List of topics 2018

Solid-state physics (Materials science MSc.)

1. Hydrogen atom and hydrogen molecular ion
Hamiltonian of hydrogen atom, solution of the Scrödinger-equation, hydrogen electron orbitals, visualizing the hydrogen electron orbitals; Hamiltonian of the hydrogen molecular ion, application of LCAO method for the hydrogen molecular ion

2. One- and two-particle wave function
time-independent and time-dependent Scrödinger-equation, one- and two-electron wave functions with and without spin, Pauli-principle, singlet and triplet spin states, variational method, prove that the expectation value of H with arbitrary wavefunction is always bigger or equal to the exact ground state energy.

3. Hydrogen molecule
Hamiltonian, molecular-orbital method, Heitler-London method, mixing of ionic and covalent bonding, hybridi orbitals

4. 1D linear chain with tight-binding approximation
Basic concept of solid-state physic: primitive cell, reciprocal lattice, Brillouin zone, Bloch theorem, dispersion relation; 1D linear chain with tight-binding approximation

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

6. Graphene
Brillouin zone of the graphene, tight-binding model, dispersion relation, dirac-cone, valley freedom, nanotubes

7. Time-independent perturbation theory
Correction of the eigenvalue and eigenvector; applications: ionic bonding, van der Waals interaction

8. Quasi-free electron approximation
Empty lattice approximation, weak potentials, Fermi-Dirac distribution, density of the states, van Hove singularity

9. Semiconductors
Band structure of a semiconductor, density of the states, temperature dependence of the chemical potential, doping, temperature dependence of the number of electron in the conduction band, metal-semiconductor interface

10. Transport phenomenon
Boltzmann-equation, relaxation time approximation, electrical conductivity, generalized transport coefficients, Peltier, Seebeck effects,