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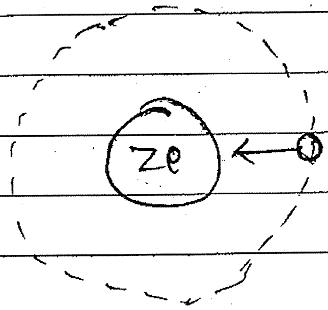
Bohr's model



$$\frac{1}{4\pi\varepsilon_0}\frac{Ze\cdot e}{r^2} = \frac{mv^2}{r}$$

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

$$m^2v^2r^2 = \frac{n^2h^2}{4\pi^2}$$

$$\frac{mv^2}{r} = \frac{Ze^2}{4\pi\varepsilon_0 r^2}$$

$$\frac{mZe^2 r^2}{4\pi\varepsilon_0 r^2} = \frac{n^2h^2}{4\pi^2 r}$$

$$r = \frac{n^2h^2\varepsilon_0}{\pi mZe^2}$$

$$\boxed{r = \frac{r_0 n^2}{Z}}$$

$$\boxed{r_0 = 0.529\ \mathring{A}}$$

$r = \sim\sim 0.53$ $\boxed{r = 0.53 \times \frac{n^2}{Z}}$

For velocity

$$r = \frac{n^2h^2\varepsilon_0}{Zm\pi e^2} = r_0\frac{n^2}{Z}$$

$$V = \frac{nh}{2\pi mr} = \frac{nh}{2\pi m \frac{n^2h^2\varepsilon_0}{\dots}}$$

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$$\boxed{V = V_0 \times \frac{Z}{n}}$$

$$T = \frac{2\pi r}{V} \propto \frac{n^3}{Z^3}$$

$$\nu \text{ or } \omega \propto \frac{Z^2}{n^3}$$

Q.1 What is the ratio of magnetic field produced by electron revolving in 1st Bohr orbit of hydrogen atom and third excited state of helium ion.

⇒ $r = 0.53 \frac{n^2}{Z}$ $\qquad n = 4$

$$B = \frac{\mu_0}{4\pi} \frac{qv\sin\theta}{r^2}$$

$$= \frac{\left(V_0 \frac{Z}{n}\right)}{\left(r_0 \frac{n^2}{Z}\right)^2} \propto \frac{Z^3}{n^5}$$

$$\boxed{B_1 = \frac{1^3}{1^5}}$$

$$\frac{B_1}{B_2} = \frac{1}{\frac{1}{128}}$$

$$B_2 = \frac{(2)^3}{(4)^5}$$

$$\frac{B_1}{B_2} = \frac{128}{1}$$

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Q.2 What is the ratio magnetic dipole moment of electron revolving in Ist orbit of hydrogen atom and 2^{nd} excited ~~stage~~ of state of helium ion

Ans

$$M = \frac{q}{2m} L$$

$$= \frac{q}{2m} \cdot \frac{nh}{2\pi}$$

$$M = i \pi r^2$$

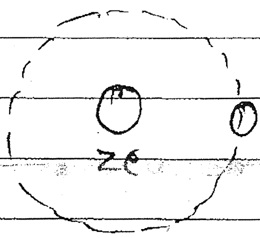
$$= \frac{q}{T} \pi r^2$$

$$= \frac{e}{2\cancel{\pi} r} v \cancel{\pi} r^2$$

$$= \frac{evr}{2}$$

$$v_0 \frac{Z}{n} \times r_0 \frac{n^2}{Z}$$

$$= v_0 r_0 n$$



$$\frac{KZe^2}{r^2} = \frac{mv^2}{r}$$

$r =$

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

$r = r_0 \frac{n^2}{Z}$, $v = v_0 Z/n$

$T = \frac{2\pi r}{v}$, $\omega = \frac{v}{r}$ $\nu = \frac{1}{T}$

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$$M = \frac{q}{2m} L = \frac{q}{2m} \cdot \frac{nh}{2\pi}$$

K.E

$\Rightarrow$ $K.E = \frac{1}{2} mv^2 = \frac{Kze^2}{2r}$ doesn't depend reference point

$P.E = \frac{-Kze \cdot e}{r} = \frac{-kze^2}{r}$ It depends reference upon reference point.

$T.E =$

$T.E = P.E + K.E = \frac{-Kze^2}{2r}$

Difference of energy in two state doesn't depends on ref of potential Energy.

$\Rightarrow$

$$\left\{ \begin{array}{l} T.E = -K.E \\ T.E = \frac{P.E}{2} \end{array} \right\}$$

$\Rightarrow$ Total energy of e in the n^{th} orbit of H-like atom/ion:

λ max ↑ ~~Energy~~ Energy ↓

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$$E_n = \frac{-1}{4\pi\varepsilon_0} \frac{Ze^2}{q\left(\frac{n^2h^2\varepsilon_0}{Z\pi me^2}\right)}$$

$$E_n = -Rhc\frac{Z^2}{n^2}$$ $Rhc = 13.6\ eV$

$$\boxed{E_n = -13.6\frac{Z^2}{n^2}\ eV}$$

Total energy of e^-, in n^{th} orbit of hydrogen atom is equal to Total energy of e^- in hydrogen like ion in Zn^{th} orbits.

Transition from n_1 to n_2 in hydrogen atom is equivalent to $Zn_1 \rightarrow Zn_2$ in Hydrogen like Ion

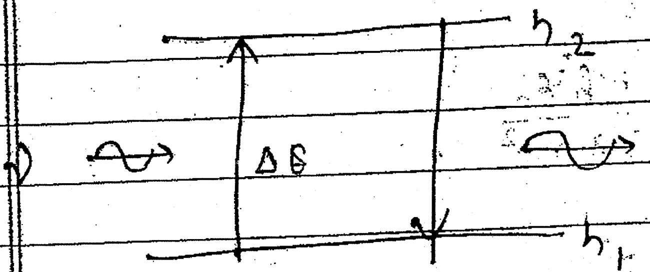
$n_1 \rightarrow n_2$ $Zn_1 \rightarrow Zn_2$

$$E_1 = -Rhc\frac{Z^2}{n_1^2} \qquad E_2 = -Rhc\frac{Z^2}{n_2^2}$$

$$\Delta E = Rhc\,Z^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

If λ is wave length to photon emitted or absorbed

$(n_2 \rightarrow n_1)$ $(n_1 \rightarrow n_2)$



$$R = \frac{1}{912\ \text{Å}}$$

$$\frac{hc}{\lambda} = Rhc\ Z^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\frac{1}{\lambda} = R \cdot Z^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

⇒ T.E = 0 ——— $n = \infty$

-0.85 ——— $n = 4$

-1.51 ——— $n = 3$

-3.4 ——— $n = 2$

-13.6 ——— $n = 1$

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$\cancel{E_n \quad \frac{E_{n-1}+E_{n+1}}{2}}$

$$E_n > \frac{E_{n-1}+E_{n+1}}{2}$$

23/10/15 $\quad E_n - E_{n-1} > E_{n+1} - E_n$

Q.1 Find the longest wavelength of Lyman series and shortest of Balmers series in A°

Ans
$$\frac{1}{\lambda} = R\left(1-\frac{1}{4}\right)$$

$$= \frac{1}{\lambda} = \frac{3R}{4} \qquad \lambda = \frac{4}{3R}$$

$$= \frac{4}{3} \times 912 = 1216\ A^\circ$$

$$\frac{1}{\lambda} = R\left(1-\frac{1}{2}\right) \qquad \lambda_2 = \frac{4}{R}$$

$$= 4 \times 912 \Rightarrow 3648\ A^\circ$$

Q.2 Hydrogen atom in ~~good~~ ground ~~sot~~ state is excited by light of photon of energy 10.7 eV, what will be observed in transmitted energy

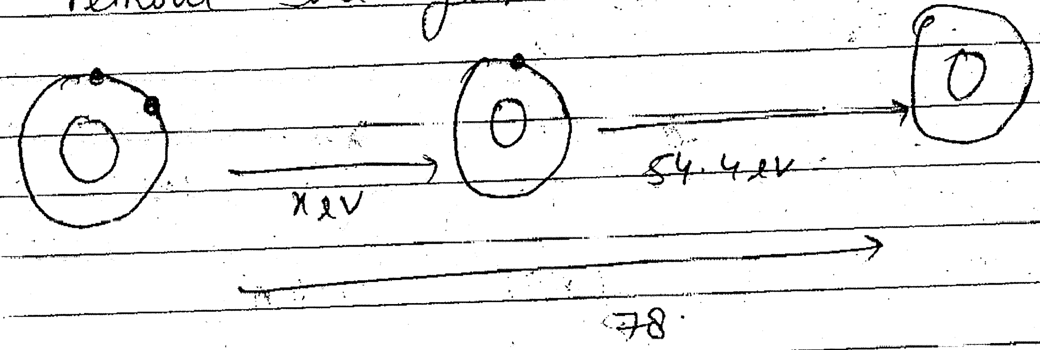
Ans Radiation of ~~the~~ same energy with same intensity.

If the energy of incident was 15 eV, what ~~was~~ would have been observed.

→ Then, some photon will be observed by hydrogen and it will emit electron with energy 1.4 eV, so in the transmitted light intensity of photon should be less.

→ Energy required to remove the both the electron from helium atom 78 eV, then how much energy will be required to remove the first electron

→

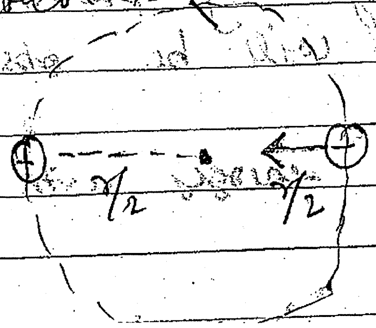


$x = 78 - 54.4$

$x = 23.6$ eV

Q.2 If mass of proton ~~is~~ is same as mass of electron, then what will be the total energy of system in first state?

Ans



$$\frac{mv^2}{r/2} = \frac{1}{4\pi\epsilon_0}\frac{e^2}{r^2} \quad (1)$$

$$2mv\frac{r}{2} = \frac{nh}{2\pi} \rightarrow (2)$$

$$\frac{2mv^2}{r} = \frac{1}{4\pi\epsilon_0}\frac{e^2}{r^2} \rightarrow (1) \qquad 2mv\frac{r}{2} = \frac{nh}{2\pi} \rightarrow (2)$$

$$\cancel{mvr = \frac{nh}{2\pi}} \qquad \cancel{m = \frac{nh}{2\pi v r}}$$

$$\cancel{\frac{2\pi nh\, v^2}{2\pi v r\, r} = \frac{1}{4\pi\epsilon_0}\frac{e^2}{r^2}}$$

$$\frac{m_e m_p}{m_e + m_p}$$

$$= \cancel{\frac{nh}{r^2} = \frac{1}{4\pi\epsilon_0}\frac{e^2}{r^2}}$$

$$\left(\frac{m_e}{\frac{m_e}{m_p}+1}\right)$$

$$= \cancel{\frac{Knhr^2}{e^2} = r^2}$$

⇒ If mass of nucleus is not too large in comparision to mass of electron, then we can find energy and radius by using reduced mass in place of mass of electron.

Atomic collosion

→ Consider hydrogen atom as first exited state.

⇒ It ~~deexi~~ ~~ex~~ dexcited to ground state

Q. Find speed of recoil of ~~remaining~~ remaining ion (or proton)

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Ex → find recoil speed of atom

Ans

M

m

$\xleftarrow{v}$ m $\frac{h\nu}{c}$ $\nu = \frac{c}{\lambda}$

$\vec{P}_{nucleus} + \vec{p}_{photon} = 0$ $1\,amu = 1.6 \times 10^{-27}$

$mV = \frac{h\nu}{c} = \frac{E}{c}$

$1.6 \times 10^{-27} \cdot V = \frac{10.2 \times 1.6 \times 10^{-19}}{3 \times 10^{8}}$

$V = \frac{10.2 \times \cancel{1.6} \times 10^{-27}}{3 \times \cancel{1.6} \times 10^{-27}}$

$V = \frac{10.2 \times 10^{0}}{3}$

$V = 3.4$ m/s

$\frac{1}{2}mv^2$

$K.E \text{ of atom} = \frac{\frac{1}{2} \times 1.6 \times 10^{-27} \times (3.4)^2}{1.6 \times 10^{-19}}$ eV

$\frac{1}{2} \times 10^{-8} (3.4)^2$

$\Delta E = 5.78 \times 10^{-8}$ eV

3.4
3.4
17
238
34+
5.78

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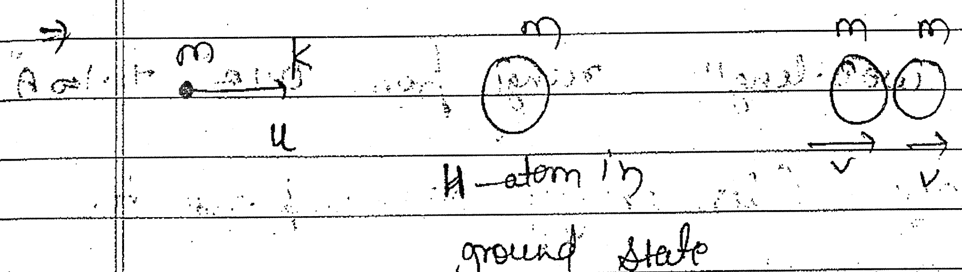
Q.1 A ~~neu~~ neutron moving with K.E, K hits the hydrogen atom in ground state at rest, find the minimum K.E of neutron so that, hydrogen atom may excite.



By conservation of momentum

$mu + 0 = 2mv$

$v = \frac{u}{2}$

maximum possible loss in K.E $= \frac{1}{2}mu^2 - \frac{1}{2}mv^2 \times 2$

$= \frac{1}{4}mu^2 = \frac{K}{2}$

$= \boxed{\frac{1}{2}\frac{m_1 m_2}{m_1+m_2} v_{rel}^2}$

If max possible loss is

P.E. $\left(\frac{K}{2}\right) < 10.2$ eV

then collision must be elastic

if $\frac{K}{2} \geq 10.2 \Rightarrow$ then atom may excite and inelastic collision