Chapter 12 – Infrared Spectroscopy

Lecture Notes

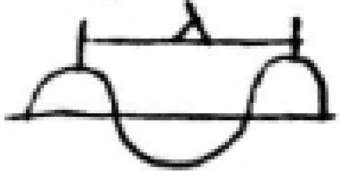
I. Section 12.1 – Electromagnetic Radiation

A. Important Terms

1. **Electromagnetic Radiation** – light and other forms of radiant energy

2. **Wavelength** – (λ) This is the distance between consecutive peaks on awave

3. **Frequency** – (ν) the number of full cycles of a wave that pass in a given second



II. Section 12.2 – Molecular Spectroscopy

A. What is spectroscopy?

Spectro – ancient greek → "light"

Scopy - " " → study of

The general definition of spectroscopy: the study of the interaction of radiation (light) and matter (a compound) as a function of wavelength

B. **Molecular Spectroscopy** – The study of the interaction of radation (light) and matter (molecule) as a functon of wavelegth

C. The three types of spectroscopy that we're interested in:

Region of the Electromagnetic Spectrum	Frequency (hertz)	Type of Spectroscopy	Absorption of Electromagnetic Radiation Results in Transition Between
Radio frequency	**3×10^{7}-9×10^{8}**	**Nuclear magnetic resonance**	**Nuclear spin states**
Infrared	**1×10^{13}-1×10^{14}**	**Infrared**	**Vibrational energy levels**
Ultraviolet-visible	**2.5×10^{14}-1.5×10^{15}**	**Ultraviolet-visible**	**Electronic energy levels**

Table 12.3. Types of Energy Transitions from Absorption of Energy from Three Regions of the Electromagnetic Spectrum (pg. 458)

b. From this, we can derive the frequency of a stretching vibration from Hooke's Law: $\nu = 4.12\sqrt{\frac{K}{\mu}}$, where K is the force constant of the vibration (dynes/cm), μ is the reduced mass of the two atoms $[\mu = \frac{m_1 m_2}{m_1 + m_2}]$ (m = amu)

2. The take home message: The peak position of a stretching vibration is...
   a.

   b.

D. Correlation Tables

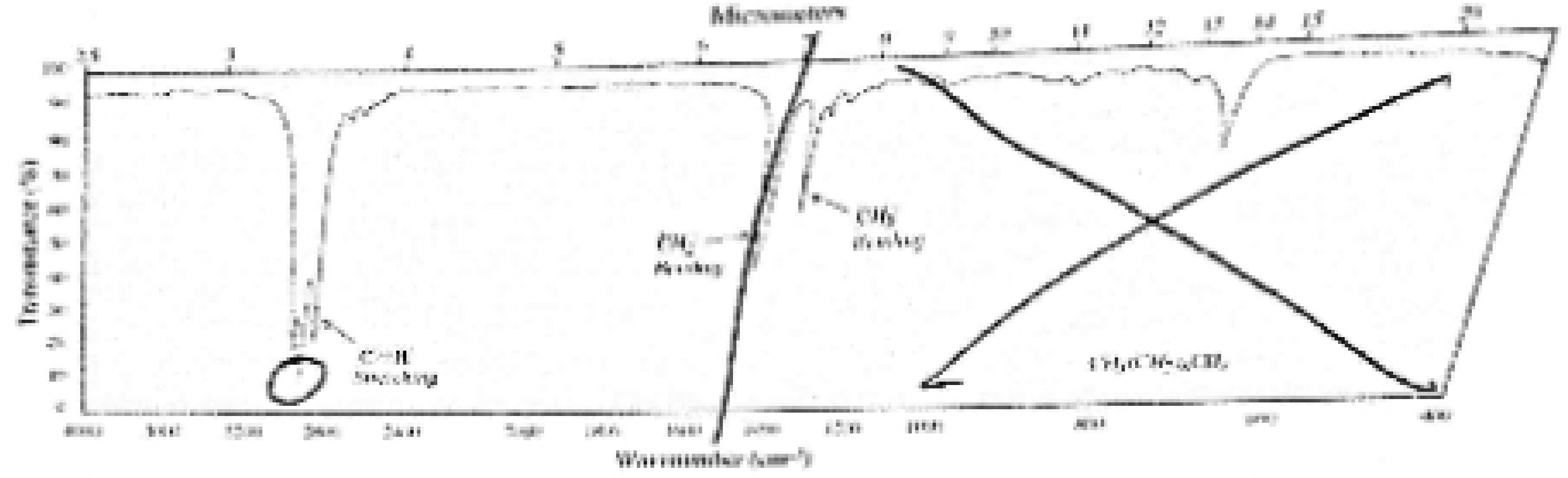
1. What is the difference between the **Functional Group Region** and the **Fingerprint Region?**
   Functional group Region: 4000 $\bar{\nu}$ - 1500 $\bar{\nu}$ (shows most organic functional groups) Fingerprint region - 1500 $\bar{\nu}$ - 400 $\bar{\nu}$. complex part of the spectrum. Shows detailed interaction

2. Key functional groups (**YOU MUST MEMORIZE THESE**):
   a. C-H sp^3 hybridized = $\sim$ 2950 - 3000
   b. C-H sp^2 hybridized = $\sim$ 3100
   c. C=C bond = $\sim$ 1600 (alkenes, aromatics
   d. C-H sp hybridized = $\sim$ 3300
   e. $C\equiv C$ bond = $\sim$ 2300 - 2100
   f. O-H (alcohol) = 3600 - 3200 ν
   g. N-H = 3500 - 3300
   h. C=O (aldehyde, ketone, carboxylic acid, amide, ester) = $\sim$ 1700

IV. Section 12.4 – Interpreting Infrared Spectra

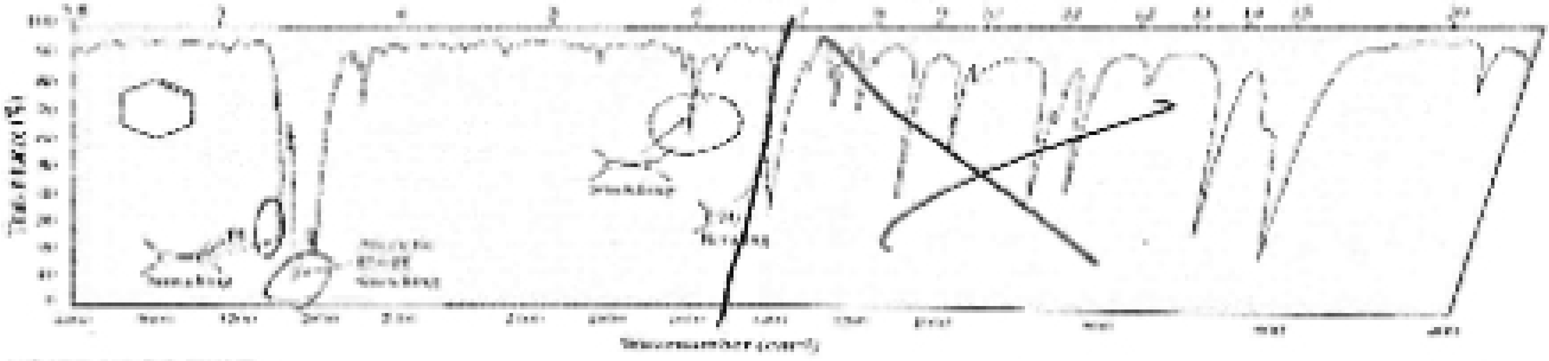
A. Alkanes – IR spectrum of decane

@ 3000 ū ⇒ C-H sp3 hybridized



B. Alkenes – IR spectrum of cyclohexene

~3000ū = C-H sp3 hybridized
~3100ū = C-H sp2 hybridized
~1600ū = C=C



C. Alkynes – IR spectrum of 1-octyne

~2900 ū ⇒ C-H sp3 hy.
~3300 ū ⇒ C-H sp-hybridized