Question 1
What is the Stark effect and why can perturbation theory be applied to it? What quantities (cheat sheet formulas from question 3 on quiz #24) are actually being used in Merzbacher’s coverage of the Stark effect?

The Stark effect occurs when an atom is placed in a (constant and uniform) electric field. Perturbation applies because the strength of the external electric field is typically several orders of magnitude smaller than the atomic field. To discuss the effect of an electric field on the atom, we need the first and second correction to the energy as well as the first correction to the wave function. It turns out that we will also need the results from degenerate perturbation theory.

Question 2
Recall the degeneracies of central fields and Coulombic central fields. Also recall the parity values of specific angular momentum states. Now combine these with the parity selection rules from chapter 17 to argue which calculations within the Stark effect can be done within regular (nondegenerate) Schrodinger-Rayleigh perturbation theory, and which calculations need degenerate perturbation theory.

All states with a given \( n \) and \( l \) but arbitrary \( m \) are degenerate for central fields. In addition different \( l \) levels for a given \( n \) value are degenerate in the Coulombic case. States with given \( l \) and \( m \) have a parity value of \((-1)^l\). For tensor operators of odd rank such as vector, i.e., rank-1, operators, matrix elements between equal parity states vanish. Therefore the many degenerate \( m \) states will not be connected by the position operator \( r \) and nondegenerate theory will be good enough. On the other hand, states with different \( l \) in the Coulombic case will connect and degenerate perturbation theory will be needed.

Question 3
What is the purpose of degenerate perturbation theory (be specific)?

To set up a proper basis from which to develop ordinary nondegenerate perturbation theory by diagonalizing the degenerate subspace with respect to the total Hamiltonian (including the perturbation).

Question 4
Why would you want to use degenerate perturbation theory, even when the levels are not strictly degenerate?

Because if the levels are very close \( E_i - E_j \ll \epsilon \) the series converges very slowly.

Question 5Pick one.

What is meant by "level crossing"? What is the definition of atomic "polarizability"?

Level crossing occurs when the ranking of the energy levels changes as one varies a parameter of the hamiltonian slowly.

Polarizability of the atom is its response to an external electric field; it is the extent to which an electric field creates a dipole moment in response to an electric field.