

List of topics 2021

Solid-state physics (Materials science MSc.)

1. Phonons

Phonon band structure of a 1D lattice model, acoustic and optical modes, sound velocity, equivalent wavenumbers

2. Hydrogen atom and hydrogen molecular ion

Hamiltonian of hydrogen atom, solution of the Schrödinger-equation, hydrogen electron orbitals, visualizing the hydrogen electron orbitals; Hamiltonian of the hydrogen molecular ion, application of LCAO method for the hydrogen molecular ion

3. One- and two-particle wave function

time-independent and time-dependent Schrödinger-equation, one- and two-electron wave functions with and without spin, Pauli-principle, singlet and triplet spin states, variational method.

4. Hydrogen molecule

Hamiltonian, molecular-orbital method, Heitler-London method

5. 1D linear chain with tight-binding approximation

Basic concept of solid-state physics: primitive cell, reciprocal lattice, Brillouin zone, Bloch theorem, dispersion relation; 1D linear chain with tight-binding approximation

6. Dimerized chain

Dispersion relation of a dimerized linear chain, metal or insulator?, Peierls distortion

7. Quasi-free electron approximation

Empty lattice approximation, weak potentials, Fermi-energy, Fermi-Dirac distribution, Fermi-surface, density of the states,

8. Semiconductors

Band structure of semiconductors, conductance and valence band, electron and hole mass, n-doped and p-doped semiconductors, conductivity vs. temperature plot for a n-doped semiconductor,

9. Transport phenomenon

Drude-model, Boltzmann-equation, relaxation time approximation, electrical conductivity, generalized transport coefficients, Peltier, Seebeck effects,

10. Electrons in magnetic field; magnetism

Classical description, cyclotron frequency, Hall-effect; Paramagnetism, Curie susceptibility, Anti- and ferromagnetic order, Curie temperature, Curie-Weiss law, Domain-walls