


THE MINISTRY OF SCIENCE AND EDUCATION OF THE RUSSIAN FEDERATION  
THE NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY  
«MISIS»

APPROVED:  
Deputy Chair of the Admissions  
Committee

  
A.A. Volkov  
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of the college of New Materials and  
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College director

  
professor Sergey Kaloshkin  
«22» September 2022.

**ENTRANCE EXAMINATION CONTENT  
FOR THE MASTER'S DEGREE PROGRAM  
IN MATERIALS SCIENCE AND TECHNOLOGY  
CODE 22.04.01**

Moscow 2022

**PROGRAM**  
admission test  
«Materials Science and Engineering»

Master's programs  
«Advanced Materials Science»

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**I. Explanatory Note**

The purpose of the entrance examination is to establish upon entering the master's programs the level of the candidate's knowledge of subject-related educational and scientific materials and compliance with the training requirements of the state educational standard of higher education in «Advanced Materials Science» and «Science and Materials of Solar Energy».

Entrance examinations are held in the form of an interview with use of remote technologies.

The duration of the entrance examination is not to exceed 40 minutes.

The maximum score is 100 points and is the combined sum of the scores from the results of the interview component and the score for individual achievement.

The maximum amount of points for the interview component is 60 points. Two questions derived from program content comprise the interview component. Each question is scored from 0 to 20 points. Additionally, the level of knowledge of professional terminology in English is being evaluated from 0 to 20 points. The results of the evaluation interview are the sum of points earned for each question and for the level of knowledge of professional terminology demonstrated in English.

The maximum amount of points for the individual achievement component is 40 points and consists of assessing the following achievements: academic achievement (cumulative grade point average from previous post-secondary institutions of higher education, publications, participation in conferences, scientific achievements, achievements in educational and social activities (certificates, diplomas, etc.) from 0 to 20 points; Statement of Purpose from 0 to 10 points; and letter(s) of recommendation from 0 to 10 points total.

Candidate must earn a minimum of 20 points to be considered eligible for admission.

## **II. Examination Content Outline**

1. Structure of crystals. The symmetry of the crystal lattice, structure of typical elements and compounds. Amorphous substance. The structure of the polymers. Liquid crystals.
2. Defects in the crystal structures. Point defects. The equilibrium concentration of point defects. Nonequilibrium defects and their origins. Linear defects. Dislocations, types of dislocations, parameters of the dislocations. The interaction of dislocations. The sources of dislocations. Stacking faults. Intraphase and interphase boundaries. Interaction of intrinsic defects with each other and impurity atoms.
3. The concept phase. The structure of the pure elements and solid solutions. Classification of solid solutions. Phase equilibrium in multicomponent systems. Gibbs phase rule. Chemical Equilibrium. Equilibrium constant for chemical reaction. Effect of pressure and temperature. Chemical potential. Phase transitions of type I and type II. The main types of phase diagrams of binary systems. Classification of phase transformations. Polymorphic transformation. Diffusion and martensitic transformations. Decomposition of supersaturated solid solutions. Chemical reaction rate. Dependence on concentration and temperature.
4. Crystallization. Thermodynamics and kinetics of crystallization. Homogeneous and heterogeneous nucleation of crystals in the melt. Mechanisms of crystal growth. Directional solidification. Epitaxial growth.
5. Diffusion. Phenomenological laws of diffusion. Self-diffusion and heterodiffusion. Atomic diffusion mechanisms. The role of vacancies, dislocations and grain boundaries. Diffusion in the concentration gradient. Reaction diffusion.
6. Physical properties of solids. Methods of investigation of the physical properties of materials. Microscopic probe methods and materials research. Basic methods of X-ray analysis. Electron diffraction and neutron diffraction. The notion of spectroscopic methods of investigation.
7. The mechanical and physical properties of materials. Hardness and microhardness. Plasticity of Solids. Mechanical testing.
8. The photoelectric effect. External and internal photoelectric effect, the basic laws. Fowler theory. p-n junction. Charge distribution in the p-n junction. Properties of p-n junction.

### **III. Recommended Reading**

1. William D. Callister, David G. Rethwisch. Fundamentals of Materials Science and Engineering: An Integrated Approach, 4th Edition. Wiley. 2012.
2. Ashby, M. F. and D. R. H. Jones, Engineering Materials 1, An Introduction to Their Properties and Applications, 3d edition, Elsevier, Oxford, 2005.
3. Ashby, M. F. and D. R. H. Jones, Engineering Materials 2, An Introduction to Microstructures, Processing and Design, 3d edition, Elsevier, Oxford, 2006.
4. ASM Handbook, Volume 9, Metallography and Microstructures. ASM International. 2004