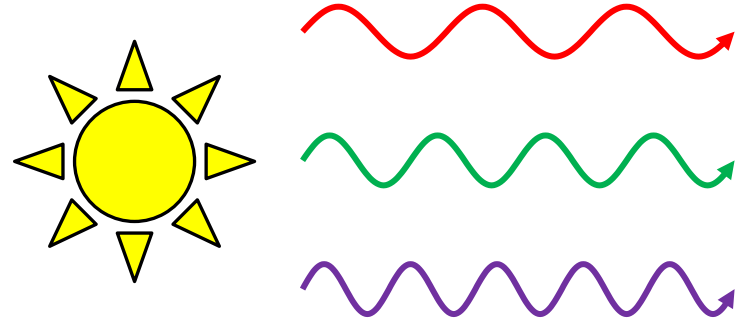


Essential Question

How much energy does a photon carry?

What Is a Photon?

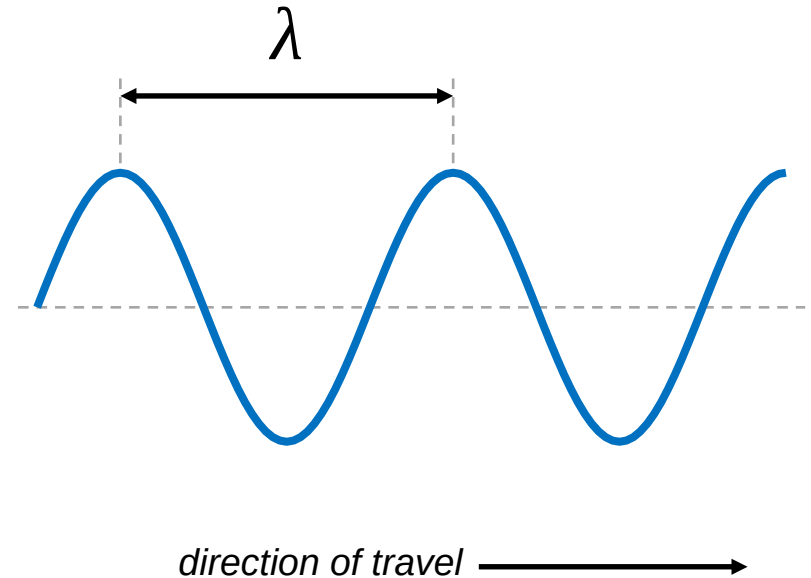
- A packet of light energy
- Light acts like a wave and like a particle



Each wavy arrow = one photon

Wavelength and Frequency

- **Wavelength (λ):** crest-to-crest distance
 - meters (m) or nanometers (nm)
- **Frequency (ν):** waves passing per second
 - s^{-1} or hertz (Hz)



Speed of Light

$$c = \lambda \nu$$

c

speed of light
 $2.998 \times 10^8 \text{ m/s}$

λ

wavelength (m)

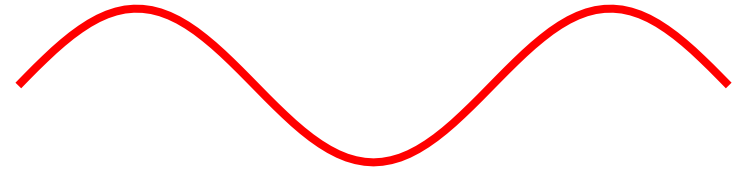
ν

frequency (s^{-1})

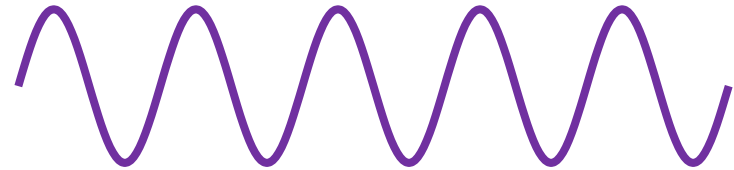
- All light travels at this speed in a vacuum

Wavelength vs. Frequency

- Longer $\lambda \rightarrow$ lower ν
- Shorter $\lambda \rightarrow$ higher ν
- Their product is always c



long λ , low ν



short λ , high ν

Energy of a Photon

$$E = h\nu$$

E

energy of one photon (J)

h

Planck's constant
 $6.626 \times 10^{-34} \text{ J}\cdot\text{s}$

ν

frequency (s^{-1})

- Higher frequency $\rightarrow$ more energy per photon

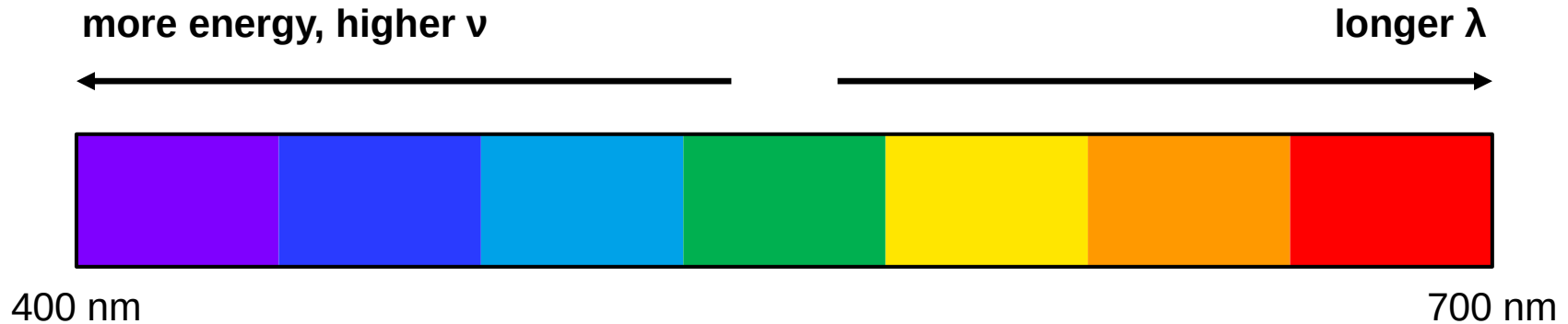
Energy and Wavelength

$$\boxed{E = h\nu} + \boxed{\nu = c/\lambda} \Rightarrow \boxed{E = hc/\lambda}$$

- Higher $\nu \rightarrow$ more energy
- Shorter $\lambda \rightarrow$ more energy

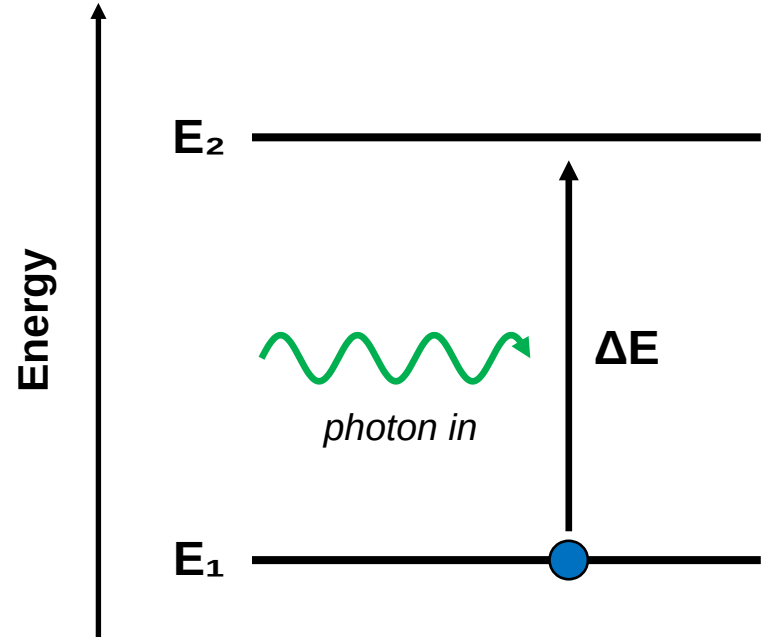
Visible Light and Energy

- Violet: shortest λ , most energy
- Red: longest λ , least energy



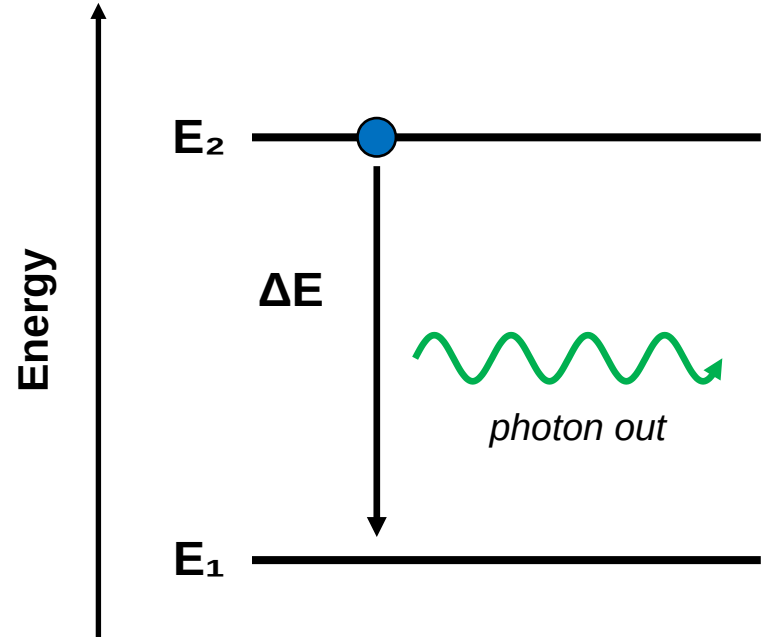
Absorbing a Photon

- Electron jumps to a higher level
- Atom gains energy
- Energy gained = photon energy



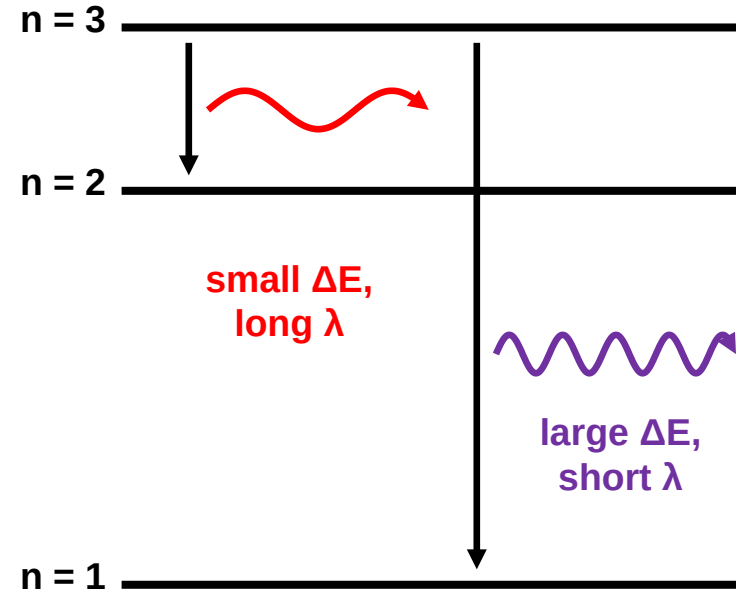
Emitting a Photon

- Electron drops to a lower level
- Atom loses energy
- Energy lost = photon energy



Bigger Gap, Bigger Photon

- Larger gap $\rightarrow$ more energy
- Higher ν and shorter λ
- Photon energy = size of gap



Example: Frequency from Wavelength

A green laser pointer emits light with a wavelength of 532 nm. Calculate the frequency of this light.



$$\lambda = 532 \text{ nm}$$

Example: Energy from Frequency

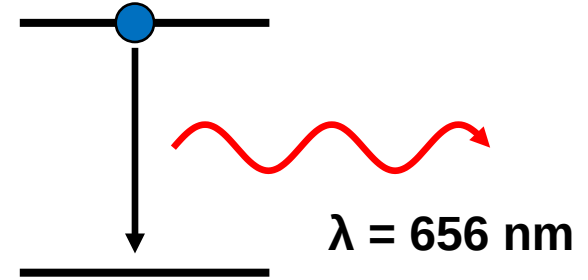
A photon of blue light has a frequency of $6.38 \times 10^{14} \text{ s}^{-1}$. Calculate the energy of the photon.



$$\nu = 6.38 \times 10^{14} \text{ s}^{-1}$$

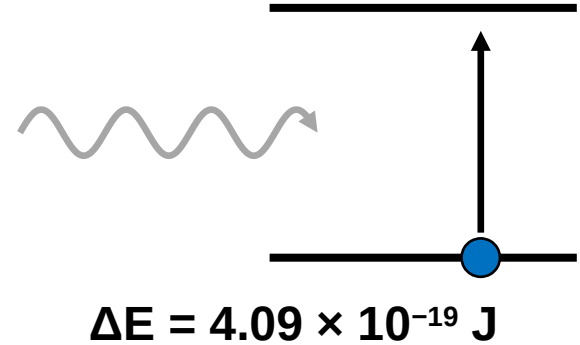
Example: Energy from Wavelength

A hydrogen atom emits a photon with a wavelength of 656 nm. By how much does the energy of the atom decrease?



Example: Wavelength from Energy

An atom absorbs a photon, and the atom's energy increases by $4.09 \times 10^{-19} \text{ J}$. Calculate the wavelength of the photon in nm.



Big Ideas

- Light energy comes in photons
- $c = \lambda\nu$: λ and ν are inverses
- $E = h\nu$: higher ν , more energy
- Atom's energy change = photon energy

