CHM 598, Photochemistry, Spring 2005

Homework 1, due Jan 27th

1. Give values for the following physical constants

   i) speed of light, c (cm s^{-1}) — 2.998×10^{10} cm s^{-1}

   ii) Avagadro's number, N — 6.022×10^{23}

   iii) Planck constant, h (J s) — 6.626×10^{-34} J s

2. Give the energy of the following Irradiation wavelengths in kJ/mol, kcal/mol, cm^{-1}, eV

   i) 184.7 nm — 647.7 kJ/mol, 154.8 kcal/mol, 54,140 cm^{-1}, 6.71 eV

   ii) 253.7 nm — 471.5 kJ/mol, 112.7 kcal/mol, 39,420 cm^{-1}, 4.88 eV

   iii) 366.0 nm — 326.8 kJ/mol, 78.1 kcal/mol, 27,320 cm^{-1}, 3.39 eV

3. A medium pressure mercury lamp with a filer solution gives 2 watts of energy at 313 nm. Assume all of this light is absorbed by the sample, how many seconds will it take for 10^{-3} moles of product to be formed if each photon absorbed converts one molecule of starting material into product?

   2 watts = 2 joules per second

   313 nm = 382500 J/mol

   313 nm = 6.35×10^{-19} J/photon

   2 watts at 313 nm = 3.15×10^{18} photons per second

   6 watts at 313 nm = 5.2×10^{-6} Einsteins (moles of photons) per second

   therefore, 10^{-3} / 5.2×10^{-6} seconds for 10^{-3} moles of photons = **191 seconds**

4. A laser emits pulses of light of 355 nm in 10 ns, at a rate of 10 Hz (10 pulses per second). Each pulse has an energy of 10 mJ. Calculate the average power of the laser in Watts, the peak power of the laser, the number of photons in each pulse. The beam is used to excite a sample contained in a 1 cm^2 cuvette. Assume the beam is round with a radius of 1 mm, and that in the cell, 90% of the light is absorbed. What is the average concentration (moles/L) of excited states that are formed in the cell with each pulse?

   10 mJ x 10 = 100 mJ per second, average power is 0.1 Watts

   10 mJ in 10 ns = 1×10^{6} J per second = 1×10^{6} Watts peak power

   355 nm = 336970 J/mol

   10 mJ of 355 nm = 2.968×10^{-8} moles of photons

   number of moles of photons absorbed by the sample = 2.67×10^{-8} moles of photons

   volume of sample irradiated = (π x 0.1 x 0.1) x 1 (pathlength) = 0.031 cm^2

   moles per liter of photons absorbed = 2.67×10^{-8} / 0.031 * 1000 = 8.6×10^{-4}