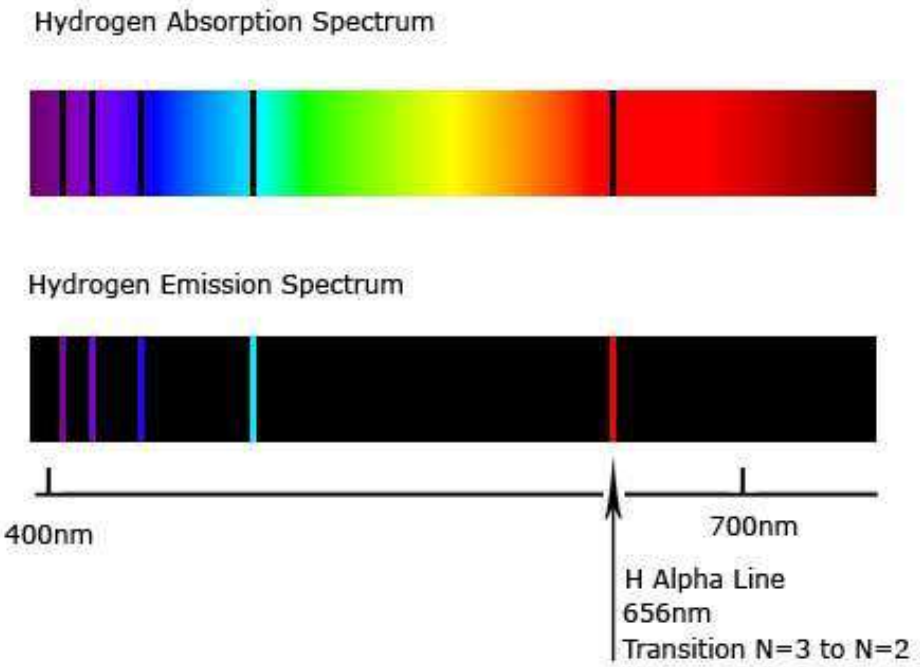
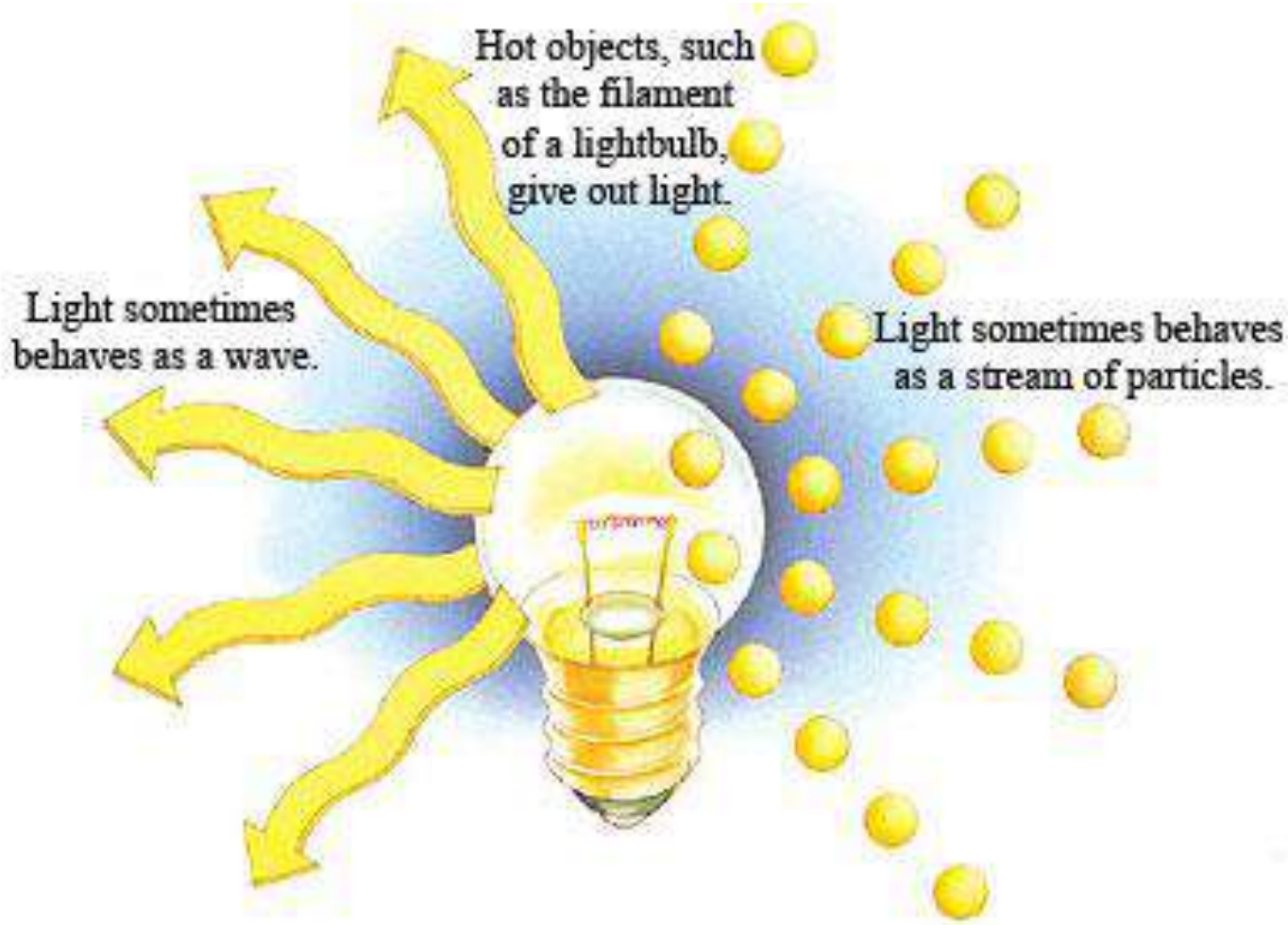
NOTES: 5.3 – Light and Atomic Spectra (more Quantum Mechanics!)

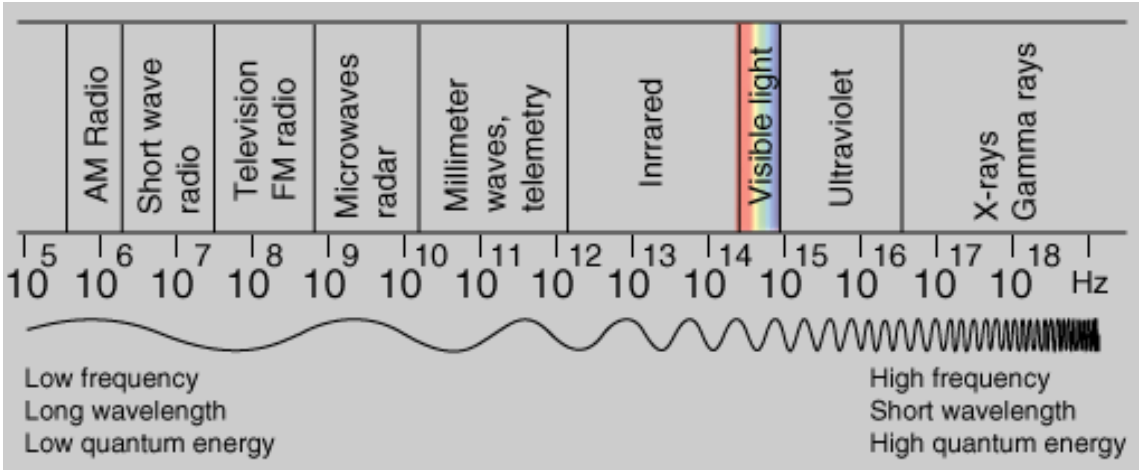


Light – WAVE or PARTICLE?



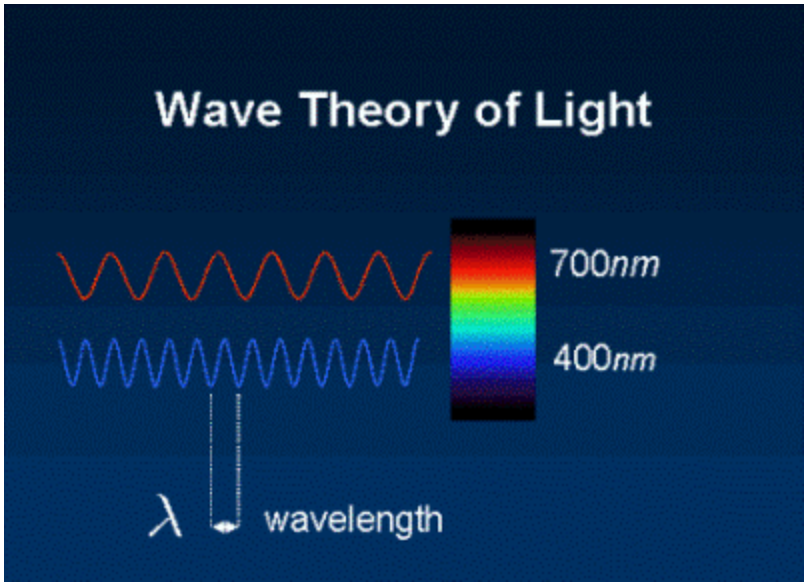
Electromagnetic Radiation

- Electromagnetic radiation includes:
  - -radio waves
  - -microwaves
  - -infrared waves
  - -visible light
  - -ultraviolet waves
  - -x-rays
  - -gamma rays



Electromagnetic Radiation

- according to the “wave” model, light consists of electromagnetic waves
- all EM waves travel in a vacuum at a speed of **3.0 x 10^8 m/s**

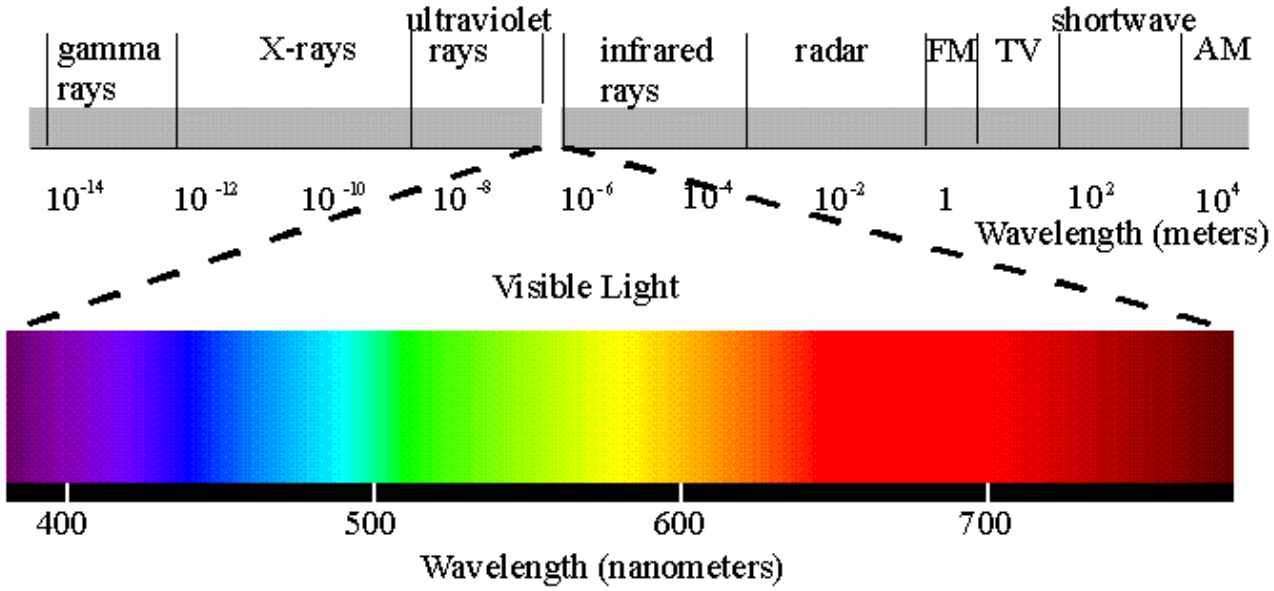


Electromagnetic Radiation

- Electromagnetic radiation (**radiant energy**) is characterized by its:

-WAVELENGTH (color): λ (Greek letter lambda)

-FREQUENCY (energy): ν (Greek letter nu)



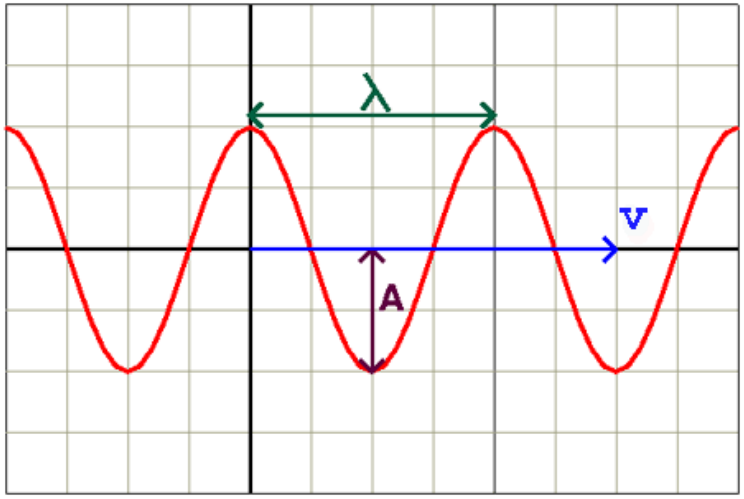
WAVES

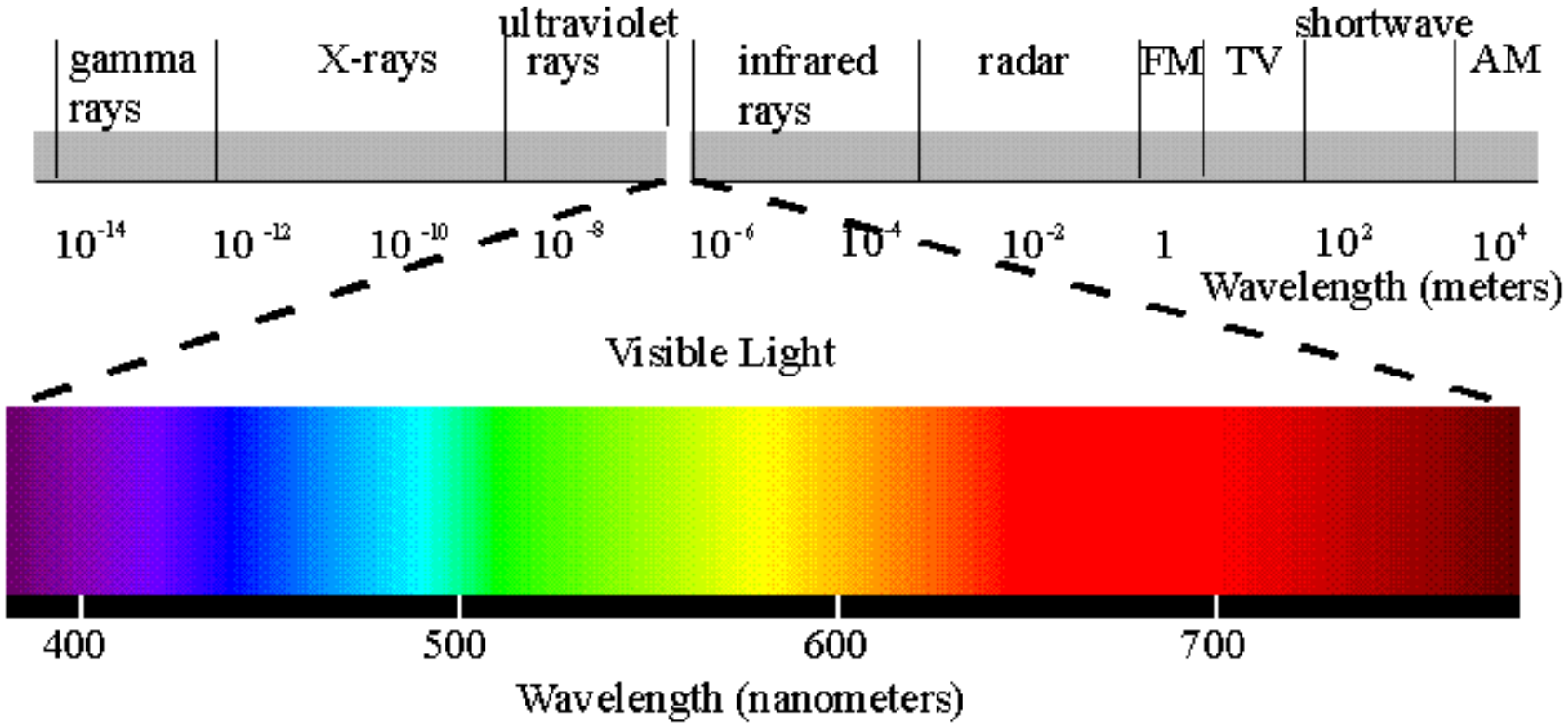
- **Wavelength** = distance between successive "crests"

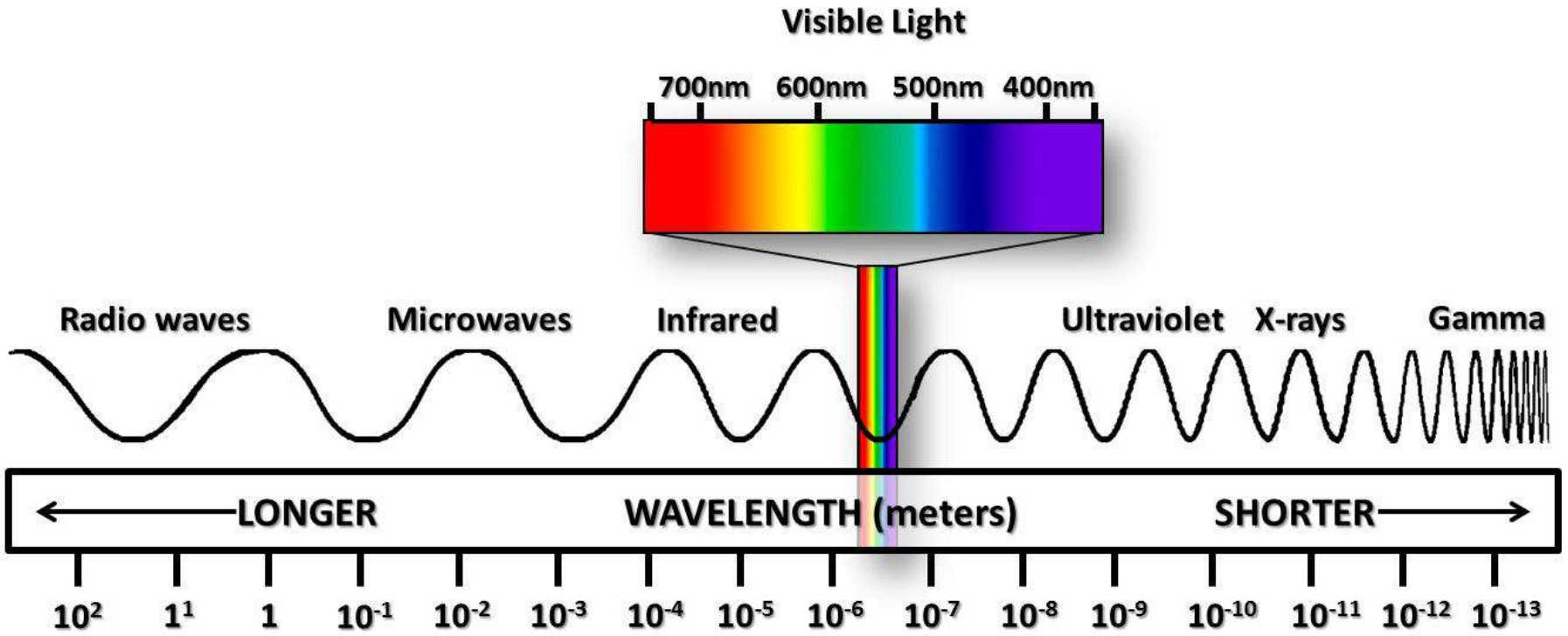
  ➔ measured in units of length (m, nm)

- **Frequency** = the # of crests passing a given point per second

  ➔ measured in # per sec, or s^{-1}, or Hertz

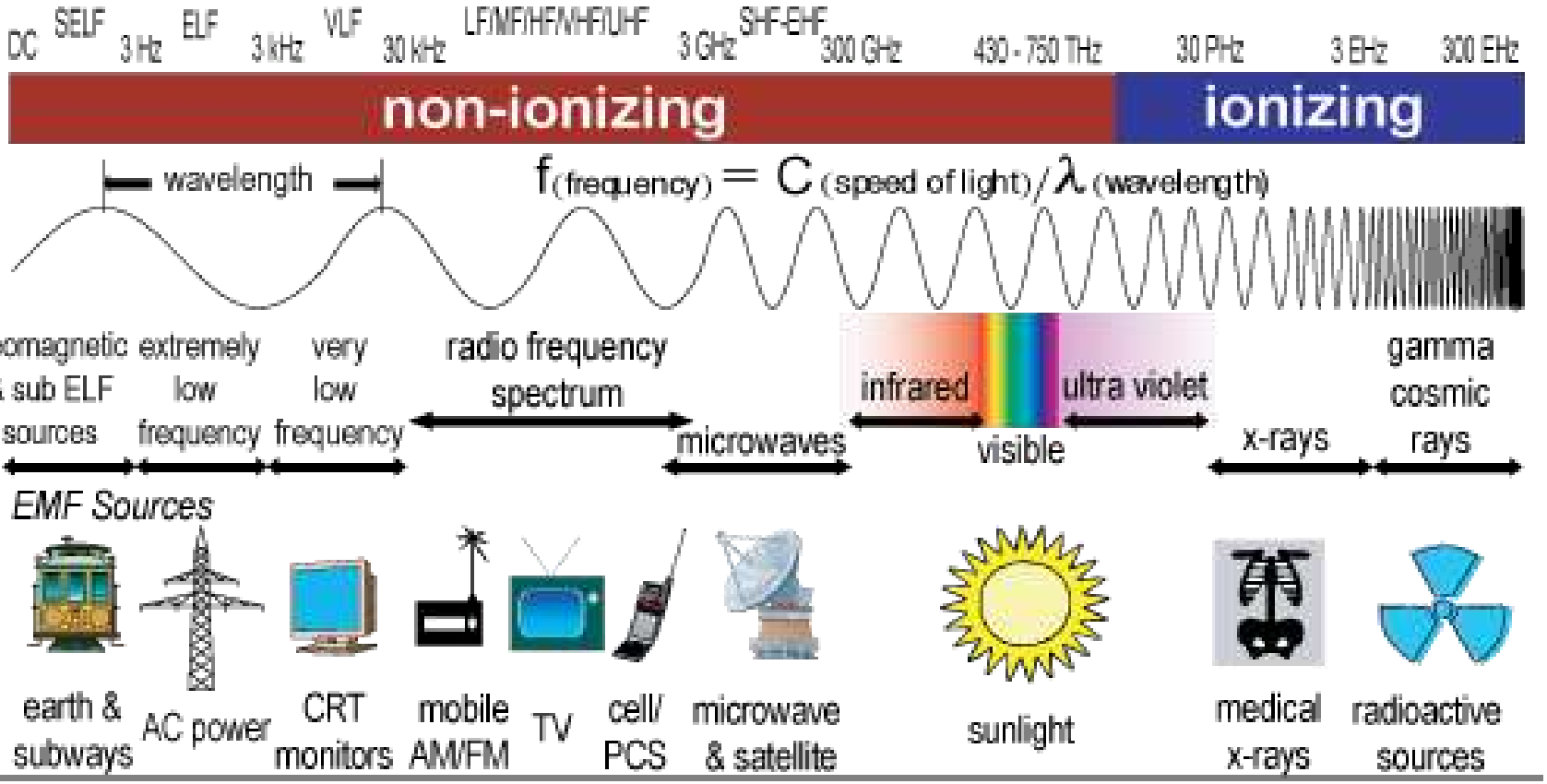



gamma rays
X-rays
ultraviolet rays
infrared rays
radar
FM
TV
shortwave
AM
10^{-14}
10^{-12}
10^{-10}
10^{-8}
10^{-6}
10^{-4}
10^{-2}
1
10^{2}
10^{4}
Wavelength (meters)
Visible Light
400
500
600
700
Wavelength (nanometers)



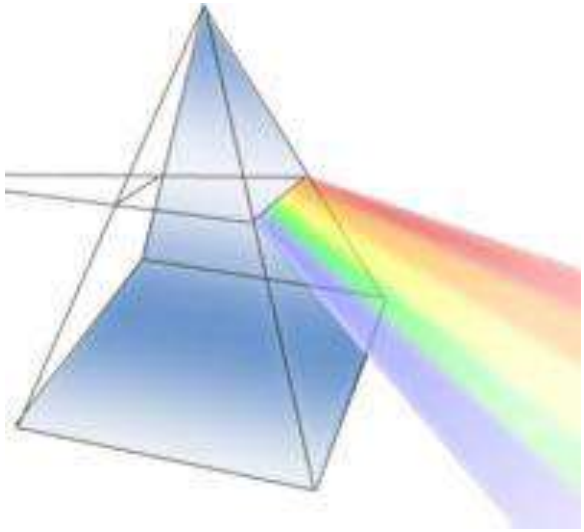
- **NOTICE**: as wavelength **decreases**, frequency (& therefore **ENERGY**) **increases**!

THE ELECTROMAGNETIC SPECTRUM



Gigahertz (GHz) 10-9 Terahertz (THz) 10-12 Petahertz (PHz) 10-15 Exahertz (EHz) 10-18 Zettahertz (ZHz) 10-21 Yottahertz (YHz) 10-24

VISIBLE LIGHT:



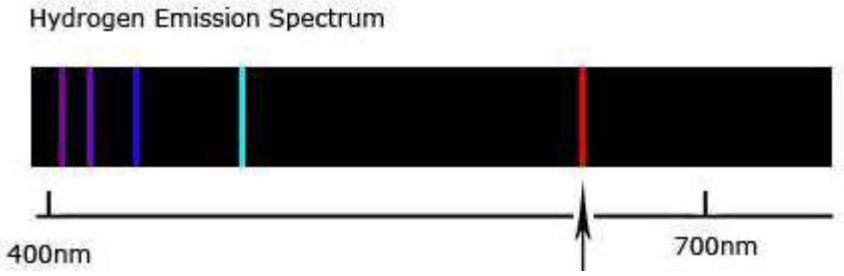
- When sunlight or white light is passed through a prism, it gives the **continuous spectrum** observed in a rainbow.
- each color blends into the next in the order:
  red, orange, yellow, green, blue, indigo, violet

- **RED LIGHT**: longest wavelength, lowest freq.

- **VIOLET LIGHT**: shortest wavelength, highest freq.

Light and Electrons

- each element emits light when it is excited by an electric current passing through its gas or vapor
- the atoms first **absorb energy**, then lose the energy as they **emit light**
- passing light emission through a prism gives a unique **atomic emission spectrum**

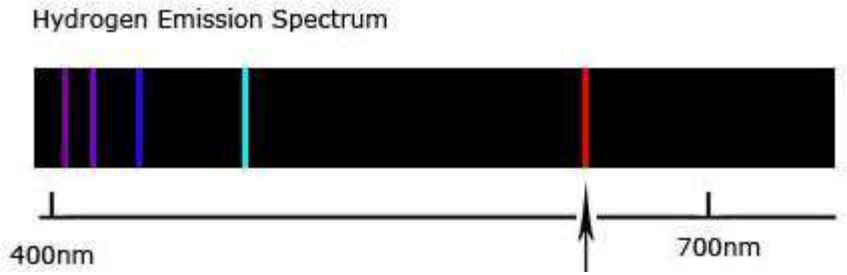


Light and Electrons

- ***recall***: white light gives a continuous spectrum
- atomic emission spectra: **relatively few lines**

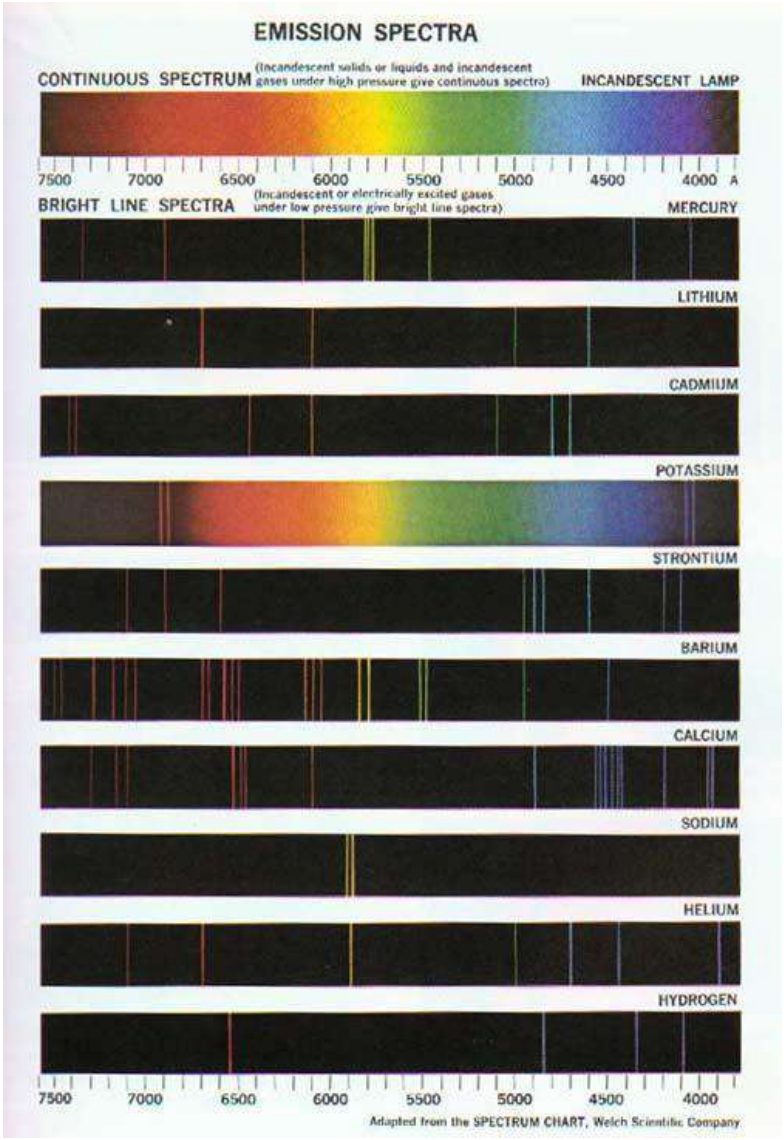
***this suggests the emission of very specific, exact frequencies of energy/light!*

- each line corresponds to a **specific** amt. of energy being emitted!!

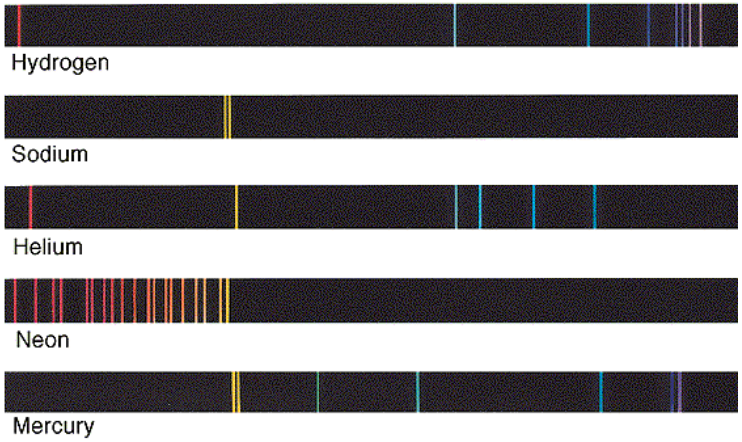


Bright Line Emission Spectrum

- The light emitted by an element when its electrons return to a lower energy state can be viewed as a **bright line emission spectrum.**



Light and Electrons



- the emission spectrum of each element is unique to that element
- emission spectra can be used to identify the components of an unknown compound

***we can even discover the composition of far away stars by studying their emission spectra!! (stars are hot, glowing bodies of gases!)*

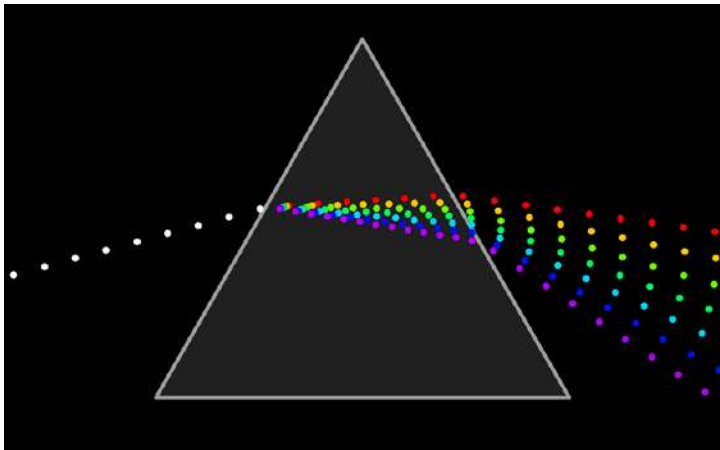
Wow…Science is cool!

The Quantum Concept:

- according to classical physics, there is no limit to how small the energy gained or lost by an object can be…so…
- classical physics cannot explain emission spectra which only allows SOME amounts of energy, but not others…enter:
- **Max Planck**! (1858-1947) – he wondered, what if light energy consists of little packets of energy called "**QUANTA**"?

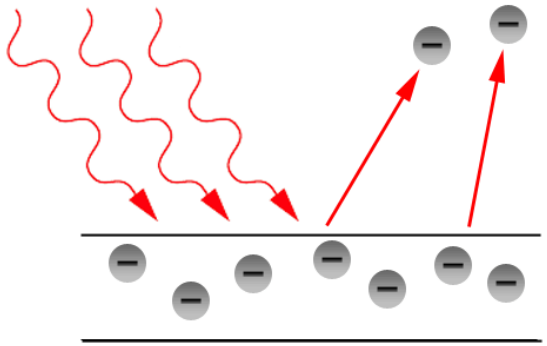
The Quantum Concept:

- Einstein added the proposal we can describe light as composed of particles, or **PHOTONS**.
- each photon of light has a particular amount or packet of energy (a **quantum**).
- the amt. of energy (frequency) possessed by a photon depends on the color (wavelength) of the light.



The Quantum Concept & the Photoelectric Effect:

- Photons – light quanta or “packets of energy”
- Photons can be observed indirectly through “photoelectric effect”
- **PHOTOELECTRIC EFFECT** - metals eject electrons called photoelectrons when light shines on them



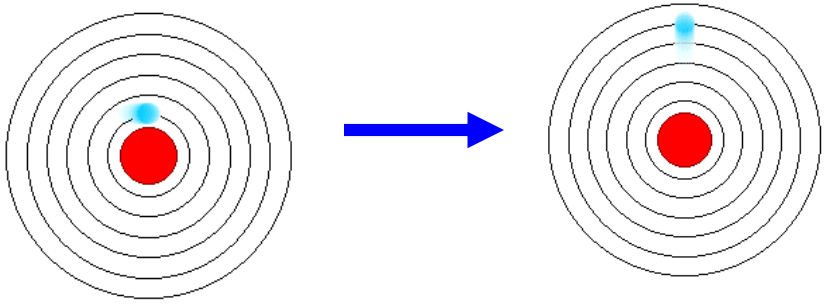
The Quantum Concept & the Photoelectric Effect:

- HOWEVER, not all colors / frequencies of light will work on all metals! (because only specific frequencies, quanta, may be absorbed)
- in what ways do we use the energy of light to generate electricity???

  -cars with photoelectric cells; solar-powered calculators; etc.

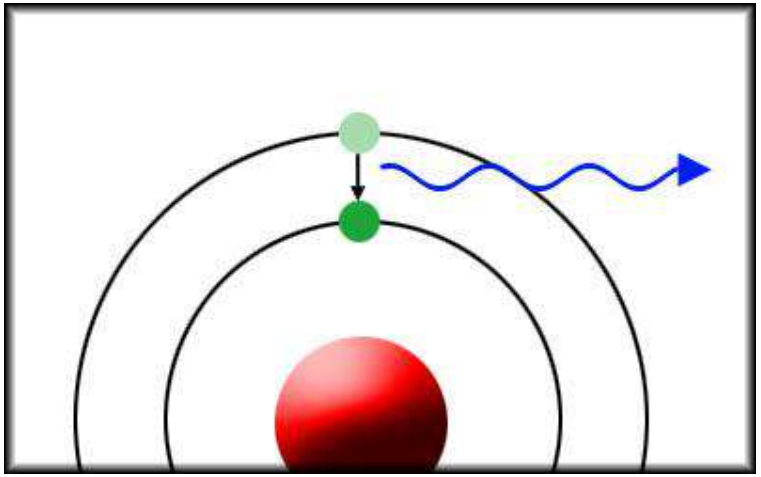
What does this have to do with electron arrangement in atoms?

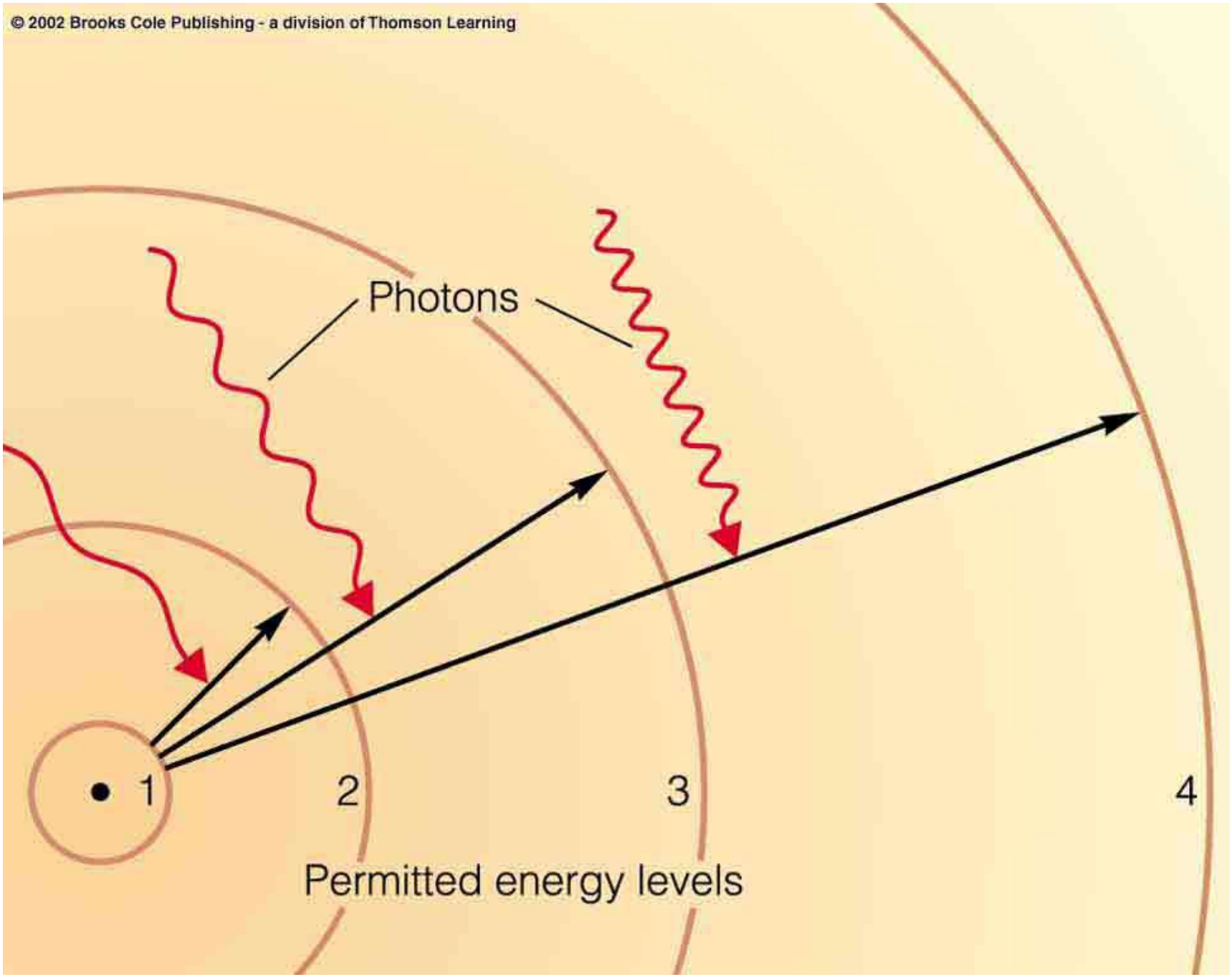
- When all electrons are in the lowest possible energy levels, an atom is said to be in its **GROUND STATE**.
- When an atom absorbs energy so that its electrons are “boosted” to higher energy levels, the atom is said to be in an **EXCITED STATE.**



Electron States

- Ground state – lowest energy level or n = 1
- Excited state – energy level of n = 2, 3, 4….
- energy levels are **quantized** (only certain values of electron energy are possible).
- **QUANTA** of energy are absorbed and then released when electrons drop from an excited state to a lower energy state
- Only electrons in transition from high to low energy levels emit energy in the form of light





Bright Line Emission Spectrum

- The light emitted by an element when its electrons return to a lower energy state can be viewed as a **bright line emission spectrum.**