

Exam questions for the course "Quantum Solid State Physics"

Questions from the first semester (included in the exam of the second semester)

1. The structure of periodically-ordered crystals.
2. The reciprocal lattice of periodically ordered crystals. Brillouin zone.
3. Methods for experimental determination of crystal structure.
4. Classification of Bravais lattices.
5. Incommensurably modulated crystals. Quasicrystals.
6. Liquid crystals and polymers; examples.
7. Substances in an amorphous state. Gels, aerogels and opals.
8. Effect of temperature on X-ray scattering; the Debye-Waller factor.
9. Specific heat of solids.
- 10.* Methods for determining the Debye temperature.
11. Normal modes of a monoatomic linear chain.
12. Normal modes of a diatomic linear chain; gap in the spectrum of vibrational excitations.
- 13.* Normal vibrational modes of the Bravais lattice and lattices with a basis in two-dimensional and three-dimensional cases.
14. Density of vibrational states.
- 15.* Number of independent components of the modulus tensor of elasticity of crystals and amorphous media.
16. Interatomic interactions and coupling in solids.
17. Thermal conductivity. Its temperature dependence.
18. Phonon umklapp scattering processes.
19. Metals, semimetals, semiconductors, dielectrics. Understanding the graphs of the band structure.
- 20.* The principle of operation of the simplest semiconductor devices: a diode, a photodiode, a solar battery, a laser, a transistor.
21. Dielectrics. Various contributions to the polarizability of dielectrics.
22. Frequency dependence of dielectric permittivity and susceptibility of dielectrics. Its description with the help of forced oscillations.
23. Calculation of the orientation susceptibility.
24. Complex dielectric permittivity and its physical meaning.
25. Ferroelectrics and piezoelectrics.
26. Various contributions to magnetic susceptibility of paramagnets and their temperature dependence.
- 27.* Adiabatic demagnetization as a cooling method.
- 28.* Nature of magnetic exchange interaction.
29. Ferromagnetism and antiferromagnetism in the mean-field approximation: temperature dependence of their magnetic susceptibility and magnetization.
30. Spin waves in ferro- and antiferromagnets. Their dispersion law. Magnons.
31. Temperature dependence of magnetization of ferromagnetics. Mean-field result, experimental, and theoretical with contribution from magnons.
32. Magnon contribution to the temperature dependence of specific heat in ferro- and antiferromagnets.
33. Frustrated magnets and spin glasses.

Main literature for home reading: "Introduction to Solid State Physics", 8th Edition, by Charles Kittel

Questions new for the second semester

34. Free electron gas and the Fermi surface
35. Theory of metals. Kinetic equation for electrons. Electric and thermal conductivity of metals.
36. Electronic properties of metals in a magnetic field: magnetoresistance and quantum oscillations.
37. Skin effect.
- 38.* Defects in crystals.
- 39.* Hopping conductivity.

40. Superconductivity.