Questions for Tutorial 8

Optical sensors

Atomic and molecular spectra

Q1: The $l = 0$ to $l = 1$ rotational transition of the CO molecule occurs at a frequency of 1.15×10^{11} Hz. *(a)* Use this information to calculate the moment of inertia of the molecule about its centre of mass. *(b)* Calculate the bond length of the molecule (i.e. the equilibrium separation of the atoms in the molecule).

Q2: The CO molecule shows a strong absorption line at the frequency 6.42×10^{13} Hz. *(a)* Calculate the effective force constant for this molecule. *(b)* What is the classical amplitude of vibration for a CO molecule in the $\nu = 0$ vibrational state?

Q3: The following data is available for the two diatomic molecules

Molecule	**Frequency (Hz)** $\nu = 0$ to $\nu = 1$	**Force constant (N/m)**
HF	8.72×10^{13}	970
HI	6.69×10^{13}	320

Using this data calculate the maximum amplitude of vibration for *(a)* the HI molecule *(b)* the HF molecule. *(c)* Which molecule has the weaker bond?

Q4: The HCl molecule is excited to its first rotational energy level, corresponding to $l = 1$. If the distance between its nuclei is 0.1275 nm, what is the angular velocity of the molecule about its centre of mass?

Q5: The $\nu = 0$ to $\nu = 1$ vibrational transition of the HI molecule occurs at a frequency of 6.69×10^{13} Hz. The same transition for the NO molecule occurs at a frequency of 5.63×10^{13} Hz. Calculate *(a)* the effective force constant and *(b)* the amplitude of vibration for each molecule. *(c)* Explain why the force constant of the NO molecule is so much larger than that of the HI molecule.