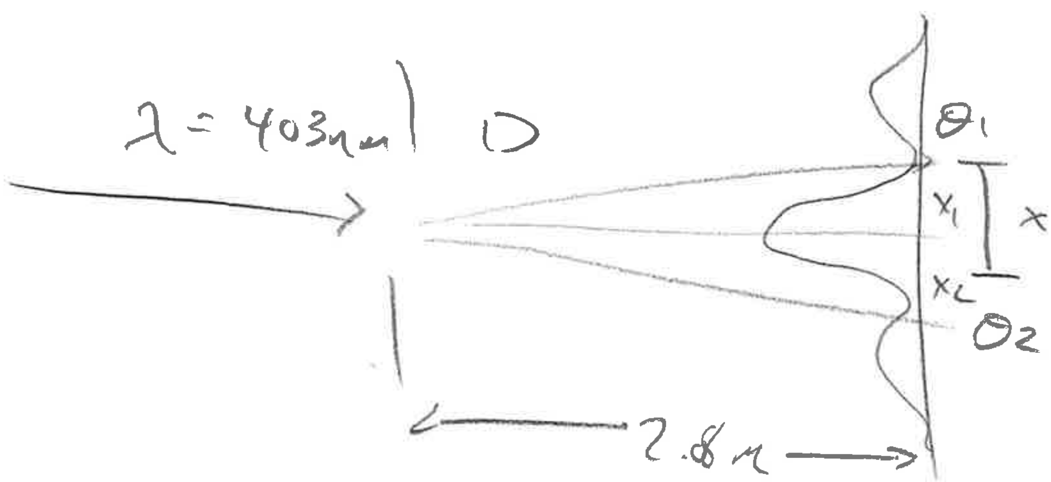
Warm Up

A 0.3 mm slit is illuminated by blue light with wavelength 403nm. What is the linear isdistance on a screen 2.8 m from the slit between the first two minima in the diffraction pattern?



First Minimum:

$m_1 = +1$

$\theta_1 = ?$

$D \sin\theta = m_1 \lambda$ (destructive, single slit)

$\sin\theta_1 = \dfrac{m_1 \lambda}{D}$

$\theta_1 = \sin^{-1}\left(\dfrac{m_1 \lambda}{D}\right)$

$\theta_1 = 0.0770°$

2

Bottom Minimum

$m_2 = -1$

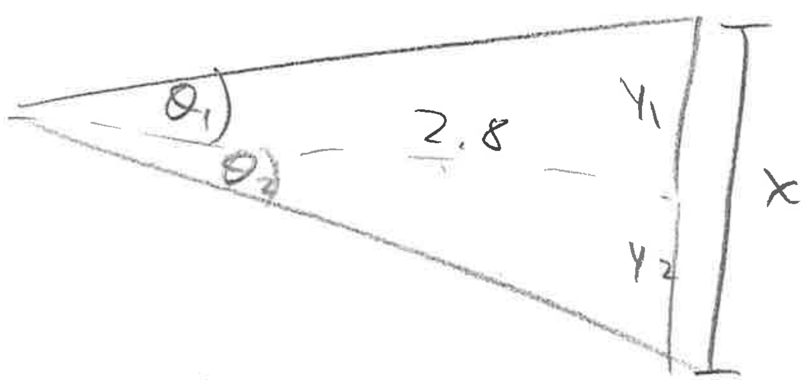
$\theta_2 = ?$

$D \sin \theta_2 = m_2 \lambda$

$\sin \theta_2 = \dfrac{m_2 \lambda}{D}$

$\theta_2 = \sin^{-1}\left(\dfrac{m_2 \lambda}{D}\right)$

$\theta_2 = -0.0770°$



$x = |y_1| + |y_2|$

$\dfrac{y_1}{2.8} = \tan \theta_1$

③

$$y_1 = 2.8 \tan\theta_2$$

$$\frac{y_2}{2.8} = \tan\theta_2$$

$$y_2 = 2.8 \tan\theta_2$$

$$x = |2.8 \tan\theta_1| + |2.8 \tan\theta_2|$$

$$x = 2.8 \left(|\tan\theta_1| + |\tan\theta_2| \right)$$

$$x = 0.00752 \text{ m}$$

$$\boxed{x = 7.52 \text{ mm}}$$

Discovery of the Atom

- Long been speculated matter was made up of smaller particles.

- Can matter be continuously subdivided?

Yes ⟶ goes forever No ⟶ Smallest unit that cannot be subdivided

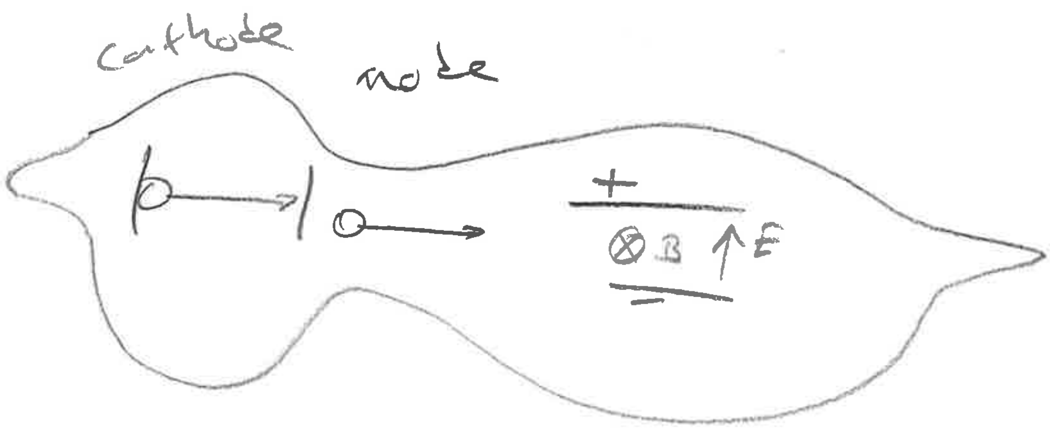
Atom - from ancient Greek atomos - uncuttable

- Greeks speculated all matter were different combinations of different atoms.

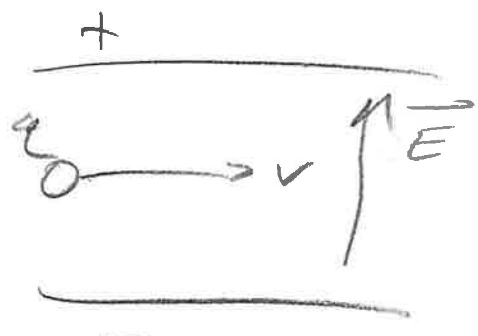
- Atoms and molecules were experimentally determined to be $\sim 10^{-10}$ m in size.

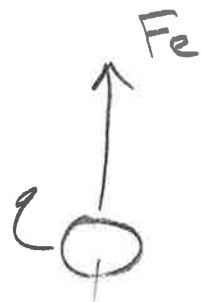
the Electron

- Two electrodes, with high potential difference, illuminate gas
- These "cathode rays" were deflected by $\vec{E}$ and $\vec{B}$ fields, indicating negative charges.



Thompson experiment





$$\Sigma F = ma$$

$$qE = ma$$

$$\frac{q}{m} = \frac{E}{a}$$

E is obtained from ΔV

a is measured from projectile path.

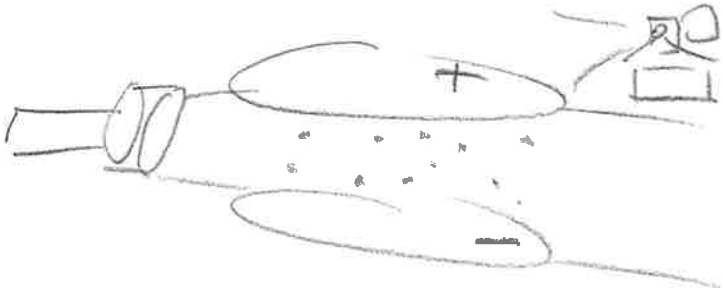
$$\frac{q_e}{m_e} = -1.76 \times 10^{11} \text{ C/kg}$$

Hydrogen ions (protons) yield

$$\frac{q_p}{m_p} = 9.58 \times 10^{7} \text{ C/kg}$$

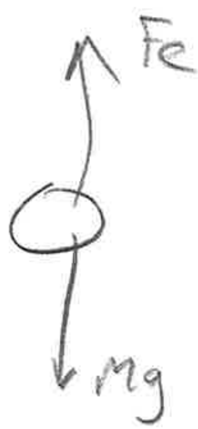
if $q_e = -q_p$,

$$\frac{m_p}{m_e} = 1836$$



charged drops

Millikan experiment



Mass comes from motion with no $\vec{E}$ field, drag.

$$\Sigma F = 0$$

$$q_e E = M_{drop}\, g$$

$$E = \frac{\Delta V}{d}$$

$$q_e = \frac{M_{drop}\, g\, d}{\Delta V}$$

$$\boxed{q_e = -1.60 \times 10^{-19}}$$

From Thompson!

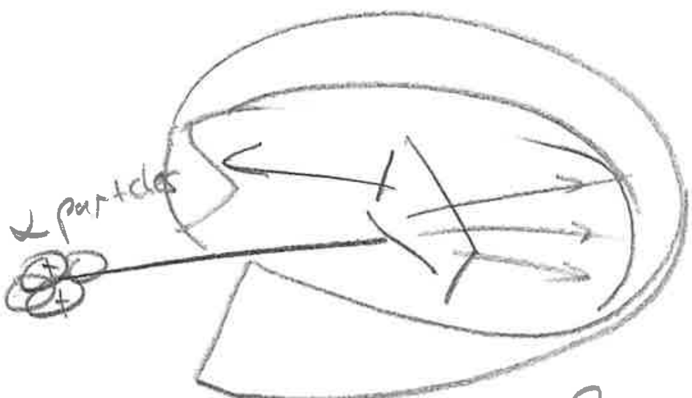
$$\frac{q_e}{m_e} = -1.76 \times 10^{11} \text{ C/kg}$$

$$\boxed{m_e = 9.11 \times 10^{-31} \text{ kg}}$$

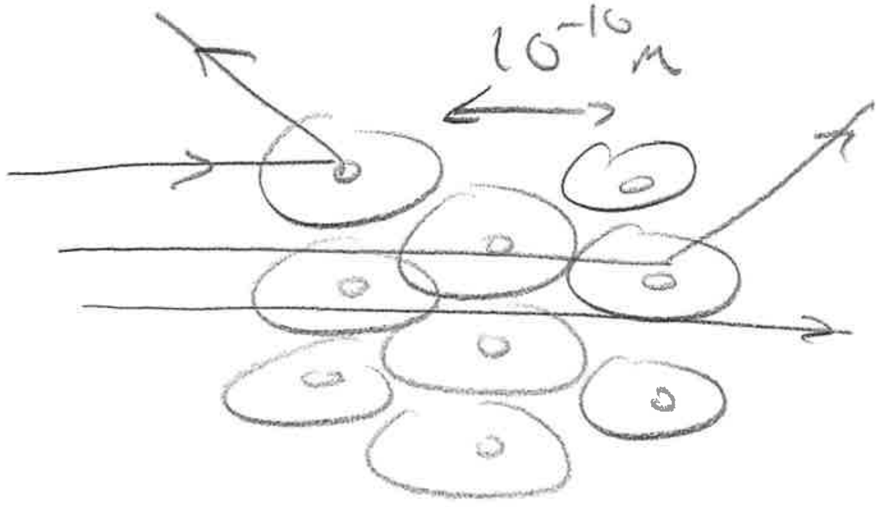
$$\boxed{m_p = 1.67 \times 10^{-27} \text{ kg}}$$

Nucleus

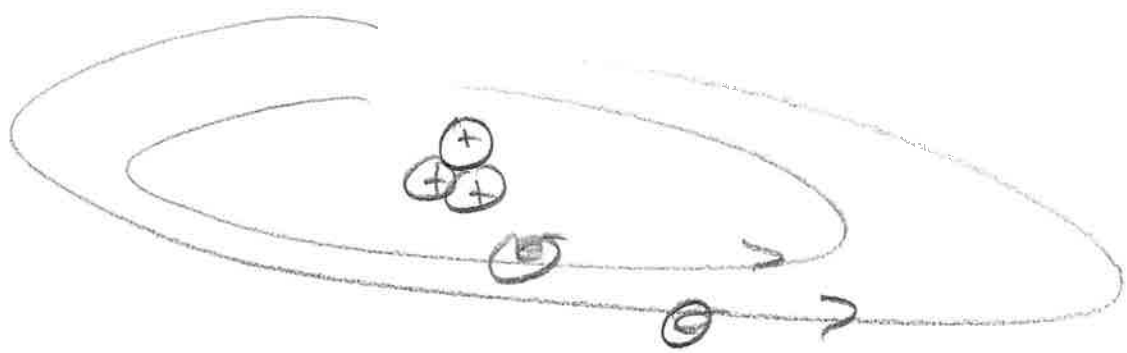
- plum pudding model



Rutherford Experiment

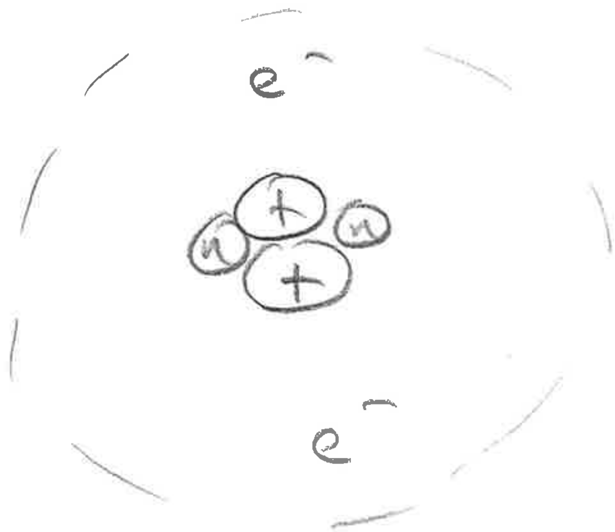


- small nuclei
- densities $\sim 10^{15}$ g/cm^3
- nucleus must be $\sim 10^{-15}$ m, 100,000 times smaller than the entire atom.
- Rutherford proposed planetary model



Binding energy

- binding energy – energy needed to dissassociate atom.



He atom

- He atom's mass is less than the sum of its parts!

$m_{He} = 4.002603\,u$

$m_p = 1.007825\,u$

$m_n = 1.008665\,u$

$2m_p + 2m_n = 4.03298\,u$

$\Delta m = (Zm_p + Nm_n) - m_{atom}$

$$BE = \Delta m c^2$$

$$\boxed{BE = \left[(Z m_p + N m_n) - m_{atom} \right] c^2}$$

$$^{Z+N}A$$

Binding Energy Problem

Calculate the binding for Lithium (^6Li) in MeV

$Z = 3$

$N = 3$

$1\,u = 1.660539 \times 10^{-27}\,kg$

$m_{Li} = 6.015121\,u$

$m_N = 1.008665\,u$

$m_p = 1.007825\,u$

$$BE = \left[(3 \cdot 1.007825) + (3 \cdot 1.008665) - 6.015121 \right] (3 \times 10^{8})^2$$

$$BE = 5.133 \times 10^{-12}\,J$$

$$\boxed{BE = 32.1\,MeV}$$