Light as Waves

DR. MIOY T. HUYNH
YALE UNIVERSITY
CHEMISTRY 161
FALL 2019

www.mioy.org/chem161

Waves of Energy

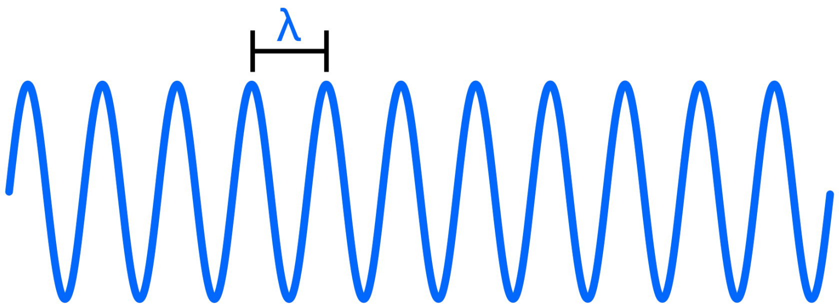
Energy (E) ⇔ Wavelength (λ) ⇔ Frequency (v)

Be able to convert between these three properties of waves.

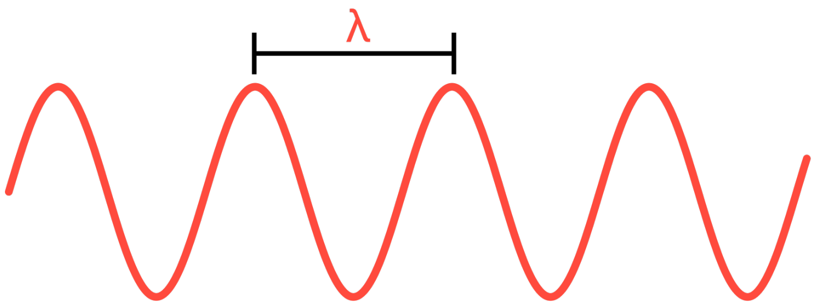
$$c = \lambda v \qquad E = hv = \frac{hc}{\lambda}$$

Property		**Value**	**Units**
Energy	E		J
Wavelength	λ		nm
Frequency	v		s^{-1} (or Hz)
Speed of light	*c*	2.998×10^{8}	m/s
Planck's constant	*h*	6.626×10^{-34}	J·s

HIGH ENERGY WAVE
HIGH FREQUENCY
SHORT WAVELENGTH



LOW ENERGY WAVE
LOW FREQUENCY
LONG WAVELENGTH

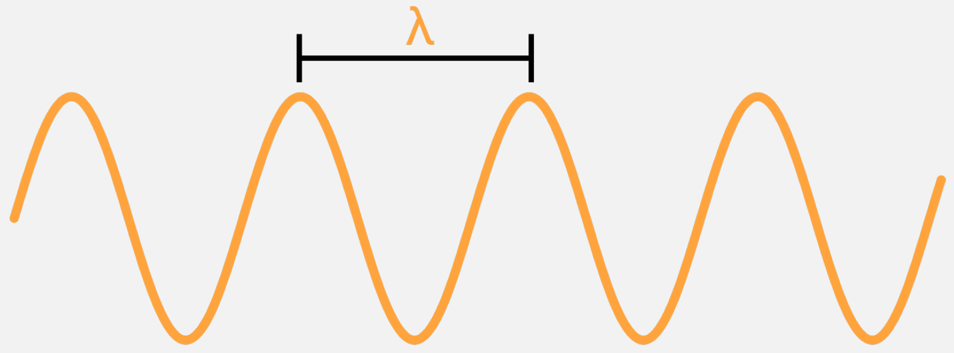


LIGHT

Q: What is light?

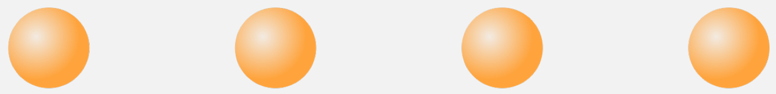
Is it a wave that carries energy?

LIGHT AS A WAVE



Is it a stream of tiny packets of energy (called photons)?

LIGHT AS A STREAM OF PARTICLES/PHOTONS

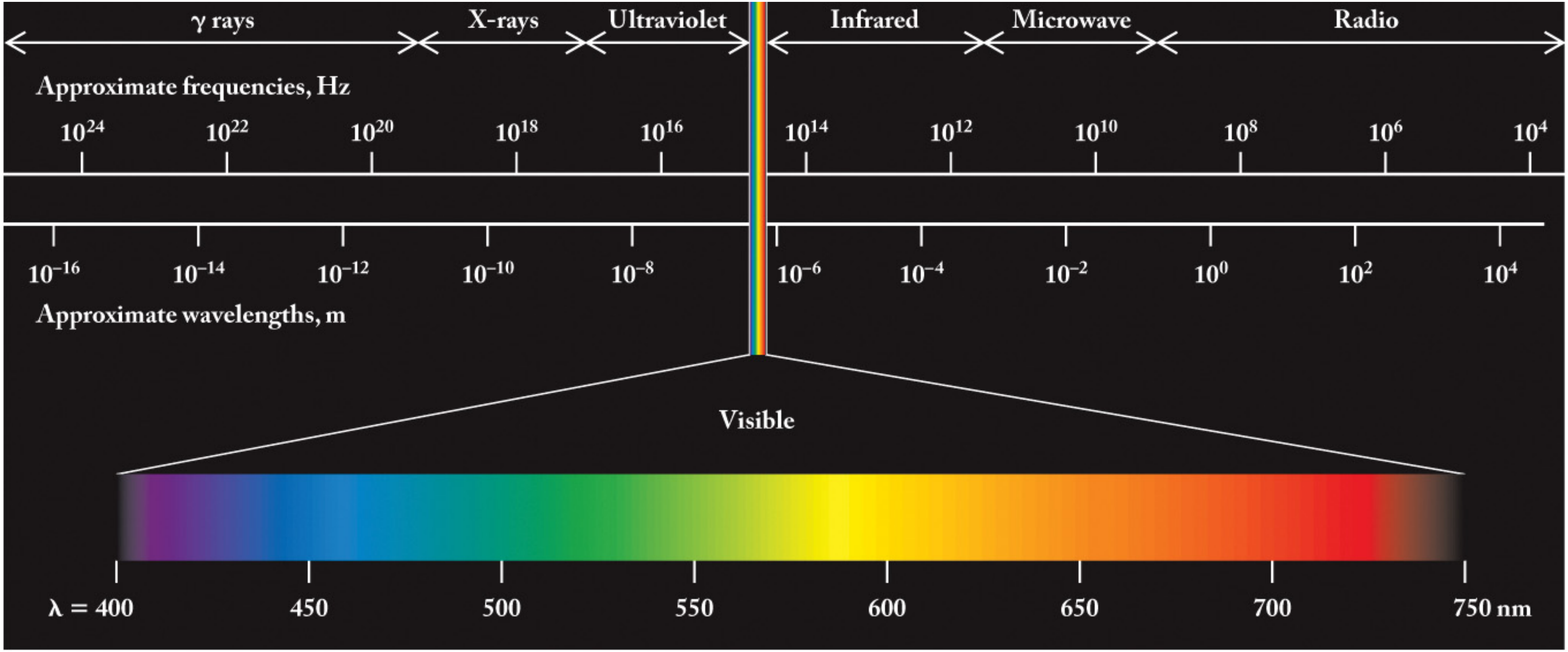


A: It behaves as both a wave and a particle.

PHOTON: a quantized packet of light with a specific wavelength

WAVE-PARTICLE DUALITY: light behaves as both a wave *and* a particle

Electromagnetic Spectrum



Shortest wavelength (highest energy)

Longest wavelength (lowest energy)

Neon (Ne) light has a frequency of 4.87×10^{14} Hz. What color would you expect this light to be?

Neon (Ne) light has a frequency of 4.87×10^{14} Hz. What color would you expect this light to be?

We can solve this problem using any of the three properties of light.

I'll show all three, which give the same answer.

Neon (Ne) light has a frequency of 4.87×10^{14} Hz. What color would you expect this light to be?

We can solve this problem using any of the three properties of light.

I'll show all three, which give the same answer.

ENERGY (E)	WAVELENGTH (λ)	FREQUENCY (v)

Neon (Ne) light has a frequency of 4.87 × 10^{14} Hz. What color would you expect this light to be?

We can solve this problem using any of the three properties of light.

I'll show all three, which give the same answer.

ENERGY (E)	WAVELENGTH (λ)	FREQUENCY (v)
		We can use the frequency (v) directly: $$\mathrm{v} = 4.87 \times 10^{14}\ \mathrm{s}^{-1}$$

Neon (Ne) light has a frequency of 4.87×10^{14} Hz. What color would you expect this light to be?

We can solve this problem using any of the three properties of light.

I'll show all three, which give the same answer.

ENERGY (E)	WAVELENGTH (λ)	FREQUENCY (v)
	We can convert from frequency (v) to wavelength (λ): $c = \lambda \mathrm{v}$ $\lambda = \dfrac{2.998 \times 10^{8}\,\frac{\mathrm{m}}{\mathrm{s}}}{4.87 \times 10^{14}\ \mathrm{s}^{-1}} = 6.16 \times 10^{-7}\ \mathrm{m}$ $\lambda = 616\ \mathrm{nm}$	We can use the frequency (v) directly: $\mathrm{v} = 4.87 \times 10^{14}\ \mathrm{s}^{-1}$

Neon (Ne) light has a frequency of 4.87 × 10^{14} Hz. What color would you expect this light to be?

We can solve this problem using any of the three properties of light.

I'll show all three, which give the same answer.

ENERGY (E)	WAVELENGTH (λ)	FREQUENCY (v)
We can convert from frequency (v) to energy (E): $E = hv$ $= (6.626 \times 10^{-31}\ \mathrm{J \cdot s})(4.87 \times 10^{14}\ \mathrm{s^{-1}})$ $E = 3.23 \times 10^{-16}\ \mathrm{J}$	We can convert from frequency (v) to wavelength (λ): $c = \lambda v$ $\lambda = \dfrac{2.998 \times 10^{8}\ \frac{\mathrm{m}}{\mathrm{s}}}{4.87 \times 10^{14}\ \mathrm{s^{-1}}}$ $= 6.16 \times 10^{-7}\ \mathrm{m}$ $\lambda = 616\ \mathrm{nm}$	We can use the frequency (v) directly: $v = 4.87 \times 10^{14}\ \mathrm{s^{-1}}$

Neon (Ne) light has a frequency of 4.87 × 10¹⁴ Hz. What color would you expect this light to be?

We can solve this problem using any of the three properties of light.

I'll show all three, which give the same answer.

ENERGY (E)	WAVELENGTH (λ)	FREQUENCY (v)
We can convert from frequency (v) to energy (E): $E = hv$ $= (6.626 \times 10^{-31}\ \mathrm{J \cdot s})(4.87 \times 10^{14}\ \mathrm{s^{-1}})$ $E = 3.23 \times 10^{-16}\ \mathrm{J}$	We can convert from frequency (v) to wavelength (λ): $c = \lambda v$ $\lambda = \frac{2.998 \times 10^{8}\ \frac{\mathrm{m}}{\mathrm{s}}}{4.87 \times 10^{14}\ \mathrm{s^{-1}}}$ $= 6.16 \times 10^{-7}\ \mathrm{m}$ $\lambda = 616\ \mathrm{nm}$	We can use the frequency (v) directly: $v = 4.87 \times 10^{14}\ \mathrm{s^{-1}}$

We can use the wavelength or frequency and the electromagnetic spectrum to find out what color of light neon emits:

Neon (Ne) light has a frequency of 4.87 × 10^{14} Hz. What color would you expect this light to be?

We can solve this problem using any of the three properties of light.

I'll show all three, which give the same answer.

ENERGY (E)	WAVELENGTH (λ)	FREQUENCY (v)
We can convert from frequency (v) to energy (E): $E = hv$ $= (6.626 \times 10^{-31}\ \mathrm{J \cdot s})(4.87 \times 10^{14}\ \mathrm{s^{-1}})$ $E = 3.23 \times 10^{-16}\ \mathrm{J}$	We can convert from frequency (v) to wavelength (λ): $c = \lambda v$ $\lambda = \dfrac{2.998 \times 10^{8}\ \frac{\mathrm{m}}{\mathrm{s}}}{4.87 \times 10^{14}\ \mathrm{s^{-1}}}$ $= 6.16 \times 10^{-7}\ \mathrm{m}$ $\lambda = 616\ \mathrm{nm}$	We can use the frequency (v) directly: $v = 4.87 \times 10^{14}\ \mathrm{s^{-1}}$

We can use the wavelength or frequency and the electromagnetic spectrum to find out what color of light neon emits: ORANGE.