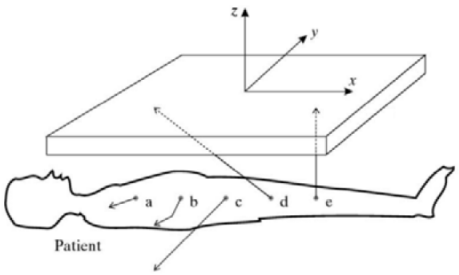
Assignment#3, Fundamentals in BioPhotonics
2021

1) (5%)

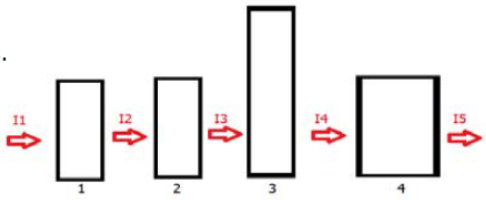


A scintillation camera that detects gamma radiations from the human body is shown in the figure. Which emissions enhance/degrade the signal to noise ratio?

2) (15%)

Let's imagine a beam propagates through many cuvettes as shown. The cuvettes differ from each other with different reasons. Here are the specs:

1) The concentration of the cuvette#2 is double of the others.
2) The height of the cuvette#3 is double of the others.
3) The width of the cuvette#4 is double of the others.



For cuvette#1, given that I_2/I_1 =0.01 and the concentration=2 M what are the ratios for succeeding intensities? (Hint: use Beer's Law)

3) (20%)

A) Vibrational wave number of a molecule is given as $k = 3000cm^{-1}$.Find the wavelength for the transition from ground level to the first level.

B) Vibrational force constant and wave number for XF are given as $K = 19.36x10^5\, g/s^2$ $k = 8.286x10^3\, cm^{-1}$ respectively. Find X atom from the reduced mass. (Hint: Take the molecules as simple harmonic oscillators and 1 atomic mass unit, $amu = 1.66x10^{-27}\, kg$)

N.B. The result will not be exact but find approximately the closest element.

4) (25%)

In general, a molecule with N atoms has 3N-6 normal modes of vibration, but a linear molecule has 3N-5 such modes (can be derived but it is not necessary). For a transition between modes there should be change in dipole moment.

A. Find number of vibrational modes for $CO_2, H_2O, O_2, N_2, CH_4, C_4H_2, NO$

B. Considering the absorption capability of the molecules given above, explain why we are not concerning about the molecules in air as potential source of global warming? What about H_2O?

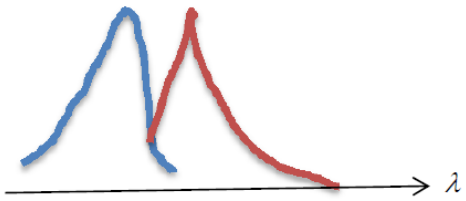
C. Given that NO molecule is in the lowest vibrational state ($K = 0.16x10^7\, g/s^2$) find the vibrational energy and the wavelength of the photon that excites it to the next level.

D. For a molecule the population ratio of i^{th} and j^{th} levels is τ_1 for electronic states, τ_2 for vibrational states and τ_3 for rotational states. Find the relation between τ_1, τ_2, τ_3.

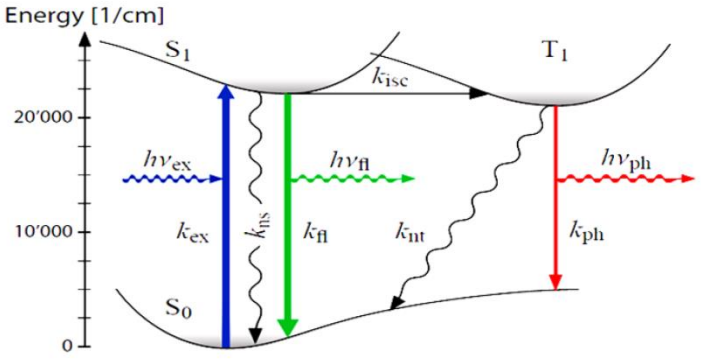
5) (10%)

A. For the Jablonski diagram given above explain what each arrow is representing.

B. The spectrum of a molecule is given below. Which one represents the excitation spectrum (verify with your answer in part A)? Why emission is mirror image of the excitation?



6) (25%)



A. For the triplet state given above find an expression for the population ratio in T_1 for steady-state excitation and an expression for quantum yield of fluorescence.

B. Propose a way to measure k_{fl} experimentally. Can you measure k_{nt} in a similar way?