

Exam topics

1. The basics of quantum mechanics I (Bohr's theory of H-atom and the spectra of H-atom)
2. The basics of quantum mechanics II (time-dependent and time-independent Schrödinger equation, particle in the box problem, free particle)
3. The basics of quantum mechanics III (postulates of quantum mechanics, commutator relations)
4. The basics of quantum mechanics IV (harmonic oscillator)
5. The basics of quantum mechanics V (particle on a ring, particle on a sphere, eigenvalue problem of \hat{L}_z and \hat{L}^2 operators)
6. The structure of the hydrogen atom I (Schrödinger equation of the H atom, spherical coordinates, eigenfunctions, and eigenvalues, atomic unit, atomic orbitals)
7. The structure of the hydrogen atom II (Stern-Gerlach experiment, spin, magnetic dipole moment, Zeeman-effect, corrections from the Dirac equation, vector model of the angular momentum, selection rules)
8. Structure of many-electron atoms I (Pauli exclusion principle, ground and excited states of the He atom, Slater determinant)
9. Structure of many-electron atoms II (diagonal rule, Atomic term symbols, Russel-Saunders and jj-coupling, Hund's rules, selection rules)
10. Optical spectroscopy I (Born-Oppenheimer approximation, variational principle, Hartree-Fock method, CI expansion)
11. Optical spectroscopy II (Boltzmann distribution)
12. Optical spectroscopy III (molecular symmetry)
13. Optical spectroscopy IV (classification of the electromagnetic spectrum, Beer-Lambert law, interpretation of optical spectra, transition dipole moment, line width)
14. Rotational spectroscopy I (rigid rotor, classification of rotors, energy and degeneracy of the rot. states [symmetric, linear and spherical tops])

15. Rotational spectroscopy II (selection rules, populations, spectra, asymmetric rotor, determination of molecular geometries, Centrifugal distortion, Stark effect)
16. Vibrational spectroscopy I (diatomic molecules, harmonic oscillator model, anharmonicity, Birge-Sponer extrapolation, rotation-vibration terms, P-, Q-, R-branches, selection rules)
17. Vibrational spectroscopy II (polyatomic molecules, selection rules, infrared spectra, analytical application, Fourier transform IR spectroscopy)
18. Electronic structure of molecules I (LCAO approximation, molecular orbitals of diatomic and polyatomic molecules, electronic excitations, selection rules)
19. Electronic structure of molecules II (UV spectroscopy, fluorescence spectroscopy)
20. Lasers and laser spectroscopy (radiative transitions, Einstein coefficients, inverse population, spectrum of lasers)
21. Lasers and laser spectroscopy (types of lasers, radiation mechanism, mode-locking, synchronous pumping, properties of laser beam, frequency tuning)
22. Lasers and laser spectroscopy (Raman spectroscopy, two-photon absorption, flash photolysis, pump and probe experiment)
23. Mössbauer spectroscopy (nuclear spin, magnetic moment, Mössbauer effect, chemical shift, experimental technique)
24. Nuclear magnetic resonance spectroscopy (magnetic moment of nuclei, interaction with magnetic field, chemical shift, spin-spin interaction in the ^1H and ^{13}C NMR, FT-NMR)
25. Mass spectrometry
26. X-ray diffraction spectroscopy