Physics 25 Practice Final - 3 hours
2 Pages - turn over!!

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Write your answers in a blue book. Calculators and one page of notes allowed. No textbooks allowed. Please make your work neat, clear, and easy to follow. It is hard to grade sloppy work accurately. Generally, make a clear diagram, and label quantities. Make it clear what you think is known, and what is unknown and to be solved for. Except for extremely simple problems, derive symbolic answers, and then plug in numbers (if necessary) after a symbolic answer is available. **Put a box around your final answer... otherwise we may be confused about which answer you really mean, and you could lose credit.**

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1. Give numerical answers to at least two significant figures for:
   (a) The Bohr radius.
   (b) The radius of a negative muon (which has a mass that is 200 times that of the electron, and the same electric charge as an electron) in the lowest Bohr orbit about a Neon nucleus ($Z = 10$).
   (c) The sum of the binding energy B and $m_e c^2$ for an electron bound in the lowest Bohr orbit about a Fermium nucleus ($Z = 100$), in units of MeV.
   (d) The value of the fine structure constant, $\alpha = e^2/(\hbar c)$
   (e) The value of $\hbar c$ in eV-nm.
   (f) The wavelength of a photon with energy of 5 MeV.
   (g) The wavelength of an alpha particle, for which $m_\alpha c^2 = 3726\,\text{MeV}$, with kinetic energy of 5 MeV.

2. A particle of mass m moves in a radially symmetric potential $V(r)$ where:
$$V(r) = \gamma r$$
   (a) Find both the radius and the energy of the lowest Bohr orbit.
   (b) Find the *ratio* of the radius of the second Bohr orbit (with $n = 2$) and the first.
   (c) Find the *ratio* of the energy of the second Bohr orbit (with $n = 2$) and the first.

3. An electron with kinetic energy $E = 100\,\text{eV}$ moves in one dimension from $x = -\infty$ to $x = 0$. There, the electron encounters a step in potential energy of height $V_0 = 90\,\text{eV}$. What is the probability that the electron is reflected back toward $x = -\infty$, both symbolically and numerically?

4. An electron with kinetic energy $E = 5\,\text{eV}$ moves in one dimension from $x = -\infty$ to $x = 0$, where $V(x) = 0$, and then the electron encounters an oddly-shaped potential barrier. The potential is described by the following equations, where V(x) is in units of eV, and x is measured in nanometers.
$$\begin{aligned} V(x) &= 0 && x < 0 \\ V(x) &= 40(1 - 2.5x) && 0 < x < 0.3 \\ V(x) &= 10 && 0.3 < x < 0.6 \\ V(x) &= 0 && 0.6 < x \end{aligned}$$

(a) Make a clear plot of the potential $V(x)$.

(b) Find the probability that the electron is transmitted through the potential, and proceeds to $x = +\infty$.

5. Consider a particle of mass m that is trapped in a potential well which has $V(x) = \infty$ for $x < 0$ and $x > a$, where a is a real number. Assume that the uncertainty Δx in the position of the particle is $a/2$. Evaluate $\Delta x \Delta p$ when the particle is in the ground state.
