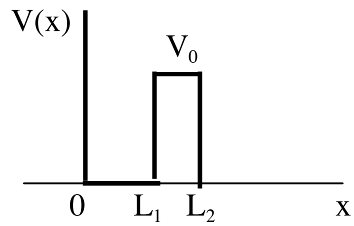
PHYSICS 4E | QUIZ 4 (open book) | SPRING QUARTER 2015
PROF. HIRSCH | | MAY 22

Use: $\hbar^2/2m_e = 3.81eVA^2$, m_e=electron mass

Problem 1 (10 pts)

L_1=5A, L_2=8A
$V(x)=\infty$ for $x<0$
$V(x)=0$ for $0<x<L_1$
$V(x)=V_0$ for $L_1<x<L_2$
$V(x)=0$ for $L_2<x$



An electron is in the region $0<x<L_1$ of the potential V(x) shown in the figure in the lowest energy state. After approximately 1 second the electron escapes from this region and is in the region $x>L_2$.
(a) Estimate approximately the value of V_0 in eV. Explain all steps. Hint: V_0 is large
(b) For the value of V_0 found in (a) and the same L_1, what should L_2 be for the electron to stay in the region $0<x<L_1$ for 10 seconds rather than 1 second?

Problem 2 (10 pts)
The wavefunction for an electron in a hydrogen-like ion with nuclear charge Ze is
$\psi(r,\theta,\phi) = Cr^3 e^{-r/a_0} f(\theta)g(\phi)$
where C is a constant and a_0 is the Bohr radius
(a) What is the energy of this electron in eV? Justify your answer.
(b) What is the value of Z? Justify your answer.
(c) What are the possible values for the quantum numbers n, ℓ and m? Justify your answer.
(d) What is the wavelength (in A) of the shortest wavelength photon that this electron can emit in making a transition from this state to another stationary state of this ion?

Problem 3 (10 pts)
For the electron described by the wavefunction in problem 2:
(a) Calculate the most probable r for this electron and explain how it is related to a Bohr orbit.
(b) Calculate $\langle 1/r \rangle$ for this electron in terms of a_0 (by doing integrals), and the average potential energy in eV.
(c) Calculate $\langle r \rangle$ for this electron in terms of a_0.
Use $\int_0^\infty dr\, r^n e^{-\lambda r} = \frac{n!}{\lambda^{n+1}}$

Justify all your answers to all problems.