

Lecture 8 CH101 A1 (MWF 9 am) Fall 2016 Copyright © 2016 Dan Dill dan@bu.edu

[TP] Which has the **highest** frequency (of jiggling)?

25% 1. An antisymmetric H stretch at $9 \times 10^{13}/s$

25% 2. A sulfide, C–S, stretch at 600 cm^{-1}

25% 3. Red light at 700 nm

25% 4. Visible light at $6 \times 10^{14}/s$

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Response Counter

10 1

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Friday, September 23, 2016

For today ...

- Practice: wavelength, frequency, and wavenumber
- IR spectra

Next lecture (Wednesday!): Complete IR spectra. Begin ch4: only sections 4.1, 4.3, and 4.4

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Wavelength, frequency, and wavenumber

One cycle of oscillation of the electric field (tugs!) that is light takes place in time τ (the **period** of oscillation).

And so the number of oscillations in one second is the **frequency** $\nu = 1/\tau$.

The **speed** that light moves through space is

$$c = \text{distance} / \text{time}$$

$$= \text{wavelength} / \text{period}$$

$$= \lambda / \tau$$

And so we have the fundamental relation

$$c = \lambda \nu$$

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What's "nu"?

Frequency $\nu = c / \lambda$

Speed of light $c = 299792458 \text{ m/s} (\approx 3 \times 10^8 \text{ m/s})$

Energy exchanged with matter $\propto \nu$

Since $1 / \lambda \propto \nu$, **energy exchanged** with matter also \propto **wavenumber** $1 / \lambda$

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What's "nu"? $\nu = c / \lambda$, $c = 299792458 \text{ m/s}$

Get practice by working through [tutorials e3.15](#) (p 75)

What is the frequency of orange light, $\lambda = 600 \text{ nm}$?

Answer: $c / \lambda = 5 \times 10^{14} / \text{s}$

Wavelength (in nm) and visibility of $2 \times 10^{15} / \text{s}$ light?

Answer: $\lambda = c / (2.0 \times 10^{15} / \text{s}) = 150 \text{ nm}$; in UV so **not visible**

What is frequency of motion at $\tilde{\nu} = 3000 \text{ cm}^{-1}$?

Answer: $c \times 1 / \lambda = 9 \times 10^{13} / \text{s}$; in IR so **not visible**



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wavelength λ versus wavenumber $\tilde{\nu} = 1 / \lambda$

Given wavelength λ , get frequency ν by **dividing it into** c :

$\lambda = 3000 \text{ nm} \rightarrow \nu = c / \lambda = \dots$

$$\nu = (3 \times 10^8 \text{ m/s}) / (3000 \times 10^{-9} \text{ m}) = 1 \times 10^{14} / \text{s}$$

Given wavenumber $\tilde{\nu} = 1 / \lambda$, get ν by **multiplying it by** c :

$\tilde{\nu} = 3000 \text{ cm}^{-1} \rightarrow \nu = c \times \tilde{\nu} = \dots$

$$\nu = (3 \times 10^{10} \text{ cm/s}) \times (3000 \text{ cm}^{-1}) = 9 \times 10^{13} / \text{s}$$



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Response
Counter

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[Quiz] Which has the **lowest** frequency (of jiggling)?

25% 1. An antisymmetric H stretch at $9 \times 10^{13} / \text{s}$

25% 2. A sulfide, C–S, stretch at 600 cm^{-1}

25% 3. Red light at 700 nm

25% 4. Visible light at $6 \times 10^{14} / \text{s}$


Response
Counter

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Infrared (IR) spectra



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What is light?

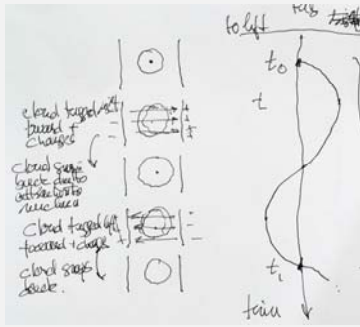
closed together
pieces of
charges

closed gaps
quick electric
attractions to
nucleus

closed together
together + charge

closed gaps
drive.

to left ~~right~~ ~~left~~ ~~right~~ 9/20/2016




$\lambda = \text{length} = \text{distance covered in } \Delta t = t_1 - t_0$

$\frac{\lambda}{\Delta t} = \text{speed} = c$

$\Delta t = \text{period} = \frac{1}{f}$

$\lambda f = \text{speed } c$




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Resonance in light-matter interaction

Demonstration: Tale of three frequencies

Frequencies match → response
Frequencies do not match → “transparency”



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