ARJUNA NEET BATCH

Structure of Atom

LECTURE - 8

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⇒ Line spectrum of hydrogen

$$\boxed{\bar{\nu} = \frac{1}{\lambda} = R_H Z^2 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)}$$

$\nu = \frac{c}{\lambda}$ $\frac{1}{\lambda}$

⇒ Limiting line $n_2 = \infty$

$\lambda \Rightarrow ?$

$\frac{1}{R} = 912\ A^\circ$

$\frac{1}{R} = 91.2\ nm$

Total no. of spectral line

$\Rightarrow \frac{(n_2 - n_1)(n_2 - n_1 + 1)}{2}$

OR

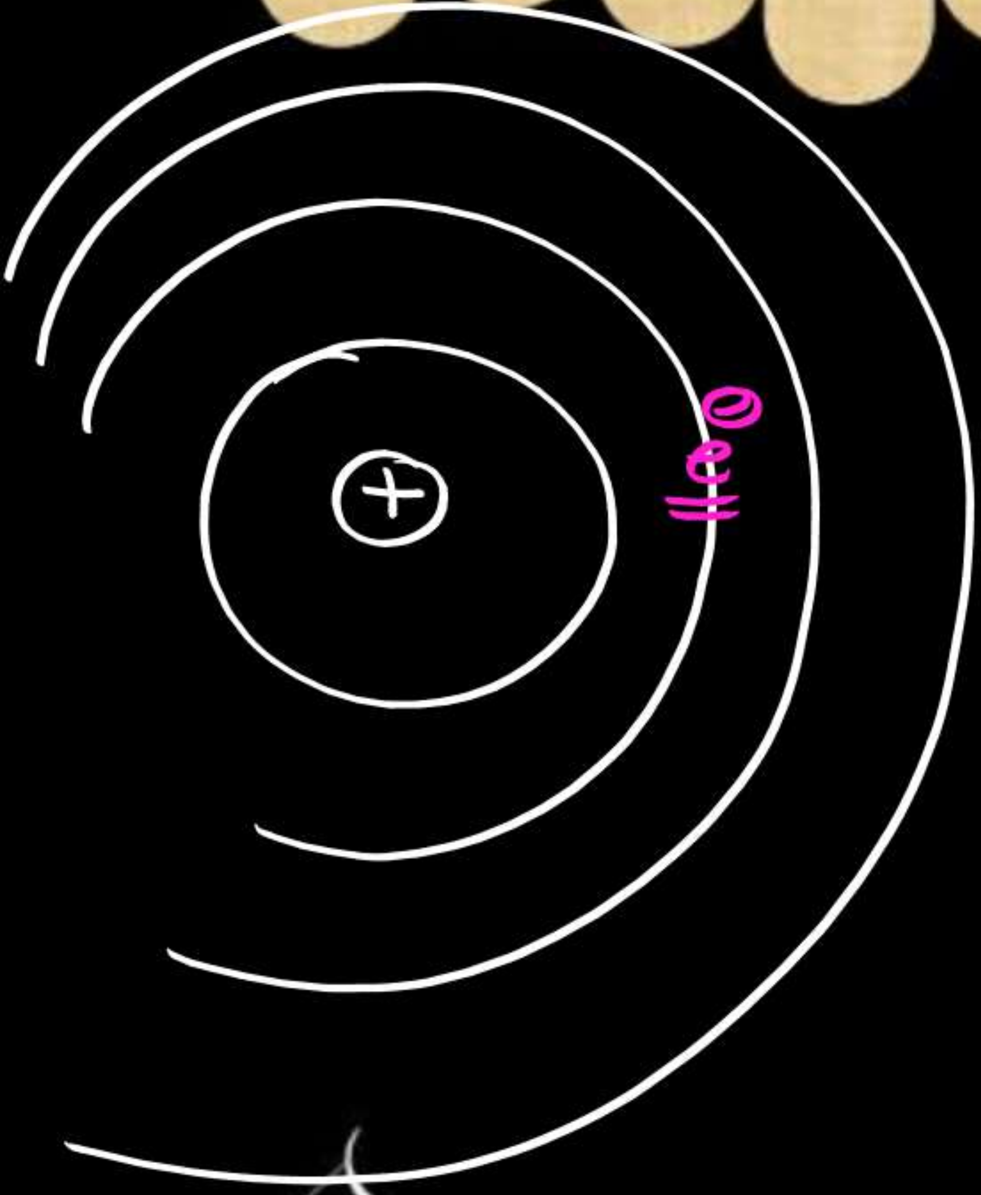
$\sum (n_2 - n_1)$

No. of lines in particular series $= n_2 - n_1$

Objective of today's class

Bohr's Atomic Model

Bohr's Atomic Model



→ Centre of an atom is occupied by heavy mass, +tively charged nucleus around Which $e^{\ominus}$ are continously revolving in fixed circular path Known as ORBITS or SHELLS SERIES / LEVELS / STATIONARY STATE.

→ As long as an $e^{\ominus}$ revolves in a shell, its energy remains same. (STATIONARY STATE).

** → As we move away from nucleus, Energy Continously $\uparrow$ but Energy difference $\downarrow$

→ Energy of an $e^{\ominus}$ in an atom is -ive because when $e^{\ominus}$ is at ∞ distance, its energy is taken as Zero.

→ Acc. to Bohr Model e^- revolve in a given shell so that its energy remains same or its possesses energy.

$$\boxed{E_2 - E_1 > E_3 - E_2 > E_4 - E_3}$$ Energy gap ↓

→ Only those orbits are permitted $\boxed{n \neq \text{fraction}}$ in which Angular momentum is simple whole no. of $\frac{h}{2\pi}$ or $\hbar$

Quantisation of Angular Momentum

$$\boxed{mvr = \frac{nh}{2\pi}}$$ → orbit angular momentum.

Orbit Angular Momentum $\boxed{mvr = \frac{nh}{2\pi}}$

Eg. if $n = 2$. Calculat Orbit Angular Momentum.

$m \rightarrow$ mass

$v \rightarrow$ velocity

$r \rightarrow$ radius

$n \rightarrow$ orbit no.

$\pi = 3.14$

$h \rightarrow$ plack's const $\rightarrow 6.626 \times 10^{-34}$ Js.

$$O.A.M = \frac{nh}{2\pi} = \frac{\cancel{2}h}{\cancel{2}\pi} \rightarrow \frac{h}{\pi}$$

$$\hbar = \frac{h}{2\pi}$$

Relation of Radius, Velocity, Orbit Frequency, Time period, Total Energy, K.E. P.E.

RADIUS

Centripetal Force = Electrostatic force.

$$\frac{\boxed{mv^2}}{\cancel{r}} = \frac{KZe^2}{r^{\cancel{2}}} \quad \text{——} \ (1)$$

$$\Rightarrow \quad v^2 = \frac{Ze^2}{rm} \quad \text{——} \ (2) \quad \text{if } K = 1$$

$\Rightarrow$ Acc. to Orbit Angular Momentum

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

Squaring both side

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

$$v^2 = \frac{n^2h^2}{4\pi^2m^2r^2} \quad \text{--- (3)}$$

Equating (2) = (3)

$$\frac{Ze^2}{\cancel{r}\,\cancel{m}} = \frac{n^2h^2}{4\pi^2 m^{\cancel{2}} r^{\cancel{2}}}$$

$$\boxed{r = \frac{n^2h^2}{4\pi^2 m Z e^2}} \quad \text{--- (4)}$$

$r \rightarrow$ radius

$n \rightarrow$ orbit

$Z \rightarrow$ Atomic no.

$h \rightarrow$ planck constant

$\Rightarrow 6.626 \times 10^{-34}$ JS

$\pi \Rightarrow 3.14$

$m \rightarrow$ mass of $e^{\ominus}$

$\Rightarrow 9.1 \times 10^{-31}$ kg

$e \rightarrow$ charge of $e^{\ominus}$

$\Rightarrow -1.6 \times 10^{-19}$ C

ARJUN

$$\boxed{r = r_0 \frac{n^2}{Z}} \quad -(5)$$

$r_0 \Rightarrow 0.529\ \text{Å}$

$r_0 \Rightarrow 52.9\ \text{pm}$

$r_0 \Rightarrow 0.0529\ \text{nm}$

Eg. Calculate the Radius of H-atom in its 1^{st} orbit ?

$r = r_0 \frac{n^2}{Z} \Rightarrow 0.529 \times \frac{(1)^2}{1}$

$\Rightarrow 0.529\ \text{Å}$

VELOCITY

Acc. Orbit Angular Momentum

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

$$\Rightarrow V = \frac{nh}{2\pi m r} \quad -(6)$$

from (4) in (6)

$$V = \frac{\cancel{n}\cancel{h}}{\cancel{2}\cancel{\pi}\cancel{m}\left(\frac{n^2 h^2}{4\pi^2 m Z e^2}\right)}$$

$$\boxed{V = \frac{Z}{n} \times 2.188 \times 10^8\ \text{cm/s}}$$

$$\boxed{V \propto \frac{Z}{n}}$$

Orbit frequency (ν) → No. of Revolutions per s

$$\Rightarrow \nu = \frac{1}{T}$$

$\because$ speed $= \dfrac{\text{distance}}{\text{Time}}$ $\Rightarrow$ Time $(t) = \dfrac{\text{Distance}}{\text{speed } (v)}$

$$\Rightarrow \nu = \frac{\text{Velocity}}{\text{Distance}} \Rightarrow \frac{v}{2\pi r}$$

⇒ from above relations of radius & velocity the value of frequency becomes.

$$\boxed{\nu = \frac{Z^2}{n^3} \times 0.657 \times 10^{12}\ s^{-1}}$$

$$\boxed{\nu \propto \frac{Z^2}{n^3}} \quad — (7)$$

Time period

$$\boxed{T \propto \frac{n^3}{Z^2}} \quad — (8)$$

Total Energy = Kinetic Energy + Potential Energy

T.E. = K.E. + P.E.

$$T.E. = \frac{1}{2}mv^2 + (-)\frac{Ze^2}{r}$$

from Eqn (1)

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

$\because$ K.E $= \frac{1}{2}mv^2$

$\because$ P.E $= -\frac{Ze^2}{r}$

$$T.E. \Rightarrow \frac{1}{2}\frac{Ze^2}{r} - \frac{Ze^2}{r}$$

$$\boxed{T.E. = -\frac{1}{2}\frac{Ze^2}{r}} \quad -(9)$$

$$T.E. = \frac{1}{2}\left(-\frac{Ze^2}{r}\right)$$

$$T.E. = \frac{1}{2}(P.E.)$$

$$\boxed{P.E. = 2 \times T.E.}$$

$$T.E. = -\frac{1}{2}\frac{Ze^2}{r}$$

$$\boxed{T.E. = -K.E.}$$

$$T.E. \Rightarrow -\frac{1}{2}\frac{Ze^2}{r}$$

from Eq^n (4)

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

$$T.E. = E_0 \frac{Z^2}{n^2}$$

$E_0 = -13.6$ ev/atom

$E_0 = -1312$ KJ/mole

$E_0 = -2.178 \times 10^{-18}$ Joule

$E_0 = -2.178 \times 10^{-11}$ erg

* $E = -13.6 \frac{Z^2}{n^2}$ eV/atom

or

* $E = -1312 \frac{Z^2}{n^2}$ KJ/mole

* $E = -2.178 \times 10^{-18} \frac{Z^2}{n^2}$ Joule

* $E = -2.178 \times 10^{-11} \frac{Z^2}{n^2}$ erg

* $E = -313.6 \frac{Z^2}{n^2}$ K Calorie/mol.

Eg. Calculate the Energy (eV/atom) of H-atom when the $e^{\ominus}$ is present in 1^{st} orbit?

$E = -13.6 \frac{Z^2}{n^2}$ $Z = 1$

$n = 1$

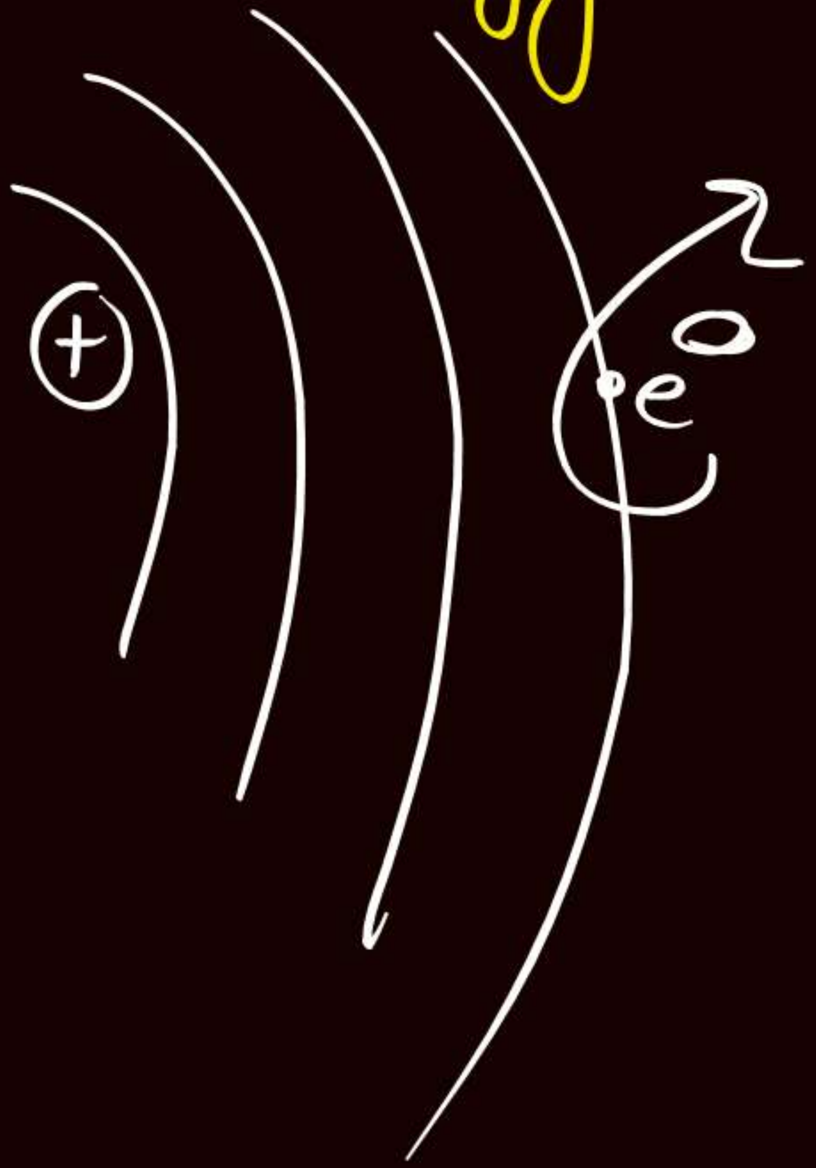
I.E.

$E = -13.6$ eV/atom

K.E = 13.6 eV/atom

P.E = −27.2 eV/atom

Ionisation Energy (I.E.) → Energy required to remove an $e^{\ominus}$ from the outermost shell of the isolated gaseous atom.



$$\boxed{T.E. = -I.E.}$$

V.Imp.

CONCLUSION

① $r \propto \frac{n^2}{Z}$

② $v \propto \frac{Z}{n}$

③ $\nu \propto \frac{Z^2}{n^3}$

④ $T \propto \frac{n^3}{Z^2}$

⑤ $T.E = -K.E.$

⑥ $2 \times T.E. = P.E$

⑦ $T.E = -I.E.$

⑧ $E = -13.6 \frac{Z^2}{n^2}$ eV/atom

or

$E = -1312 \times \frac{Z^2}{n^2}$ KJ/mole

or

$E = -2.18 \times 10^{-18} \frac{Z^2}{n^2}$ Joule

or

$E = -2.18 \times 10^{-11} \frac{Z^2}{n^2}$ erg

or

$E = -313.6 \times \frac{Z^2}{n^2}$ Kcal/mol

H- Atom (1st four Energy level

	1st orbit	2nd	3rd	4th
T.E. →	−13.6	−3.4	−1.5	−0.85
K.E. →	13.6	3.4	1.5	0.85
P.E. →	−27.2	−6.8	−3.0	−1.7

$$E = -13.6\frac{Z^2}{n^2} \rightarrow \frac{-13.6\times}{4} = -13.6$$

$\Delta E \Rightarrow$ Energy difference $\Rightarrow -13.6\, Z^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$E_2 - E_1 \Rightarrow -3.4 - (-13.6) \Rightarrow 10.2$

$E_3 - E_2 \Rightarrow -1.5 - (-3.4) \Rightarrow 1.9$

$E_4 - E_3 \Rightarrow -0.85 - (-1.5) \Rightarrow 0.65$

$n \uparrow$

$\Delta E \downarrow$

Drawback's of Bohr Model

→ This Model is applicable only on Single $e^{\ominus}$ atoms or ions, can't be applied on Multi-$e^{\ominus}$ system. because it does not take into Considerance ($e^{\ominus} - e^{\ominus}$ repulsion). ($H, He^{+}, Li^{+2}, Be^{+3}$)

→ In presence of External Electric field & Magnetic field, splitting of spectral lines take place.

Electric field → Stark Effect

Magnetic field → (Zeeman Effect)

→ It could not Explain nature of bond, or shape of molecule.


Are u ready for the Questions
GEOGRAPHY
ANIMALS
WORLD MAPS
ATLAS
7 CONTINENTS

Q. Find ratio of 1st, 2nd, 3rd orbit of radius of H-atom.

H-atom $\quad Z = 1$

$$r \propto \frac{n^2}{Z}$$

for same atom

$$r \propto n^2$$

$$r_{1^{st}} : r_{2^{nd}} : r_{3^{rd}}$$

$$(1)^2 : (2)^2 : (3)^2$$

$$\Rightarrow \boxed{1 : 4 : 9}$$

Q. Find ratio of radii of 1^{st} orbit of H, He^+, Li^{+2}.

$r \propto \frac{n^2}{Z}$ ∵ if orbit no is same

$r \propto \frac{1}{Z}$

$r_H : r_{He^+} : r_{Li^{+2}}$

$\left(\frac{1}{1} : \frac{1}{2} : \frac{1}{3}\right) 6$

$\boxed{6 : 3 : 2}$

Q. Find ratio of time period in 2^{nd} & 3^{rd} orbit of H-atom.

H- atom.

$Z = 1$ & if atom is same

$$T \propto \frac{n^3}{Z^2}$$

$$T \propto n^3$$

$$\frac{T_{2^{nd}}}{T_{3^{rd}}} = \frac{(2)^3}{(3)^3} \Rightarrow \frac{8}{27}$$

Q. Ratio of time period in 1st orbit of H & He^+.

orbit no = 1

$$T \propto \frac{n^3}{Z^2}$$

if orbit no. is same

$$T \propto \frac{1}{Z^2}$$

$$\frac{T_H}{T_{He^+}} = \frac{(Z^2_{He^+})}{(Z^2_H)}$$

$$= 4:1$$

Q. What is the K.E. & P.E. of 2nd orbit of H-atom.

$$T.E. = -13.6 \frac{Z^2}{n^2} \text{ eV/atom}$$

H-atom

$Z = 1$

$n = 2$

$$T.E. = -13.6 \times \frac{(1)^2}{(2)^2} \Rightarrow \frac{-13.6}{4} \Rightarrow \underline{-3.4 \text{ eV/atom}}$$

$$T.E. = -K.E. \qquad \boxed{K.E. = 3.4 \text{ eV/atom}}$$

$$\boxed{P.E. = -6.8 \text{ eV/atom}}$$

Q. Find the Energy of He^+ when $e^\ominus$ is Ont in 2^{nd} orbit?

He^+ $Z = 2$

$n = 2$.

$$E = -13.6 \times \frac{\cancel{Z^2}}{\cancel{n^2}}$$

$$\boxed{E = -13.6 \text{ eV/atom}}$$

K.E. = 13.6 eV/atom.

I.E = 13.6 eV/atom.

P.E. = −27.2 eV/atom.

thanks
for watching

ARJUNA