AL-FARABI KAZAKH NATIONAL UNIVERSITY

Approved at the meeting of the
Scientific and methodological Council
of Al-Farabi KazNU
Protocol № 6
from 22 June 2020 г.
Vice-rector on Academic Affairs
_____A. Khikmetov

PROGRAM OF ENTRANCE EXAM FOR THE SPECIALTY FOR APPLICANTS TO MASTER LEVEL "8D05308-NUCLEAR PHYSICS"

ALMATY 2020

The program is developed in accordance with the State educational standard on a specialty "8D05308-Nuclear physics" by candidate of science in Physics and Mathematics S.A.Zhaugasheva, PhD A.K. Bekbayev.

The program considered at the meeting of the Department of theoretical and nuclear physics
Protocol № 41 from «16» June 2020 y.
Head of the Department _____ **Abishev M.E.**

Approved at the meeting of Methodological Bureau of faculty Physics And Technology
Protocol № _____ from «_____»_____2020 y.
The Chairwoman of the Methodological Bureau _____ **Gabdullina A.T.**

Approved at the meeting of the Academic Council
Protocol № _____ from «_____»_____2020 y.

Chairman of the scientific Council,
Dean of the faculty _____ **Davletov A.E.**

Scientific Secretary _____ **Masheeva R.U.**

CONTENT

1. Goals and objectives of the entrance examination in the specialty

The entrance exam is intended to determine the practical and theoretical preparedness of the applicant and is conducted to determine the correspondence of knowledge, skills and skills to the training requirements in PhD doctoral studies in the field of training.

At the entrance examination, entering the doctorate must show the depth of knowledge in the main disciplines of previous training, research capacity, which are sufficient and necessary for the successful mastery of the PhD doctoral program.

The applicant should show the ability to work independently with contemporary literature, demonstrate his achievements in the field of modern nuclear physics in the form of author's publications, diplomas, certificates, etc.

The form of the entrance examination is a written examination. The examiners write down their answers to the questions of the examination ticket on the answer sheets, which are checked by the examination board in an encrypted form.

2. Requirements for the level of training of persons entering Ph.D.

The previous level of education of persons wishing to master the PhD doctoral program is a higher or postgraduate education.

The procedure for admission of citizens to PhD doctorates is established in accordance with the standard rules of admission in the educational organization that implement professional training programs postgraduate education.

Requirements for applicants:

must:

- *be able* to carry out a qualitative and quantitative analysis of physical processes, have the ability to determine the objectives of special studies and use the methods of the sciences studied to solve the tasks;
- *to have* knowledge of fundamental phenomena and effects in the field of physics, experimental, theoretical and computer methods of research in this field;
- *to be able* independently or in the system of further education to study special problems of physics and new methods of research

3. Prerequisites for the educational program

1. Models of nuclei
2. Nuclear reactions at intermediate energies

4. The list of examination topics

1. The atomic nucleus

Composition of the nucleus, mass number, nuclide, nuclear isomers, core mass, spin and magnetic moment of the nucleus, binding energy, energy levels of the nucleus, nuclear forces, stability of the nucleus, nuclear model.

2. Radioactivity

General characteristics of radioactivity, natural and artificial nuclei, decay energy, radioactive families, the law of radioactive decay, decay, decay, decay, Geiger-Nettol law

3. Methods of scattering

Scattering experiment, kinematics of process scattering, kinematics of decays, kinematics of birth reactions, kinematics of elastic scattering, effective scattering cross section, probability of decays.

4. Sources and Particle Detectors

Sources of particles, types of accelerators, installations with colliding beams, targets, particle detectors.

5. Properties of atomic nuclei

Elementary elements of the atom, antiparticles, mass and binding energy of the nucleus, the specific binding energy of the nucleus, spin, parity, electromagnetic moments of the nucleus, the shape of the nucleus, the size of the nucleus, the structure of the atomic nuclei.

6. Nuclear Models and Nuclear Forces

Nuclear models, a semiempirical formula for the energy of the nucleus, the model of nuclear shells, nuclear forces, the meson theory of nuclear forces.

7. Radioactive transformations

Radioactivity, radioactive series and transuranium elements, neutrinos, gamma radiation of nuclei, the Mossbauer effect.

8. Nuclear Reactions and Nuclear Power

Nuclear reactions, the mechanism of nuclear reactions, the mechanism of fission of heavy nuclei, fission chain reaction, nuclear reactors, synthesis reaction, thermonuclear energy in nature, controlled thermonuclear fusion.

Discipline *"Nuclear Reactions at Intermediate Energies"*

1. Cerenkov radiation

ChR as interference effect, threshold character of ChR, spectrum, angular distribution and polarization of ChR, ChR as part of ionization losses,

identification of particles by recording ChR.

2. Detectors

Classification of detectors, gas detectors, physical processes in the detector gas, primary and complete ionization; sigma-electrons; Drift and diffusion of charged particles; Gas strengthening; breakdown; Photoionization, and photoabsorption, ionization chamber, waveform, induction effect, cylindrical proportional counter, loading effect, working mixtures, track detectors, time-projection chamber, semiconductor detectors (PPD).

3. Accelerators and particle detectors

Accelerators, accelerators with colliding beams, detectors of single charged particles, detectors of showers and calorimeters.

4. Hadron-hadron interactions

Cross sections and decay rates, isospin, strangeness and isospin, the Bright-Wigner resonance formula, boson resonances, the creation of particles at high energies.

5. The static quark model of hadrons

Decuplet of baryons, spin and color of quarks, baryon octet, vector mesons, lepton decays of vector mesons, pion-nucleon cross section, magnetic moments of baryons.

6. Weak interactions

Classification of weak interactions, nuclear decay, Fermi theory, interaction of free neutrinos, neutrino helicity, parity violation.

7. Electromagnetic interactions

Elastic scattering of spinless electrons by nuclei, transmitted 4-momentum, electron scattering by a nucleon, quantum electrodynamics and processes of higher orders.

8. General principles of relativistic kinematics

Integrals of motion, conservation laws, relativistic transformations of angles and momenta.

9. Effective cross-sections and their formation when the coordinate system is changed.

Integral and differential cross sections, relativistic transformation of angular and impulse distributions.

5. List of recommended literature

Main literature:

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7. Квантовая теория калибровочных полей. Сб. статей. М.: Мир, 1977.
8. Рубаков В.А. Классические калибровочные поля. Бозонные теории. – 2-е изд. М.: URSS, 2005.
9. Коноплева Н.П., Попов В.Н. Калибровочные поля. – 2-е изд., М.: Атомиздат, 1980.
10. Дирак П. Лекции по квантовой механике. В кн. Принципы квантовой механики. – М.: Наука, 1979.
11. Фейнман Р., Хибс А. Квантовая механика и интегралы по траекториям. – М.: Мир, 1968.
12. Зинн-Жюстен Ж. Континуальный интеграл в квантовой механике. – М.: Физматлит, 2006.
13. Овчинников Ф.Я., Семенов В.В. Эксплуатационные режимы водо-водяных энергетических реакторов. - Изд.3-е. М.: Энергоатомиздат, 1988.
14. Казанский Ю.А., Матусевич Е.С. Экспериментальные методы физики реакторов. М.: Энергоатомиздат, 1984.
15. Корсаков В.С. и др. Технология реакторостроения. М., Атомиздат, 1977 г. 267 ст.
16. Владимиров В.И. Практические задачи по эксплуатации ядерных реакторов. М., Атомиздат, 1976 г. 295 ст.
17. Г.Г.Бартоломей, Г.А.Бать, В.Д.Байбаков, М.С.Алхутов Основы теории и методы расчета ядерных энергетических реакторов / : Под ред. Г.А.Бать. М. ; Энергоиздат, 1982.
18. Ганев И.Х. Физика и расчет реактора / Под ред. Н.А. Доллежаля. М.: Энергоиздат, 1981.

Additional literature:

1. В.И.Калашникова, М.С.Козодаев. Детекторы элементарных частиц. «Наука», М.
2. И.В.Эстулин. Радиоактивные излучения. М., 1962.
3. Над чем думают физики. Физика атомного ядра. Серия ФЬ, М. 1962
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15. Рамон П. Теория поля. Современный вводный курс. М.: Мир, 1984.
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17. Раджараман Р. Солитоны и инстантоны в квантовой теории поля. – М.: Мир, 1985.
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20. Фейнберг С.М. и др. Теория ядерных реакторов. М., Атомиздат, 1978 г. 396 ст.
21. Герасимов В.В., Монахов А.С. Материалы ядерной техники, М., Энергоиздат, 1982, 288 ст.

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23. Климов А.Н. Ядерная физика и ядерные реакторы. М.: Атомиздат, 1971.
24. Фейнберг С.М., Шихов С.Б., Троянский В.Б. Теория ядерных реакторов. Том 1. М.: Атомиздат, 1978.
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Scale of examinations for admission to doctoral studies in the specialty «8D05308-Nuclear Physics»

<table>
<tr><th>Characteristics of student work</th><th>The range of rating points</th><th>Evaluation ECTS</th><th colspan="2">Traditional (4-level) Rating scale</th></tr>
<tr><td rowspan="2">"Excellent" - work of high quality, the level of performance meets all the requirements, the theoretical content of the course of the model of the nuclei is mastered completely, without gaps, the necessary practical skills of working with the mastered material are formed, all the training tasks stipulated in the training program are fulfilled, the quality of their performance is estimated by the number of points close To the maximum</td><td rowspan="2">90-100</td><td>A</td><td rowspan="2">excellent</td><td rowspan="5">Credited</td></tr>
<tr><td>A-</td></tr>
<tr><td rowspan="3">"Very good" - the work is good, the level of implementation meets most of the requirements, the theoretical content of the course of nuclear reaction at intermediate energies is mastered completely, without gaps, the necessary practical skills of working with the mastered material are basically formed, all the training tasks stipulated in the training program are fulfilled, Of them is</td><td rowspan="3">80-89</td><td>B+</td><td rowspan="3">good</td></tr>
<tr><td>B</td></tr>
<tr><td>B-</td></tr>
</table>

Characteristics of student work	The range of rating points	Evaluation ECTS	Traditional (4-level) Rating scale	
estimated by the number of points close to the maximum				
"Good" - the level of performance of the work meets all the basic requirements, the theoretical content of the course is mastered completely, without gaps, some practical skills of working with the mastered material are not sufficiently formed, all the training assignments provided by the training program are fulfilled, the quality of performance of none of them is not estimated by the minimum score , Some of the completed tasks may contain errors	70-79	C+	satisfactorily	
		C		
		C-		
"Satisfactory" - the level of performance of the work meets most of the basic requirements, the theoretical content of the course is partially mastered, but the gaps are not essential, the necessary practical skills of working with the mastered material are basically formed, most of the training tasks provided by the training program are fulfilled, some types of tasks are executed with errors	60-69	D+	satisfactorily	Credited
		D		
"Mediocre" - the work is weak, the level of implementation does not meet most requirements, the theoretical content of the course is partially mastered, some practical skills are not formed, many of the training	50-59	D-		

Characteristics of student work	The range of rating points	Evaluation ECTS	Traditional (4-level) Rating scale	
assignments provided by the training program are not met, or the quality of some of them is estimated by the number of points close to the minimum				
"Unsatisfactory" (with the possibility of retake) -The theoretical content of the course is partially mastered, the necessary practical skills are not formed, most of the training assignments provided by the training program are not fulfilled, or the quality of their performance is estimated by the number of points close to the minimum; With additional independent work on the material of the course, it is possible to improve the quality of the performance of study assignments	25-49	F	Unsatisfactory	Not credited
"Unsatisfactory" (without the possibility of retake) - the theoretical content of the course is not mastered, the necessary practical skills are not formed, all the completed training tasks contain gross errors, additional independent work on the course material will not lead to any significant improvement in the quality of the performance of the training assignments	0-24			