Questions to the exam

(Version from 26.02.2018. The list will be replenished!)

1. What is the normal and anomalous Zeeman effect, explain the difference. How many lines will be observed for the leading electric dipole transitions between p- and d-level of hydrogen-like system placed in external magnetic field for the case of normal Zeeman effect. (Hint: think also about dipole selection rules).

2. In electron beam ion traps (EBITs) facilities atoms are ionized by the electron impact ionization. Estimate the kinetic energy of incident electrons, required to produce lithium-like iron (Z=26) ions.

3. How much energy is required to produce the electron-positron pair in the field of bare uranium nucleus (Z=92) if electron is captured to the ground (1s) state of the system.

4. What is dielectronic recombination? Which kinetic energy should have an electron, colliding with hydrogen-like argon ion (Z=18) in its ground state in order to produce helium-like Ar^{16+} ion in the $2s^2$ state?

5. Estimate the energies of the Ly-α_1 and Ly-α_2 lines of hydrogen-like uranium.

6. Consider a process of a capture of an electron into $2p_{1/2}$ and $2p_{3/2}$ states of hydrogen atom. Find a population ratio of these two states after the capture. The same for the electron capture into $3d_{3/2}$ and $3d_{5/2}$ states.

7. Make a sketch an energy spectrum (n=1 and n=2 levels only) of hydrogen-like cesium ion $^{177}Cs^{54+}$. Take into account both relativistic and hyperfine-structure effects. (Hint: the isotope 177 has the nuclear spin I=7/2)

8. The lifetime of the 2p state of hydrogen atom is about $1.56*10^{-9}$s. Estimate natural width of 2p state of Hydrogen atom. Compare it with the Lamb shift between 2s and 2p state (4.3*10-6 eV).

9. The operator that describes the weak interaction in atomic systems can be written as $H_{PV} = f(\boldsymbol{r})\,\gamma_5$ where $f(\boldsymbol{r})$ is some even function and $\gamma_5 = \begin{pmatrix} 0 & I \\ I & 0 \end{pmatrix}$. Prove that this operator leads to the mixing of atomic levels of opposite parity.

10. Why the effects of parity violation in atomic systems are most pronounced for inner-shell electrons?

11. The state $1s^2\ 2s\ 2p$: J=0 in beryllium-like ions with *zero* nuclear spin is the longest living (low-lying) electronic excitations of a tightly bound system. What is the reason for this extremely long lifetime? How one can significantly reduce this lifetime?

12. Why the field (isotope) shift is largest for s-electrons when comparing with p-, d-… electrons?