1. (Exercise 3.7) Confirm that the wavefunctions for a particle on a sphere may be written $\Psi(\theta, \varphi) = \Theta(\theta)\Phi(\varphi)$ by the method of separation of variables, and find the equation for $\Theta(\theta)$. 
2. Hydrogen atom is prepared in the state described by the following wavefunction, where N is the normalization constant.

\[ \Psi(r, \theta, \varphi) = N \cdot ((i+1)|n=5, l=3, m_l=2> - 2|n=4, l=3, m_l=-3>) \]

a) Calculate the expectation values of the operators \( H, L_z, L_x^2 + L_y^2 \)
b) What are the outcomes of the measurements of \( L_z \) in this state?
c) What are the probabilities to find the outcomes?
3. Use rising and lowering operators to obtain the expectation value of the operator $\Omega$
in the state described by the eigenfunction of a harmonic oscillator $|v>$

$$\Omega = c - x \frac{\hat{\partial}}{\hat{\partial} x} \quad c=\text{const}$$