PHYSICS 4E QUIZ 2 SPRING QUARTER 2020
PROF. HIRSCH APRIL 27

<u>Open book</u>. Show all steps in your calculations. Justify all answers. Write clearly.
Some constants:

$$hc = 12{,}400 eVA,\ \ k_B = 1/11{,}600 eV/K,\ \ m_e c^2 = 511{,}000 eV,\ a_0 = 0.529A$$

$$\hbar c = 1973 eVA \quad ; \quad ke^2 = 14.4 eVA \quad ; \quad 1A = 10^{-10} m \quad ; \quad c = 3\cdot 10^8 m/s$$

Problem 1 (10 pts+5 pts extra credit)
In a Rutherford scattering experiments with α particles with kinetic energy 6 MeV on a silver foil (Z=47) it is found that 100 α particles per second are scattered at angles larger than 120^o. For all scattering angles, the number of α particles scattered agree with the prediction of Rutherford's theory.
(a) How many α particles per second are scattered at angles between 60^o and 120^o?
(b) What quantitative statement can you make about the radius of the silver nucleus based on the results of this experiment?
(c) What is the impact parameter (in A) for α particles scattering at a 60^o angle?
(d) <u>For extra credit:</u> what is the distance of closest approach to the nucleus for an α particle scattering at a 60^o angle? Justify your answer.

Problem 2 (10 pts)
When light with a continuous spectrum of wavelengths in the range 100A to 130A is transmitted through a gas of hydrogen-like ions, dark absorption lines are seen in the spectrum of transmitted light.
(a) Give one possible value for the atomic number (Z) of these ions and for the values of the quantum numbers (n) for the initial and final state of the ions giving rise to these dark lines.
(b) Same as (a) for a different value of Z.
(c) Assuming now that this gas is cooled to sufficiently low temperatures that all electrons are in the lowest energy state initially, for which Z values can this light ionize these ions? Give all the possible values of Z.

Problem 3 (10 pts)
It takes an electron in a Bohr orbit of the hydrogen atom 77.7 fs (fs=femtosecond=10^{-15}s) to go around the orbit once.
(a) Find the radius of this orbit, in A.
(b) Find the quantum number of the orbit and the angular momentum in units of $\hbar$.
(c) Find the potential energy of this electron, in eV.
(d) Find the de Broglie wavelength λ of this electron in A.