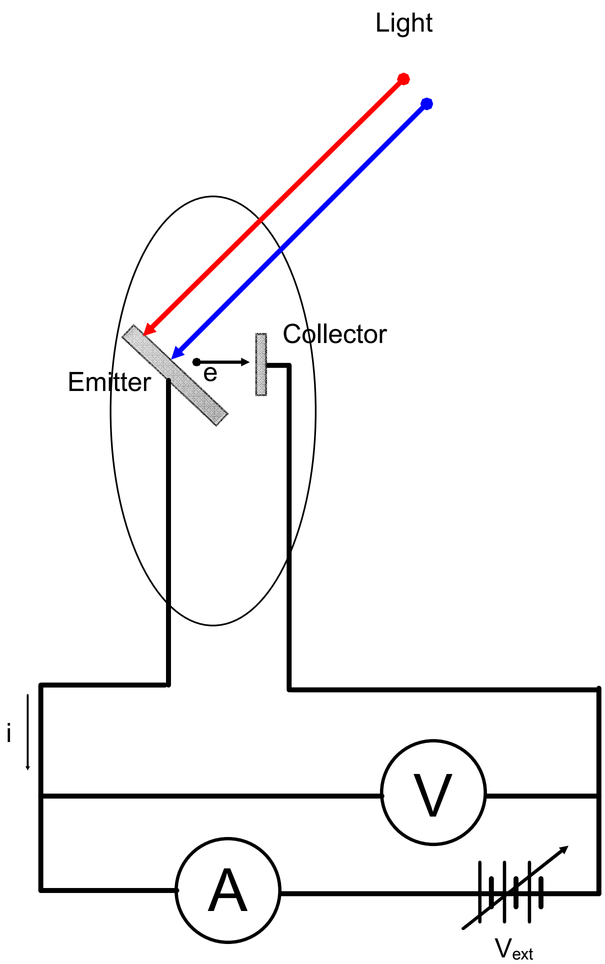
Photoelectric Effect:

Measurement of voltage & current show the following characteristics of the "Photo-electric Effect":

1. Cutoff frequency, below which no electrons are ejected from the metal
2. No time delay for electron ejection
3. Max electron energy proportional to frequency of light (above cutoff frequency), NOT intensity of light



Einstein's theory: PE Effect can only be explained by treating light as a particle (photon), NOT a wave.

$$K_{max} = hf - \phi$$

Where: $E_p = hf$ photon energy

$V_s \equiv$ "stopping potential" $\phi \equiv$ "work function"

$$K_{max} = eV_s$$

Bohr model of the hydrogen atom:

Balmer formula: (visible H lines)

$$\lambda = 364.6 \frac{n^2}{n^2 - 4} \qquad n = 3, 4, 5, \ldots$$

(units: nm)

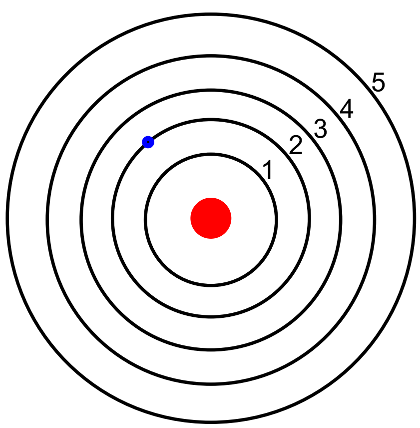
$$\frac{1}{\lambda} = R_H \left(\frac{1}{2^2} - \frac{1}{n^2} \right) \qquad R_H = 10967757.6\ m^{-1}$$

(in terms of the Rydberg constant for hydrogen)

Bohr model semi-classical treatment:

Postulates:

1. circular orbits
2. angular momentum of orbits quantized
3. no emission of light when in these orbits
4. light emitted (as photons) when electron transitions between allowed orbits



quantized orbits: $L = \frac{nh}{2\pi} = n\hbar \quad n = 1, 2, 3, \ldots$

photon energy: $E_p = hf = E_i - E_f$

quantized radii of orbits:

$$\frac{1}{4\pi\epsilon_0}\frac{e^2}{r^2} = \frac{mv^2}{r} \qquad L = mvr = n\hbar \quad n = 1, 2, 3, \ldots$$

$$e^2 = 4\pi\epsilon_0 m v^2 r = 4\pi\epsilon_0 m r\left(\frac{n\hbar}{mr}\right)^2 = 4\pi\epsilon_0 \frac{n^2\hbar^2}{mr}$$

$$r = 4\pi\epsilon_0 \frac{n^2\hbar^2}{me^2} \quad n = 1, 2, 3, \ldots$$

quantized total energy of orbits:

$E \equiv$ total energy

From Virial Theorem: $E = \frac{1}{2}V \qquad V = -\frac{e^2}{4\pi\epsilon_0 r}$

$V \equiv$ potential energy

$$E = -\frac{e^2}{4\pi\epsilon_0 2r}$$

using quantized radii, get quantized energies:

$$E_n = -\frac{me^4}{(4\pi\epsilon_0)^2 2\hbar^2}\frac{1}{n^2} \qquad n = 1, 2, 3, \ldots$$

Using Bohr's 4th postulate:

$$f = \frac{E_i - E_f}{h} = \frac{1}{h}\left[-\frac{me^4}{(4\pi\epsilon_0)^2 2\hbar^2}\right]\left[-\frac{1}{n_i^2} + \frac{1}{n_f^2}\right)$$

$$f = \left(\frac{1}{4\pi\epsilon_0}\right)^2 \frac{me^4}{4\pi\hbar^3}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

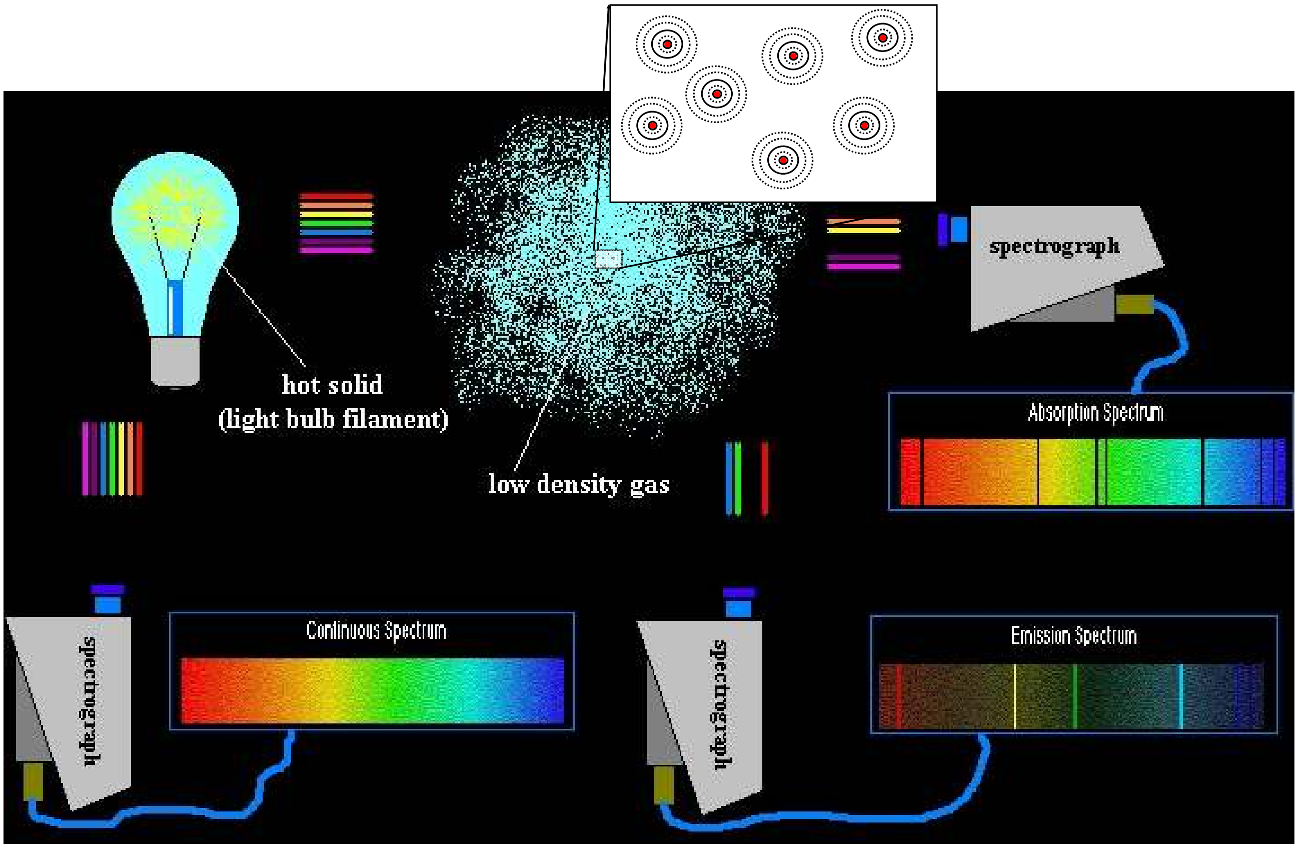
$$\frac{1}{\lambda} = \frac{f}{c}$$

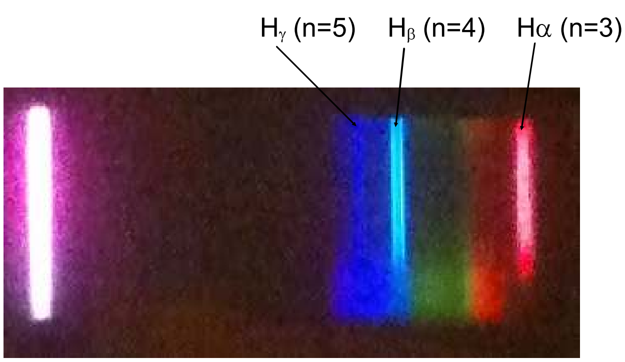
$$\frac{1}{\lambda} = \left(\frac{1}{4\pi\epsilon_0}\right)^2 \frac{me^4}{4\pi\hbar^3 c}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$\frac{1}{\lambda} = R_\infty\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$ $R_\infty \equiv$ Rydberg constant for center of mass at center of nucleus

for Balmer series: $n_f = 2$

$$\boxed{\frac{1}{\lambda} = R_\infty\left(\frac{1}{2^2} - \frac{1}{n^2}\right) \quad n = 3, 4, 5, \ldots}$$





$$\lambda = 364.6\,\frac{n^2}{n^2-4}$$

$n = 3, 4, 5, \ldots$

(units: nm)