Infrared spectroscopy

• depends upon a change in the *vibrational state* of a molecule

\[
\begin{align*}
E^* & \quad \quad \text{H} \quad \text{C}≡\text{C}–\text{CH}_3 \\
 & \quad \quad \quad \quad \quad \downarrow \\
E_0 & \quad \quad \text{H}–\text{C}≡\text{C}–\text{CH}_3 \\
\Delta E &= E^* - E_0 = h\nu
\end{align*}
\]

• here, \( \nu = \text{about } 10^{14} \text{ Hz} \) which corresponds to \( \lambda = 2.5 - 16 \times 10^{-6} \text{ m} \)

• normally for convenience use *wavenumbers*, \( \text{1/} \lambda \text{ cm}^{-1} \), when referring to the IR frequency causing bond vibration

\[
4000 \quad - \quad 200 \text{ cm}^{-1}
\]

(higher E) \quad (lower E)
The vibrational behavior of the chemical bonds in molecules is well-described by Hooke’s Law

\[ \nu = \frac{1}{2\pi c} \sqrt{\frac{k}{\mu}} \]

so the frequency of the vibration depends upon

- the *masses* of the bonded atoms: the greater the difference, the lower the frequency
- the *strength* of the bond: the weaker the bond, the lower the frequency
- a *change in the dipole moment* of the bond as it vibrates
How an IR spectrometer works

- as the wavelength of radiation is varied, is the detector hot or not?