Approved at the Academic Council meeting
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ENTRANCE EXAMINATION CONTENT
FOR THE MASTER'S DEGREE PROGRAM
IN MATERIALS SCIENCE AND TECHNOLOGY
CODE 22.04.01 MATERIALSCIENCE AND TECHNOLOGY

Master program «Advanced Materials Science»
and «Science and Materials of Solar Energy»

Moscow 2024

PROGRAM
admission test
«Materials Science and Technology»

Master's programs
«Advanced Materials Science»
«Science and Materials of Solar Energy»

The content of the program: page

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 amount of points for the interview component is 100 points. Ten questions derived from program content comprise the interview component. Each question is scored from 0 to 10 points. The results of the evaluation interview are the sum of points earned for each question.

Candidate must earn a minimum of 40 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