Atomic and molecular physics
themes of the comprehensive exam

1. Eigenvalue problem of the attractive Coulomb potential: the primary spectrum of the Hydrogen atom, the fine structure and other corrections

2. Stark effect and polarizability of the H atom

3. Spin and orbital angular momentum, addition of angular momenta

4. The spectrum of the He atom: ground state and excied states with perturbation theory, singlet and triplet states, exchange interaction

5. The variational method and its application for the ground state of the He atom

6. The one-electron approximation for atoms, the Hartree and Hartree-Fock methods

7. Electronic configurations of atoms, spin-orbit couplings, Hund's rules.

8. Selection rules and atomic spectra.

9. Atoms in magnetic fields, Zeeman effect

10. The eigenvalue problem for molecules, separation of nuclear and electronic motion, adiabatic and Born-Oppenheimer approximations

11. Molecular orbitals for the H_2^+ molecular ion and the H_2 molecule, the VB method

12. The Hartree-Fock method for molecules, the Roothan equations.

13. The origin of the chemical bond, the virial theorem

14. Rotational spectra of diatomic molecules, centrifugal distortion

15. Vibrational spectra of diatomic molecules, harmonic and anharmonic oscillations, vibrational transitions.

16. Electronic states of multielectron atoms, hybridization, simple molecules: H_2O, CO_2, NH_3

17. Spectra of multiatomic mulecules, electronic transitions, vibrational and rotational structure, fluorescence and Raman spectra.

Literature:
W. Demtröder: Atoms, Molecules and Photons, Springer, 2006
B. Bransden, C. Joachain: Physics of Atoms and Molecules, 2nd ed, Prentice Hall 2003
P. Atkins, R. Friedman: Molecular quantum mechanics 4th ed., Oxford 2005