Aktobe Regional University named after K. Zhubanov

Questions of Doctoral studies entrance exam on

educational program 8D05301-Physics

1. The principle of relativity. The Galilean and Lorentz transformations. Equations of physics in covariant form
2. The principle of symmetry, superposition, uncertainty principle. The correspondence principle as a reference point in the construction of new physical theories
3. The law of conservation of energy and the uniformity of time
4. The laws of conservation of momentum and angular momentum as a consequence of translational invariance and isotropy of space.
5. Quantum numbers and the energy of the hydrogen atom. Quantum superposition. Classical superposition
6. The uncertainty relation for energy-time. Uncertainty ratio, the uncertainty principle
7. Magnetic field and its characteristics
8. Classification of materials, data on their shape, methods for studying thermal, electrical, magnetic and optical properties
9. Amorphous materials and their characteristics
10. The structure of the materials. Concept: component, phase, composition. Micro-and macro-analysis. The concept of physical methods of materials research
11. Types of defects, their classification, influence on properties
12. Metals. Features of the atomic crystal structure of metals. Isotropy, anisotropy, allotropy. Construction of real metals. Mechanisms of metal crystallization
13. Ferrous metals. Cast iron: properties and use of cast iron, classification of cast iron. Steel: classification of steel, quality and structure. Two-phase diagrams. Structural steel. Heat-resistant steels. Structures of the pearl, martensitic, and martensitic-ferrite classes.
14. Melts of metals. Tool steels and alloys. Non-ferrous metals and alloys: aluminum and its alloys; copper and its melts. Application of metals
15. Ceramics: Areas of production and use of ceramic materials, their advantages and disadvantages. Methods of fighting fever. Areas of operation of ceramic materials
16. Glass: inorganic glass, their types and heat treatment, areas of use. Organic glasses, their advantages and disadvantages. Application areas.
17. Polymers. Classification of polymer materials. General characteristics, their types and properties, and areas of use.
18. Semiconductors. Basic information about semiconductors. Semiconductor structures
19. Electronic excitations in alkali-halide crystals
20. Impurity defects in alkali-halide crystals
21. Dislocations in alkaline halide crystals
22. Mechanical compression of the crystal lattice in alkali-halide crystals
23. Hydrostatic compression of alkali-halide crystals
24. Uniaxial compression of alkali-halide crystals
25. Basic information about uniaxial deformation of alkali-halide crystals
26. Halogen radiation defects in alkali-halide crystals
27. Plastic and elastic deformation of alkali-halide crystals
28. Main characteristics of composite materials and methods of production
29. Mechanical properties. Stress and strain. Elastic deformation. Plastic deformation
30. Electrical properties: theory of conductivity; conductors, insulators, superconductors
31. Optical properties: Transparent and opaque materials. Colour. Luminescence. Optical fibers and modern optical devices. Lasers.
32. Magnetic properties: magnetic materials. General information about ferromagnets. Magnetic and magnetic materials and their requirements. Diamagnets
33. Open systems that exchange matter, energy, and information with the environment. Examples of open systems, from living and inanimate nature.

34. Information and entropy. Information and open systems. Conditions for generating information. Entropy as the average value of information
35. Fractals and dynamic chaos. Fractal objects in nature. Fractal dimension. Multifractals. Examples of multifractals. Interaction of fractals.
36. Crystallography and crystal structure. Classification of crystals by type of symmetry. Bravais gratings. Interatomic interactions and binding energy in crystals
37. The heat capacity of crystals (according to Einstein, according to Debye). Anharmonism and thermal expansion of solids.
38. The law of conservation of charge. Lorentz force
39. Maxwell's equations in integral and differential form, their physical meaning
40. The Fourier method. Green's theorems.
41. Motion of charged particles in the electromagnetic field
42. Plane monochromatic waves. Scale of electromagnetic waves.
43. The Lorentz condition
44. Electric dipole field
45. The principle of relativity of Galileo. The Galilean transformations.
46. The relativistic law of addition of velocities.
47. Electrostatics. Electrostatics of conductors.
48. Electrostatics of dielectrics.
49. Forces acting on conductors and dielectrics.
50. Superconductors and their characteristics
51. Using the uncertainty relation for the coordinate and momentum to estimate the zero-point energy of a harmonic oscillator
52. Spherical potential well, the energy of zero oscillations of the harmonic oscillator
53. Explanation of the stability of the atom and the impossibility of finding an electron inside the nucleus based on the uncertainty ratio. Tunnel effect and over-barrier scattering
54. Introduction using the uncertainty relation for energy and time, the concept of virtual particles in the microcosm. Estimation of the mass of quanta. The concept of virtual particles in the microcosm
55. Particle beam accelerators-synchrotrons and synchrophasotrons. Accelerators on opposite beams. Particle beam accelerators-synchrotrons and colliders. Large Hadron Collider
56. Multiplet. Zeeman splitting of atomic levels in a magnetic field. Splitting of atomic levels in an electric field. The Stark effect.
57. The relation of the spectral function to entropy. The evolution of entropy. Prigogine's theorem, minimum entropy production. Nonequilibrium and stationary states
58. Decay of electronic excitations in alkali-halide crystals. Radiative annihilation of electronic excitations in alkali-halide crystals.
59. Decay of autolocalized excitons into anionic Frenkel defects
60. Decay of autolocalized excitons into cationic Frenkel defects
61. Association of halogen radiation defects in alkali-halide crystals
62. Local disturbances of the crystal lattice in alkali-halide crystals
63. Physico-chemical properties of alkali-halide crystals doped with homologous cations
64. General regularities of luminescence and radiation defect formation during the decay of autolocalized excitons in alkali-halide crystals under low-temperature deformation
65. Methods for evaluating mechanical strength. Methods for determining hardness. Properties that can be detected during dynamic tests. The effect of residues on metals and melts. Methods for determining the strength of materials.
66. Modern methods of materials research. Optical microscopy. Scanning electron microscopy. Scanned probe microscopy.
67. Nonlinearity and stochastization of dynamical systems. Nonlinear pendulum, phase portrait. An attractor and a strange attractor. Dynamic and statistical patterns in nature.

68. Self-organization in living and inanimate nature. Klimontovich's theorem. Renormalization of the temperature. Decrease in entropy during self-organization.
69. The zone theory of solids. Classification of solids by the energy spectrum of electrons. Free Fermi electron gas.
70. Bloch's theorem. Brillouin zones. Analysis of the laws of dispersion, allowed and forbidden energy states. The effective mass of the electron.
71. Energy zones and the Fermi surface. Thermal conductivity and electrical conductivity of crystals.
72. Defects in crystals. Classification of defects, types of crystal lattice defects. The effect of defects on the physical properties of crystals.
73. Objects and methods of research in corpuscular optics.
74. Mathematical apparatus of electrodynamics. The nabla operator. The Ostrogradsky-Gauss and Stokes theorems.
75. Wave equations. Electromagnetic waves in a vacuum. The speed of light. Combining electricity, magnetism and optics
76. Wave equations. Electromagnetic waves in a vacuum. The speed of light. Combining electricity, magnetism and optics
77. Cauchy-Riemann conditions.
78. The Biot-Savard-Laplace law and its application for calculating fields.
79. Equations for a constant magnetic field in a vacuum in integral and differential
80. The circulation theorem and its application for calculating the magnetic field
81. Faraday's law of electromagnetic induction in integral and differential forms
82. The complete system of Maxwell's equations for vacuum, displacement current
83. Multipole decomposition of the potential
84. Experimental bases of SRT. The Michelson-Morley experience
85. Lorentz transformations. Lorentzian reduction
86. Einstein's Postulates. A thought experiment with a light clock.
87. Derivation of Lorentz transformations.
88. Consequences of the Lorentz transformations and their experimental confirmation.
89. The law of conservation of energy for the particle + field system. Energy density and energy flux density of the electromagnetic field.
90. Integrated capacity
91. Conformal transformations
92. Poisson formula for the upper half-plane
93. Solving mixed boundary value problems
94. The Keldysh-Sedov method
95. The Euler method
96. The Adams method
97. The Runge-Kutta method
98. Image method for plane and ball
99. Invariants of the electromagnetic field
100. Covariant expression for the Lorentz force
101. Phase equilibrium diagrams. Thermodynamic conditions of equilibrium of a two-component melt.
102. Formation of the structure of materials during crystallization. Thermodynamic bases, Mechanisms of metal crystallization, and kinetics. Methods of research of amorphous materials
103. Thresholds of nuclear reactions, production of antiprotons. Short-lived resonant particles. The lifetime of fast-moving elementary particles.
104. Exciton mechanism of formation of radiation defects in alkali-halide crystals
105. Exciton mechanism of formation of radiation defects in alkali-halide crystals

106. Creation of electronic excitations in the field of vacancy defects of alkali-haloid crystals
107. Equipment for measuring the absorption characteristics of alkali-halide crystals
108. Experimental setup for measuring the luminescent characteristics of alkali-halide crystals
109. Technology of low-temperature deformation of alkali-halide crystals
110. Method of measuring the ionic conductivity of alkali-halide crystals
111. Methods of growing alkali-halide crystals
112. Continuum theory of exciton autolocalization in ionic crystals
113. Continuum theory of exciton hole component autolocalization in undeformed alkali-halide crystals
114. Quantitative calculation of the barrier height for exciton autolocalization in alkali-halide crystals
115. Continuum theory of exciton autolocalization in comprehensively compressed alkali-haloid crystals
116. Continuum theory of exciton autolocalization in alkali-halide crystals under uniaxial compression
117. Mechanisms of exciton decay into primary radiation defects in alkali-halide crystals
118. Tunnel recharge of radiation defects in alkali-halide crystals
119. Specific features of radiative and nonradiative relaxation of excitons in the continuum model of their autolocalization in alkaline haloid crystals
120. Stabilization of halogen radiation defects in KBr crystals under low-temperature uniaxial deformation
121. Radiation defect formation in alkali-halide crystals under low-temperature uniaxial deformation
122. Geometric criteria for the formation of H-centers in alkali-halide crystals under low-temperature uniaxial deformation
123. Temperature dependence of the luminescence of autolocalized excitons in alkali-halide crystals under low-temperature uniaxial deformation
124. Dynamics of the crystal lattice. Vibrations of atoms in one-dimensional and three-dimensional lattices. Acoustic and optical phonons.
125. Synergetics, its role in the knowledge of nature and society. Application of the theoretical provisions of synergetics to condensed matter physics, turbulence, biological and social systems
126. Solving two-dimensional problems in corpuscular optics
127. Calculations of electrostatic potentials reduced to two-dimensional ones.
128. Circulation of the electrostatic field strength. The potential of the point charge field. The superposition principle for the potential.
129. The differential form of the equations of electrostatics and their solution for a given charge distribution.
130. The Poisson equation and its solution for a given charge distribution. The Laplace equation.
131. Radiation of electromagnetic waves. Electric dipole radiation. Near and wave zones.
132. Harmonic dipole emitter. The intensity of the radiation.
133. Calculation of the field of dipole systems.
134. Calculation of the field of quadrupole systems
135. Vector potential of a current loop.
136. Physically infinitesimal volume. Averaging of microscopic fields.
137. The problem of averaging the charge density and current density. The polarization vector and the magnetization vector.

138. Maxwell's equations for averaged fields in matter.
139. Material equations. Boundary conditions.
140. Some methods for solving electrostatic problems.
141. Magnetostatics. The field of stationary currents in bulk and linear conductors.
142. Coefficients of induction and mutual induction.
143. Equations for a constant magnetic field in a vacuum in integral and differential forms. Vector potential. The Poisson equation for the vector potential.
144. Calculation of the field of a conducting ball in a homogeneous electric field.
145. Analysis of the band structure by the density of states
146. Solid-phase synthesis of phosphors and determination of structural features by X-ray diffractometry
147. Determination of solute concentration by absorption spectra
148. Molecular absorption spectroscopy
149. Atomic emission spectroscopy
150. Atomic absorption spectroscopy

Literature

1. С. О. Алексеев, Е. А. Памятных, А. В. Урсулов, Д. А. Третьякова, К. А. Ранну. Введение в общую теорию относительности, ее современное развитие и приложения. – Екатеринбург, 2015. -380 с
2. Трофимова Т.И. Курс физики. –Москва, 2006. -560 с.
3. В. С. Кушнер, А. С. Верещак, А. Г. Схиртлаздзе, Д. А. Негров, О. Ю. Бургонов. Материаловедение. –Омск, 2008.-232 с.
4. Моряков О.С. Материалтану. –Москва, 2015. -288 б.
5. С.Н. Чеботарев. Физика конденсированного состояния. –Новочеркасск, 2017. -91 с.
6. Шункеев К.Ш. Люминесценция и радиационные дефекты в щелочногалоидных кристаллах при понижении симметрии решетки. – Актобе: Издательство АГПИ, 2012. – 516 с.
7. Спивак-Лавров, С.У. Шарипов, Т.Ж. Шугаева. Электродинамика и теория относительности. –Актобе, 2021. -456 с.
8. Панова Т.В., Геринг Г.И. Физика конденсированного состояния вещества. – Омск, 2008. – 101 с.
9. Ю.И. Тюрин, И.П. Чернов, Ю.Ю. Крючков;Физика. Квантовая физика: учебник / Томский политехнический университет. – Томск: Изд-во Томского политехнического университета, 2009 – 320 с.
10. Тарасов, Л. В. Введение в квантовую оптику / Л.В. Тарасов. - М.: ЛКИ, 2017. - 306 с.
11. Кислов, А. Н. Атомная и ядерная физика : учеб. пособие / А. Н. Кислов. — Екатеринбург : Изд-во Урал. ун-та, 2017. — 271с.
12. Е.А. Памятных. Электродинамика : специальная теория относительности. теория электромагнитного поля. — Екатеринбург : Изд-во Урал. ун-та, 2014 — 72 с.
13. Ю. В. Емельянова, М. В. Морозова, Е. С. Буянова. Спектроскопические методы анализа в аналитической химии: практикум. – Екатеринбург : Изд-во Урал. ун-та, 2017 – 88 с.