Atomic Physics

→ Rutherford's atomic model

No. of α-particles scattered is $N = \dfrac{Qnt\, Z^2 e^4}{(8\pi\varepsilon_0)^2 r^2 (KE)^2 \sin^4(\theta/2)}$

impact parameter $b = \dfrac{1}{4\pi\varepsilon_0} \dfrac{Z_1 Z_2 e^2}{\frac{1}{2}mv^2} \cot(\theta/2)$, closest appr. $r_0 = \dfrac{1}{4\pi\varepsilon_0} \dfrac{Z_1 Z_2 e^2}{KE}$

→ Bohr's atomic model:

i) $L = mvr = \dfrac{nh}{2\pi}$

ii) $\Delta E = E_2 - E_1 = h\nu = \dfrac{hc}{\lambda}$

iii) Radius of n^{th} orbit $(r_n) = 0.53 \dfrac{n^2}{Z} \text{Å} = \dfrac{n^2 h^2 \varepsilon_0}{\pi m Z e^2}$

iv) velocity of revolving e^- in n^{th} orbit $V_n = \dfrac{c}{137} \dfrac{Z}{n} = \dfrac{e^2}{2\varepsilon_0 h}\left(\dfrac{Z}{n}\right)$

$V_n = 2.18 \times 10^6\ Z/n\ (m/s)$

v) Angular momentum $(\omega_n) = 41.5376 \times 10^{15} \times \dfrac{Z^2}{n^3} \dfrac{rad}{sec}$

$\omega = \dfrac{\pi m e^4}{2\varepsilon_0^2 h^3} \dfrac{Z^2}{n^3}$

vi) frequency (f_n) (or) $(\nu_n) = 6.62 \times 10^{15} \times \dfrac{Z^2}{n^3}$ Hz

vii) time period $(T_n) = 1.51 \times 10^{-16} \dfrac{n^3}{Z^2}$ sec $= \dfrac{4\varepsilon_0^2 h^3}{me^4}\left(\dfrac{n^3}{Z^2}\right)$

viii) acceleration $= a_c = \dfrac{v^2}{r} = \dfrac{\left[\frac{c}{137}\left(\frac{Z}{n}\right)\right]^2}{0.53 \frac{n^2}{Z}}$ (∴ centripetal acceleration)

$\boxed{\text{Recoil velocity} = p = mv}$

$v = P/m$

$a_c \propto \dfrac{Z^3}{n^4}$

ix) electric current $(I) = 1.06\left(\dfrac{Z^2}{n^3}\right)$ milli ampere, $I \propto me^5$

x) Magnetic induction $(B_n) = \dfrac{12.58 \times Z^3}{n^5}$ Tesla (T), $B_n \propto m^2 e^7$

xi) Magnetic moment $\boxed{(M) = 9.26 \times 10^{-24}\, n}$ Am^2

(∴ n = no. of orbits) $M \propto \dfrac{e}{m}$

xii) $KE = \dfrac{1}{8\pi\varepsilon_0}\left(\dfrac{Ze^2}{r}\right)$, $PE = \dfrac{-Ze^2}{4\pi\varepsilon_0 r}$

$T.E = PE + K.E$

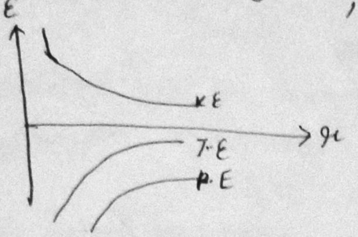
$T.E = \dfrac{-Ze^2}{8\pi\varepsilon_0 r} = \dfrac{-me^4}{8\varepsilon_0^2 h^3 c}(ch)\dfrac{Z^2}{n^2}$

$KE : PE : T.E = 1 : -2 : -1$ $\quad T.E = -13.6 \left(\frac{Z^2}{n^2}\right) eV$

$E = h\nu \quad h = 6.624 \times 10^{-34} Js = 4.14 \times 10^{-15} eVs \quad T.E = \frac{-me^4}{8\varepsilon_0^2 h^2 c^3} (ch) \frac{Z^2}{n^2}$

$1 eV = 1.6 \times 10^{-19} J, \quad 1J = \frac{1}{1.6 \times 10^{-19}} eV$

xiii)



$E \propto m \propto Z^2 \propto \frac{1}{n^2}$

xiv) Rydberg constant $(R) = \underline{1.097 \times 10^7} /m$

xv) Rydberg energy $= Rch = 2.17 \times 10^{-18} J = 13.6 eV$

xvi) wave number $\bar{\nu} = \frac{1}{\lambda} = RZ^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

xvii) conservative force $(F) = -\left(\frac{du}{dr}\right)$, $P.E = -\int \vec{F} \cdot d\vec{r}$

$PE = -\int F(dr)$

→ n^{th} excited state of $e^{\ominus}$ = $(n+1)$ orbit of $e^{\ominus}$

→ no of spectral lines $= \frac{n(n-1)}{2}$

if $n_1 \neq 1, n_2 \neq 1$ then spectral lines $= \frac{(n_2 - n_1)(n_2 - n_1 + 1)}{2}$

→ De-Broglie wave eqn: $\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mKE}} = \frac{h}{\sqrt{2mVq}}$

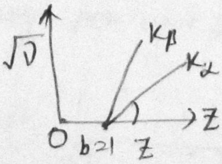
$\lambda_{e^-} = \frac{12.27}{\sqrt{V}} Å$, $\lambda_{p^+} = \frac{0.286}{\sqrt{V}} Å$, $\lambda_n = \frac{0.286}{\sqrt{KE}} Å$, $\lambda_{D_1^2} = \frac{0.202}{\sqrt{KE}} Å$

$\lambda_\alpha = \frac{0.101}{\sqrt{V}} Å$,

Wave nature of e^-'s is used in $e^{\ominus}$ microscope of 10^5 magnification

→ Bragg's eqn. $\quad 2d\sin\theta = n\lambda$

→ Moseley's law: $\sqrt{\nu} = a(Z - b) \quad \sqrt{\nu} \propto Z$



$E_{K\gamma} > E_{K\beta} > E_{K\alpha}$

b = screening const, b=1, for K

b = 7.4 for L

λ for X-rays $\quad \frac{1}{\lambda} = R(Z-b)^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$\frac{\lambda_{K\alpha}}{\lambda_{K\beta}} = \frac{32}{27}$