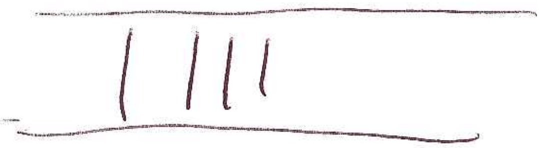
The nuclear atom

1.) History

a) atomic spectra

- slides

Balmer series



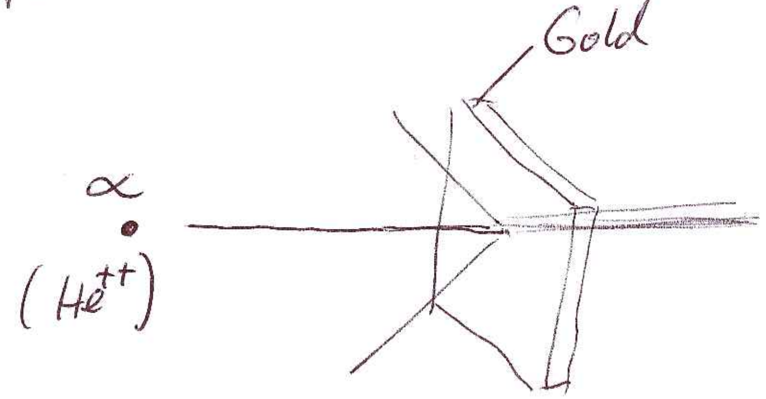
$$\lambda_n = 364.6 \; \frac{n^2}{n^2-4} \; \text{nm}$$

General case

$$\frac{1}{\lambda_{nm}} = R \left(\frac{1}{m^2} - \frac{1}{n^2} \right) \qquad n > m$$

R: Rydberg constant

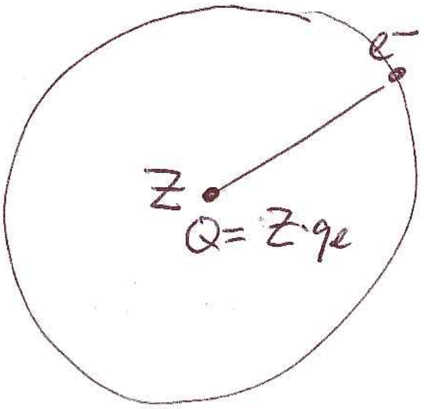
Rutherford



→ Nuclear structure

Data explained by
Coulomb scattering from massive nuclei (Gold)

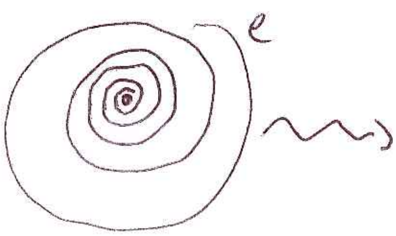
Bohr model



electrons on Keplerian orbits of central potential

$$F = \frac{k Z e \cdot e}{r^2} = \frac{m v^2}{r} \qquad *1$$

~~Bohr:~~ Problem : e should radiate



<u>Bohr:</u> $n \lambda = 2 \pi r$

$$n\left(\frac{h}{p}\right) = 2 \pi r$$

$$n \hbar = \underbrace{p r}_{m v r} = L$$ quantization of L

$$* \quad m v^2 r = k \cdot Z e^2 \qquad (1)$$

$$m^2 v^2 r^2 = n^2 \hbar^2 \qquad (2)$$

$$m r = \frac{n^2 \hbar^2}{k Z e^2} \qquad (2)/(1)$$

$$\boxed{r = \frac{n^2 \hbar^2}{Z m k e^2}} = n^2 \frac{a_0}{Z}$$

$$a_0 = \frac{\hbar^2}{mke^2} = 0.0529\ \text{nm} \quad (= 0.529\ \text{Å})$$

Bohr radius

Energy

$$E = \frac{p^2}{2m} + V(r)$$

$$= \frac{p^2}{2m} - \frac{Zke^2}{r}$$

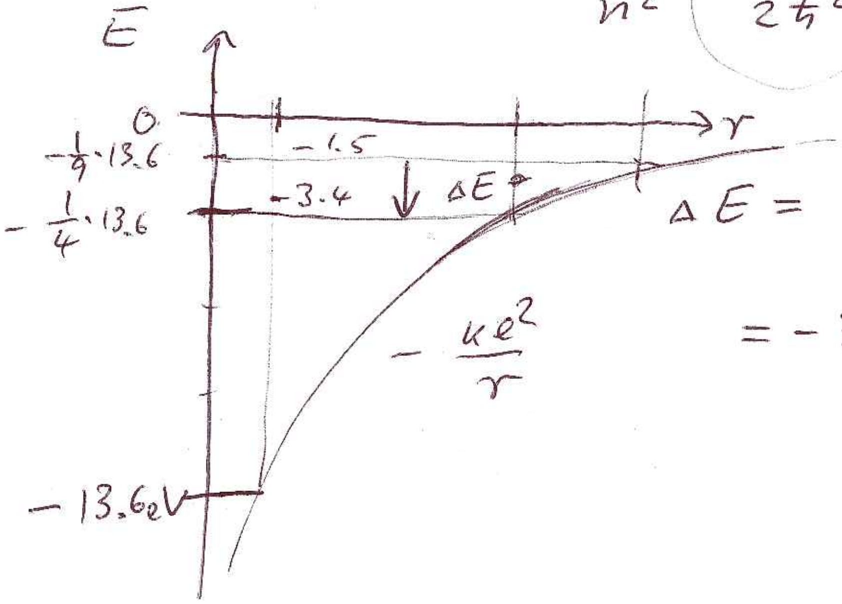
$$= \frac{1}{2m}\left(\frac{n\hbar}{r}\right)^2 - \frac{Zke^2}{r}$$

$$= \frac{1}{2m}\left(\frac{Zmke^2}{n\hbar}\right)^2 - \frac{Zke^2 \cdot Zmke^2}{n^2\hbar^2}$$

$$= -\frac{Z^2 m k^2 e^4}{2n^2\hbar^2}$$

$$= -\frac{Z^2}{n^2} \cdot \frac{mk^2e^4}{2\hbar^2}$$

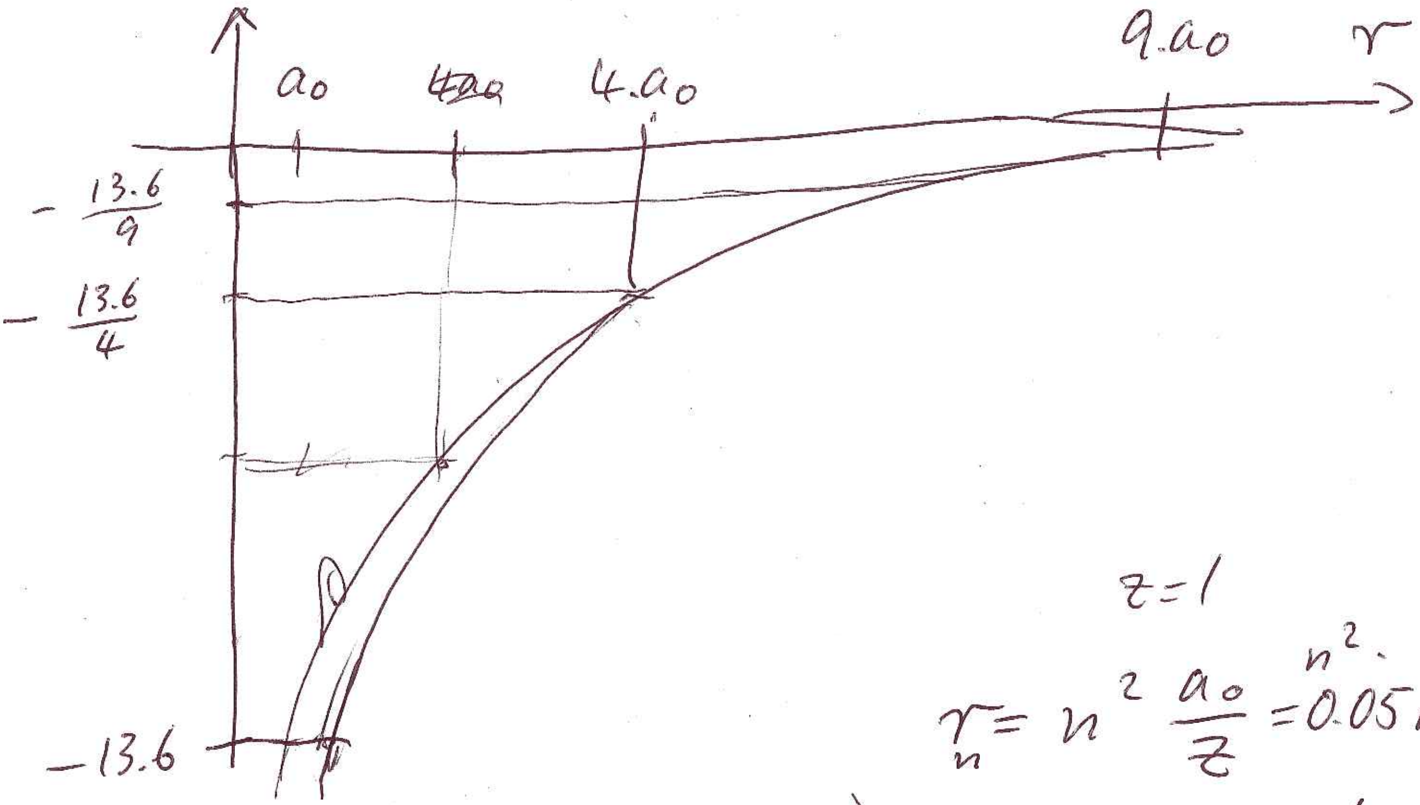
13.6eV



$$\Delta E = E_n - E_m$$

$$= -Z^2 \cdot (13.6\text{eV}) \left(\frac{1}{n^2} - \frac{1}{m^2}\right)$$

Radii & energy of orbits



$Z = 1$

$$r_n = n^2 \frac{a_0}{Z} = 0.05\, n^2 \text{ nm}$$

$$E_n = -(13.6\text{ eV})/n^2$$