AL-FARABI KAZAKH NATIONAL UNIVERSITY

Approved at the meeting
Academic Committee (NCC)
KazNU them. al-Farabi
vice-rector for academic work
_____ A. K. Hikmetov
protocol №6 from "22" June 2020

EXAMINATION PROGRAM FOR STUDENTS IN THE EDUCATIONAL PROGRAM «8D07110-MATERIAL SCIENCE AND TECHNOLOGY OF NEW MATERIALS»

Almaty 2020

The program is developed in accordance with the State General Education Standard for the educational program "8D07110-Materials Science and Technology of New Materials".

The program was considered at a meeting of the Department of Solid State and Nonlinear Physics.
Protocol № «_____» _____2020

Head of the department _____ M.K. Ibraimov

Considered at a meeting of the Methodical Bureau of the Faculty of Physics and Technology
Protocol № «_____» _____2020

Chairman of the Methodical Bureau _____ A.T. Gabdullina

Approved at the meeting of the Academic Council
Protocol № «_____» _____2020
Chairman of the Academic Council,
Dean of the Faculty _____ A.E. Davletov

Scientific Secretary _____ R.U. Masheeva

1. Goals and objectives of the exam in the educational program "8D07110-Materials Science and Technology of New Materials"

The exam is held to determine the practical and theoretical training of the master and to check the compliance of knowledge and skills with the requirements of doctoral studies in the field of training.

2. Previous minimum level of education for those wishing to master the doctoral programs in the educational program "8D07110-Materials Science and Technology of New Materials"

Requirements for applicants: Applicants must

- be familiar with the physical nature of the formation of substances, the laws of formation of the phase composition, structure and properties of materials depending on their chemical composition, methods of preparation and processing;
- know the basic regularities of interrelationships between phase composition, structure and properties of materials; theoretical bases of technological processes of production and processing of materials and finished products from them; device and operation of scientific and technological devices and equipment;
- be able to practical use the methods of studying the structure and properties of materials; to develop technologies for obtaining and processing of new materials;
- must have the skills of mathematical processing of research results, compilation of scientific and technological documentation;
- must be competent in matters of technical and environmental safety, protection of human life, legal norms and economic problems.

3. Prerequisites of the educational program

1. Modern material science - 5 cr.
2. Nanotechnology in materials science - 5 cr.
3. Perspective functional materials - 5 cr.

4. List of exam topics

Discipline "Modern Materials Science"

1. The purpose and place of the discipline of material science. A brief history of the discipline.
2. General information about amorphous materials and ways to obtain them.
3. The main types of dielectrics. Electrical conductivity of dielectrics.
4. Types of chemical bonds in materials: ionic, covalent, metallic. Basic methods of studying the structure of materials. Types of crystal lattices.
5. Concepts of phase, component and structural component. Micro and macro analysis. Physical methods of studying materials.
6. Defects in the crystal and their types. The effect of defects on the properties of materials. Dislocations and types.
7. Kinetics, mechanism and thermodynamic basis of crystallization of metals. Structures and phases in metal solutions (solvents, chemical bonds, intermediate phase, impurities) and conditions of their formation.
8. Phase equilibrium diagrams. Thermodynamic equilibrium conditions in two-component mixtures. Dependence of Gibbs energy on the state of the mixture.
9. Metals: ferrous metals. Classification of steel and its quality, structure and application.
10. Instrumental steel. Non-ferrous metals and their alloys. Aluminum and copper alloys.

11. Methods of obtaining ceramic materials and their scope. Ways to deal with their fragility.

12. Inorganic glass and their types. Organic glass. Heat treatment.

13. The main types of polymers and ways to obtain them. Characteristics and properties of polymers and scope.

14. Types of semiconductor materials. Electrical properties of semiconductors. Scope of application.

15. Composite materials and ways to obtain them. Composite materials with metal and polymer matrices. Ways to obtain basic composite materials: glass plastic and carbon plastic.

16. Mechanical properties of materials. Stress and strain. Elastic and plastic deformation. Properties determined by static stretching.

17. Methods for determining the mechanical strength and hardness of materials.

18. Electrical properties of materials: theory of conductivity, conductors, insulators, superconductors.

19. Optical properties of materials: transparent and opaque materials. Light. Luminescence. Optical fibers and modern optical devices. Lasers.

20. Magnetic properties of materials: ferromagnetism, dia-paramagnetism. Magnetic materials.

21. Modern methods of studying materials. Optical microscopy. Scanning probe microscopy.

22. Semiconductor devices: light-emitting semiconductor diodes, lasers.

23. Technology of obtaining nanomaterials, their properties and structure.

Discipline "Nanotechnology in materials science."

1. What is nanotechnology? Areas and directions of application of nanotechnology. History of the development of nanotechnology.

2. Types of nanomaterials: consolidated nanomaterials, nanoconductors, nanopolymers, nanobiomaterials, fullerenes and tubular nanostructures, catalysts, nanoporous materials and supramolecular structures. Nanoparticles (nanopowders). The science of small objects (nanoscience).

3. Quantum funnels, dots and wires. Nanoparticles (Nna powders).

4. Obtaining nanomaterials on the principle of "top-down" and "bottom-up".

5. Production of nanomaterials: Nanostructuring under the influence of shear pressure.

6. Obtaining nanomaterials: Nanostructuring by crystallization of amorphous structure.

7. Production of nanomaterials: compaction of nanoclusters. Ways to obtain nanopowders.

8. Production of nanomaterials: Condensation method (Gleiter method). High energy grinding.

9. Production of nanomaterials: Mechanochemical synthesis. Plasmochemical synthesis.

10. Obtaining nanomaterials: Synthesis under the influence of ultrasound.

11. Extraction of nanomaterials: Electric explosion of wires. Consolidation methods. Electric discharge welding.

12. Extraction of nanomaterials: Intensive plastic deformation (rotation under the influence of high pressure, angular sealing of the channel).

13. Production of nanomaterials: Nanostructuring by crystallization of amorphous structure.

14. Technology of nanostructured membranes: thermal evaporation, ion deposition, gas phase deposition, pulse electroplating, thermal decomposition.

15. Fundamentals of nanotechnology of semiconductor nanomaterials. Molecular-beam epitaxy. Mechanisms for obtaining semiconductor quantum dots.

16. Mechanisms of nanofilm growth on the mechanisms of Folmer-Weber, Franco-van der Merve, Krastanovu-Stransky

17. Methods of CVD and PCVD.

18. Basics of technology of polymeric, porous, tubular and biological nanomaterials. Hybrid and supramolecular materials. Nanoporous materials (molecular filters). Tubular nanomaterials. Polymeric nanomaterials.

19. The main methods of design of nanostructures: electronolithography and nanoimprinting, local epitaxy and epitaxy of surface stress structures, self-formation and synthesis in matrices (template synthesis), probing methods of lithography.

20. The method of local probe oxidation. Physicochemical basis of the method of local probe oxidation.

"Perspective or advanced functional materials"

1. General characteristics of the study of metals and structural methods of research.
2. Atomic-crystalline structure of metal
3. Defects of the metal crystal lattice
4. Materials based on high molecular weight compounds
5. Non-metallic inorganic materials
6. Ceramic materials
7. Composites
8. Classification of materials according to the structural basis
9. Materials with electrical functions
10. Materials with magnetic functions
11. Materials with optical functions
12. Materials with biological functions
13. Materials with thermophysical functions

5. List of used literature

"Modern material science"

The basic literatures:

1.Коробова Н.Е., Сарсембинов Ш.Ш. “Introduction to the material science” (Введение в материаловедение)/ N. Korobova, Sh. Sarsembinov. – Алматы: Казак университеті, 2006. – 325с.

Additional literatures:

1. Modern Physical Metallurgy and Materials Engineering, /Ed. R. E. Smallman, R J Bishop.- 1999.

2. Smallman R.E., Ngan A.H.W. «Physical Metallurgy and Advanced Materials», http://www.twirpx.com/file/432338/

3. http://swiat-zaproszen.pl/materials-science&page=2

4. Barett C.R., Nix W.D., Tetelman A. S. “ The principles of engineering materials”, 1998.

Nanotechnology in materials science

The basic literatures:

1. Кобояси Н. Введение в нанотехнологию. М.: БИНОМ. 2005, -134 с.

2. Головин Ю.И. Введение в нанотехнологию. М.: Машиностроение. 2007, -496 с.

3. Суздалев И.П. Нанотехнология: физико-химия нанокластеров, наноструктур и наноматериалов. М.: КомКнига, 2006, -592 с. (Синергетика: от прошлого к будущему).

4. Пул-мл. Ч., Оуэнс Ф. Нанотехнологии, (Мир материалов и технологий). М.: Техносфера, 2006, -336 с.

5. Андриевский Р.А., Рагуля А.В. Наноструктурные материалы. М.: «Академия», 2005, -192 с.

6. Миронов В. Основы сканирующей зондовой микроскопии. М.: «Техносфера», 2005, 144 с.

7. Сб. под ред. Мальцева П.П. Наноматериалы. Нанотехнологии. Наносистемная техника. Мир материалов и технологий. М.: Техносфера, 2006, -152 с.

Additional literatures:

1. Неволин В.К. Зондовые нанотехнологии в электронике, (Мир электроники). М.: Техносфера, 2006, -160 с.
2. Сборник под ред. Мальцева П.П. Наноматериалы. Нанотехнологии. Наносистемная техника, (Мир материалов и технологий. Мировые достижения за 2005 год). М.: Техносфера, 2006, -152 с.
3. Под ред. Чаплыгина Ю.А. Нанотехнологии в электронике. М.: Техносфера, 2005, -448с.
4. Андриевский Р.А. Наноматериалы: концепция и современные проблемы // Российский химический журнал. - 2002. - Т. 46. - № 5. - С. 50-56.
5. Нанотехнология в ближайшем десятилетии. Прогноз направления исследований / Под ред. М. Роко, Р.С. Вильямса, П. Аливисатоса; Пер. С англ. под ред. Р.А. Андриевского. -М.: Мир, 2002. - 292 с.
6. Фейнман Р. Внизу полным полно места: приглашение в новый мир физики // Химия и жизнь. 2002. № 12. - С. 20-26.
7. Харрис П. Углеродные нанотрубы и родственные структуры. Новые материалы XXI века / Пер. с англ. под ред. Л.А.Чернозатонского. М.: Техносфера, 2003. - 336 с.
8. Помогайло А.Д., Розенберг А.С., Уфлянд И.Е. Наночастицы металлов в полимерах. М.: Химия, 2000, -672 с.
9. Сарсембинов Ш.Ш., Приходько О.Ю., Максимова С.Я. Физические основы модификации электронных свойств некристаллических полупроводников. Гл. X. Модификация электронных свойств пленок аморфного алмазоподобного углерода. Алматы: Казак университеті, 2005, -341 с.

"Perspective or advanced functional materials"

The basic literatures

1. Вест А. Химия твердого тела. Теория и приложения. // М.: Мир, 2008, Т.1.–558с., Т.2.–336с.
2. Третьяков Ю.Д., Метлин Ю.Г. Фундаментальные физико-химические принципы в неорганическом материаловедении. // ЖВХО, Т.36, №6, 1991, с.265.
3. Панич А.Е., Куприянов М.Ф. Физика и технология сегнетокерамики. // Ростов н/Д, изд-во Ростовского унив.-та, 2009.–180с.
4. Барфут Дж., Тейлор Дж. Полярные диэлектрики и их применение. // М.: Мир, 2001.–527с.
5. Бикяшев Э.А. Учебное пособие: ″Активные полярные диэлектрики″ для студентов IV-го курса химического факультета ЮФУ (специальность: "Химия, физика и механика материалов"). // ИИК ЮФУ.
6. Третьяков Ю.Д., Гудилин Е.А. Химические принципы получения металлоксидных сверхпроводников. // Успехи химии, 2000, Т.69, №1, С.3–40.
7. Третьяков Ю.Д. Неорганическая химия – основа новых материалов. // Химия и жизнь, 2007, №5, С. 15–17.

Additional literatures:

1. Романовский Б.В., Макшина Е.В. Нанокомпозиты как функциональные материалы. // Соросовский образовательный журнал, 2004, Т.8, №2, С.50–55.
2. Укше Е.А., Букун Н.Г. Твердые электролиты. // М.: Наука, 1977.– 176с.
3. Пикин С.А., Блинов Л.М. Жидкие кристаллы. // М.: Квант, 1982.–208с.

6 Scale of examination results in doctoral studies in 8D07110 - "Materials Science and Technology of New Materials"

Pricing in alphabetical order	Numerical equivalent of a score	% content	in the traditional system	Competence scale
A	4,0	95-100	Өте жақсы	Аталмыш баға келесі жағдайларда қойылады, егер докторант 1) Кәсіби қызметтерде жалпы және өндірістік менеджменттің негізгі категорияларын біледі және қолдана алады, технологиялық үдерістерді басқару обьектісі ретінде сараптау, негізгі өндірістік ресурстардың бағалық құндылығын өткізу, кәсіпорын ресурстарын қолдану бойынша ақпаратты сараптау және қамту дағдысына ие. 2) Өнімнің сапасын басқарудың жүйелерінің негізін және осы жүйенің енуіне дайындығын игереді. 3) Жасалатын материал, техника және технологиялардың техникалық және экологиялық қауіпсіздігін қамтамасыз ету бойынша біріншілік өндірістік бөлімдердің жұмыстарының оперативтік жоспарларын дайындау, технологиялық үдерістерлі басқару, тәуекел ету және өлшемді анықтау жұмыстарын игере алады, оқыс жағдайларда аз жұмысшылардың әрекетіндегі реті мен қорғау тәсілдерін біледі. 4) Жоғарытехнологиялық инновациялық бизнестің, соның ішінде кіші бизнестің менеджменті негізін, «Материалтану және материалдар технологиясы» бағыты бойынша кәсіби қызметте білім, еп және дағдыларын қолдану дайындығын игереді.

A-	3,67	90-94		Аталмыш баға келесі жағдайларда қойылады, егер докторант 1) Әртүрлі тағайындалымдағы органикалық емес және органикалық материалдардың, оның ішінде наноматериалдарды, негізгі түрлерін біледі, олардың қолданылуының сенімділік және ұзақ қолданылуы, экономикалық және экологиялық салдарын есепке алғандағы берілген эксплуатация шарттары үшін материалдарды өздігімен таңдау дағдысына ие.; 2) Технологиялық үдерістер мен операцияларды оларды іске асуының тағайындалуы мен әдістері есебімен қолдана алады, нормативтік және әдістемелік материалдарды өндірістің технологиялық дайындығы, экономикалық сараптама есебімен өнім мен үдерістердің сапасы, стандартизация және сертификация бойынша қолдана алады. 3) материалдар мен олардан алынған өнімдердің құрылымы мен қасиеттері, зерттеу және дйындаудың жүзеге асуының технологиялық үдерістерінің негізгі параметрлерін өлшеу және бақылау үшін өздігімен қолдана алу дағдысына ие. 4) Өндіріс үдерістерінің автоматтандыру әдістері мен құралдарын өздігімен дайындай алу, тиімді, техникалық және экологиялық қауіпсіз өндірісті қамтамасыз ететін еңбек ұйымын қабылдау және әдістерін, жабдықтар мен жабдықталуды таңдай алады.

B+	3,33	85-89	Жақсы	This grade is given in the following cases, if a doctoral student 1) Knows the main types of inorganic and organic materials for various purposes, including nanomaterials, has the ability to independently select materials for the given operating conditions, taking into account the reliability and longevity of their use, economic and environmental consequences; 2) apply technological processes and operations, taking into account the purpose and methods of their implementation, apply regulatory and methodological materials on the technological readiness of production, the quality of products and processes, standardization and certification, taking into account economic expertise. 3) the ability to independently use the structure and properties of materials and their products, to measure and control the main parameters of technological processes of research and development. 4) be able to independently develop methods and tools for automation of production processes, to accept the organization of labor and choose the methods, equipment and supplies that provide efficient, technically and environmentally safe production.
B	3,0	80-84		This grade is given in the following cases, if a doctoral student 1) Has mastered the basic base of theoretical and applied sciences and can develop them independently by applying them in professional activities in the theoretical and practical research, analysis and modeling of materials and processes. 2) Has mastered the basic state and methods of social sciences, humanities and economics and can apply them in solving professional problems, taking into account its consequences for society, economy and ecology. 3) can apply in practice the natural sciences, general vocational and special disciplines in order to understand the problems of "Materials Science and Materials Technology". material and technology of materials ». 4) Can develop and apply ideas, make an original contribution to this science, engineering and technology.

B-	2,67	75-79		This grade is given in the following cases, if a doctoral student 1) master the purpose and complex research, practice and diagnostics of materials, the process of production, processing and modification of manufactured substances. 2) the use of technical substances and its basic parameters, the properties of substances contained in the material. 3) purification of the process environment, the study of physical and chemical properties of metals. 4) knows about the production and technological defects, extensively on the methods of non-destructive testing, know their domestic, modern and foreign methods.