Before-class Questions #9:

Question 1: Which approximation do we make for expanding the interaction Hamiltonian, the leading term of which gives the dipole transition? What must we assume about the wavelength of light?
Answer 1: The dipole approximation: k*r << 1. This means that the wavelength of the light is much larger than the atom's size.

Question 2: In terms of fine structure constant, how much weaker are magnetic dipole and electric quadrupole transitions relative to electric dipole transitions?
Answer 2: The matrix element is alpha times smaller, therefore the transition is alpha^2 times smaller.

Question 3: What does the rank of the spherical tensor representing the interaction matrix element tell us about a transition?
Answer 3: How much angular momentum is supplied or absorbed by the photon in the interaction.

Question 4: The photon is a spin one particle. In an atomic transition, can a photon supply more than one unit of angular momentum? If so, how?
Answer 4: The photon does not have to be emitted at the origin. Therefore, with respect to the origin, the photon can carry away angular momentum greater than one.

Question 5: What should the polarization of your photon's electric field be with respect to the quantizing magnetic field in order to drive a pi (delta m = 0) transition?
Answer 5: E parallel to B.

Question 6: With a photon's k-vector parallel to the quantizing magnetic field, is it possible to drive a pi transition? Why or why not?
Answer 6: It is impossible, since the polarization when projected onto the quantization axis is sigma_+ and sigma_-, driving delta m = +-1 transitions.