Wave numbers for O_2 and N_2

A. Given the force constants for N_2 and O_2 are 2287 and 1133 N/m, respectively, calculate their vibrational frequencies.

Solution: You will need to use the reduced mass that you calculated in part A. Recall that the classical relationship between the frequency and the force constant holds also in quantum mechanics

$$\tilde{\nu} = \frac{1}{2\pi c}\sqrt{\frac{k}{\mu}}$$

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For nitrogen we have

$$\tilde{\nu} = \frac{1}{2(3.14159)(2.99\ x\ 10^{10}\ cm/s)}\sqrt{\frac{2287\ N/m}{1.162\ x\ 10^{-26}\ kg}} = 2360\ cm^{-1}$$

For oxygen we have:

$$\tilde{\nu} = \frac{1}{2(3.14159)(2.99\ x\ 10^{10}\ cm/s)}\sqrt{\frac{1133\ N/m}{1.328\ x\ 10^{-26}\ kg}} = 1554\ cm^{-1}$$

Wave numbers for O_2 and N_2

If you are given the vibrational wavenumbers you can obtain the force constants as follows:

For oxygen $k = m\omega^2 = 4\pi^2 c^2 \mu \tilde{\nu}^2$

$= 4(3.14159)^2(2.99 \times 10^{10}\ \text{cm/s})^2(1.337 \times 10^{-26}\ \text{kg})(1551\ \text{cm}^{-1})^2$

$= 1133$ N/m

For nitrogen $k = m\omega^2 = 4\pi^2 c^2 \mu \tilde{\nu}^2$

$= 4(3.14159)^2(2.99 \times 10^{10}\ \text{cm/s})^2(1.17 \times 10^{-26}\ \text{kg})(2353\ \text{cm}^{-1})^2$

$= 2287$ N/m

B. Calculate the infrared absorption intensity of the v=0 → v=1 transition of O_2.

Solution: Neither N_2 nor O_2 has a dipole moment. Therefore, neither has a vibrational (infrared) absorption spectrum.