بسم الله الرحمن الرحيم

جامعة الملك سعود
كلية العلوم
قسم الفيزياء

الأسم .... الرقم الجامعي

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1. (a) The quantum yield of $S_1 \rightarrow S_0$ transition for Rhodamine 6G is 0.87, and the corresponding lifetime is ≈ 5 ns. Calculate the radiative and nonradiative lifetimes (τ_{sp} and τ_{nr}, respectively) of the S_1 level (assume η=1.36 for ethanol).

   (b) From a knowledge of the radiative life time τ_{sp} of Rhoamine 6G (from part a),

   (i) Calculate the corresponding $|\mu|$, where λ =0.59 μm at the maximum of the emission curve.

   (ii) Calculate the effective atomic dimension, a.

2. Consider a 488 nm Ar-ion gas laser. The tube length L=1 m, tube mirror reflectance are 99.9% and 95%. The linewidth $\Delta\nu$=3 GHz, the loss coefficient is α=0.1 m^{-1}, spontaneous decay time $\tau_{sp}=1/A_{21}$=10 ns and η=1.

   (i) What is the threshold population inversion?

   If the mirrors are concave and have radius of curvature equal to 1 m. calculate the beam diameter at;

   (ii) The center of the laser.

   (iii) At the mirrors.

   (iv) At distance of 10 m from the laser.

   (v) What is the divergence angle of the beam?

3. Consider a two-level system, non-degenerate, homogeneously broadened system of atoms with line-shape function $g(\nu)$ and energy levels E_1 and E_2. This system is pumped in a steady-state by monochromatic radiation with intensity I_ν and frequency $\nu = (E_2 - E_1)/h$.

(a) give stimulated transtion rate W_{21} in terms of the pump intensity I_v and other atomic parameters.

(b) Derive a steady-state expression for $(N_1-N_2)/(N_1+N_2)$ of this system in terms of W_{12}, W_{21} and A_{21}. N_1 and N_2 are the population density for the lower and upper state respectively; A_{21} is the spontaneous emmision rate.

(c) Can acheieve population inversion for this system? If so, what is the necessary pump intensity I_v?

4. The R_1 laser transition of Ruby has a good approximation a Lorentzian shape of width (FWHM) 330 GHz at room temperature. The measured peak transition cross-section is $\sigma = 2.5\times10^{-20}$ cm^2. Calculate the radiative lifetime (the refractive index is η=1.76). Since the observed room temperature lifetime is 3 ms, what is the fluorescence quantum yield?

5. Derive the expression $A = \dfrac{16\pi^3 \nu_0^3 \eta |\mu|^2}{3h\varepsilon_0 c^3}$ for the Einstein A coefficient, i.e. the rate of spontaneous emission.

PHYSICAL CONSTANTS

Rest mass of electron	m	$= 9.110 \times 10^{-31}$ kg
Charge of electron	e	$= 1.602 \times 10^{-19}$ C
Avogadro's constant	N_A	$= 6.022 \times 10^{23}$ mol^{-1}
Planck's constant	h	$= 6.626 \times 10^{-34}$ J s
Boltzmann's constant	k	$= 1.381 \times 10^{-23}$ J K^{-1}
Speed of light (vacuum)	c	$= 2.998 \times 10^{8}$ m s^{-1}
Stefan-Boltzmann constant	σ_{SB}	$= 5.670 \times 10^{-8}$ W m^{-1} K^{-4}
Permittivity of a vacuum	ε_0	$= 8.854 \times 10^{-12}$ Fm^{-1}

مع تمنياتي لكم بالتوفيق والنجاح