PHYSICS 4E QUIZ 2 SPRING QUARTER 2017
PROF. HIRSCH MAY 1

Show all steps in your calculations. Justify all answers. Write clearly.
Suggestion: do the problems you find easiest first
Some constants:

$$hc = 12,400 eVA, \;\; k_B = 1/11,600 eV/K, \;\; m_e c^2 = 511,000 eV$$

$$\hbar c = 1973 eVA \;\; ; \;\; ke^2 = 14.4 eVA \;\; ; \;\; 1A = 10^{-10} m \;\; ; \;\; m_{neutron} c^2 = 939.6 MeV$$

Problem 1 (10 pts)
10 million α particles with kinetic energy 7.2 MeV are incident on a tin foil (Z=50) of thickness 3μ (30,000A). Assume the density of tin is 0.333 atoms/A^3.
(a) What is the distance of closest approach for a head-on collision with a tin nucleus, in A?
(b) What is the impact parameter (in A) for which α particles are scattered at a 90 degree angle?
(c) How many α particles are scattered at angles larger than 90 degrees, assuming the radius of the tin nucleus is smaller than the distance calculated in (a)?
(d) For extra credit (3 pts) Approximately how many α particles are scattered at angles between 90^0 and 92^0?

Problem 2 (10 pts)
According to classical electromagnetism, an electron moving in a circular orbit will emit electromagnetic radiation of frequency equal to its frequency of revolution, $f = v/2\pi r$.
(a) Using formulas derived from the Bohr model of hydrogen, find an expression for the wavelength of the radiation that would be emitted by an electron in the n-th Bohr orbit according to classical electromagnetism.
(b) From your result in (a), find numerical values (in A) for those wavelengths for the orbits n=4 and n=5, λ_4 and λ_5.
(c) Find the wavelength of the photon emitted or absorbed when an electron makes a transition between orbits n=4 and n=5 according to Bohr's theory. Give your answer for this wavelength, λ_{45}, in A.
(d) Compare λ_{45} with $(\lambda_4 + \lambda_5)/2$ and explain why they agree or disagree.

Problem 3 (10 pts)
An electron and a neutron have the same de Broglie wavelength. Find the ratio of the kinetic energy of the electron to the kinetic energy of the neutron:
(a) assuming they are both non-relativistic.
(b) assuming they are both extremely relativistic.
(c) Find the range of de Broglie wavelengths that a relativistic neutron will have.
Definitions:
non-relativistic: kinetic energy much smaller than rest energy
relativistic: kinetic energy equal or larger than rest energy
extremely relativistic: kinetic energy much much larger than rest energy