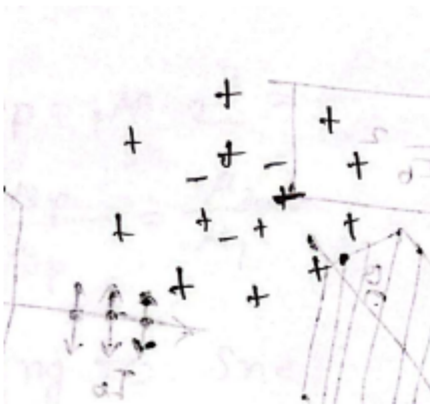
Atomic Model

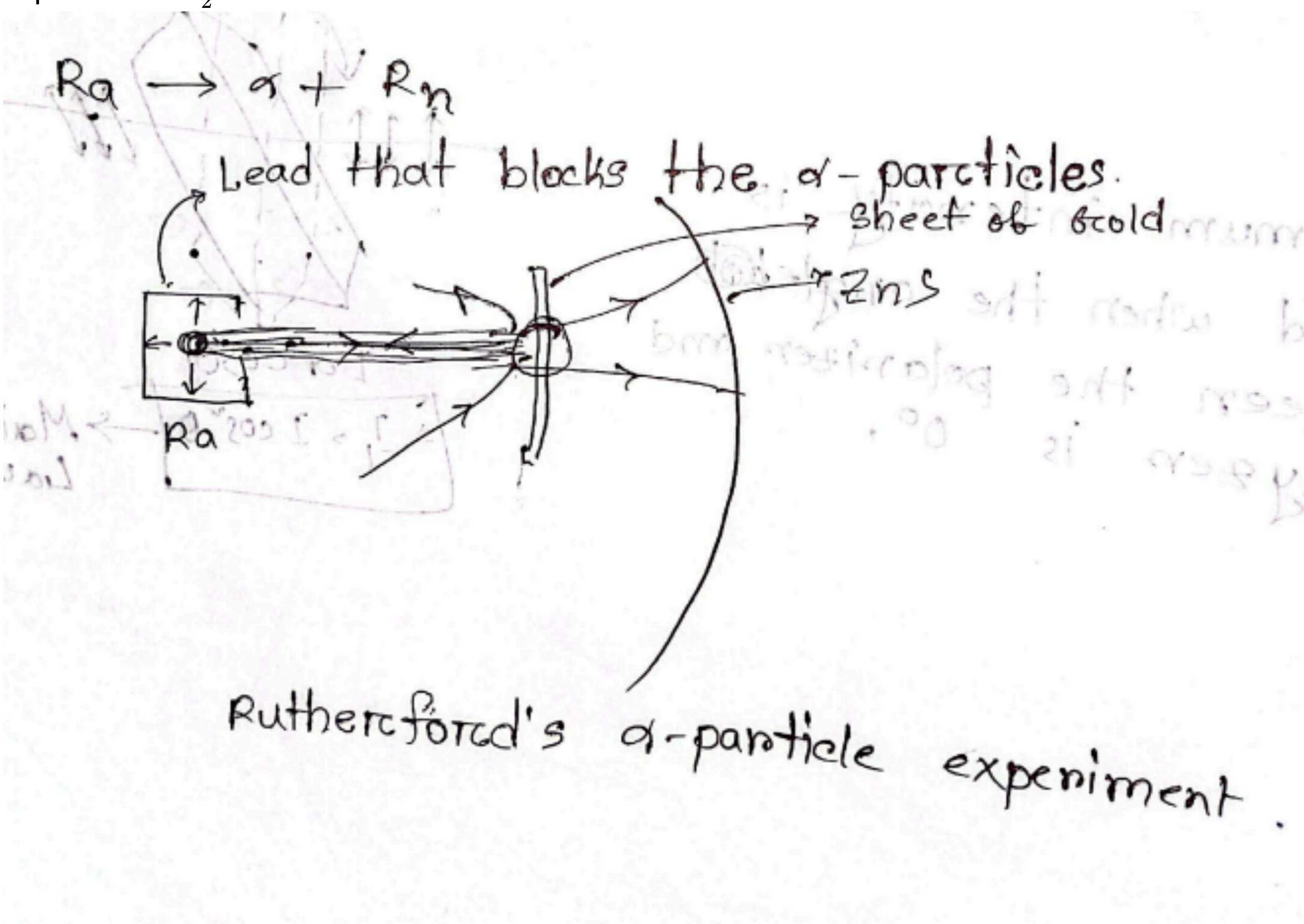
Thomson Model

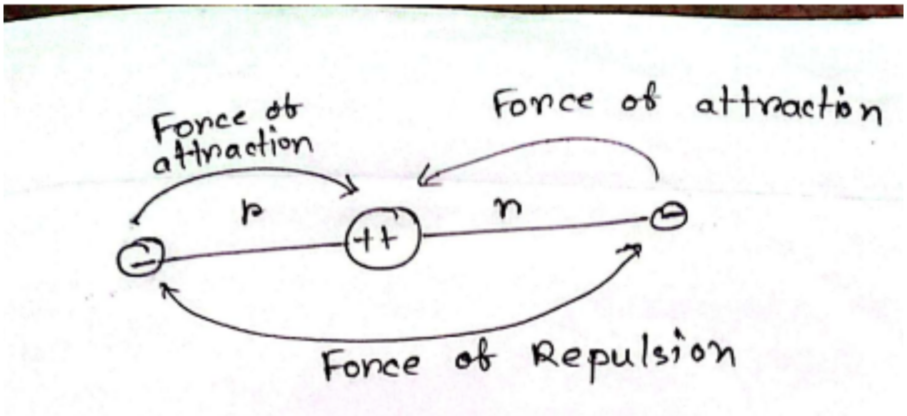
An atoms is a heavy sphere of positive charges that are uniformly distributed and the electrons are distributed in a circular shape.



Rutherford's Model

α-particles $\rightarrow {}_{2}^{4}He^{2+}$





Limitation of Rutherford Model:
Attraction force between nucleus and electron

$$F_A = \frac{2e \times e}{4\pi\epsilon_o r^2}$$

Repulsion force between electrons,

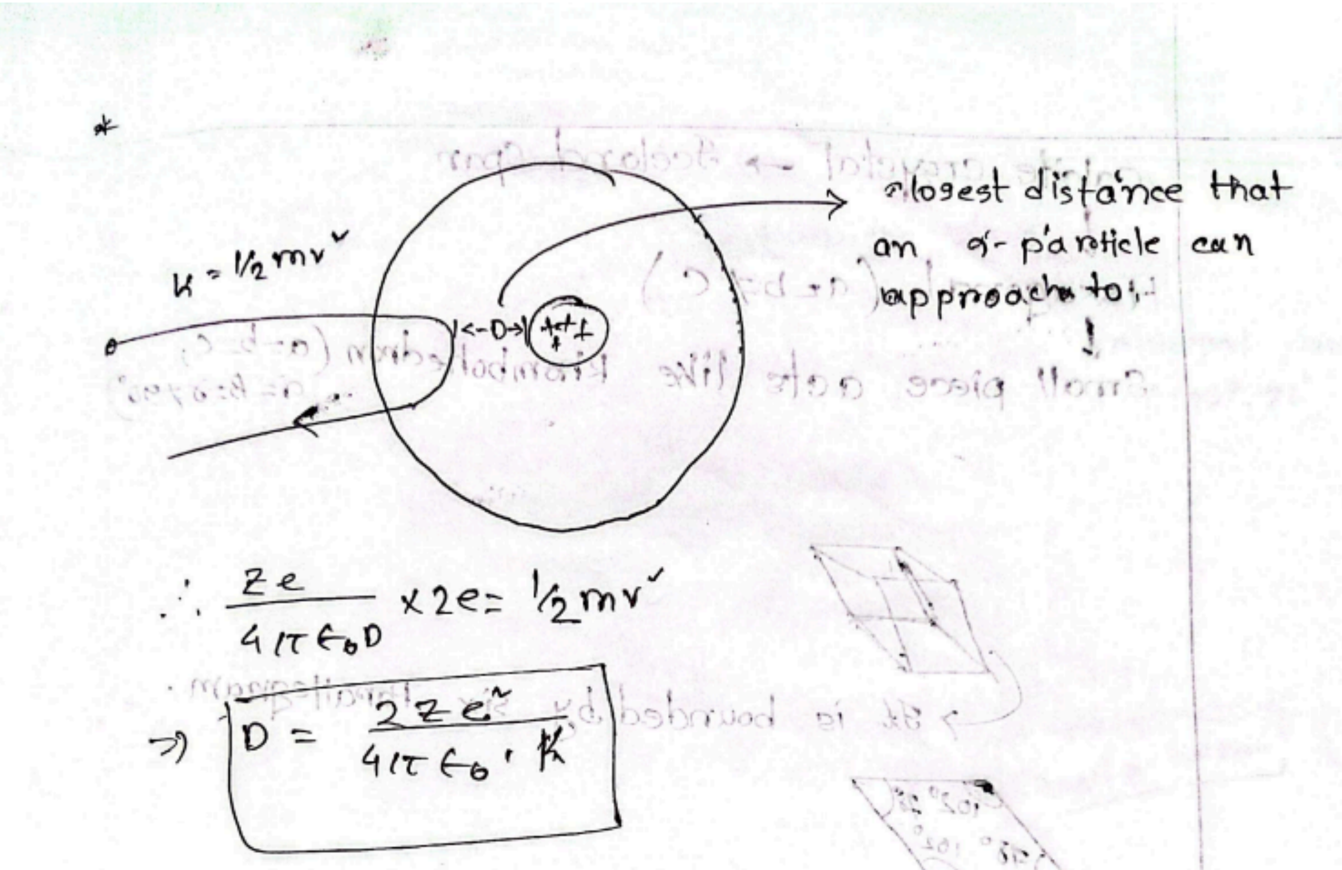
$$F_R = \frac{e \times e}{4\pi\epsilon_o r^2}$$

According to Rutherford Mode, $F_A > F_R$. So, the electrons will fall in the nucleus.

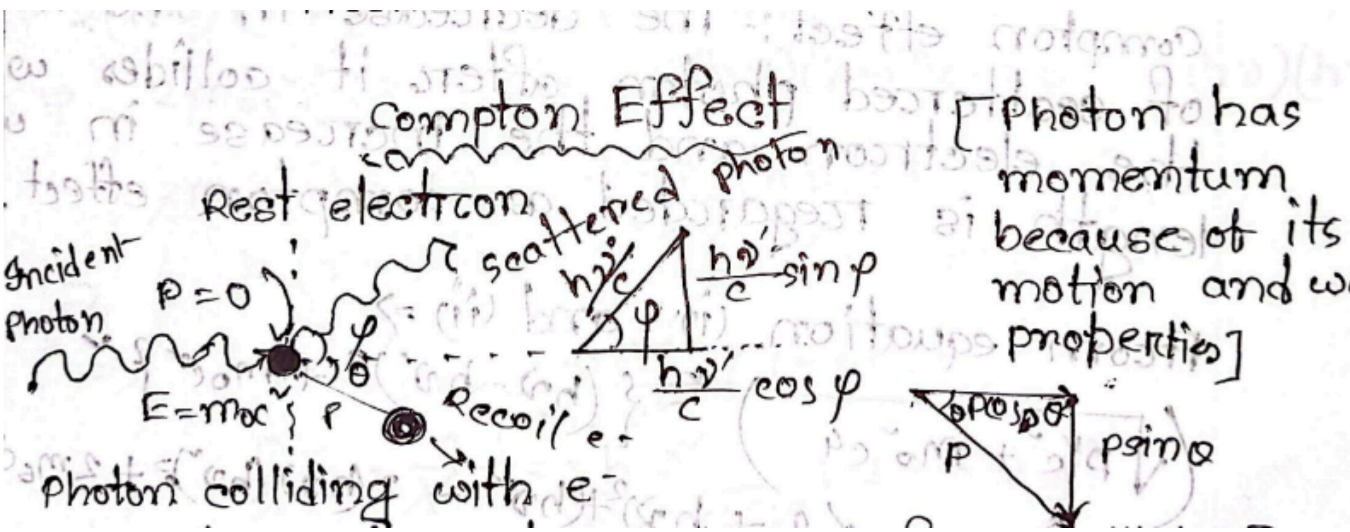
According to Rutherford,

$$\frac{mv^2}{r} = \frac{Ze^2}{4\pi\epsilon_o r^2}$$

But according to Maxwell, electrons will continue to lose energy and its radius of rotation will cease to decrease. So, it will ultimately fall in the nucleus.



Compton Effect



Compton effect is the event of photon colliding with an electron.

Photon has momentum because of its motion and wave properties

Momentum of photon, $p = \frac{hv}{c}$ [Before Collision]
After collision photo will lose some energy and e^- will gain that and it will recoil the electron.
The photo will scatter with an angle of ϕ

Now, the momentum of scatter photon is,

$$p = \frac{hv'}{c}$$

Loss in photo energy is gain in kinetic energy of electron

$$hv - hv' = \text{Kinetic Energy}$$

For recoiled electron,

$$E = \sqrt{p^2c^2 + m_o^2c^4} \ldots (i)$$

$$E = \text{K. E.} + m_oc^2 \ldots (ii)$$

$$p = p$$

Formally Compton effect is the decrease in the frequency of scattered photon after it collides with the electron and the increase in wavelength is regarded as Compton effect

From equation (i) and (ii)

$$\left(\sqrt{p^2c^2 + m_o^2c^4}\right)^2 = \left\{(hv - hv') + m_oc^2\right\}^2$$

$$p^2c^2 = (hv)^2 + (hv')^2 - 2(hv)(hv') + 2m_oc^2(hv - hv') \ldots (iii)$$

According to the elastic collision property
total moment of the system along the horizontal and vertical remains constant

$$\therefore \frac{hv}{c} + 0 = \frac{hv'}{c}\cos\phi + p\cos\theta$$

$$\Rightarrow p\cos\theta = \frac{hv}{c} - \frac{hv'}{c}\cos\phi$$

$$\Rightarrow (pc\cos\theta)^2 = (hv - hv'\cos\phi)^2$$

$$p^2c^2\cos^2\theta = (hv)^2 - 2(hv)(hv')\cos\phi + (hv')^2 \ldots (iv)$$

Along the vertical axis

$$0 + 0 = \frac{hv'}{c}\sin\phi - p\sin\theta$$

$$pc\sin\theta = (hv')\sin\phi$$

$$p^2c^2\sin^2\theta = (hv')^2\sin^2\phi \ldots (v)$$

$$(iv) + (v)$$

$$\Rightarrow p^2c^2 = (hv)^2 + (hv')^2 - 2(hv)(hv')\cos\phi \ldots (vii)$$

putting the values of p^2c^2 in the equation (iii)

$$-2(hv)(hv') + 2m_oc^2(hv - hv') = -2(hv)(hv')\cos\phi$$

$$\Rightarrow 2m_o c^2(hv - hv') = 2(hv)(hv')(1 - \cos\phi)$$

$$\Rightarrow h(v - v') = \frac{h^2 v v'}{m_o c^2}(1 - \cos\phi)$$

$$\Rightarrow \frac{c}{\lambda} - \frac{c}{\lambda'} = \frac{hc^2}{m_o c^2 \times \lambda \times \lambda'}(1 - \cos\phi)$$

$$\Rightarrow \lambda\lambda'\left(\frac{1}{\lambda} - \frac{1}{\lambda'}\right) = \frac{h}{m_o c}(1 - \cos\phi)$$

$$\Rightarrow \lambda' - \lambda = \frac{h}{m_o c}(1 - \cos\phi)$$

$$\lambda' = \lambda + \frac{h}{m_o c}(1 - cos\phi)$$

$$\therefore \lambda' > \lambda$$

The delta of wavelength will be maximum when $\phi = 180^{\circ}$