QUALIFICATION PROFILE

Doctoral Program: DOCTORAL PROGRAM: "PHYSICAL CHEMISTRY"

Field of higher education: 4. NATURAL SCIENCES, MATHEMATICS AND INFORMATICS

Professional field: 4.2. CHEMICAL SCIENCES

Program Objective

The doctoral program "Physical Chemistry", within professional field 4.2. Chemical Sciences, prepares highly qualified specialists in the field of physicochemical analysis of substances and materials. The program combines in-depth theoretical preparation with experimental research, carried out under the supervision of experienced academic staff and utilizing state-of-the-art scientific equipment available in the laboratories of the Institute of Optical Materials and Technologies – Bulgarian Academy of Sciences (IOMT-BAS).

Form and Duration of Study

- Full-time learning: up to 3 years
- Distance learning: up to 4 years
- Independent learning: up to 5 years

Main Research Areas

The doctoral program in *Physical Chemistry* encompasses a wide range of contemporary research topics, addressing both fundamental and applied aspects of interactions between chemical substances, phase transitions, surface phenomena, and molecular structures. Key areas of study include:

- Thermodynamics and phase studies – investigation of equilibrium and non-equilibrium states, phase transitions and diagrams, thermochemical analysis and calorimetry of materials;
- Chemical kinetics and reaction mechanisms – study of reaction rates and pathways, influence of catalysts and environmental conditions, methods for identifying intermediates and transition states;
- Molecular spectroscopy and spectrometry – application of infrared (IR), ultraviolet-visible (UV-Vis), Raman, nuclear magnetic resonance (NMR), mass spectrometry, and other techniques for structural, dynamic, and state analysis of molecules;
- Techniques for determining crystal structure, morphology, and phase composition – X-ray diffraction (XRD), optical microscopy, scanning (SEM) and transmission (TEM) electron microscopy;

- Surface and interfacial physicochemistry – analysis of adsorption, wetting, capillary phenomena, contact angles, surface chemistry, and intermolecular interactions;
- Colloidal and nano-physical chemistry – synthesis, stability, and characterization of colloidal solutions, nanoparticles, and nanomaterials, including their interactions with various media;
- Solid-state physical chemistry – research on crystal structures, defects, phase transitions, magnetism, and electrical properties of solid materials, including ionic and electronic conductivity;
- Modeling and computational chemistry – use of quantum chemical and molecular dynamics methods for simulating chemical processes and the behavior of substances in different environments;
- Physical chemistry of biologically relevant molecules – analysis of proteins, DNA, lipids, and biopolymers, as well as their interactions with nanomaterials, membranes, and drugs;
- Photophysical and photochemical processes – study of absorption, fluorescence, photochemical reactions, and light–matter interactions in the context of photocatalysts, sensors, optoelectronic devices, etc.;
- Development of novel analytical methods and sensor technologies – creation of highly sensitive methods for detection and quantification of chemical substances using optical, spectroscopic, and electrochemical techniques.

Due to its interdisciplinary nature, the program's research activities have applications in materials science, nanotechnology, environmental science, pharmacy, energy, biomedicine, agriculture, food science, and industrial chemistry.

Learning Objectives

- To develop in-depth knowledge in physical chemistry and related scientific disciplines;
- To master modern experimental and theoretical methods for the analysis of chemical systems;
- To prepare for independent scientific and applied research activity;
- To encourage participation in national and international scientific projects and forums.

Acquired Knowledge and Skills

Graduates of the *"Physical Chemistry"* doctoral program will acquire the following competencies:

- In-depth knowledge of physical chemistry, including structural characterization, thermodynamics, kinetics, and spectroscopy;
- Understanding of the capabilities and applications of modern scientific methods and instrumentation used in chemical research;
- Skills in conducting and interpreting highly precise experimental work;
- Ability to use modeling and simulation to describe chemical processes and properties of substances;
- Proficiency in scientific communication in a foreign language, including writing and presenting scientific publications;

- Capacity to apply interdisciplinary approaches and analytical thinking in solving complex scientific and technological problems.

Career Opportunities

Graduates holding a PhD degree in "Physical Chemistry" are qualified to pursue professional realization in the following areas:

- Scientific research – at the Bulgarian Academy of Sciences, universities, and international scientific institutes in chemistry, physics, pharmacy, and materials science;
- Academic teaching – at universities and higher education institutions in disciplines related to physical, analytical, and theoretical chemistry;
- Development and applied research – in laboratories and companies in the chemical, pharmaceutical, energy, and electronics industries;
- Consulting and expert activities – in the fields of qualitative and quantitative analysis, chemical quality control, and product certification;
- Participation in international scientific programs, mobility schemes, and postdoctoral specializations – such as Horizon Europe, Marie Skłodowska-Curie Actions (MSCA), COST, and others.