Optical properties of materials
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Exercise 6.1: Absorption of molecular compounds in solution

1) The molar decadic extinction coefficient of a dye dissolved in hexane is known to be $\varepsilon_{dye} = 855\ dm^3\ mol^{-1}\ cm^{-1}$ at 270 nm. Calculate the percentage reduction in intensity when light of that wavelength passes through 2.5 mm of a solution of concentration 3.25 mmol dm^{-3}.

2) Calculate the cross-section of individual dye molecules at the same wavelength. How does the cross-section compare to the size of the molecule? Hint: Approximate the dye to a disk of 10 Å diameter.

Exercise 6.2: Estimation of fluorescence and phosphorescence quantum yields

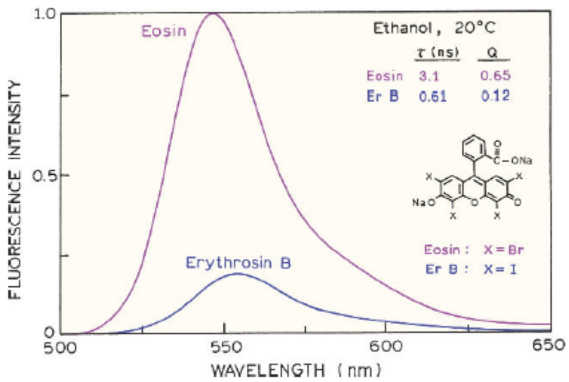

Figure 1 : Emission spectra of eosin and erythrosin B

Eosine is a red dye used to stain proteins, muscle fibers and collagen. It was also used in paintings (notably by Van Gogh!). Erythrosin-B is a red-pink dye used for food coloring and as dental plaque disclosing agent. Emission spectra, lifetimes (τ) and quantum yields (Q) for eosin and erythrosin B (ErB) are shown in Figure 1.

1) The quantum yield for fluorescence is determined by the radiative and non-radiative decay rates. Calculate the natural lifetime of fluorescence (τ_f) and the radiative and non-radiative decay rates of eosin and ErB. What rate accounts for the lower quantum yield of ErB?

2) We now consider the phosphorescence process. Typically, the emissive rates of fluorescence and phosphorescence (k_f and k_p, respectively) vary greatly. Phosphorescence lifetimes are typically near 1-10 ms. Assume that the natural lifetime for phosphorescence emission of these compounds is 10 ms, and that the non-radiative decay rates of the two compounds are the same for the triplet state as for the singlet state. Estimate the phosphorescence quantum yields of eosin and ErB at room temperature.