Before-class Questions #10:

Q1: We are interested in the interaction of a (two-level) atom with light. What is the frequency scale separating the width of narrowband spectral distributions from broadband spectral distributions?
A1: \Gamma, the natural linewidth/inverse decay rate of the excited state.

Q2: What restrictions must we impose to describe atom-light interactions (specifically, Rabi oscillations of the state of a two-level atom due to a monochromatic field) and neglecting spontaneous emission?
A2: Since the effects of spontaneous emission will only become apparent at times t ~ (\Gamma)^(-1), we restrict ourselves to times t << (\Gamma)^(-1). If we want to observe full Rabi cycles, this requires strong driving fields, i.e. we need a large Rabi frequency \omega_R >> \Gamma.

Q3: How does the probability of a two-level atom being driven to the excited state scale with time t for t << (\delta)^(-1) = (\omega - \omega_0)^(-1)?
A3: P ~ t^2, for both monochromatic and broadband light.

Q4: Which two effects in the two-level atom is not accounted for by perturbation theory?
A4: Power broadening. The generalized Rabi frequency in the perturbative regime is \Omega_R = (\omega_R^2 + \Delta^2)^(1/2) ~= \Delta, and depletion of the initial state.

Q5. What process is responsible for thermal equilibrium in a system of light and two-level atoms? What would a simple rate argument tell you about the ratio of excited to ground states (N_e/N_g = ?) if we had only the Einstein B coefficients? Compare with the result you would expect for N_e/N_g for two-level atoms in thermal equilibrium (ignore degeneracy).
A5: Spontaneous emission. If spontaneous emission did not exist, a simple rate argument would give the result N_e/N_g = 1 (reached asymptotically for long times). For a two-level atom in thermal equilibrium, N_e/N_g = Exp[- hbar \omega_eg / k T] (the Boltzmann factor).