Practice problems – Schrodinger Equation and Atomic Physics

1. A particle is in the second excited state (n=3) in a one-dimentional square potential with absolutely impenetrable walls (0<x<L). Find the probability of the particle being in the region 1/3 L < x < 2/3 L.
2. A particle is in the ground state in a three-dimensional square box with each side of length L. Find the normalization constant of the wavefunction.
3. In a particular semiconductor device an oxide layer forms a barrier 0.6 nm wide and 9 eV high between two conducting wires. Electrons accelerated through 4 V approach the barrier. A) What fraction of incident electrons will tunnel through the barrier? B) Through what potential difference should the electrons be accelerated in order to increase the tunneling fraction by a factor of 2?
4. The moment of inertia of a compact disk is 10^{-5} kg m^2. A) Find the angular momentum $L=I\omega$ when the disk rotates at $\omega/2\pi$=735 rev/min and B) Find the approximate quantum number l .
5. A hydrogen atom is in a state with $l = 3$ and m=2. A) Compute the minimum possible energy of the electron. B) What are the possible values of L_z?
6. The wavefunction of a particle of mass m in a 1D potential $U(x) = kx^2/2$ has in the ground state the form $\psi(x) = Aexp(-\alpha x^2)$, where A is the normalization factor and α is a positive constant. Making use of the Schrodinger equation, find the energy of the particle in this state.

Answers:

1. 1/3
2. $A=(2/L)^{3/2}$
3. A) $4.9x10^{-6}$. B) ~4.45 V (may need to solve graphically)
4. A) $7.7x10^{-4}$ kg m^2/s. B) $7.3*10^{30}$.
5. $E_n = 13.6/16$
6. $E=\hbar\omega/2$ where ω=sqrt(k/m); α=sqrt(km)/2$\hbar$.