 Alexander Dubček University 

of Trenčín

**Centre for Functional and Surface Functionalized Glass- FunGlass**

**Study plans**

Continuing students

Academic year 2022/2023

**Characteristics of the study program and study plans**

**Name of the study program:** Inorganic technologies and non-metallicmaterials

**Name of the study field:** 16. Chemical engineering and technologies

**Training center:** Centre for Functional and Surface Functionalized Glass

**Study degree:** III.

**Academic title awarded**: Philosophiae doctor in short PhD.

**Study form:** daily/ external

**Study lenght:** 4 years/ 5 years

**Guarantor of the study program:** prof. Dušan Galusek, DrSc.

**Graduate profile:**

Graduates of PhD study program in the area of Inorganic Technology and Non-metallic Materials gain deep knowledge on scientific methods of research related to preparation of new types of non-metallic inorganic materials, with special focus on glass, ceramics, and surface modification of a broad range of various materials, including biomaterials. Graduates are able to solve problems related to inorganic technologies, development and characterization of new materials. They have special knowledge in the area of glass, inorganic binders, ceramic and refractory materials and inorganic additives. They have deep theoretical knowledge in the field of thermodynamics and kinetics and are capable of solving challenging engineering problems in technical practice. Graduates understand methods of studying structures as well as materials characteristics.

**From the graduate's point of view, the study program offers a wide range of prospective employment in:**

- research and development in academic institutions in the Slovak Republic, in particular:

* in universities providing education in materials and chemical technologies,
* on SAS institutes dealing with research in the field of materials and chemical technologies,

industrial companies in glass production, but also in companies producing refractory materials and inorganic binders (cement plants) in various positions, from foremen, technologists and production managers, to researchers in industrial development in the field and workers in application and operation laboratories. Potential employers in Slovakia are: RONA, a.s. Lednické Rovne; Vetropack Nemšová; Johns Manville Slovakia, Trnava; Knauff Insulation, Nová Baňa; Medical Glass, Bratislava; PPC Insulators, Čáb; Cementáreň Ladce; CEMMAC, Horné Srnie;....

Due to the experience of working in an international environment in a training workplace, the employment is not limited to employers in the Slovak Republic only, but ensures the possibility of employment on the European labour market.

Study program: **Inorganic technologies and non-metallic materials- III. degree**

Study form: **Daily**

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| Year of study: | **1** |  |  |  |  |  |  |  |
| Semester: | **Winter** |  |  |  |  |  |  |  |
| **Subject type** | | **Code** | **Subject** | **Credits** | **E -Exam NG – Non Graded** | **Scope per week** | | **Prerequisites** |
| **L** | **EA** |
| CS | **PrS** | CPV/atAnCh1d/21 | Inorganic Chemistry | 7 | E | 4 | 10 | Not necessary |
| CS | **PrS** | CPV/atFCHd/21 | Physical Chemistry | 8 | E | 2 | 14 | Not necessary |
| CS | **PrS** | CPV/atAMaTVd/21 | Inorganic materials and their production technologies | 8 | E | 2 | 14 | Not necessary |
| CS | **PrS** | CPV/atAnJd/21 | English Language | - | NG | 2 | - | Not necessary |
| Scientific part | |  |  |  |  |  |  |  |
| PP |  | CPV/atExP1d/21 | Experimental work | 10 | NG |  | 13 | Not necessary |
|  |  |  |  |  |  |  |  |  |
| Semester: | **Summer** |  |  |  |  |  |  |  |
| **Subject type** | | **Code** | **Subject** | **Credits** | **E -Exam NG – Non Graded** | **Scope per week** | | **Prerequisites** |
| **L** | **EA** |
| CES | **PrS** | CPV/atAlyChd/21 | Analytical Chemistry | 5 | E | 2 | 8 | Inorganic chemistry, Inorganic materials and their production technology |
| CES |  | CPV/ChTTvSd/21 | Glass production technology | 5 | E | 2 | 8 | Inorganic materials and their production technology |
| CES |  | CPV/atKold/21 | Colloid | 5 | E | 2 | 8 | Physical Chemistry |
| CES |  | CPV/atMoSpd/21 | Molecular Spectroscopy | 5 | E | 2 | 8 | Physical Chemistry |
| CES |  | CPV/atAnNmd/21 | Inorganic nanomaterials | 5 | E | 2 | 8 | Inorganic materials and their production technology |
| CES |  | CPV/atApSd/21 | Applied statistics | 5 | E | 2 | 8 | Not necessary |
| CS |  | CPV/atAnJd/21 | EnglishLanguage | 7 | E | 2 | 10 | Not necessary |
| Scientific part | |  |  |  |  |  |  |  |
| CS |  | CPV/atExP2d/21 | Experimental work II | 15 | NG |  | 20 | Experimental work I |
| **Obligation to obtain the number of credits** | | | | **60** | **5xE + 3xNG** | **14** | **59** |  |

CS-compulsory subject, CES-compulsory elective subject, PrS-profile subject, L-lecture, EA-educational activity

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year: | **2** |  |  |  |  |  |  |  |
| Semester: | **Winter** |  |  |  |  |  |  |  |
| **Subject type** | | **Code** | **Subject** | **Credits** | **E -Exam NG – Non Graded Exam** | **Scope per week** | | **Prerequisites** |
| **L** | **EA** |
| Scientific part | |  |  |  |  |  |  |  |
| CS |  | CPV/atExP3d/21 | Experimental work III | 20 | NG |  | 25 | Experimental work II |
|  |  |  |  |  |  |  |  |  |
| Semester: | **Summer** |  |  |  |  |  |  |  |
| **Subject type** | | **Code** | **Subject** | **Credits** | **E -Exam NG – Non Graded Exam** | **Scope per week** | | **Prerequisites** |
| **L** | **EA** |
| CS |  | CPV/DSd/21 | Dissertation exam | 15 | E |  | 20 | all compulsory, and selected compulsory elective subjects |
| Scientific part | |  |  |  |  |  |  |  |
| CS |  | CPV/atExP4d/21 | Experimental work IV | 20 | NG |  | 23 | Experimental work III |
| CS |  | CPV/atMK1d/21 | Active participation in an international conference I | 5 | NG |  | 8 | Experimental work I to III, English Language |
| **Obligation to obtain the number of credits** | | | | **60** | **1xE + 3xNG** |  | **76** |  |

CS-compulsory subject

L-lecture

EA- educational activity

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year: | **3** |  |  |  |  |  |  |  |
| Semester: | **Winter** |  |  |  |  |  |  |  |
| **Subject type** | | **Code** | **Subject** | **Credits** | **E -Exam NG – Non Graded Exam** | **Scope per week** | | **Prerequisites** |
| **L** | **EA** |
| Scientific part | |  |  |  |  |  |  |  |
| CS |  | CPV/atExP5d/21 | Experimental work V | 25 | NG |  | 30 | Experimental work IV |
|  |  |  |  |  |  |  |  |  |
| Semester: | **Summer** |  |  |  |  |  |  |  |
| **Subject type** | | **Code** | **Subject** | **Credits** | **E -Exam NG – Non Graded Exam** | **Scope per week** | | **Prerequisites** |
| **L** | **EA** |
| Scientific part | |  |  |  |  |  |  |  |
| CS |  | CPV/atExP6d/21 | Experimental work VI | 22 | NG |  | 27 | Experimental work V |
| CS |  | CPV/atMK2d/21 | Active participation in an international conference II | 5 | NG |  | 8 | Experimental work I to V, English Language |
| CS |  | CPV/atPČ1d/21 | Publishing activity I | 8 | NG |  | 14 | Experimental work I to V, English Language |
| **Obligation to obtain the number of credits** | | | | **60** | **4xNG** |  | **79** |  |

CS-compulsory subject

L- lecture

EA- educational activity

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year: | **4** |  |  |  |  |  |  |  |
| Semester | **Winter** |  |  |  |  |  |  |  |
| **Subject type** | | **Code** | **Subject** | **Credits** | **E -Exam NG – Non Graded Exam** | **Scope per week** | | **Prerequisites** |
| **L** | **EA** |
| Scientific part | |  |  |  |  |  |  |  |
| CS |  | CPV/atExP7d/21 | Experimental work VII | 25 | NG |  | 30 | Experimental work VI |
|  |  |  |  |  |  |  |  |  |
| Semester | **Summer** |  |  |  |  |  |  |  |
| **Subject type** | | **Code** | **Subject** | **Credits** | **E -Exam NG – Non Graded Exam** | **Scope per week** | | **Prerequisites** |
| **L** | **EA** |
| CS |  | CPV/atPDPd/21 | Dissertation project | 17 | NG |  | 25 | Experimental work I-VII, Active participation in international conference I and II, Publishing activity I and II |
| CS |  | CPV/atODPd/21 | Defense of the dissertation | 10 | E |  | 15 | Experimental work I-VII  Active participation in international conference I and II, Publishing activity I and II,  Dissertation thesis project |
| Scientific part | |  |  |  |  |  |  |  |
| **Subject type** | | **Code** | **Subject** | **Credits** | **E -Exam NG – Non Graded Exam** | **Scope per week** | | **Prerequisites** |
|  | **L** | **EA** |
| CS |  | CPV/atPČ2d/21 | Publishing activity II | 8 | NG |  | 14 | Experimental work I to VII, English language, Publishing activity I |
| **Obligation to obtain the number of credits** | | | | **60** | **1xE + 3xNG** |  | **84** |  |
| **Number of credits for the whole study** | | | | **240** |  |  |  |  |

Study program: **Inorganic technologies and non-metallic materials- III. degree**

Study form: **External**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year: | **1** |  |  |  |  |  |  |  |
| Semester: | **Winter** |  |  |  |  |  |  |  |
| **Subject type** | | **Code** | **Subject** | **Credits** | **E -Exam NG – Non Graded Exam** | **Scope per week** | | **Prerequisites** |
| **L** | **EA** |
| CS | **PrS** | CPV/atAnCh1d/21 | Inorganic Chemistry | 7 | E | 4 | 10 | Not necessary |
| CS | **PrS** | CPV/atFCHd/21 | Physical Chemistry | 8 | E | 2 | 14 | Not necessary |
| CS | **PrS** | CPV/atAMaTVd/21 | Inorganic materials and their production technologies | 8 | E | 2 | 14 | Not necessary |
| CS | **PrS** | CPV/atAnJd/21 | English Language | - | NG | 2 | - | Not necessary |
| Scientific part | |  |  |  |  |  |  |  |
| CS |  | CPV/atExP1d/21 | Experimental work I | 10 | NG |  | 10 | Not necessary |
|  |  |  |  |  |  |  |  |  |
| Semester: | **Summer** |  |  |  |  |  |  |  |
| **Subject type** | | **Code** | **Subject** | **Credits** | **E -Exam NG – Non Graded Exam** | **Scope per week** | | **Prerequisites** |
| **L** | **EA** |
| CES | **PrP** | CPV/atAlyChd/21 | Analytical Chemistry | 5 | S | 2 | 8 | Inorganic chemistry, Inorganic materials and their production technology |
| CES |  | CPV/ChTTvSd/21 | Glass production technology | 5 | S | 2 | 8 | Inorganic materials and their production technology |
| CES |  | CPV/atKold/21 | Colloid | 5 | S | 2 | 8 | Physical Chemistry |
| CES |  | CPV/atMoSpd/21 | Molecular Spectroscopy | 5 | S | 2 | 8 | Physical Chemistry |
| CES |  | CPV/atAnNmd/21 | Inorganic nanomaterials | 5 | S | 2 | 8 | Inorganic materials and their production technology |
| CES |  | CPV/atApSd/21 | Applied statistics | 5 | S | 2 | 8 | Not necessary |
| CS |  | CPV/atAnJd/21 | EnglishLanguage | 7 | S | 2 | 10 | Not necessary |
| Scientific part | |  |  |  |  |  |  |  |
| CS |  | CPV/atExP2d/21 | Experimental work II | 15 | NG |  | 20 | Experimental work I |
| **Obligation to obtain the number of credits** | | | | **60** | **5xE + 3xNG** | **14** | **75** |  |

CS-compulsory subject, CES-compulsory elective subject, PrS-profile subject, L-lecture, EA-educational activity

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| Year: | **2** |  |  |  |  |  |  |  |
| Semester: | **Winter** |  |  |  |  |  |  |  |
| **Subject type** | | **Code** | **Subject** | **Credits** | **E -Exam NG – Non Graded Exam** | **Scope per week** | | **Prerequisites** |
| **L** | **EA** |
| Scientific part | |  |  |  |  |  |  |  |
| CS |  | CPV/atExP3d/21 | Experimental work III | 20 | NG |  | 25 | Experimental work II |
|  |  |  |  |  |  |  |  |  |
| Semester: | **Summer** |  |  |  |  |  |  |  |
| **Subject type** | | **Code** | **Subject** | **Credits** | **E -Exam NG – Non Graded Exam** | **Scope per week** | | **Prerequisites** |
| **L** | **EA** |
| CS |  | CPV/DSd/21 | Dissertation exam | 15 | E |  | 20 | all compulsory, and selected compulsory elective subjects |
| Scientific part | |  |  |  |  |  |  |  |
| CS |  | CPV/atExP4d/21 | Experimental work IV | 20 | NG |  | 30 | Experimental work III |
| CS |  | CPV/atMK1d/21 | Active participation in an international conference I | 5 | NG |  | 8 | Experimental work I to III, English Language |
| **Obligation to obtain the number of credits** | | | | **60** | **1xE + 3xNG** |  | **76** |  |

CS-compulsory subject,

L- lecture, EA-educational activity

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year: | **3** |  |  |  |  |  |  |  |
| Semester: | **Winter** |  |  |  |  |  |  |  |
| **Subject type** | | **Code** | **Subject** | **Credits** | **E -Exam NG – Non Graded Exam** | **Scope per week** | | **Prerequisites** |
| **L** | **EA** |
| Scientific part | | | | | | | | |
| CS |  | CPV/atExP5d/21 | Experimental work V | 14 | NG |  | 18 | Experimental work IV |
|  |  |  |  |  |  |  |  |  |
| Semester: | **Summer** |  |  |  |  |  |  |  |
| **Subject type** | | **Code** | **Subject** | **Credits** | **E -Exam NG – Non Graded Exam** | **Scope per week** | | **Prerequisites** |
| **L** | **EA** |
| Scientific part | | | | | | | | |
| CS |  | CPV/atExP6d/21 | Experimental work VI | 14 | NG |  | 18 | Experimental work V |
| **Obligation to obtain the number of credits** | | | | **28** | **2xNG** | **0** | **36** |  |

CS-compulsory subject

L-lecture, EA-educational activity

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year: | **4** |  |  |  |  |  |  |  |
| Semester: | **Winter** |  |  |  |  |  |  |  |
| **Subject type** | | **Code** | **Subject** | **Credits** | **E -Exam NG – Non Graded Exam** | **Scope per week** | | **Prerequisites** |
| **L** | **EA** |
| Scientific part | | | | | | | | |
| CS |  | CPV/atExP7d/21 | Experimental work VII | 14 | NG |  | 30 | Experimental work VI |
|  |  |  |  |  |  |  |  |  |
| Semester: | **Summer** |  |  |  |  |  |  |  |
| **Subject type** | | **Code** | **Subject** | **Credits** | **E -Exam NG – Non Graded Exam** | **Scope per week** | | **Prerequisites** |
| **L** | **EA** |
| CS |  | CPV/atExP8d/21 | Experimental work VIII | 15 | NG |  | 20 | Experimental work VII |
| CS |  | CPV/atMK2d/21 | Active participation in an international conference II | 5 | NG |  | 8 | Experimental work I to VII, English Language |
| CS |  | CPV/atPČ1d/21 | Publishing activity I | 8 | NG |  | 14 | Experimental work I to VII, English Language |
| **Obligation to obtain the number of credits** | | | | **42** | **4xNG** | **0** | **60** |  |

CS-compulsory subject, L-lecture, EA-educational activity

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year: | **5** |  |  |  |  |  |  |  |
| Semetser: | **Winter** |  |  |  |  |  |  |  |
| **Subject type** | | **Code** | **Subject** | **Credits** | **E -Exam NG – Non Graded Exam** | **Scope per week** | | **Prerequisites** |
| **L** | **EA** |
| Scientific part | | | | | | | | |
| CS |  | CPV/atExP9d/21 | Experimental work IX | 15 | NG |  | 20 | Experimental work VIII |
|  |  |  |  |  |  |  |  |  |
| Semester: | **Summer** |  |  |  |  |  |  |  |
| **Subject type** | | **Code** | **Subject** | **Credits** | **E -Exam NG – Non Graded Exam** | **Scope per week** | | **Prerequisites** |
| **L** | **EA** |
| CS |  | CPV/atPDPd/21 | Dissertation project | 17 | NG |  | 25 | Experimental work I-VII, Active participation in international conference I and II, Publishing activity I and II |
| CS |  | CPV/atODPd/21 | Defense of the dissertation | 10 | E |  | 15 | Experimental work I-VII  Active participation in international conference I and II, Publishing activity I and II,  Dissertation thesis project |
| Scientific part | | | | | | | | |
| CS |  | CPV/atPČ2d/21 | Publishing activity II | 8 | NG |  | 14 | Experimental work I to VII, English Language, Publishing activity I |
| **Obligation to obtain the number of credits** | | | | **50** | **1xE+3xNG** | **0** | **74** |  |
| **Number of credits for the whole study** | | | | **240** |  |  |  |  |

CS-compulsory subject, L-lecture, EA-educational activity

Subject annotations:

***Analytical Chemistry***

Knowledge of current instrumental analytical chemistry. Analytical methods used to determine elemental and phase composition in materials research. Sampling, mechanical, physical and chemical treatment of the sample for analysis. ICP spectroscopic methods used in the characterization of materials: (inductively coupled plasma optical emission spectrometry (ICP OES), inductively coupled plasma mass spectrometry (ICP MS), laser ablation (LA ICP MS) X-ray fluorescence spectrometry (XRF). Electron microscopy ( SEM) used in the characterization of materials. Use of X-rays in the characterization of materials (Powder methods. Principle and their applications in the identification of substances and determination of their structure. Characterization of thin films and nanoparticles (SAXS, WAXS, texture, residual stresses).

***English Language***

Multiculturalism in the scientific community, aspects of international communication, respecting different cultural environments, ethnicity + norms of social behavior for different situations. Specifics of informal and formal language and its use in professional communication (characteristics for colloquial and professional language), specifics of academic / technical English. Grammatical patterns - morphological and syntactic analysis, perception of English as an interactive means of communication, nonverbal communication and polysemy for expressions in colloquial and professional style. Oral expression (speaking) - public oral expression in the academic context of the English language (primary role of oral expression - interpretation vs. conversation), audiovisual aids. Basic pillars of academic written expression ("Informed texts", stylistic principles, text organization, including abstracts, annotations, structure, academic integrity ...). Latin and foreign language expressions in professional language (calculation, interlingual homonyms, paronyms). Work with compound expressions in professional English, simplification of technical text.

***Inorganic Chemistry***

Introduction to chemistry, basic terms and definitions: (Enthalpy of chemical reaction, Gibbs energy of chemical reaction, Equilibrium of chemical reactions, Kinetics of chemical reactions). Types of chemical reactions: (Proteolytic reactions, hydrolysis and solvolysis reactions, Complex-forming reactions, Precipitation reactions, Oxidation-reduction reactions, Heterogeneous reactions). Atom structure and chemical bonding theory, Atomic models, basic building blocks of an atom. Chemical bonding in solids. The relationship between the structure of the electron shell of the element and its position in the periodic table. Relationship between the structure of the electron shell of the element and its chemical properties. Chemistry of s-elements and p-elements. Chemistry of d-element and f-element compounds. Chemistry of biogenic elements and ions with therapeutic effects. Chemistry of selected chemical compounds. Oxide chemistry, chemistry of precursor preparations of inorganic materials and glass. Chemistry of sol-gel preparations of inorganic materials and glass

***Inorganic materials and their production technologies***

Basic principles of academic ethics and scientific work. Materials: natural and synthetic materials, raw materials, distribution, use, structure and microstructure. Phase equilibria, phase diagrams and their use in the preparation of materials. Methods and procedures used in the production of materials. Technological steps in the preparation of materials I: synthesis, treatment and characterization of input raw materials. Technological steps in the preparation of materials II: shaping. Technological steps in the preparation of materials III: sintering. Key properties of materials I: mechanical properties and methods of their measurement. Key properties of materials I: functional properties and methods of their measurement. Ceramic materials: division and properties of advanced ceramics, transparent ceramics. Biomaterials - bioinert, bioactive, bioresorbable materials. Functional coatings - chemical and physical methods of application and characterization of coatings.

***Inorganic nanomaterials***

Introduction to nanotechnology, nanoscience. Colloidal systems and their stabilization. Micellar systems, microemulsion, miniemulsion and emulsion polymerization. Mechanism of growth and stabilization of nanoparticles. Properties of nanoparticle surfaces and their modification. 0,1,2 and 3 dimensional particles and their associates. Sol-gel procedures for the preparation of nanomaterials. Preparation of nanomaterials by hydrolysis and solvolysis of salts. Preparation of metal, oxide and composite nanoparticles. Microemulsion process, reduction of metal salts in the presence of surfactants. Preparation of semiconductor nanoparticles. Preparation and modification of carbon nanomaterials. Nanosensors and nanoconjugates.

***Applied Statistics***

Variables and their properties, types of variables and their characteristics. Parameters of basic - descriptive statistics, the importance of normality of data distribution. Experiment design from the aspect of statistics, target population, sample, selection criteria. Working hypotheses, formulation of null and alternative hypotheses. Point and interval estimates of statistical parameters. Significance level, error I. and II. kind, p-value of the test criterion. Parametric tests - general principles, advantages and weaknesses. Nonparametric tests - general principles, comparison with parametric tests. Interpretation of the p-value of the test criterion of the statistical test from the aspect of the investigated phenomenon. Examples of variables from the field, characteristics of their properties, phenomena and their probability. Examples of experiment design, determination of the required number of tested set of samples. Postulation of null and alternative hypotheses according to the nature of the tested variables. Execution of data collection and calculation of descriptive statistics of monitored numerical variables. Verification of normality of data distribution and homogeneity of variances of tested variables.

***Physical Chemistry***

Fundamentals of thermodynamics, phase equilibria, equilibria of chemical reactions, chemical kinetics, transport processes, electrochemistry, fundamentals of chemical physics, physical chemistry of surfaces. Ad hoc topics according to the focus of the dissertation project.

***Colloid***

Basic definitions and concepts of colloid chemistry and surface chemistry. Surface phenomena and structure of the phase interface. Adsorption phenomena at the mobile phase interface. Adsorption isotherms. Surfactants and inactive substances. Adsorption phenomena at the solid phase interface. Adsorption at the interface of condensed phases. Molecular kinetic properties of dispersion systems - Brownian motion, diffusion. Sedimentation in dispersion systems and sedimentation methods of dispersion analysis. Sedimentation-diffusion equilibrium in dispersion systems. Thermodynamics of solutions, osmosis and membrane equilibria. Rheological properties of dispersion systems - viscosity. Optical properties of dispersion systems - light scattering. Electrical properties of dispersion systems - electric bilayer, electrokinetic phenomena, electrocapillary phenomena.

***Molecular spectroscopy***

Basic definitions and terms used in spectroscopy. Electromagnetic radiation, interaction of electromagnetic radiation with matter. Theoretical foundations of spectroscopy (Schrödinger time equation; quantum mechanical description of energy states of atoms and molecules; spectral terms; Einstein's phenomenological theory of radiation-substance interaction; shape, width of spectral bands and intensity of quantum transitions). Experimental bases of spectroscopic methods. Atomic absorption spectrometry (theoretical basis, instrumentation in AAS), Atomic fluorescence spectrometry. Optical atomic emission spectrometry (theoretical foundations, instrumentation in OAES). UV-VIS-NIR spectroscopy (theoretical basis - Lambert-Beer law; types of electron transitions; electron transitions in ions of transition and rare earth elements; probability of spectral transitions and absorption intensity; selection rules; Frank-Condon principle; environmental influence) matrix) for spectral band shift.

***Glass production technology***

History of glass and introduction to glass production. Definition of glass, structure of glass, composition, crystallization, phase separation. Properties of glass and glass-forming melt: (viscosity, density, surface tension, thermal properties, electrical properties, optical properties. Technology: basic raw materials, types of glass, special glasses, melting and shaping, furnace technology, refractory materials, defects in glass, additive production, ion exchange.

***Active participation in an international conference I a II***

Study of professional literature according to the supervisor's recommendation and according to one's own choice. Processing of results and preparation of a presentation or postage. Presentation of results at an international conference. Consultation with a trainer / specialist trainer.

***Defense of the dissertation***

Preparation of a presentation for the defense of the dissertation. Individual consultations with a trainer / specialist trainer as required. Presentation of the dissertation before the Commission for the defense of dissertations at the training workplace, answering the questions of the opponents, as well as answering the questions asked in the public debate by the members of the commission and the professional public.

***Dissertation exam***  
Study of professional literature related to the topic of the dissertation. Analysis of studied knowledge. Preparation and writing of dissertations. On the basis of the latest knowledge gained from the study and in consultation with the supervisor / trainer specialist, specification of the objectives of the dissertation. Preparation of a presentation for the dissertation exam, including preparation of answers to the opponent's questions.

***Dissertation project***

Analysis and statistical analysis of the obtained results. Interpretation of the obtained results and synthesis of conclusions. If necessary, individual consultations with a trainer / specialist trainer. Writing a dissertation in the form of a scientific dissertation on a topic defined in an individual study plan. Presentation of the dissertation (so-called discharge) in front of the members of the academic community of the training workplace.

***Experimental work I-IX***

Training in the ethics of scientific work. Training on the basics of good laboratory practice. Study of professional literature according to the supervisor's recommendation and according to one's own choice. Training to work with the experimental equipment needed for the dissertation project according to the supervisor's recommendation and according to one's own choice. Experimental work in the laboratory. Consultation with a trainer / specialist trainer.

***Publishing activity I a II***

Ethics of publishing results in the professional press. Study of professional literature according to the supervisor's recommendation and according to one's own choice. Processing of results and preparation of manuscript. Sending the manuscript to the press. Consultation with a trainer / specialist trainer.