This set consists of 4 problems and the total points is 4. Show key formulas and intermediate results. Pay attention to the significant figures.

4.50 (1 point) Photons of wavelength 315 nm or less are needed to eject electrons from a surface of electrically neutral cadmium.

(a) What is the energy barrier (in electron volts, eV) that electrons must overcome to leave an uncharged piece of cadmium?

(b) What is the maximum kinetic energy of electrons ejected from a piece of cadmium by photons of wavelength 200 nm?

(c) Suppose the electrons described in (b) were used in a diffraction experiment. What would be their wavelength?

4.52. (1 point) Express the velocity of the electron in the Bohr model for fundamental constants (m_e, e, h, ε_0), the nuclear charge Z, and the quantum number n. Evaluate the velocity of an electron in the ground states of He^+ ion and U^{91+}. Compare these velocities with the speed of light c. As the velocity of an object approaches the speed of light, relativistic effects become important. In which kinds of atoms do you expect relativistic effects to be greatest?

3. (1 point) Although the Bohr model does not apply to atoms or ions with more than one electron, it works reasonably well for the $n = 2$ to $n = 1$ transition (denoted K_α in physics) for most metal elements.

(a) Derive the formula for calculating the K_α emission wavelength from the atomic number Z and physical constants.

(b) Physicist Henry Moseley discovered in 1913 that the experimental K_α wavelength depends on $Z - 1$ instead of Z. What will be the metal that emits a K_α X-ray of 1.54 Å wavelength?

5.46. (1 point) The wave function of an electron in the lowest (that is, ground) state of the hydrogen atom is

$$\psi(r) = \left(\frac{1}{\pi a_0^3}\right)^{1/2} \exp\left(-\frac{r}{a_0}\right)$$

$$a_0 = 0.529 \times 10^{-10}\ \text{m}$$

(a) What is the probability of finding the electron inside a sphere of volume 1.0 pm^3, centered at the nucleus (1 pm = 10^{-12} m)?

(b) What is the probability of finding the electron in a volume of 1.0 pm^3 at a distance of 52.9 pm from the nucleus, in a fixed but arbitrary direction?

Hint: assume the probability of finding the electrons in the small sphere is constant to avoid the calculus integrals of function.