Quiz 11.1 – Molecular Spectroscopy

Name: Key

Lineshapes

Find the doppler broadening width (in cm^{-1}) for two gas samples, with $v_{avg} = 425\ ^{m}/_{s}$ and $v_{avg} = 1650\ ^{m}/_{s}$

$\nu = \left(1 \pm \frac{s}{c}\right)\nu_0 = \nu_0 \pm \frac{s}{c}\nu_0$, so the doppler broadening half-width is $\frac{s}{c}\tilde{\nu}_0 = \delta\tilde{\nu}$

for $425\ ^{m}/_{s}$, this is $1.4 \cdot 10^{-6}\ \tilde{\nu}_0$ for $1650\ ^{m}/_{s}$, it is $5.5 \cdot 10^{-6}\ \tilde{\nu}_0$

An O_2 gas molecule at standard temperature and pressure will undergo a collision about every $100\ ps$. Find the lifetime broadening width (in cm^{-1}), assuming that the excited state lifetime is limited by molecular collisions.

$$\delta\tilde{\nu} = \frac{5.3\ cm^{-1}}{\tau/ps} \qquad \delta\tilde{\nu} = \frac{5.3\ cm^{-1}}{100ps/ps} = 0.053\ cm^{-1}$$

An O_2 gas molecule under very low pressures (say, within a nebular cloud in space) may undergo a collision about every $5\ s$. Find the lifetime broadening width (in cm^{-1}), assuming that the excited state lifetime is limited by molecular collisions.

$$5_s = 5 \cdot 10^{12}\ ps$$

$$\delta\tilde{\nu} = \frac{5.3\ cm^{-1}}{5 \cdot 10^{12}\ ps/ps} = 1.06 \cdot 10^{-12}$$