Chapter 37 Problem 20 †

Given
$f = 1.32 \times 10^{14}\ Hz$

Solution
Find the spacing between vibrational energy levels.

In a harmonic oscillator the energy levels are given by

$$E_n = (n + \tfrac{1}{2})\hbar\omega$$

The difference between two levels is

$$\Delta E = E_n - E_{n-1} = (n + \tfrac{1}{2})\hbar\omega - ((n-1) + \tfrac{1}{2})\hbar\omega$$

$$\Delta E = (n + \tfrac{1}{2} - n + 1 - \tfrac{1}{2})\hbar\omega = \hbar\omega$$

Since $\hbar = h\pi$ and $\omega = 2\pi f$, then

$$\Delta E = \frac{h}{2\pi} 2\pi f = hf$$

Substitute in the appropriate values gives

$$\Delta E = (6.63 \times 10^{-34}\ J \cdot s)(1.32 \times 10^{14}\ Hz) = 8.75 \times 10^{-20}\ J$$

Converting this to electron volts gives

$$\Delta E = 0.547\ eV$$

†Problem from Essential University Physics, Wolfson