Czech Technical University in Prague
Fakulty of Nuclear Science and Physical Engineering

PROBLEM AREAS

to Entrance Exams in

DOCTORAL STUDIES

Field of Study: Physical Engineering
Specialization: Solid State Engineering

Study program: Applications of Natural Sciences

Subject	Solid State Theory
Problem Areas	

1. Binding forces in crystals, crystal lattice vibrations (acoustic and optical branches, phonons), specific heat of the crystal lattice.
2. Schrödinger equation for solids (adiabatic approximation, single-electron approximation). Solution of Schrödinger equation in Hartree-Fok approximation, Bloch theory of electron movement in periodic crystal field.
3. Fundamental methods of calculating electron band structure, Fermi surface, effective mass tensor; Wannier theory of electron movement in perturbated periodic potential.
4. Localized electronic states in crystals; properties of conduction electrons in statistical equilibrium.
5. Boltzmann kinetic equation, electron scattering on lattice vibrations and ionized impurities, relaxation time of conduction electrons in metals and semiconductors, basic transport phenomena.
6. Dispersion and absorption of electromagnetic waves in solids, inter- and intra-band optical transitions in solids, Frenkel and Mott-Wannier exciton model.
7. Polarons in ionic crystals, Pauli paramagnetism and Landau's diamagnetism, cyclotron resonance.
8. Phase transitions of the 1st and 2nd order, paramagnetism of atomic and ionic assemblies, Weiss phenomenological theory of ferromagnetism, Neel theory of molecular field of antiferromagnetics and ferromagnetics, crystalline structures of antiferromagnetics and ferromagnetics, Heisenberg quantum theory of ferromagnetism, spin-waves theory of ferromagnetism.
9. Temperature dependence of magnetization and thermal capacity of ferromagnetics, various types of magnetic arrangements and their study by neutron diffraction.
10. Basic methods of mathematical modeling of condensed matter: DFT, MD, mesoscale modeling.

Subject	Solid State Physics

Problem Areas

1. Types of bonding forces in condensed matter - ionic, covalent, metallic, Van der Waals, hydrogen.
2. Structure and defects of condensed matter - macroscopic symmetry of crystals, crystal lattice, liquid crystals, nanocrystals, amorphous substances, structural defects, diffusion.
3. Mechanical properties of solids - elastic and plastic deformation, dislocation dynamics, ductility and strength of solids..
4. Thermal properties of solids - thermal capacity, thermal expansion and thermal conductivity of the crystalline lattice.
5. Electronic structure of solids - basic properties of wave functions and electronic spectrum in periodic potential of crystals.
6. Physics of metals – metallic lattice, ordered and disordered systems, point defects in metals, diffusion, dislocations in simple lattices and their movement, short- and long-range interactions of dislocations.
7. Model of free electrons, electrical, magnetic, optical and thermal properties of metals, superconductivity. Plasma reflection edge, phenomenological theory of electro-optical and piezo-optical properties of crystals, electro-, magneto- and acousto-optical phenomena.
8. Physics of dielectrics - orientational, ionic and electronic polarization, optical properties, feroelectrics, phase transitions, Kramers - Kronig relations, propagation of EM waves in medium, Fresnel equations, nonlinear optics, luminescence.
9. Physics of semiconductors - intrinsic and extrinsic semiconductors, electrical conductivity, Hall effect, contact phenomena, PN junction, photoelectric properties, surface properties, transistors.
10. Experimental methods of solid state studies - X-ray, electron and neutron diffraction analysis, Raman spectroscopy, special methods for the study of structure and chemical composition of solid surfaces, basics of preparation and properties of thin layers and multilayer assemblies.