

Quiz #3
Name _____

Week: Sept. 12 -Sept. 14
Chemistry 331

Equations:

$$\Phi_f = \frac{k_f}{k_f + k_{nr}}, \quad k_{obs} = k_f + k_{nr}, \quad \mu = ezd, \quad v = \frac{1}{2\pi} \sqrt{\frac{k}{\mu}}, \quad E = \frac{h^2 n^2}{8mL^2}$$

Electron mass = 9.1×10^{-31} kg, electron charge = 1.62×10^{-19} Coulomb

1 Debye = 3.33×10^{-30} Cm

1. A fluorescent dye has an observed lifetime of 9 ns. The quantum yield for fluorescence is 90%. Determine the fluorescent rate constant and the rate constant for competing non-radiative decay processes. (8 points)

Solution: The observed rate constant is $k_{obs} = 1/\tau_{obs} = 1/9 \times 10^{-9} \text{ s} = 1.1 \times 10^8 \text{ s}^{-1}$
The quantum yield is

$$\Phi_f = \frac{k_f}{k_f + k_{nr}} = \frac{k_f}{k_{obs}}$$

$$k_f = \Phi_f k_{obs} = 0.9(1.1 \times 10^8 \text{ s}^{-1}) = 1 \times 10^8 \text{ s}^{-1}$$

$$k_{nr} = k_{obs} - k_f = 1.1 \times 10^8 \text{ s}^{-1} - 1 \times 10^8 \text{ s}^{-1} = 1 \times 10^7 \text{ s}^{-1}$$

The fluorescent rate constant is $k_f =$ _____.

The non-radiative decay rate is $k_{nr} =$ _____.

2. Calculate the dipole moment of acetone. Electronic structure calculations show that this dipole moment corresponds to the displacement of 0.5 of an electron charge by 1.2 Angstroms. Please give your answer in Debye. (6 points)

$$\mu = ezd = (1.62 \times 10^{-19} \text{ C})(1.2 \times 10^{-10} \text{ m})(0.5)$$

Solution: $= 9.72 \times 10^{-30} \text{ Cm} (1 \text{ Debye} / 3.33 \times 10^{-30} \text{ Cm})$

$$= 2.91 \text{ D}$$

The dipole moment is _____.

3. Which of the following molecules has a pure rotational spectrum? Circle the molecules that DO have a pure rotational spectrum (6 points).

NH₃, CH₄, O₂, HF, C₆H₆, CO₂, N₂, CO