Models change.

They are analyzed, critiqued.

"Does the current model explain all known facts regarding it?"

Rutherford's Model:

- Developed from gold foil experiment
- Did not explain chemical properties of atoms
- Electrons outside nucleus? Why aren't they drawn into nucleus?
- Does not explain the line spectrum of hydrogen. What is that?

Line Spectrum

(Atomic Emission Spectrum)

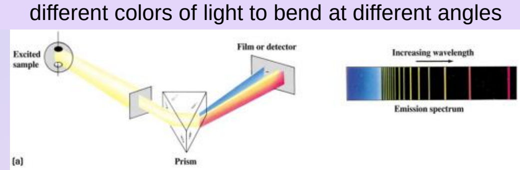
It is light given off by element when exposed to some sort of exciting energy (heat, electricity)

- Combination of only certain wavelengths
- Unique to that element
- Separated by passing through a *spectroscope*

Spectroscope

Used to measure frequencies of lines produced in emission spectrum

Contains a thin, plastic prism that causes the different colors of light to bend at different angles

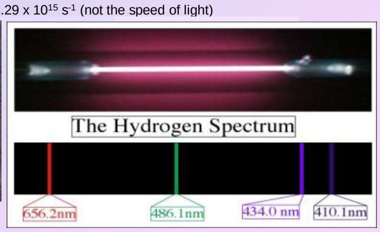


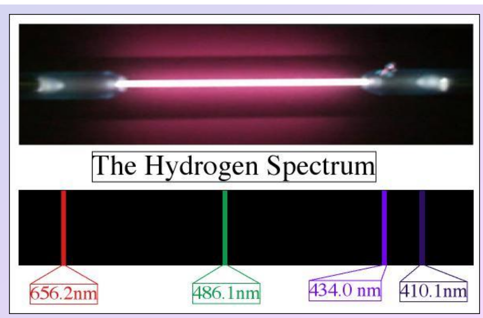
Line Spectrum of Hydrogen (the Balmer Series)

- The four lines of visible light seen as hydrogen is energized and the light is passed through a prism
- Balmer found the frequencies fit the formula:

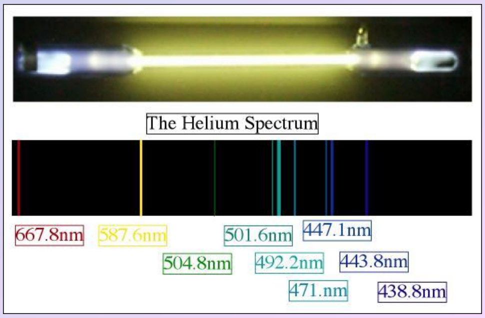
$\nu = c(1/2^2 - 1/n^2)$ … where n = 3, 4, 5, 6

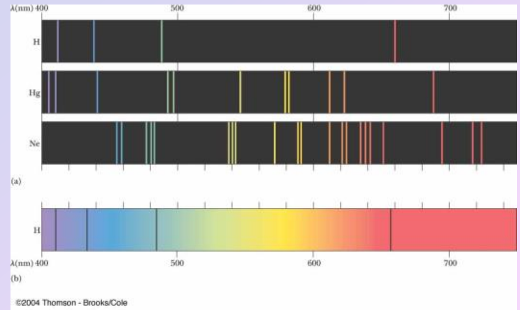
c = $3.29 \times 10^{15}\ s^{-1}$ (not the speed of light)





Balmer Series

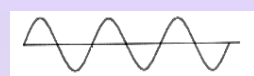


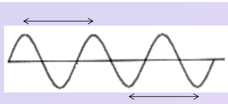


Light is a form of Radiant Energy

Radiant Energy

- Energy traveling through space as a wave
- Move at the speed of light → 3.00×10^8 m/s (in a vacuum)

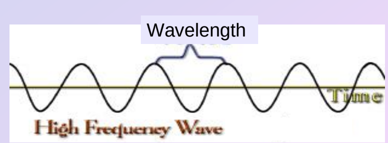


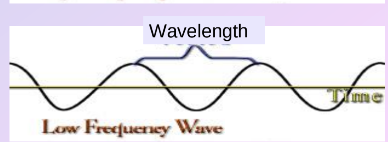


Wavelength, λ
- The distance from a point on one wave to the same point on a consecutive wave
- Units: m, nm

Frequency, *ν*
- The number of waves that occur in a unit of time
- Units: s^{-1}, Hz (Hertz), waves/second

$\lambda \nu = c$





$E = h\nu$

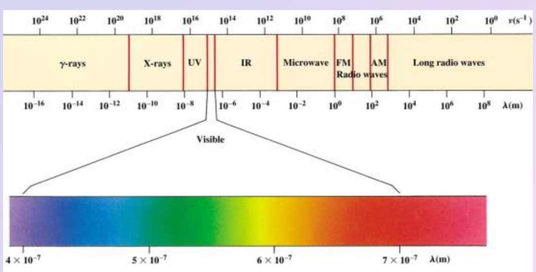
Planck's constant
6.63 x 10^{-34} Js

Electromagnetic Spectrum

A range of the different forms of radiant energy

radio radar microwave IR **visible** UV X-rays gamma cosmic
(infrared) (ultraviolet)

longest wavelength — shortest wavelength
lowest frequency — highest frequency
lowest energy — highest energy



LIGHT

R O Y G B I V

750nm 400nm

Continuous Spectrum

Rainbow – colors sorted by wavelength

White light

All colors blended

Ex: sunlight, fluorescent

Ionizing radiation

- Enough energy to eject e- from atoms
- Gamma, cosmic, X-rays, high ν UV
- High ν (10^{16} and above) , high energy, low λ
- Can cause tissue damage, cancer

Non-ionizing radiation

- Can still cause damage to body
- Visible, low ν UV – sunburn
- IR – heat burn

Light is a wave.

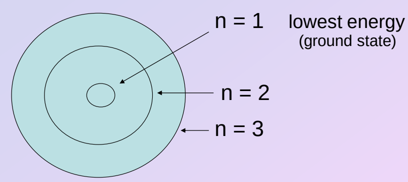
Bohr (1913)

- Proposed an explanation for the line spectrum of hydrogen

Niels Bohr
Nobel Prize in Physics, 1922,
for explaining H atom spectrum

Bohr's proposal:

- Made the assumption that the electron moves in stable orbits around the nucleus
- The energies of the orbits are "quantized"
  (only certain amounts allowed)
- When the electron is in an orbit of a certain radii, it doesn't emit electromagnetic radiation



The higher the n value, the higher the energy

- The electron moves to higher energy states (excited states) by absorbing energy (photons of certain *v*)
- When the electron moves to a lower energy state it emits energy (photons of certain *v*)

The energy absorbed/emitted corresponds to the energy difference between the two energy levels (orbits)

$$\Delta E = E_f - E_i = (-2.18 \times 10^{-18} \text{ J})(1/n_f^2 - 1/n_i^2)$$

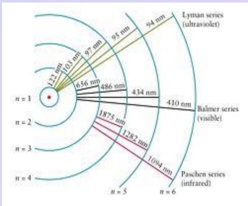
Ex: Calculate the energy change when the hydrogen electron moves from energy level 3 to energy level 1.

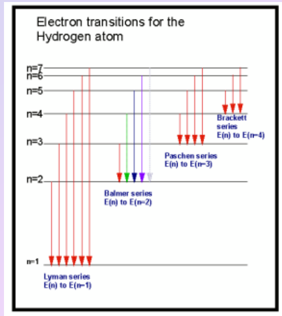
$(-2.18 \times 10^{-18} \text{ J})(1/1^2 - 1/3^2)$

$(-2.18 \times 10^{-18} \text{ J})(1 - 1/9) = -1.94 \times 10^{-18} \text{ J}$

negative
because energy is released

- Balmer series:
  If $n_f = 2$ and $n_i = 3, 4, 5, 6$
  These are lines in the *visible* range
- Paschen series:
  If $n_f = 3$, these are lines in the *infrared* range
- Lyman series:
  If $n_f = 1$, these are lines in the *ultraviolet* range





Bohr proposed an
updated model of the atom
to explain the cause of the lines
in emission spectra of hydrogen

The calculated wavelengths of the lines
are *very* close to measured values

His model was significant in
demonstrating the importance of
wave characteristics
and
suggesting the concept of **energy levels**

BIG Problem:
Bohr's model does not work for
atoms with more than one electron

Rydberg Equation Predicts the Hydrogen Spectrum

Rydberg Equation

- Empirically derived to fit hydrogen's atomic spectrum
- Predicts λ's of invisible line spectra
  e.g. Hydrogen's Ultraviolet line spectrum

$$\frac{1}{\lambda} = R\left(\frac{1}{n^2} - \frac{1}{n^2}\right)$$

$R = 1.096776 \times 10^7\ m^{-1}$ $n = 1, 2, 3, 4, \ldots$