Final examination FYSN445 - March 19, 2010
(Answers also in Finnish accepted)

Problem 1.
Answer briefly the following questions:
(a) Explain the Thermal Nuclear Reactor Concept and derive the expression for the neutron multiplication factor.
(b) Explain the role of delayed neutrons in reactor control.
(c) Explain the difference between fissile and fertile isotopes.

Problem 2.
(a) Thin layers of gold (Au) and aluminum (Al) are evaporated on top of a thick silicon carbide (SiC) substrate, Al being the topmost layer. Sketch the acquired Rutherford Back Scattering (RBS) spectrum when the sample is bombarded with 4 MeV $^4He^{++}$ beam. Z(C) = 6, M(C) = 12.0 u; Z(Si) = 14, M(Si) = 28.1 u; Z(Al) = 13, M(Ti) = 27.9 u; Z(Au) = 79, M(Au) = 197.0 u.
(b) Explain shortly:
-What are the benefits of using heavy ion beams in RBS?
-How does an increase in the projectile energy affect on the sensitivity, mass resolution and depth resolution of an RBS experiment? What are possible problems with higher beam energies?

Problem 3.
Explain the principle of positron emission tomography method. What are the most important factors defining the image resolution of this method?

Problem 4.
(a) What is the effective half-life of ^{135}Xe ($T_{1/2\beta^-}$ =9.1 h) in a thermal neutron flux of 10^{14} n/cm^{2}s at a temperature of 800 ^{0}C ? (Help: $\sigma_{a,\,20C} / \sigma_{a,800\,C}$ = 1.1581/0.9887; $\sigma_{a,20C}$ = 2.65 10^6 barn?)
(b) Describe what happens to ^{135}Xe as a function of time after a shutdown of a reactor? Would it be wise to try to turn the reactor to full power again 2, 10 or 100 hours after the shut down?