative measurements.
3.2 Numeracy and calculation skills, including such aspects as uncertainty analysis, order-of-magnitude estimations, and correct use of units.
3.3 Information-management competences, in relation to primary and secondary information sources, including information retrieval through on-line computer searches
3.4 Ability to analyse data and summarize it in the form of reports.
3.5 The capacity to adapt to new situations and to make decisions.
3.7 Skills in planning and time management.
3.8 Interpersonal skills, relating to the ability to interact with other people and to engage in team-working particularly Interacting with customers and their requirements
3.9 Communication competences, covering both written and oral communication, in one of the major European languages (English, German, Italian, French, Spanish) as well as in the language in which the degree course is taught.
3.10 Study competences needed for continuing professional development. These will include in particular the ability to work in an accredited laboratory.
3.11 Manage analytical laboratory according to the requirements of ISO 17025
3.12 Ethical and legal commitment, civil responsibility.

Program code: 06.53_2.13.20

Program content

	Course title	Course type	ECTS Credits	Course code
S E M E S T E R 1				
Obligatory courses				
1.	**Metrology in the analytical chemistry**	obligatory	6	53.7.20.O-01
2.	**Introduction to stochastic processes**	obligatory	6	53.7.20.O-02
3.	**Chemometrics**	obligatory	6	53.7.20.O-03
4.	**Metrology in physical measurements**	obligatory	6	53.7.20.O-04
Elective courses group 1 (one course to be attended)				
5.	**Methods for experimental data processing**	elective	3	53.7.20.E-1.01
6.	**Electroanalytical methods**	elective	3	53.7.20.E-1.02
7.	**Environmental chemistry**	elective	3	53.7.20.E-1.03
8.	**Organic spectroscopy**	elective	3	53.7.20.E-1.04
Elective courses group 2 (one course to be attended)				

9.	**Reliability of the environmental sampling**	elective	3	53.7.20.E-2.01
10.	**Sample preparation methods**	elective	3	53.7.20.E-2.02
11.	**Specialized software**	elective	3	53.7.20.E-2.03
12.	**Condensed matter investigation methods**	elective	3	53.7.20.E-2.04
		Total	**30**	
S E M E S T E R 2				
Obligatory courses				
13.	**Quality control and quality assurance**	obligatory	6	53.7.20.O-05
14.	**Modern analytical chemistry**	obligatory	6	53.7.20.O-06
Elective courses group 3 (one course to be attended)				
15.	**Laser spectroscopy**	elective	3	53.7.20.E-3.01
16.	**Chromatography**	elective	3	53.7.20.E-3.02
17.	**Quantum chemistry**	elective	3	53.7.20.E-3.03
18.	**Renewable Energy Sources and Systems**	elective	3	53.7.20.E-3.04
Master Thesis				
19.	**Master Thesis**	obligatory	15	
		Total	**30**	

ECTS Specification for the Module/Course Unit Descriptions *(from the "Key Features")*

• Course title: **Metrology in the analytical chemistry**
• Type of course: **Obligatory**
• Level of course:
• Semester/trimester: **Semester 1**
• Number of credits allocated (workload based) – **6 ECTS credits**
• Name of lecturer: **Petko Mandjukov, Associated professor, Ph.D. Elitsa Chorbadzhiyska Assistant professor**
• Objective of the course (expected learning outcomes and competences to be acquired): **The aim of the course is to introduce students to the basic methods for analytical data treatment and revealing the metrology characteristics of the analytical methods.**

• Prerequisites: **General requirements for the admission to the Master program.**

• Course contents:

1. **Basic metrological terms.**
2. **Statistics in the analytical chemistry. Basic statistic criteria. ANOVA.**
3. **Uncertainty and bias in analytical chemistry. Uncertainty propagation law.**
4. **Modeling of the measurement process. Identification of the uncertainty sources.**
5. **Uncertainty budget. Contributions of different factors to the general uncertainty. Examples – primary methods: gravimetric and volumetric analysis.**
6. **Methods for uncertainty estimation in complex analytical procedures.**
7. **Regression analysis. Statistics of the linear regression. Calibration. Uncertainty estimation.**
8. **Multiple linear regression. Nonlinear calibration algorithms.**

9. **Presentation of the analytical results.**
10. **National and European regulations related to the metrology in analytical chemistry and presentation of the results.**

• Literature:

1. **F. Settle, Ed. *Handbook of Instrumental Techniques for Analytical Chemistry.* Prentice Hall PTR, 1997.**
2. **F. Rouessac, A. Rouessac. *Chemical Analysis. Modern Instrumental Methods and Techniques.* John Wiley & Sons, 1998.**
3. **D. Harvey. *Modern Analytical Chemistry.* Mc Graw-Hill Higher Education, 2000.**
4. ***Analytical Chemistry,* Editors: R. Kellner, J.-M. Mermet, M. Otto, H. Widmar, WILEY-VCH, 2002.**
5. **J. M. Hollas. *Modern Spectroscopy.* John Wiley & Sons, 2004.**
6. **P.C. Meier, R.E. Zeund, *Statistical methods in analytical Chemistry.* John Wiley & Sons, 2000.**
7. **P.C.Brereton. *Chemometrics. Data analysis for the laboratory and chemical plants.* John Wiley & Sons, 2003.**
8. **S. Mitra, Ed. *Sample Preparation Techniques in Analytical Chemistry*. Wiley-Interscience, 2003.**
9. **S. Rabinovich. *Measurements Errors and Uncertainties.* Springer, 2005.**
10. ***Quantifying Uncertainty in Analytical Measurement, 2nd ed.; Ellison, S. L. R.; Rösslein, M.; Williams, A., Eds.; EURACHEM/CITAC, 2000.***

• Teaching methods: **Lectures, seminars, individual work, problem-solving groups.**
• Assessment methods: **Course project and final examination with contributions to the final rank 60% and 40% respectively.**
• Language of instruction: **Bulgarian, English**

ECTS Specification for the Module/Course Unit Descriptions *(from the "Key Features")*

• Course title: **Introduction to Stochastic Processes**
• Type of course: **Obligatory**
• Level of course:
• Semester/trimester: **Semester 1**
• Number of credits allocated (workload based) – **6 ECTS credits**
• Name of lecturer: **Elena Karashtranova, Associated professor, Ph.D.**
• Objective of the course (expected learning outcomes and competences to be acquired): **The course provides basic knowledge of stochastic processes and their application in the field of Metrology. The students should obtain basic knowledge about:**

- **Stochastic Processes**
- **The Application of Stochastic Processes in the Field of Metrologics**

• Prerequisites**: General requirements for the admission to the Master programme.**

• Course contents:

1. **Random Variables**
2. **Multivariate Probability Distributions**
3. **Mathematical Expectation**
4. **Moments, Variance and Covariance.**
5. **Convolutions**
6. **Stochastic Processes and Principles of Modeling**
7. **Stochastic Processes Classification**
    - Stochastic Processes in Chemistry
    - Branching processes

- The Markov property
- Stationary Markov processes
- Markov chains
- The decay processes

• Literature:

1. **Chiang, Chin Long, Introduction to Stochastic Processes in Biostatistics, Wiley Series in Probability and Mathematical Statistics, John Wiley & Sons, Inc., 1968**

• Teaching methods: **seminars, tutorials, discussions, project based method.**

• Assessment methods: **Project- 30%, Final Test- 70%. The course is successful completed with at least 55% of all scores.**

• Language of instruction: **Bulgarian, English**

ECTS Specification for the Module/Course Unit Descriptions *(from the "Key Features")*

• Course title: **Chemometrics**
• Type of course: **Obligatory**
• Level of course:
• Year of study: **Year 1**
• Semester/trimester: **Semester 1**
• Number of credits allocated (workload based) – **6 ECTS credits**
• Name of lecturer: **Mikhail Kolev, Associated professor, Ph.D.**
• Objective of the course (expected learning outcomes and competences to be acquired): **Students should obtain basic knowledge and practical skills in mathematical methods commonly used in data treatment; optimization; modelling of processes and systems; data smoothing, multivariate statistical analysis etc.**
• Prerequisites: **Basic Basic knowledge of mathematics, analytical chemistry and instrumental methods for analysis, computer skills.**

• Course contents:

1. **Basic statistical treatment of the analytical results.**
2. **Variation analysis.**
3. **Regression analysis. Multiple linear regression. Nonlinear calibration.**
4. **Time series analysis.**
5. **Correlation analysis.**
6. **Multivariate statistics. Cluster analysis.**
7. **Optimisation methods. Application for solving various problems.**
8. **Digital filters for data smoothing.**
9. **Principles of neural network computing.**

• Literature:

1. ***Analytical Chemistry*****, Editors: R. Kellner, J.-M. Mermet, M. Otto, H. Widmar, WILEY-VCH, Venheim.**
2. **D. Massart, L. Kaufman. *The Interpretation of Analytical Chemical Data by the Use of Cluster Analysis.*. John Wiley & Sons, New York, 1983**
3. **F.-T. Chau, Y.-Z. Liang, J. Gao, X.-G. Shao. *Chemometrix. From basics to wavelet transform.* John Wiley & Sons, 2004.**
4. **P.C. Meier, R.E. Zeund, *Statistical methods in analytical Chemistry.* John Wiley & Sons, 2000.**
5. **P.C.Brereton. *Chemometrics. Data analysis for the laboratory and chemical plants.* John Wiley & Sons, 2003.**

6. **J.D. Hamilton. *Time Series Analysis.* Princeton University Press, Princeton, 1994.**

• Teaching methods: **lectures, tutorials, individual student's work**
• Assessment methods: **course project (C); project presentation (P) / Rating: = 0.6 x [C] + 0.4 x [P]**
• Language of instruction: **Bulgarian, English**

ECTS Specification for the Module/Course Unit Descriptions *(from the "Key Features")*

• Course title: **Metrology in physical measurements**
• Type of course: **Obligatory**
• Level of course:
• Semester/trimester: **Semester 1**
• Number of credits allocated (workload based) – **6 ECTS credits**
• Name of lecturer: **Lyubomir Pavlov, Professor, D.Sc.**
• Objective of the course (expected learning outcomes and competences to be acquired): **The discipline contains material from measurement of physics quantities, reviewing and extending some elements from bachelor's education level. The discipline contains base terms from metrology and metrological control of different physics factors and others. The aim of the course is to give basic normative acts, regulations, at pawn by physics measurements, and information about separated periods in metrology development.**
• Prerequisites : **General knowledge in physics.**

• Course contents:
1. **Metrology regulations in Bulgaria.**
2. **Metrologic control.**
3. **Declaring the measurement and registration instruments.**
4. **Checking of the measurement instruments.**
5. **Calibration of the measurement tools.**
6. **Measurements of mass and length.**
7. **Measurement of time.**
8. **Measurement of debit and consumption.**
9. **Measurement of energy and power.**
10. **Control of radiation pollution.**
11. **Analysis of the spectra of ionization radiation.**

• Literature:
1. Русев Д., Електромеханични измервателни уреди, Т., 1988
2. Додова М., История на метрологията в България, Изд. Стандартизация, С., 1993
3. Наредба №6 за единици, величини и еталони, ДВ, бр.2, 1995
4. Бринсман Б., Метрология в Западна Европа, "Промишлена метрология", 1992
5. Манов Е., Колев Н. и др., Електрически измервания, под редакцията на Б. Матраков, ТУ-София, 2005

• Teaching methods: **lectures, exercises, individual student's work**

• Assessment methods: **Current evaluation at exercises and final written examination with discussion upon the end of the course with contributions to the final mark 30% and 70% respectively.**

• Language of instruction: **Bulgarian, English**

ECTS Specification for the Module/Course Unit Descriptions *(from the "Key Features")*

• Course title: **Methods for Data Processing**
• Type of course: **Elective**
• Level of course:
• Semester/trimester: **Semester 1**
• Number of credits allocated (workload based) – **3 ECTS credits**
• Name of lecturer: **Stefan Stefanov, Associated professor, Ph.D.**
• Objective of the course (expected learning outcomes and competences to be acquired): **Students should obtain basic knowledge and skills for applying some important methods for experimental data processing and some computational methods for solving optimization problems.**
• Prerequisites: **Basic knowledge in mathematical analysis, linear algebra, analytic geometry.**
• Course contents:

1. **Lagrange interpolation problem. Lagrange formula for the interpolating polynomial.**
2. **Interpolation error.**
3. **Divided differences. Newton form of the interpolating polynomial.**
4. **Spline interpolation. Linear and cubic splines.**
5. **Hermitte interpolation problem.**
6. **Least squares data fitting.**
7. **Numerical differentiation.**
8. **Line search. Dichotomous search. Golden section method. Fibonacci search.**
9. **Unconstrained minimization. Derivative-free methods: cyclic coordinate method, method of Hooke and Jeeves, method of Rosenbrock. Applications.**
10. **Gradient methods. Steepest descent method. Rate of convergence.**

• Literature:

1. **M. S. Bazaraa, H. D. Sherali and C. M. Shetty – "Nonlinear Programming. Theory and Algorithms", John Wiley & Sons, Inc., New York, 2-nd ed., 1993. [There is a Russian translation of the 1-st ed.: М. Базара, К. Шетти – "Нелинейное программирование. Теория и алгоритмы", "Мир", Москва, 1982].**
2. **B. Boyanov – "Lectures on Numerical Analysis", Sofia, 1995 [in Bulgarian: Б. Боянов – "Лекции по числени методи", София, 1994].**
3. **Richard L. Burden, J. Douglas Faires – "Numerical Analysis", 6-th ed., Brooks/Cole Publishing Company, ITP An International Thompson Publishing Company, 1997.**
4. **J. Douglas Faires, Richard Burden – "Numerical Methods", 2-nd ed., Brooks/Cole Publishing Company, ITP An International Thompson Publishing Company, 1998.**
5. **"Numerical Methods Problem Book", 2-nd ed., St. Kliment Ohridski Sofia University Publishing House, Sofia, 1994 [in Bulgarian: Колектив – "Сборник от задачи по числени методи", 2-ро изд., Университетско издателство "Св. Климент Охридски", София, 1994].**
6. **B. Sendov, V. Popov – Numerical Analysis", Nauka and Izkustvo Publishing House, Sofia, vol. I, 1976, 2-nd ed. 1996, vol. II, 1978 [in Bulgarian: Бл. Сендов, В. Попов – "Числени методи", I част, "Наука и изкуство", София, 1976, 2-ро изд. 1996 г.; II част, 1978].**
7. **S.M. Stefanov – "Numerical Analysis", MS4004-2203, Limerick, 1998.**
8. **S.M. Stefanov – "Separable Programming. Theory and Methods", Kluwer Academic Publishers, Dordrecht – Boston – London, 2001.**

• Teaching methods: **Lectures and practical assignments. Term projects.**

• Assessment methods: **Final grade is calculated as follows: 20 % of the grade of two homework, 20 % of the grade of two term projects, 30 % of the grade of Part I and 30 % of the grade of Part II of the final exam.**

• Language of instruction: **Bulgarian, English**

ECTS Specification for the Module/Course Unit Descriptions *(from the "Key Features")*

• Course title: **Electroanalytical methods**
• Type of course: **Elective**
• Level of course:
• Semester/trimester: **Semester 1**
• Number of credits allocated (workload based) – **3 ECTS credits**
• Name of lecturer: **Mario Mitov, Professor, Ph.D.**
• Objective of the course (expected learning outcomes and competences to be acquired): **Theory and application of modern electroanalytical techniques - potentiometry, voltammetry, polarography, impedance methods and others.**
• Prerequisites: **BSc in Chemistry, Physics or Ecology; Courses in General Chemistry, Physicochemistry, Analytical Chemistry, Instrumental Methods of Analysis.**
• Course contents:

1. **Overview of electrochemical systems and electrode processes**
2. **Metrology of variables in electrochemical cells**
3. **Basic electrochemical thermodynamics. Free energy and cell emf. Electrochemical potentials.**
4. **Kinetics of electrode reactions. Electrochemical reaction mechanism and rate-determining steps. Electrochemical reaction rate and overpotentials. Current-potential characteristics.**
5. **Classification of electroanalytical methods**
6. **Potentiometry. Ion-selective electrodes. Potentiometric titration.**
7. **Potential step methods – overview. Chronoamperometry – applications to reversible and irreversible electrode reactions.**
8. **Polarographic analysis. Pulse polarographic methods. Trace analysis applications.**
9. **Chronocoulometry. Diagnostic criteria for different reaction mechanisms.**
10. **Potential sweep methods. Linear and cyclic voltammetry. Applications to reversible, quasi-reversible and irreversible systems.**
11. **Controlled current methods. Chronopotentiometry. Analytical applications.**
12. **Hydrodynamic methods. Rotating disk electrode. Applications.**
13. **Impedance methods. Equivalent circuits. Chemical analysis by AC voltammetry.**
14. **Electrochemical instrumentation. Potentiostats. Galvanostats. *iR*-drop compensation.**

• Literature:

1. A.J.Bard, L.R.Faulkner, Electrochemical Methods: Fundamentals and Applications, John Wiley & Sons, NY, 1980.
2. Analytical Instrumentation Handbook, ed. by G.W.Ewing, Marcel Dekker, Inc., NY, 1990.
3. Instrumental Analysis, ed. by G.D.Christian and J.E.O'Reilly, Prentice Hall, 1993.
4. Radiometer Analytical, Trace Analysis using Voltammetry.

• Teaching methods: **Lectures, demonstrations, lab practice**
• Assessment methods: **Intermediate tests, final exam**
• Language of instruction: **Bulgarian, English**

ECTS Specification for the Module/Course Unit Descriptions *(from the "Key Features")*

• Course title: **Environmental Chemistry**
• Type of course: **Elective**
• Level of course:
• Semester/trimester: **Semester 1**
• Number of credits allocated (workload based) – **3 ECTS credits**
• Name of lecturer: **Mitko Stoev, Associated professor, Ph.D.**

• Objective of the course (expected learning outcomes and competences to be acquired): **This course is a part of application of Metrology in the field of Environmental Chemistry. The energy production, energy use and air, soil and water pollution are discussed. The main emissions from energy production, carbon dioxide and their environmental consequences are shown. The chemical explanation of the Greenhouse Effect and Global Warming is presented. Toxic organic compounds, heavy metals and the pollution of environments are included. The chemistry of natural water and purification of polluted water are discussed. The origins of waste and recycling processes are explained. Life cycle assessment and basics of environmental monitoring are shown. The main futures of application of metrology into Environmental Chemistry are included.**

• Prerequisites : **General requirements for the admission to the Master programme.**

Co-requisites**: Basics of Metrology**

• Course contents:

1. **Air and energy: Stratospheric Chemistry, Air pollution**
2. **Greenhouse Effect and Global Warming.**
3. **Energy use, CO_2, emissions, and their environmental consequences.**
4. **Toxic organic chemicals: pesticides, organochlorine insecticides, herbicides, PCBs.**
5. **Toxic heavy metals: mercury, lead, cadmium, arsenic.**
6. **Water: Chemistry of natural water, Purification of polluted water**
7. **Waste and contaminated soil management: wastes, soils and sediments**
8. **Recycling of household and commercial waste**
9. **Life cycle assessments**
10. **Environmental monitoring**
11. **Metrology and Environmental Chemistry**

• Literature:

1. G. Baird: „Environmental Chemistry“, University of Western Ontario, W. H. Freeman and Company, New York, 1998.
2. C. Mungall, D. J. McLaren: “The Challenge of Global Change”, Oxford University Press, Toronto, 1990.
3. A. Gore: “Earth and the Balance, Ecology and the Human Spirit”, Houghton Mifflin Press, New York, 1992.

• Teaching methods: **Multimedia, Online Internet Multilanguage e-platform (http://e-learning.swu.bg), Power Point presentation, Demonstrations**

• Assessment methods: **Tests – 40%, assignments – 30%, Laboratory work -30%**

• Language of instruction: **Bulgarian, English**

Specification for the Module/Course Unit Descriptions *(from the "Key Features")*

• Course title: **Organic spectroscopy**
• Type of course: **Elective**
• Level of course:
• Semester/trimester: **Semester 1**
• Number of credits allocated (workload based) – **3 ECTS credits**
• Name of lecturer: **Atanas Georgiev Chapkanov, Associated Professor, Ph.D.**
• Objective of the course (expected learning outcomes and competences to be acquired):
The proposed course Methods of Organic spectroscopy is semi optional for the students in Master of Science "Metrology in Chemistry" as a degree of education. The course objective is to introduce the students with the principals and specific application of spectral methods.

• Prerequisites :
For assimilation of the presented material as prerequisites is previous basic knowledge about analytical and organic chemistry, instrumental methods used for analysis of organic compounds and their practical application.

• Course contents:
Subject 1. Methods of molecular spectroscopy. Theory and principals. Electromagnetic spectrum
Subject 2. Normal and exited state of molecule. Electronic, vibrational and rotational state.
Subject 3. Electronic spectra of basic chromophores in organic chemistry.
Subject. 4. Vibrational spectrum of molecules. Group frequencies.
Subject. 5. Characteristic frequencies of basic functional group in the organic compounds.
Subject 6. Application of FT-IR spectroscopy and other specific techniques for analysis.
Subject 7. Emission spectral analysis. Fluorescence and phosphorescence spectroscopy. Principals and application in organic chemistry.

Practical exercises:
Subject 1. Sample preparation.
Subject 3. UV-VIS measurement in conjugated systems.
Subject 4. Characteristics frequencies in biological-active systems by FT-IR –spectroscopy.
Subject 5. Analysis of emission fluorescence spectra of organic compounds.

• Literature:
1. Spasov, St., Arnaudov, M., Application of spectroscopy in organic chemistry. *"Science &Art"*, Sofia, 1978.
2. Christian G., O'Reilly J., "Instrumental analysis", Second Edition, Prentice Hall, 1993, by Allyn & *Bacon*.
3. Christian G., Callis J., Davidson E., "Modern Fluorescence Spectroscopy", E. Wehry (ed.), Plenum Press, New York, 1981

• Teaching methods:
Lectures are 2 classes per week and illustrated with examples for solving problems related to analysis of organic compounds. For lectures presentation multimedia system are used. Students can be use the university library, INTERNET and consulting hours in their education.
• Assessment methods:

There are two tests during the teaching course witch ratings are in 20/80 percent ration with the final oral examination rating.

• Language of instruction: **Bulgarian, English**

ECTS Specification for the Module/Course Unit Descriptions *(from the "Key Features")*

• Course title: **Reliability of the environmental sampling**
• Type of course: **Elective**
• Level of course:
• Semester/trimester: **Semester 1**
• Number of credits allocated (workload based) – **3 ECTS credits**
• Name of lecturer: **Mihail Mihailov, Associated professor, Ph.D.**
• Objective of the course (expected learning outcomes and competences to be acquired): **The objects of the course are organization, methods and regulations of sampling procedures related to the environmental monitoring.**
• Prerequisites: **General requirements for the admission to the Master programme.**

• Course contents:

1. **Importance of the sampling as a part of environmental monitoring activities.**
2. **Characteristics of the sampling from objects of ecological assessments. Main points and methods.**
3. **Sampling procedure for air pollution control. Characteristics. Regulations and requirements.**
4. **Sampling procedure for surface waters investigations. Methods and regulations.**
5. **Sampling for assessment of ecological status of underground waters. Regulations and methods.**
6. **Sampling for analysis and ecological assessment of soils. Regulations and methods.**
7. **Sampling for assessment of the ecological influence of the solid waists. Regulations and methods.**
8. **Sampling for analysis and estimation of the noise and radiation loads. Characteristics and regulations.**
9. **Sampling for assessment of the status of protected nature areas. Characteristics and regulations.**
10. **Requirements for representativeness of sampling from ecological objects. Regulations, technical potential.**
11. **Organization of the sampling from objects and systems subject of ecological monitoring. Requirements and methods.**

• Literature:

1. **Environmental standards. ISO library.**
2. **Environmental management systems. Methodological guidelines.**
3. **Environmental assessments. General principles and support techniques.**

• Teaching methods: **Lectures, seminars, practical work, individual work.**
• Assessment methods: **Current control and final test.**
• Language of instruction: **Bulgarian, English**

ECTS Specification for the Module/Course Unit Descriptions *(from the "Key Features")*

• Course title: **Sample preparation in analytical chemistry.**
• Type of course: **Elective**
• Level of course:
• Semester/trimester: **Semester 1**
• Number of credits allocated (workload based) – **3 ECTS credits**
• Name of lecturer: **Petko Mandjukov, Associated professor, Ph.D., Elitsa Chorbadzhiyska Assistant professor**
• Objective of the course (expected learning outcomes and competences to be acquired): **General information for the commonly used methods for sample digestion, pre-concentration, matrix separation etc.**
• Prerequisites: **General requirements for the admission to the Master program.**

• Course contents:

1. **Statistical aspects of the sample preparation. Error propagation.**
2. **Sample drying, weighting, digestion methods.**
3. **Microwave digestions. Advantages and limitations.**
4. **Pre-concentration methods.**
5. **Sampling procedures and preservation of environmental samples.**
6. **Sample treatment for mobile forms determination.**
7. **Sample preparation for speciation analysis.**
8. **Matrix separation procedures.**
9. **Sample preparation in DNA analysis.**
10. **Selection of the proper sample preparation procedure. Cases from the analytical practice.**

• Literature:

1. **S. Mitra, Ed. *Sample Preparation Techniques in Analytical Chemistry.* Wiley-Interscience, 2003.**
2. **F. Settle, Ed. *Handbook of Instrumental Techniques for Analytical Chemistry.* Prentice Hall PTR, 1997.**
3. **F. Rouessac, A. Rouessac. *Chemical Analysis. Modern Instrumental Methods and Techniques.* John Wiley & Sons, 1998.**
4. **C. Herbert, R. Johnston, *Basics of Mass Spectrometry*, CRC Press, 2002.**
5. **D. Harvey. *Modern Analytical Chemistry.* Mc Graw-Hill Higher Education, 2000.**
6. ***Analytical Chemistry*, Editors: R. Kellner, J.-M. Mermet, M. Otto, H. Widmar, WILEY-VCH, 2002.**
7. **J. M. Hollas. *Modern Spectroscopy.* John Wiley & Sons, 2004.**

• Teaching methods: **Lectures, laboratory training, individual work.**
• Assessment methods: **Current control and final test with contribution to the final mark 40% and 60% respectively.**
• Language of instruction: **Bulgarian, English**

ECTS Specification for the Module/Course Unit Descriptions *(from the "Key Features")*

• Course title: **Specialized software /Statistical analysis of data with the help of IT (MS Excel, Statistica, SPSS)/**
• Type of course: **Elective**
• Level of course:
• Semester/trimester: **Semester 1**

• Number of credits allocated (workload based) – **3 ECTS credits**
• Name of lecturer: **Elena Karashtranova, Associated professor, Ph.D.**
• Objective of the course (expected learning outcomes and competences to be acquired): **The students should learn how to:**

- **Apply the methods of statistics in practice**
- **Realize concrete applications with the help of IT.**

• Prerequisites: **General requirements for the admission to the Master programme. Basic knowledge on Probability and statistics, Information Technology.**
• Course contents:

1. **Data Modeling**
2. **Measures of Central Tendency**
3. **Measures of Spread**
4. **The Distribution of Measurements and Results**
   - Populations and Samples
   - Probability Distributions for Populations
   - Confidence Intervals for Populations
   - Probability Distributions for Samples
   - Confidence Intervals for Samples
5. **Statistical Analysis of Data**
   - Significance Testing
   - Constructing a Significance Test
6. **Multivariate Analysis**
7. **Regression**
8. **Factor Analysis**
9. **Measuring Instruments and Their Properties**

• Literature:

1. **Richard G. Bereton, Data analysis for the laboratory and Chemical Plant, University of Bristol, UK**

• Teaching methods: **Seminars, tutorials, discussions, project based method.**
• Assessment methods: **Project- 30%, Final Test- 70%. The course is successful completed with at least 65% of all scores.**
• Language of instruction: **Bulgarian, English**

ECTS Specification for the Module/Course Unit Descriptions *(from the "Key Features")*

• Course title: **Condensed matter investigation methods**
• Type of course: **Elective**
• Level of course:
• Semester/trimester: **Semester 1**
• Number of credits allocated (workload based) – **3 ECTS credits**
• Name of lecturer: **Dimitrina Petrova Kerina, Associated professor, Ph.D.**
• Objective of the course (expected learning outcomes and competences to be acquired): **The course objective is to introduce the students with the main methods for the condensed matter experimental investigation.**
• Prerequisites : **A prerequisite for assimilation of the presented material are previous knowledge about chemical coupling in condensed matter; solid state's and liquid's structures; elastic, dielectric, magnetic and optical properties of the condensed matter; electron states in the crystals; band-gap structure and macroscopic dielectric polarization.**

• Course contents:

Subject 1. **Diffraction methods for structural investigations of the condensed matter – 8 classes**

Subject 2. **Elasticity properties of condensed matter determination – 2 classes**

Subject 3. **Measurement methods of the magnetic matter properties - 10 classes**

Subject 4. **Measurement methods of the dielectric medium properties – 4 classes**

Subject 5**: Measurement methods of some condensed matter's optical properties – 4 classes**

Subject 6. **Measurement methods of some superconductor's properties – 2 classes**

• Literature:

1. Apostolov, A., Experimental methods in solid state physics, *"Science $Art"*, Sofia, 1983.

2. Apostolov. A., Condensed matter physics, *Sofia University publishing house*, 1991.

3. Nai, D., Physical prorerties of the crystals, *Foreign literature*, Moskva, 1960.

• Teaching methods: **An ex cathedra method of teaching consists of 2 classes per week. Students can use the university library, INTERNET and consulting hours in their schooling.**

• Assessment methods: **There are two tests during the teaching course witch ratings are in 20/80 percent ratio with the final oral test rating.**

• Language of instruction: **Bulgarian, English**

ECTS Specification for the Module/Course Unit Descriptions *(from the "Key Features")*

• Course title: **Quality control and quality assurance**
• Type of course: **Obligatory**
• Level of course:
• Semester/trimester: **Semester 2**
• Number of credits allocated (workload based) – **6 ECTS credits**
• Name of lecturer: **Mario Mitov, Associated professor, Ph.D.**
• Objective of the course (expected learning outcomes and competences to be acquired): **An introduction to the theory and practice of the quality control and quality assurance of the analytical procedures.**
• Prerequisites: **General requirements for the admission to the Master program.**
• Course contents:

1. **Chemical analysis. International comparability of the results. Economic impact.**
2. **GLP concept.**
3. **Validation of analytical procedures.**
4. **Traceability of the measurement results. Definitions and terminology. Traceability hierarchy.**
5. **Primary analytical methods.**
6. **Statistics for analytical methods evaluation. Inter-laboratory comparisons. ANOVA.**
7. **Reference materials. Types of reference materials. Preparation of reference materials. Use of reference materials for validation and quality control.**
8. **Internal quality control (RM, CRM, standards, quality charts).**
9. **External quality assessment. Quality system. ISO documents.**
10. **Accreditation. Bulgarian and European regulations.**

• Literature:

1. ***International Vocabulary of basic and General terms in Metrology –ISO 1993.***
2. ***The Fitness for Purpose of Analytical Methods A Laboratory Guide to Method Validation and Related Topics. EURACHEM, LGC, Teddington, 1998.***
3. ***The Use of Matrix Reference Materials In Environmental Analytical Processes Eds.: A. Fajgelj, M. Parkany; RSC, Cambridge, 1999.***
4. ***The Use Of Recovery Factors In Trace Analysis Ed.: M. Parkany; RSC, Cambridge, 1996.***
5. ***Quality In The Food Analysis Laboratory R. Wood, A. Nilsson, H. Wallin; RSC, Cambridge, 1998.***
6. ***ISO 17025 General requirements for the competence of calibration and Testing Laboratories, 1999***
7. ***ISO Guide 30, 31, 33, 34 and 35 – Reference Materials***
8. ***Statistics for Analytical Chemistry - J.C. Miler and J.N. Miler***
9. ***ISO 3534-1 Statistics – Vocabulary and symbols***
10. ***ISO Guide 43 Proficiency Testing by InterLaboratory Comparisons***
11. ***ILAC Guide 13 Requirements for the Accreditation of Providers of Proficiency Testing Schemes***

• Teaching methods: **Lectures, seminars, individual work, problem-solving groups.**
• Assessment methods: **Course project and final examination with contributions to the final rank 60% and 40% respectively.**
• Languag of instruction: **Bulgarian, English**

ECTS Specification for the Module/Course Unit Descriptions *(from the "Key Features")*

• Course title: **Modern Analytical Chemistry**
• Type of course: **Obligatory**
• Level of course:
• Semester/trimester: **Semester 2**
• Number of credits allocated (workload based) – **6 ECTS credits**
• Name of lecturer: **Petko Mndjukov, Associated professor, Ph.D., Chorbadzhiyska Assistant professor**
• Objective of the course (expected learning outcomes and competences to be acquired): **The course aim is to introduce students to the basic concepts in the modern analytical chemistry; development of the instrumentation; new tasks; new techniques; solving of specific problems.**

• Prerequisites: **General requirements for the admission to the Master program.**

• Course contents:

1. **Instrumental methods for element analysis. Heavy metal pollution control. Mobile forms determination.**
2. **Speciation. Methods for determination of chemical forms. Limitations.**
3. **Theoretical approaches. Phase diagrams E/pH.**
4. **Mass spectrometry as a detecting method. Hyphenated techniques.**
5. **Specific calibration techniques. Isotope dilution. Isotope ratios determination.**
6. **Sample preparation approaches for trace analysis. Matrix separation.**
7. **Labeling methods. Application in the environmental and biochemical investigations.**
8. **Automatic analytical systems. Flow injection concept. Automatic environmental control stations.**
9. **Control of the environmental pollution with organic compounds.**

• Literature:

1. **F. Rouessac, A. Rouessac.** ***Chemical Analysis. Modern Instrumental Methods and Techniques.*** **John Wiley & Sons, 1998.**
2. **D. Harvey.** ***Modern Analytical Chemistry.*** **Mc Graw-Hill Higher Education, 2000.**
3. ***Analytical Chemistry,*** **Editors: R. Kellner, J.-M. Mermet, M. Otto, H. Widmar, WILEY-VCH, 2002.**
4. **Г. Крисчън, Дж. О'Рейли.** ***Инструментален анализ.*** **Унив. Изд. "Св. Кл. Охридски", София, 1998.**
5. **J. M. Hollas.** ***Modern Spectroscopy.*** **John Wiley & Sons, 2004.**
6. **Materials from INTERNET.**

• Teaching methods: **lectures, tutorials, individual student's work.**

• Assessment methods: **course project, laboratory tutorial mark, final test contributing 50%, 20% and 30% to the final mark respectively.**

• Language of instruction: **Bulgarian, English**

ECTS Specification for the Module/Course Unit Descriptions *(from the "Key Features")*

• Course title: **Laser spectroscopy**
• Type of course: **Elective**
• Level of course:
• Semester/trimester: **Semester 2**
• Number of credits allocated (workload based) – **3 ECTS credits**
• Name of lecturer: **Lyubomir Pavlov, Professor, D.Sc.**
• Objective of the course (expected learning outcomes and competences to be acquired): **i) new laser sources and quantum standards of frequencies, which consist a subject of development namely in Metrology, and in European Bureau of Standards and Measurement Science; ii) new experimental methods of space-temporally resolved laser spectroscopy; iii) applications of laser sources to atomic and molecular spectroscopy**
• Prerequisites: **General requirements for the admission to the Master programme.**
• Course contents:

1. **Lasers in metrology and coherent quantum standards of frequency.**
2. **Laser mode selection and experimental realization of single-mode lasers.**
3. **Resonant interaction of tuneable laser sources with atoms.**
4. **Laser photo-ionization spectroscopy. Practical applications.**
5. **Laser spectroscopy of Doppler-broadened transitions.**
6. **Laser spectroscopy of highly excited atoms. Applications of multiphoton absorption to atomic and molecular spectroscopy.**
7. **High resolution laser spectroscopy of collisional line broadening and line shifts.**
8. **Doppler-free laser spectroscopy of counter-propagating ultrashort laser pulses.**
9. **Picosecond laser spectroscopy of molecular dynamics in chemistry.**
10. **Applications of laser spectroscopy to diagnostics of atmosphere. Laser spectroscopy in meteorological remote sensing.**
11. **Methods of Coherent anti-Stokes Raman Spectroscopy (CARS) in experimental study of relaxation processes in molecules.**
12. **Polarization spectroscopy and line profiles of polarization signals.**
13. **Transient coherent effects in laser spectroscopy. Photon echoes.**
14. **Laser spectroscopy of bio-molecules. Pump-probe laser techniques in characterizing ultrashort decay in photosynthesis. Data processing of the obtained experimental results.**
15. **High resolution space-temporal spectroscopy in measurements of fundamental constants in atoms.**
16. **Laser cooling of ions. High resolution laser spectroscopy of cooled particles.**

• Literature:

1. **W.Demtroder – "Laser spectroscopy" – Springer series in Chemical Physics, vol. 5, Berlin-Heidelberg-New York, pp. 1 – 700 (1981).**
2. **J.Michael Hollas –"High resolution spectroscopy", John Wiley & Sons, Chichester-New York-Weinheim-Brisbane-Singapore-Toronto, pp. 1 - 743 (1998).**
3. **W.Persson, S.Svanberg –"Laser spectroscopy VIII" – Springer-Verlag, vol. 55, (1987).**
4. **A.R.W.McKellar, T.Oka, B.P.Stoicheff –"Laser spectroscopy V"- Springer-Verlag, volume 30 (1981).**
5. **R.Balian, S.Haroche, S.Liberman –"Frontiers in Laser spectroscopy"- North-Holland publishing company (1977).**
6. **D.C.Hanna, M.Yuratich, S.Cottert –"Nonlinear optics of free atoms and molecules"- Springer series in Optical Science, vol. 17 (1979).**

• Teaching methods: **Lectures**
• Assessment methods: **Final test**
• Language of instruction: **Bulgarian, English**

ECTS Specification for the Module/Course Unit Descriptions *(from the "Key Features")*

• Course title: **Chromatography**
• Type of course: **Elective**
• Level of course:
• Semester/trimester: **Semester 2**
• Number of credits allocated (workload based) – **3 ECTS credits**
• Name of lecturer: **Dancho Danalev, Head assistant professor, Ph.D.**
• Objective of the course (expected learning outcomes and competences to be acquired): **The objects of the course are theoretical basis and practical applications of the chromatographic techniques. Special attention is paid to the hyphenated techniques involving various chromatographic devices, as well as to specific application for element speciation analysis.**

• Prerequisites: **General requirements for the admission to the Master programme.**

• Course contents:
1. **Theory of column chromatography. Basic terms.**
2. **Optimization of the chromatographic separation.**
3. **Gas chromatography**
4. **High performance liquid chromatography**
5. **Ion chromatography**
6. **Practical application of the chromatography methods**
7. **Hyphenated techniques based on chromatographic separation**
8. **Speciation**

• Literature:
8. **D. Harvey.** ***Modern Analytical Chemistry.*** **Mc Graw-Hill Higher Education, 2000.**
9. ***Analytical Chemistry*****, Editors: R. Kellner, J.-M. Mermet, M. Otto, H. Widmar, WILEY-VCH, 2002.**
10. **P. Sadek.** ***Illustrated Pocket Dictionary of Chromatography.*** **John Wiley & Sons, 2004.**
11. **J. Cases, Ed..** ***Encyclopedia of Chromatography.*** **Marcel Dekker, 2005.**
12. **J. Cases, R. Scott.** ***Chromatography Theory.*** **Marcel Dekker, 2002.**

• Teaching methods: **Lectures, seminars, practical work, individual work with students.**
• Assessment methods: **Current control and final test.**
• Language of instruction: **Bulgarian, English**

ECTS Specification for the Module/Course Unit Descriptions *(from the "Key Features")*

• Course title: **Quantum Chemistry**
• Type of course: **Elective**
• Level of course:
• Semester/trimester: **Semester 2**
• Number of credits allocated (workload based) – **3 ECTS credits**
• Name of lecturer: **Jivko Velkov, Associated professor, Ph.D.**

• Objective of the course (expected learning outcomes and competences to be acquired):
Introduction to the basic concepts and methods in quantum chemistry and extension of the theoretical background in the field of molecular spectroscopy

• Prerequisites: **General requirements for the admission to the Master programme. Basic knowledge of structure of matter and instrumental methods for analysis.**

• Course contents:

LECTURES
1. One-electron approximation.
2. Ab initio methods. Types of orbital basis sets. DFT. Semi-empirical methods.
3. Energy spectrum of molecules.
4. General theory of quantum transitions.
5. Structure and energy spectrum of systems with translational symmetry.

PRACTICAL EXERCISES
1. Demonstration of programs.
2. Visualization of the theoretically calculated spectra and comparison to experimentally recorded ones.
3. Individual work on personal assignment – a specific molecule for each student.
4. Instructions for preparation of the term project.
5. Presentation of the term project and discussion of results.

• Literature:

1. **N. Tuytuylkov, Quantum Chemistry, Nauka i izkustvo, 1978 (in Bulgarian)**
2. **HyperChem 7.0 Reference Manual, Hypercube Inc., Gainesville FL, 2002**
3. **Gaussian 03W Reference manual, Gaussian Inc., Pittsburgh PA, 2003**
4. **G. Andreev, Molecular Spectroscopy, Plovdiv University, Plovdiv, 1999 (in Bulgarian).**

• Teaching methods: **Lectures and practical assignments. Term project**

• Assessment methods: **Written final exam and discussion. Written exam (60%) + term project (30%) + current control (10%). The results obtained during the practical exercises are submitted as written term project and presented/defended at the end of the semester to earn 30% of the final grade**.

• Language of instruction: **Bulgarian, English**

ECTS Specification for the Module/Course Unit Descriptions *(from the "Key Features")*

• Course title: **Renewable Energy Sources and Systems**
• Type of course: **Elective**
• Level of course:
• Semester/trimester: **Semester 2**
• Number of credits allocated (workload based) – **3 ECTS credits**

• Name of lecturer: **Mitko Stoev , Associated professor, Ph.D.**

• Objective of the course (expected learning outcomes and competences to be acquired): **The renewable energy sources and advanced technological system for sustainable energy utilization are discussed. The main futures of solar energy, wind energy, small hydropower, hydrogen energy, biomass and energy storage are presented in details. The sustainable solar energy potential and climate conditions in different climatic zones are analyzed for effective application of advanced technology for energy utilization. The standard measurement of climatic monitoring, physical and chemical monitoring of the environment are studied in details for effectively utilization of energy from renewable energy sources. The main points in theoretical analysis and testing of passive and active thermal solar energy, water desalination and purification and photovoltaic systems are included.**

• Prerequisites: **General requirements for the admission to the Master programme.**
Co-requisites**: Basics of Metrology**

• Course contents:

1. **Energy. Sustainable energy supply. Renewable energy sources.**
2. **Climate variation in different climatic zones. Solar radiation - the sun, solar spectrum, solar radiation, spectral distribution.**
3. **Solar energy and systems. Active and passive thermo systems.**
4. **Wind energy and systems. Wind generators.**
5. **Small hydropower and systems.**
6. **Biomass and systems.**
7. **Geothermal energy and systems.**
8. **Hydrogen energy and systems. Fuel cells and electrolysers.**
9. **Energy storage systems. Batteries and accumulation systems.**
10. **Energy efficiency of renewable energy systems. Measurements.**
11. **Environmental monitoring and renewable energy systems.**
12. **Metrology in renewable energy systems.**
13. **Energy applications from renewable energy systems in our life.**

• Literature:

1. R. Hill, Phil O'Keefe, C. Snape: "The Future of Energy Use", Earthscan Publications Ltd., London, 1996.
2. Godfrey Boyle: "Renewable Energy: Power for Sustainable Future", Oxford University Press, 1996.
3. L. D. Partain: "Solar cells and their applications", John Wiley & Sons, Inc. 1995
4. M. S. Imamura, P. helm, W. Palz: "Photovoltaic system technology: European Handbook", H. S. Stephens & Associaties, Brussels, 1992.
5. S. Kaplanis: "Technology of PV – Systems and Applications", Brasov, 2003.

• Teaching methods: **Multimedia, Online Internet Multilanguage e-platform (http://e-learning.swu.bg), Power Point presentation, Demonstrations**

• Assessment methods: **Tests – 40%, assignments – 60%**

• Language of instruction: **Bulgarian, English**