**«Synthesis of nanostructured materials»**

1. **The name of the educational program in which the discipline is read: Master's program "Nanoscale Structure of Materials" in the direction 03.04.02 "Physics".**
2. **Total labor intensity**

According to the Working curriculum for full-time masters in the direction 03.04.02 "Physics" of the master's program "Nanoscale structure of materials" for the discipline "Concepts of synthesis of nanomaterials" there are only 216 hours; of these, 18 hours of lectures, 36 hours of laboratory work, 126 hours of independent work by students.

1. **Place of discipline in the structure of the educational program**

The discipline "Concepts of synthesis of nanomaterials" (Б1. ДВ5) refers to the Disciplines of choice Block 1 "Disciplines of choice." To study this academic discipline, the following knowledge, skills and abilities formed by previous disciplines are needed: "Condensed matter physics", "Symmetry and properties of new materials", "Methods of diagnosing materials". Formed by this academic discipline knowledge, skills and abilities will be required in the subsequent study of such disciplines as "Concepts of nanomaterials synthesis", "Research methods in biophysics".

1. **Purpose of studying the discipline**

The purpose of mastering the discipline "Synthesis of nanostructured materials" is to develop students' knowledge in the field of methods for the synthesis of nanostructured materials for energy and medicine.

1. **Requirements for the results of mastering the discipline**

The process of studying the discipline is aimed at the formation of elements of the following competencies in accordance with the ФГОС ВО and ОП ВО in this area of training. In particular, the formation of common cultural competencies ОК-1 and ОК-З, general professional competencies of ОПК-1, ОПК-З, ОПК-4, professional competencies of ПК-З and ПК-5.

1. **Content of the discipline**

**Module 1. "Nanostructured materials for energy."**

***Topics:***

Basic concepts of nanotechnology. The influence of size effects on the physico-chemical properties of materials. The main areas of use of nanostructured materials.

Ways to get energy. Electrochemical energy sources: advantages and achievements. Chemical current sources (CCS): principle of operation, classification, main processes and quantitative characteristics. Lithium power sources. Electrodes in lithium-ion batteries. The concept of intercalation and cathode implantation of lithium. Ways to increase the cycleability of lithium. Materials for the negative electrode (anode) in lithium-ion batteries: carbon nanomaterials, silicon-based nanomaterials, metal nanomaterials, metal oxides. Materials for the positive electrode (cathode) in lithium-ion batteries: lithium cobalt, materials based on orthosilicates, vanadium oxides, double phosphates. Varying the properties of polymer electrolytes by introducing nanoscale additives.

Fuel cells (FC). Classification and purpose of various types of FC. Low-temperature fuel cells. Electrochemical reactions occurring at the electrodes of low-temperature FC. Stages of the reaction of oxygen electroreduction. Parallel cathodic reactions. The problem of electrocatalysis in low-temperature FC. The main types of platinum-containing cathode and anodic catalysts. Electrochemical methods for the study of the catalytic activity of electrocatalysts. Determination of surface area by adsorption-desorption of hydrogen and CO. Cyclic voltammetry. Potentiostatic methods. Cooking and the problem of aging catalytic ink.

The influence of the nature of the carrier on the electrocatalytic properties of nanoparticles. Porous substrates with different surface areas: carbon materials, organometallic framework structures. The effect of doping on the catalytic properties of platinum nanoparticles. Materials based on shell-core structures. Kirkendall effect. Hollow nanoparticles. Getting free catalysts. The problem of the stability of the anodic electrocatalyst to the toxic effect of carbon monoxide. Methanol FC. Electrooxidation of ethanol.

Nanomaterials for solar energy. Types of solar cells. Photoelectrochemical cells Gretzel. The main types of nanoparticles used in solar cells. Colloidal quantum dots. Organic solar panels.

**Module 2. "Nanostructured materials for biomedicine"**.

***Topics:***

The use of magnetic nanoparticles in medicine. Factors affecting the magnetic properties of nanoparticles. Magnetic particles based on iron oxides. Doping of iron oxides with rare-earth ions. The main methods of obtaining magnetic nanoparticles based on iron oxides. Modifying the surface of magnetic nanoparticles; encapsulation. The influence of particle size on the scope: magnetic separation, hyperthermia, targeted delivery, magnetic resonance imaging. Gold nanoparticles in medicine. Chemical methods for the synthesis of colloidal gold with given sizes and size distribution of particles. Functionalization of gold nanoparticles. General principles of conjugation of nanoparticles with biomolecules. Areas of use for gold nanoparticles: protein quantification, diagnosis of infectious diseases, antibody production.

**Module 3. "Obtaining nanostructured composites"**.

***Topics:***

Production of nanostructured composites for biomedical applications. Platinum materials. Composites based on graphene oxide. Composites based on ion exchange matrices. Biosensors.

1. **Basic educational technology**

In the process of teaching the “synthesis of nanostructured nanomaterials” discipline, both traditional educational technologies (lectures, seminars, practical and test papers) and active innovative approaches to the organization of the educational process are used. Interactive forms include: a seminar in an interactive mode with discussion elements for the revitalization of students.

1. **Forms of control**

Current: attendance of lectures, performance of laboratory work, protection of laboratory work. Boundary control on the modules. Exam certification.

1. **Additional useful information**

Successful learning requires knowledge of chemistry in the scope of a university program for non-core specialties (at least in the scope of the school curriculum), as well as the fundamentals of nanochemistry, as well as individual sections of the theory of the structure of matter and electrochemistry.

Teacher for the discipline is Dr. Vera V. Butova