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.

$$\omega = \sqrt{\frac{k}{\mu}}$$

The quantity ω is the angular frequency, which is related to the frequency in Hz as $\omega = 2\pi\nu$. To obtain the answer in wavenumbers (cm^{-1}) we divide by c.

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

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:

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

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

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

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

$= 1133$ N/m

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

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

$= 2287$ 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.

Infrared absorption intensity for oxygen = ________________________.