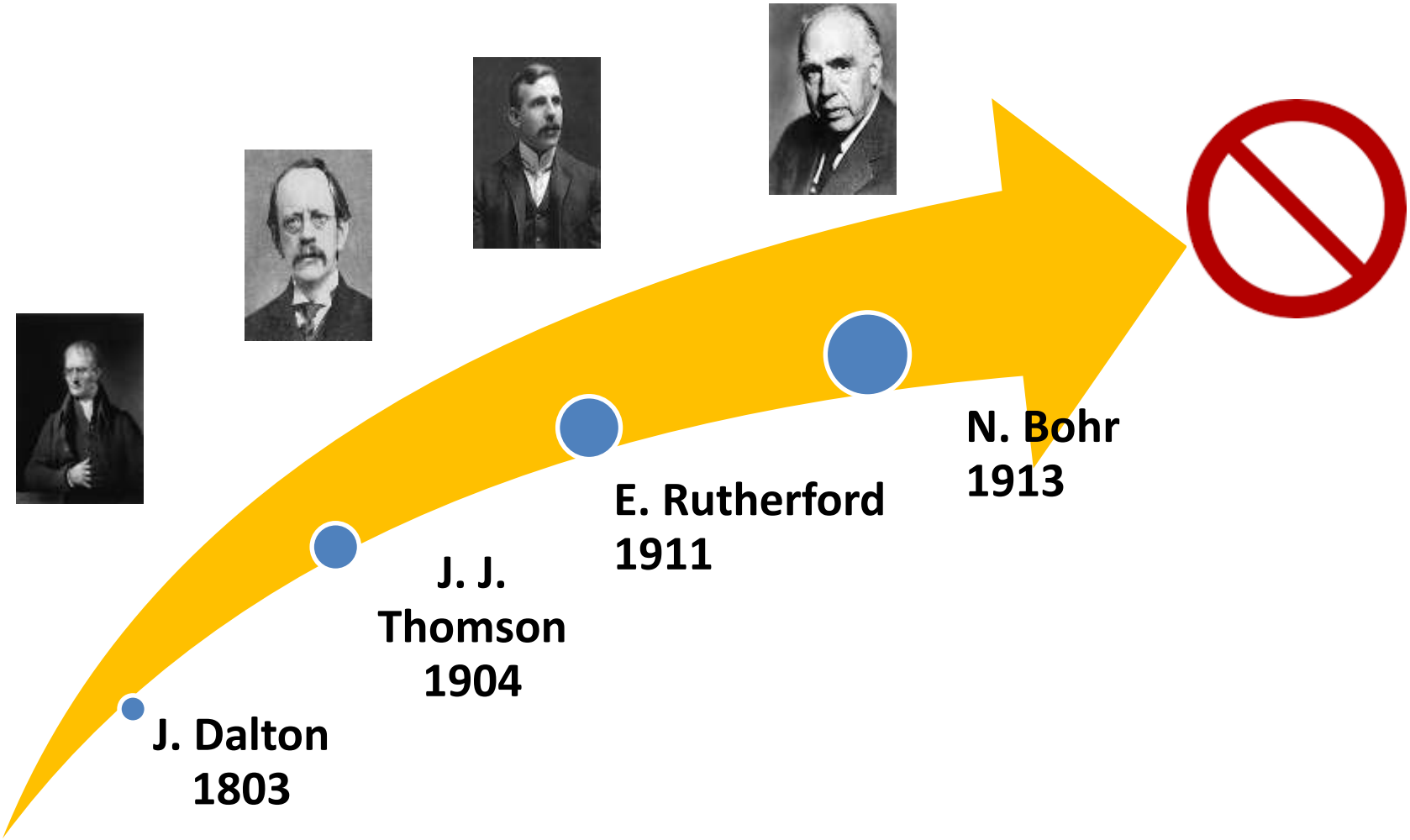
Limitations of Bohr's Theory

Dr. Mithil Fal Desai

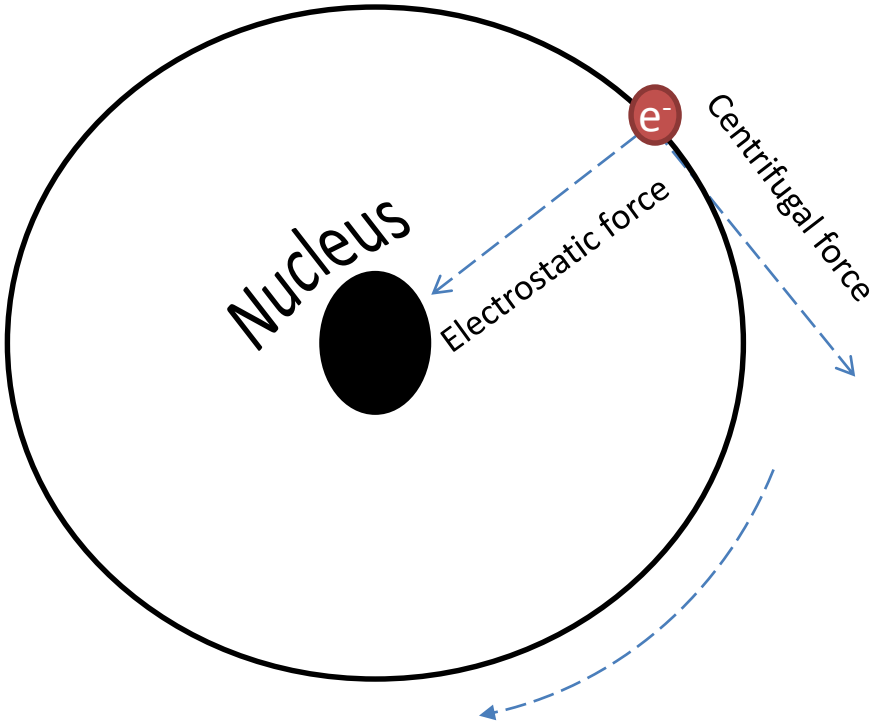
Shree Mallikarjun and Shri Chetan Manju Desai College
Canacona Goa

Background



Neil Bohr postulated

- Electron does not radiate energy as it moves in a particular orbit.
- Electron can move from one orbit to another absorbing or radiating energy.
- Centrifugal force in which electron orbits is equal to electrostatic force, thus electron remains in orbit.

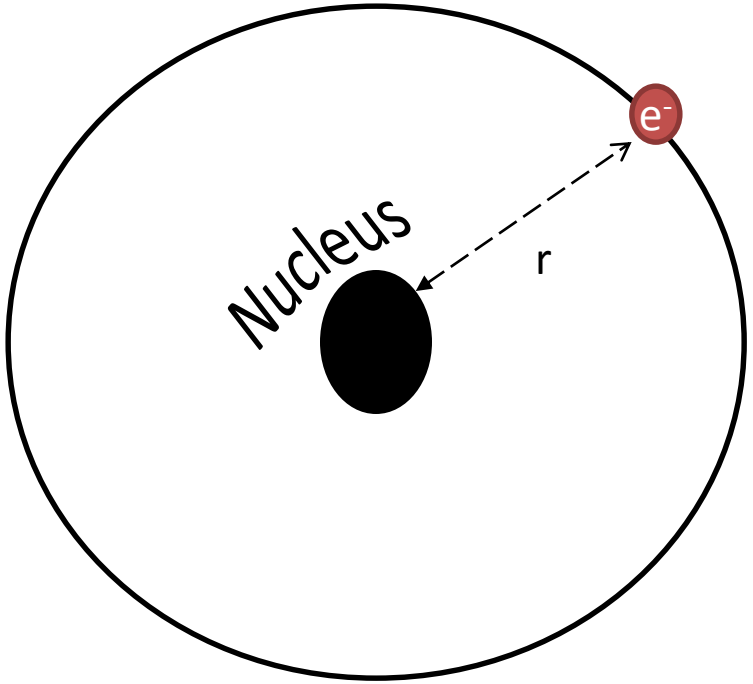


Calculating Bohr radius

Electron to remain in orbit

$$\boldsymbol{Cetrifugal\ force = Electrostatic\ force}$$

$$\frac{mv^2}{r} = \frac{Ze^2}{4\pi\varepsilon_\circ r^2} \ldots\ldots\ldots\ldots 1$$



Where,

r is radius of atom, mass of electron m = 9.1091 X 10^{-31} Kg; charge on electron e = 1.60210 X 10^{-19} C; vacuum permittivity of vacuum ε_o = 8.854185 X $10^{-12}J^{-1}m^{-1}C^2$

Calculating Bohr radius

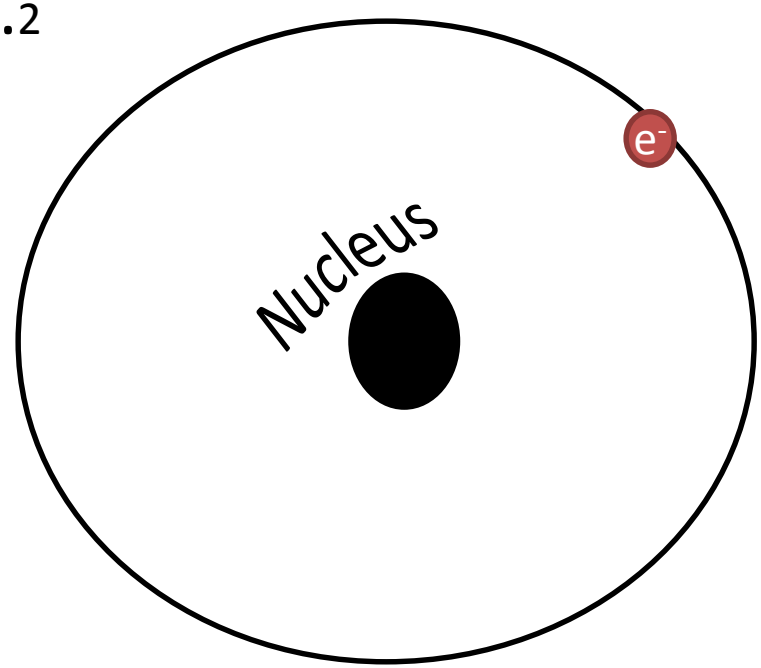
According to Plank 'Energy is discrete': only certain energy levels are possible which integral multiple of h/2π (of n a whole number 0, 1, 2, 3…)
Plank constant h = 6.6262 X10^{-34}Js

$$Angular\ momentum = Electrostatic\ force$$

$$mvr = \frac{nh}{2\pi} \ldots\ldots\ldots\ldots\ldots\ldots 2$$

From 1 and 2

$$r = \frac{n^2 h^2 \varepsilon_\circ}{\pi Z m e^2}$$



For Hydrogen, Z = 1, than for

n=1; r = 1 X 0.0529 nm
n=2; r = 2^2 X 0.0529 nm

Energy of orbit and energy of electronic transition

For energy we can consider equation 1

$$E = -\frac{1}{2}mv^2 = -\frac{Z^2e^4m}{8\,n^2h^2\varepsilon_\circ^2} \text{.....3}$$

Difference in energy (ΔE) of two orbits

$$E_2 - E_1 = -\frac{Z^2e^4m}{8n_2^2h^2\varepsilon_\circ^2} - (-\frac{Z^2e^4m}{8n_1^2h^2\varepsilon_\circ^2})$$

$$\Delta E = \frac{Z^2e^4m}{8h^2\varepsilon_\circ^2}(\frac{1}{n_1^2} - \frac{1}{n_2^2}) \text{ .....4}$$

Energy of orbit and energy of electronic transition

$$E = hv = h\tilde{\nu}C$$

$$\tilde{\nu} = wavenumber$$

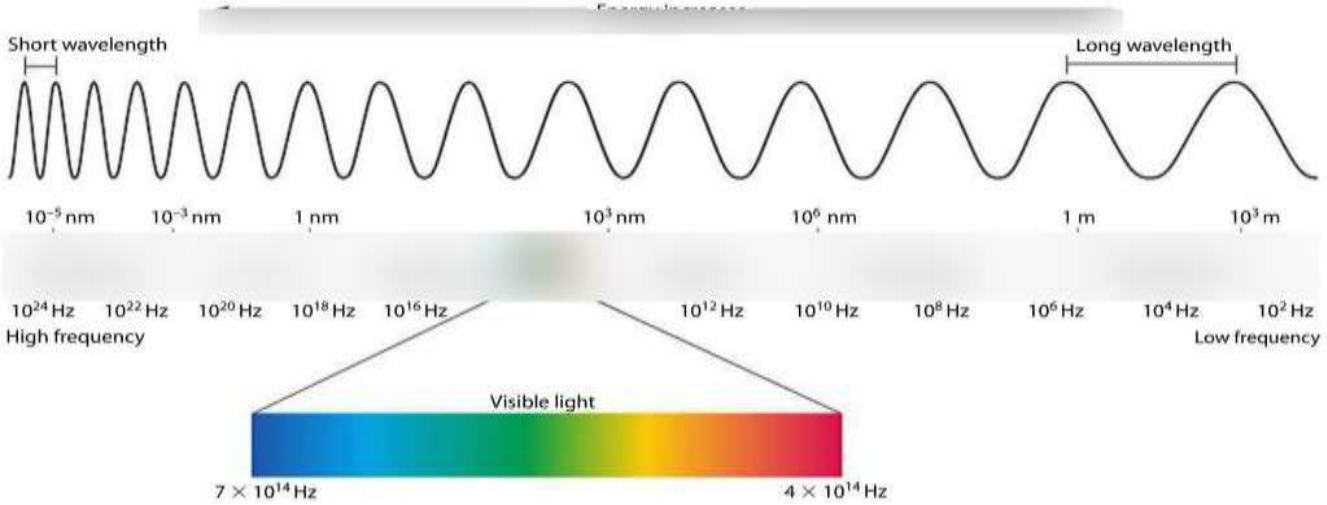
Then,

$$\tilde{\nu} = \frac{Z^2 e^4 m}{8h^3 \varepsilon_\circ^2 C}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\tilde{\nu} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

R= Rydberg constant =1.0973 X 10^7 m^{-1}

Bohr orbit of hydrogen atom and spectral series



Series name	n_1	n_2	ʎ nm	Electromagnetic radiation
Lyman	1	2,3,4,5…	91.2-121.6	UV
Balmer	2	3,4,5,6…	383.5-656.2	Visible
Paschen	3	4,5,6,7…	954.6-1875.0	Infrared
Brackett	4	5,6,7,8…	2630-4050	Infrared
Pfund	5	6,…..	7400	infrared

Limitations

- Spectral lines is a collection of several lines very close together.
- does not spectral series for the atoms having a more number of electrons.
- Bohr theory does not explain the use of the principle of quantization of energy
- Bohr assumes electrons are at a fixed point
- No justification of the Zeeman effect or Stark effect.

Bohr's Theory

- Why electron does not slow down as it moves in orbit?
- Why circular path it follows?
- Why electron does not collide with nucleus as electron is negative and nucleus positive.