1. For the 4 level laser gain medium described in the figure below, answer the following questions.
   a. To improve the gain of the laser, should the lifetime of level 1 be increased or decreased?
   b. If the populations in level 0 and 3 are identical for a moment, and a short pulse of coherent light is directed into the laser medium, how much light will come out of the medium (how much gain or loss will the pulse see). You may assume that the incident light is made of photons with energy equal to the energy different between states 0 and 3.

2. In a 2 level system, calculate the percentage of the atoms with electrons in the excited state if the energy of the excited state is $1.6 \times 10^{-19}$ joules greater than the ground state and the atoms are at 1000 degrees Kelvin. Assume that there is no optical field applied (Boltzmann’s constant = $1.38 \times 10^{-23}$ joules / K)

3. Describe how laser light is different (if it is) than natural light coming from a standard incandescent light bulb in the following areas. Describe in as much detail as possible what determines the characteristics for both cases (laser and natural).
   a. Polarization
   b. Directionality
   c. Frequency content

4. Describe the basic principle behind Q-switching and its advantages.

5. What is the expected laser mode spacing (frequency) of a HeNe laser with a cavity length of 30 cm?