Reexam Kaleidoscope Modern Physics

donderdag 7 february 2013, 9:00-12:00, Tentamenhal

- Answer all question short and to the point, but complete; write legible.
- Use of a calculator is not allowed.
- $hc = 1240$ eV nm ; $\hbar c = 200$ eV nm ; 1 $u = 931.5$ MeV/c^2.
- Put your name and student number on each sheet. Good luck!

1. Explain what the Compton effect is. Calculate the Compton wavelength $\lambda_C = h/(m_e c)$ of an electron in nm ($m_e = 0.5$ MeV/c^2).
2. Calculate the wavelength in nm and the frequency in Hz of the Lyman-α line $n = 2 \rightarrow n = 1$ in hydrogen. First calculate $E_2 - E_1$ in eV. What is the "color" of this line?
3. Explain what the K_α-line is in an X-ray spectrum of atoms. Why does it hold that $E \sim (Z-1)^2$? A mixture of iron (Fe, $Z = 26$) and an unknown material X are irradiated with electrons. The wavelengths of the K_α-lines are 0.194 nm for iron and 0.229 nm for material X. What is the atomic number Z, of this material?
4. Explain what fluorescence and phosphorescence are. Give an application of both.
5. Formulate the Pauli-principle for two electrons. Give the electron configuration for technetium (Tc, $Z = 43$). Explain the concept Fermi-energy for metal (no formulas!).
6. Explain what α-, β- en γ-decay are. A ${}^{235}_{92}$U-nucleus decays into a series to ${}^{207}_{82}$Pb. How many α- and how many β-particle are emitted in that series?
7. Why does ${}^{235}_{92}$U fission easier with slow neutrons ($K \simeq 0$) than ${}^{238}_{92}$U? How many neutrons are produced in the fission reaction $n + {}^{235}_{92}\mathrm{U} \rightarrow {}^{133}_{51}\mathrm{Sb} + {}^{98}_{41}\mathrm{Nb} + ?n$? Estimate the energy release in MeV. The atomic masses for the U, Sb and Nb isotopes are 235.04 u, 132.92 u en 97.91 u; the neutron mass is 1.01 u.
8. Name all fundamental fermions and bosons and give their spin. Which of the four fundamental interactions is the electron subject to? And the neutrino? And the neutron?
9. Formulate the uncertainty principle for energy and time. Estimate the range of the weak interaction in fm, assuming a mass of the Z^0-boson of 90 GeV/c^2. What is the range of the strong nuclear force? And of the electromagnetic and gravitational forces?
10. Fermi-problem: If the entire land area of the earth would be divided equally between all people, how much would each person get?