BT 301: Biophysics Tutorial 3 (28 Aug 2023) Instr: R. Swaminathan

1. Convert the following energy values into units of kcal/mole
   a) 500 nm b) 10,000 cm^{-1} c) 1 eV d) 100.8 MHz (FM Channel)

2. Using the Boltzmann distribution, calculate the population distribution of 1000 molecules between ground and excited states when the energy gap between the states is a) 220 nm b) 3657 cm^{-1} c) 80 kcal/mole d) 6.3 x 10^{11}Hz

3. If a protein that contains six tryptophan residues and three tyrosine residues, calculate the absorbance for 1 mg/mL sample at 280 nm in aqueous buffer given molecular weight is 14,313 Da. [ε_{Trp} (280 nm) = 5700 M^{-1} cm^{-1}; ε_{Tyr} (280 nm) = 1300 M^{-1} cm^{-1}]

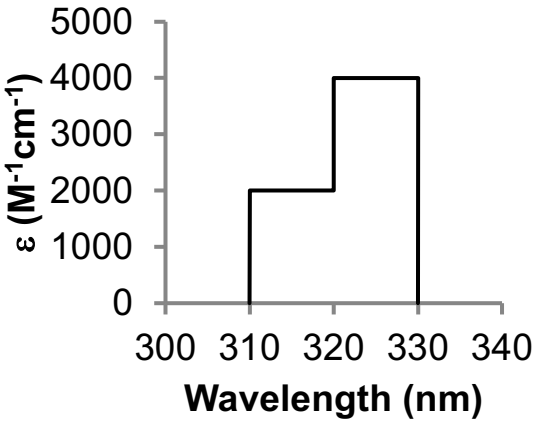
4. The C–C bond dissociation enthalpy is 348 kJ/mole. Calculate the λ corresponding to this energy. If one shines light at this wavelength, will it break all C–C bonds? Explain.

5. A student records the following absorbance values for his samples in an experiment:
   0.06, 0.12, 0.21, 0.37, 0.48, 0.51, 0.75, 0.9, 1.5
   Should she trust all of the readings above? If no, which readings are likely to be error prone. Justify your answer.

6. Consider a dilute but fine suspension of sand particles from Brahmaputra shore in water. How will the absorbance spectrum of such a sample look like between 300—600 nm.

7. Derive the Beer-Lambert equation $A = \varepsilon.c.l$

8. The graph below shows absorption spectrum of a molecule in water (n = 1.33). The spectrum is simplified for ease of integration. Calculate the dipole strength of the absorption band, the transition dipole moment and the oscillator strength. Specify the units of all quantities.



9. Take the CARBONYL chromophore in formaldehyde with MO configuration { σ_{CO}^2 π_{CO}^2 n_{CO}^2}. Draw the energy level diagram and show the following transitions between singlet states:
   a. n to π^*
   b. π to π^*
   c. σ to σ^*

10. What is the Born-Oppenheimer approximation?

11. What is the Frank-Condon principle?

12. Photomultiplier tube (PMT) is used to detect and measure light intensity transmitted from a sample in a spectrophotometer. However, PMT quantum efficiency is poor at longer wavelengths like 800 nm compared to shorter wavelengths like 400 nm. Explain why? What alternative detectors can be employed instead of PMT to overcome this problem.

13. A chromophore absorbs one photon of light at 400 nm and promptly jumps to a higher energy electronic state with a matching energy gap. If light of 800 nm is incident on the same sample, can the chromophore absorb two photons and make a transition to a similar higher energy electronic state. Justify your answer.