Laser Physics Test  
example

1. A monochromatic beam of electromagnetic radiation has an intensity of 1 W/m2. What is the average number of photons per m3 (photon density) for 1 kHz radio-waves and 10 MeV energy gamma rays? [1 eV = 1.6\*10-19 J] (2 points)
2. Estimate the zero-point energy of an electron confined into a 3D region of size 10-14m, which is the order of magnitude of a nucleus. Compare this energy with the Coulomb potential energy of an electron and a proton separated by the same distance. Based on this comparison, can an electron be captured in a nucleus? (3 points)
3. What are the expressions for the energy levels and wave functions of a particle closed in a two dimensional potential box of sides a and b? How a particular wavefunction is normalized using a C constant? (3 points)
4. Calculate the angular velocity, the potential energy and kinetic energy of the electron, which is in the state n = 3 in a Hydrogen atom. Which are the possible quantum numbers of this electron? (3 points)
5. Which transitions (main quantum number pairs) result in emission of visible photons (with wavelengths between 400 nm and 700 nm) in a Hydrogen atom – at least 3 pairs? (2 points)
6. Which configuration has minimal energy and is thus more likely (arrows indicate the orientation of the spin vectors)? (1 point)

K

L

s

p

s

p

s

p

s

p

1. How the wave functions of the two electrons in a He atom are constructed from the individual orbital and spin wave functions? Write down the antisymmetric wave function of the configuration in determinantal form that contains both orbital and spin components for Ms=1 in He. (3 points)
2. How are the molecular orbitals derived from the atomic orbitals? What is the difference between bonding and antibonding orbitals e.g. in a H2 molecule? Sketch the difference in the energy-atomic distance diagram between bonding and antibonding molecular orbitals in a H2 molecule. Which quantity sets the optimum distance between the atoms? (3 points)
3. In a cylinder of volume V and cross section area A propagates a monochromatic photon stream of frequency ν and intensity I, parallel to the cylinder axis. What is the probability of the induced emission and absorption when the cylinder is filled with a material characterized by a transition cross section σ(ν)? What should we do when we want to extend the analysis to a not monochromatic photon flux of bandwidth Δν? (2 points)
4. The characteristic lifetimes are given in the figure (*tsp* = 150 µs, *nr =*5 ms, **20 = 1 ms, **1 = 1500 µs). Is the transition 2 → 1 good for a laser transition? Write also arguments! How large is the lifetime of level 2? And the transition lifetime to the transition 2 → 1 (2 points)

**1

*tsp*

*nr*

**20