Quantization

Quantization of angular momentum: $L = mvr = n\frac{h}{2\pi}$ $\quad$ $\boldsymbol{L \propto n}$

- Electron in outer orbit have larger angular momentum

- **Velocity of electron in n^{th} orbit:** $v_n = \frac{Ze^2}{2\varepsilon_o nh} = \frac{c}{137}\frac{Z}{n}$ $\quad$ $[C = 3\times10^8\ m/s]$
- **Radius of n^{th} orbit:** $r_n = \frac{\varepsilon_o n^2 h^2}{\pi m Z e^2} = 0.53\ (A^o)\frac{n^2}{Z}$ $\quad$ $[1A^o = 10^{-10} m]$
- **Energy of electron in n^{th} orbit:** $E_n = -\frac{Z^2\, m\, e^4}{8\,\varepsilon_o^2\, n^2\, h^2} = -13.6\ (\text{eV})\frac{Z^2}{n^2}$

$1eV = 1.6\times10^{-19} J$ | $1eV = 1V$

Potential energy, **PE** $= -\frac{Z^2\, m\, e^4}{4\,\varepsilon_o^2\, n^2\, h^2}$

Kinetic Energy, **KE** $= \frac{Z^2\, m\, e^4}{8\,\varepsilon_o^2\, n^2\, h^2}$

Total energy, **E** $= -\frac{Z^2\, m\, e^4}{8\,\varepsilon_o^2\, n^2\, h^2}$

$PE = -2\ KE$
$E = -KE$
$PE = 2\ KE$

$hc = 2\times10^{-25}$

Energy of Photon (radiation)

$E = hf = \frac{hc}{\lambda}$

- $E = E_2 - E_1$
- $f = \frac{E_2 - E_1}{h}$
- $\lambda = \frac{hc}{E_2 - E_1}$

E_2 = Higher energy
E_1 = Lower energy

$\frac{1}{\lambda} = \frac{me^4}{8\varepsilon_0^2\, c\, h^3}\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$n_1 = lower\ orbit$
$n_2 = higher\ orbit$

Here, $\frac{me^4}{8\varepsilon_0^2\, c\, h^3} = R$

$= 1.097\times10^7\ m^{-1}$

$\therefore \frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

Excitation energy,
$E = E_{excited} - E_{ground}$

Ionization energy,
$E = E_\infty - E_1$
$= -E_1$

Note:
If, Energy = 3 eV
Then,
Potential = 3 V

De Broglie wavelength (Wavelength of matter wave)

$\lambda = \frac{h}{p} = \frac{h}{mv}$

$E_k = kinetic\ energy\ or\ Energy\ (J)$

- $\lambda = \frac{h}{\sqrt{2mE_k}}$ $\quad [1\ eV = 1.6\times10^{-19} J]$

$V = accelerating\ potential$ (Volt- V)

- $\lambda = \frac{h}{\sqrt{2mqV}}$

Heisenberg Uncertainty principle:

$\Delta x \times \Delta p \geq \frac{h}{2\pi}$

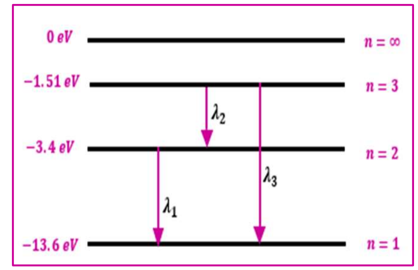
or

$\Delta x \times m\,\Delta v \geq \frac{h}{2\pi}$

Δx =error in position
Δp =error in momentum
Δv =error in velocity

1. a. State postulates of Bohrs atomic model. 2
 b. Obtain an expression for the energy of n[th] orbit of hydrogen atom. 3
 c. An electron is in 4[th] excited state. How many emission lines are possible? 2
 [Number of emission lines= $\frac{\Delta N\ (\Delta N+1)}{2}$ $\quad$ $[\Delta N = n_2 - n_1]$

 d. Calculate the energy in electron volt (eV) of a quantum of X-radiation of wavelength 0.15 nm. [$\boldsymbol{Ans}$: **8125 eV**] 2
 e. Find the wavelength of radiation emitted from hydrogen atom when an electron jumps from second excited orbit to second orbit. [$\epsilon_o = 8.854\times10^{-12}\ C^2N^{-1}m^{-2}$, $m_e = 9.1\times10^{-3}\ Kg$]. [**Ans=6590$A^o$**] 3
 f. A hydrogen atom is in ground state. What is the quantum number to which it will be excited absorbing a photon of energy 12.75 eV? 2
 g. What is the significance of negative energy of an electron in an atom? 2
 h. An electron in an atom has total energy of -3 eV. Find it's KE and PE. 2
2. a. Calculate the wavelength of EM radiation emitted by hydrogen atom which undergoes a transition between energy levels -1.36×10^{-19} J and -5.45×10^{-19} J.
 [Given plank constant, $h = 6.62\times10^{-34}$ Js] [4841A°] 2
 b. How is Balmer series is originated in H-atom? Find the ratio of maximum to minimum wavelength in Balmer series. 2
 c. The first member of Balmer series of hydrogen atom has a wavelength of 6563 A°. calculate the wavelength of its second member. 2
 d. Define excitation and ionization potential. Find the second excitation potential and ionization potential of H-atom 2
3. From the information given in the given figure,



 a. Identify the atom.
 b. Find Second excitation potential and second excitation energy of the atom.
 c. Ionization energy (in J) and ionization potential of the atom.
 d. The minimum and maximum energy of electron in the given atom.
 e. Find the wavelength of these lines in emission spectrum (as assigned in the figure).
4. a. A stone is dropped from the top of a building. How does its de-Broglie wavelength change?
 b. Calculate the de Broglie wavelength of electron having kinetic energy of 400 eV.
 [mass of electron= $9.1\times10^{-31}\ kg$.] 2
 c. Calculate the de Broglie wavelength of the proton having kinetic energy of 3600 V.
 [$m = 1.67\times10^{-27}\ Kg, h = 6.6\times10^{-3}\ JS$]. 2
 d. An $\alpha - particle$ of mass $6.64\times10^{-27} Kg$ is emitted in radioactive decay with an energy of 4.2 MeV. What is its de-Broglie wavelength? [Ans: $7\times10^{-15} m$] 2
 e. What is matter wave? An electron and proton are accelerated by same potential, which particle have longer de-Broglie wavelength? 2
 f. How is Paschen series originated in Hydrogen atom? 2

5. a. State Heisenberg uncertainty principle. 1
 b. Show that electron cannot exist inside a nucleus. 2
 c. If an electron position can be measured to an accuracy of 10[-9] m. How accurately can its velocity be measured? ($m = 9.1\times10^{-31}\ Kg$). 2
 d. An electron is confined within a region of width $1.0\times10^{-10}\ m$. (a). Estimate the minimum uncertainty in x-component of electron's momentum. (b) If the electron has momentum with magnitude equal to the uncertainty found in part (a) what is its K.E.? Mass of electron = $9.1\times10^{-31} kg$. [Ans:$1.05\times10^{-25}\ kg\ m/sec, 3.818\ eV$] 2
 e. Determine the ratio of the energy of a photon of X-radiation of wavelength 0.1 nm to that of a photon of visible radiation of wavelength 500 nm. [Ans: 5000: 1] 2