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FUNDAMENTAL PARTICLES

→ JJ-Thomson in 1887 discovered electrons through different discharge tube experiments but the name "electrons" was given by ~~Stoney~~ "Stoney" in 1887

→ Protons were discovered by Goldstein in 1886 but the name protons was given by Rutherford.

→ Neutrons were discovered by James Chadwick in 1932 through artificial radioactivity.

PROPERTIES OF CATHODE RAYS

(Main Headings only)

(i) EFFECT OF ELECTRIC AND MAGNETIC FIELD
(ii) STRAIGHT LINE MOTION
(iii) MATERIAL PARTICLES
(iv) x-RAYS PRODUCTION
(v) HEATING EFFECT
(vi) IONIZATION
(vii) CHEMICAL EFFECT
(viii) PENETRATION
(ix) FLUROSCENCE

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MEASUREMENT OF e/m RATIO

JJ Thomson subjected a beam of Cathode rays (Electron Particles) to see the effects of Electric and magnetic fields.

CASE I : ABSENCE OF ELECTRIC AND MAGNETIC FIELD

The Electrons from Cathode ray strouck the fluroscent screen at **B**, in the absence of any magnetic or electric field

CASE II : ONLY ELECTRIC FIELD APPLIED

Under the Effect of Electric Field, they strike at point **A**

CASE III : ONLY MAGNETIC FIELD APPLIED

Under the Effect of Magnetic field, they strike at point **C**.

CASE IV : BOTH ELECTRIC AND MAGNETIC FIELD

Electric & magnetic fields were adjusted in a way that the electrons again strike at point "**B**"

ENERGY

energy

DERIVATION

Total energy = Kinetic energy + Potential energy

E_{total} = K.E + P.E → eq(x)

POTENTIAL ENERGY

∴ The electric potential energy at distance "r" from "Q" is ∴ $U = \frac{Qq}{4\pi\varepsilon_0}\left[\frac{1}{r}\right]$ → from 2nd year Book

or ∴ $P.E = \frac{Kq^2}{r}$

→ where "k" is constant & equals "$\frac{1}{4\pi\varepsilon_0}$"

→ and "Q" & "q" are two opposite charges

→ and "r" is the distance between charges which is written $\left(\frac{1}{r}\right)$

So, $P.E = \frac{1}{4\pi\varepsilon_0 r}e^2 \Rightarrow P.E = \frac{Ze^2}{4\pi\varepsilon_0 r}$

→ "e" is charge & "Z" is atomic number

So, $P.E = -\frac{Ze^2}{4\pi\varepsilon_0 r}$ → eq (i)

→ the negative sign shows opposite charge pull of potential energy

→ The potential energy is due to position of 2 opposite charges

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→ Also because when we bring electron from infinity to orbit it stores Potential energy

⇒ KINETIC ENERGY

Kinetic energy $= \frac{1}{2}mv^2$ → eq (ii)

→ Due to mass (m) & velocity (v)
→ Due to the motion of the electron

⇒ DERIVATION

putting eq (i) & (ii) in eq (x)

$E_{Total} = K.E + P.E$ *(ADDING OF ENERGIES)

$$E_{total} = \frac{1}{2}mv^2 + \left[\frac{-Ze^2}{4\pi\varepsilon_0 r}\right]$$

$$E_{total} = \frac{1}{2}mv^2 - \frac{Ze^2}{4\pi\varepsilon_0 r}$$ (* By VALUE OF Mv^2)

As $mv^2 = \frac{Ze^2}{4\pi\varepsilon_0 r}$, which is in derivation of radius

$$E_{total} = \frac{1}{2}\left[\frac{Ze^2}{4\pi\varepsilon_0 r}\right] - \frac{Ze^2}{4\pi\varepsilon_0 r}$$

$$= \frac{Ze^2}{4\pi\varepsilon_0 r}\left(\frac{1}{2} - 1\right)$$ [taking common]

$$= \frac{Ze^2}{4\pi\varepsilon_0 r}\cdot\left(\frac{-1}{2}\right)$$ [Solving]

$$= \frac{-Ze^2}{8\pi\varepsilon_0 r} = \frac{-Ze^2}{8\pi\varepsilon_0}\cdot\frac{1}{r}$$

[Separating r]

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(* Now, BY VALUE OF "r")

$$\because r = \frac{\varepsilon_0 n^2 h^2}{\pi m Z e^2}$$

or $$\frac{1}{r} = \frac{\pi m Z e^2}{\varepsilon_0 n^2 h^2}$$

As we know

$$\boxed{\frac{a}{\frac{b}{c}} = \frac{a \times c}{b}}$$

$$E_T = \frac{-Ze^2}{8\pi\varepsilon_0} \cdot \frac{1}{\left(\frac{\varepsilon_0 n^2 h^2}{Z m \pi e^2}\right)}$$ [putting value of r]

$$= \frac{-Ze^2 \times Z\,m\,\cancel{\pi} e^2}{8\cancel{\pi}\varepsilon_0 \times \varepsilon_0 n^2 h^2} = \frac{-Z^2 e^4 m}{8\varepsilon_0^2 n^2 h^2}$$

[cancelling π & multiplying]

$$E_T = \frac{-Z^2 e^4 m}{8\varepsilon_0^2 n^2 h^2}$$

FOR HYDROGEN

$$E_T = \frac{-(1)^2 e^4 m}{8\varepsilon_0^2 n^2 h^2}$$, [Since atomic no of H is 1]

$$E_T = \frac{-me^4}{8\varepsilon_0^2 n^2 h^2}$$ (* No putting at no of H)

FOR ANY ORBIT OF HYDROGEN (n)

$$E_n = \frac{-me^4}{8\varepsilon_0^2 h^2} \left[\frac{1}{n^2}\right]$$ [Separating n]

→ "n" shows the number of orbit thus $[E_T = E_n]$

As $$\frac{me^4}{8\varepsilon_0^2 h^2} = 2.18 \times 10^{-18} J$$

(* Now separating "n" & putting value of constants)

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We can calculate this value if don't want to memorize by:-

putting
$m = 9.11 \times 10^{-31}$ kg
$e = 1.6 \times 10^{-19}$ C
$\varepsilon_0 = 8.85 \times 10^{-12}\ N^{-1}m^{-2}C^{2}$
$h^2 = 6.64 \times 10^{-34}$ J.S

or, (better to memorize), So;

$\frac{me^4}{8\varepsilon_0^2 h^2} = -2.18 \times 10^{-18}$ J

$E_n = -2.18 \times 10^{-18} \times \left(\frac{1}{n^2}\right)$ J [putting value of constants]

$E_n = \frac{-K}{n^2}$, As $K = 2.18 \times 10^{-18}$

[* replacing the constant value with K]

→ negative sign shows decrease in Energy

⇨ TO CONVERT IN KJ/MOLE

$\times \frac{NA}{1000}$ [Multiply by NA or 6.023×10^{23} & divide by 1000]

or, $E_n = \frac{-K}{n^2} \times \frac{NA}{1000}$

$E_n = \frac{-2.18 \times 10^{-18}}{n^2} \times \frac{6.02 \times 10^{23}}{1000}$

$E_n = \frac{-1313.35}{n^2}\ \frac{KJ}{mole}$

** The final formula to find energy of Hydrogen orbits in KJ/mole **

$$\boxed{E_n = \frac{-1313.35}{n^2}\ KJ/mole}$$

➡ We can put 1, 2, 3 (orbit no) to find energies

➡ first energy level is called "ground state", rest are called "Excited States"

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→ ENERGY DIFFERENCES OF ORBITS

As $E = \frac{-mZ^2e^4}{8\varepsilon_0 n^2 h^2}$

Also $E_\Delta = E_2 - E_1$

So, replacing n with n_1 & n_2 which are the lower & Higher energy orbits

So, $\left[\frac{-mz^2e^4}{8\varepsilon_0^2 n_2^2 h^2}\right] - \left[\frac{-mz^2e^4}{8\varepsilon_0^2 n_1^2 h^2}\right]$

$\left[\frac{-mz^2e^4}{8\varepsilon_0^2 n_2^2 h^2}\right] + \left[\frac{mz^2e^4}{8\varepsilon_0^2 n_1^2 h^2}\right]$

Now, $\frac{mz^2e^4}{8\varepsilon_0^2 h^2}\left[-\frac{1}{n^2} + \frac{1}{n_1}\right]$

Replacing "z" with "1" for "H" $\frac{mz^2e^4}{8\varepsilon_0^2 h^2}\left[\frac{1}{n_1} - \frac{1}{n_2}\right]$

As the value of constants are 2.18×10^{-18} J

thus,

$\Delta E = 2.18 \times 10^{-18}\left[\frac{1}{n_1} - \frac{1}{n_2}\right]$

→ thus, Energy Difference can be found by:-

$$\boxed{\Delta E = 2.18 \times 10^{-18}\left[\frac{1}{n_1} - \frac{1}{n_2}\right]}$$

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FREQUENCY

frequency

** DERIVATION **

PLANK'S QUNTAM THEORY

According to plank, Energy is emitted or absorbed in form of packets called "quantam."

Also, $\Delta E \propto \nu$

$\Delta E = h\nu$, where h is plant's constant

DERIVATION

- As $\Delta E = 2.18 \times 10^{-18} J \left[\frac{1}{n_1} - \frac{1}{n_2}\right]$

So,

$$2.18 \times 10^{-18} J \left[\frac{1}{n_1} - \frac{1}{n_2}\right] = h\nu$$ → putting value of ΔE

→ writing in its constant form

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

→ Rearranging:-

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

→ Dividing 'h' in other side

$$\boxed{\nu = \frac{me^4}{8\varepsilon_0^2 h^3}\left[\frac{1}{n_1} - \frac{1}{n_2}\right]}$$ hz or cycles per second

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WAVE NUMBER

DERIVATION

→ RELATION BTW FREQUENCY & WAVE NUMBER

As we know $v = f\lambda$
where 'f' is frequency
'λ' is wavelength
v is speed or velocity

Now, $c = \nu\lambda$

replacing 'v' with speed of light "c"
replacing 'f' with "ν" which is 'new'

Now $c = \nu\lambda$

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

$\nu = c \times \frac{1}{\lambda}$, As we know $\left[\frac{1}{\lambda} = \bar{\nu}\right]$

because wave numbe($\bar{\nu}$) & wavelength (λ) are inversely proportional

so, $\boxed{\nu = c\bar{\nu}}$

→ DERIVATION OF WAVE NUMBER

As, value of "ν" is $\frac{Z\, me^4}{8\varepsilon_0^2 h^3}\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$ so,

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→ putting values,

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

→ Dividing 'c' on other side

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

→ Replacing constants with R,

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

$$\boxed{\bar{\nu} = 1.09678 \times 10^7 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]}$$

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ORBITS AND ORBITALS

PKMZ "GHAR" & "ROOM" CONCEPT

→ ORBITS

We can consider them as houses
Consider there are 4 houses that are K, L, M, N.
These houses are called Shells, Energy-levels or orbits
Symbol :- "n"

→ ORBITALS

Consider the orbitals are rooms in those houses.
These rooms are named as s, p, d & f.
There is a specific number of rooms in each house or Specific number of sub-shells in each shell. Symbol :- "l"

These rooms can be called orbitals, sub-shells or Sub-energy energy-levels

Electrons are living in these sub-shells or rooms in specific amount

Shell K contains s subshell
Shell L constains s & p subshell
Shell M contains s, p & d subshell
Shell N contains s, p, d & f subshells

→ QUANTAM NUMBER (P.Q.N)

It tells or represents number of shells that is K, L, M & N

FORMULA :- $2n^2$ (Here n is shell number & result is number of Electrons)

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- **EXAMPLE:-** To find Electrons in L Shell which is 2nd, thus $n = 2$

As $2n^2$

$2(2)^2$

$2(4) = 8$

- thus Shell "L" or "2nd" Shell can accomodate 8 electrons
- Natural numbers 1,2,3,4

→ AZIMUTHAL QUANTAM (A.Q.N)

It shows or represents subshells or "rooms".

- **FORMULA:-** $2(2l+1)$ [where l is sub-shell number & result shows number of electrons in subshell
- **VIP NOTE:-** The subshell or room is always one less than shell or room number.
- **EXAMPLE:-** As subshell "s" is present in 1st shell "K" so $n=1$ as we know sub-shell is one less than shell so, the sub-shell will be 0 putting zero in formula

$2(2l+1)$

$2(2(0)+1)$

$2(0+1)$

2, here sub-shell s contains 2 electrons

→ Whole numbers 0,1,2,3

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- Ghar → (shells, orbits, Energy levels)
- Room → (subshells, orbitals, Sub-energy levels)
- People → (Electrons)

→ Shell / orbit PQN (n)	K < 1	L < 2	M < 3	N 4	$2n^2$
→ Sub shell / orbitals A.Q.N (l)	S	s, p	s, p, d	s, p, d, f	2(2l+1)

$l = n - 1$		$2(2l+1)$
$l = 0$	s	$2(2(0)+1) = 2(1) = 2e^-$
$l = 1$	p	$2(2(1)+1) = 2(2+1) = 6e^-$
$l = 2$	d	$2(2(2)+1) = 2(4+1) = 10e^-$
$l = 3$	f	$2(2(3)+1) = 2(6+1) = 14e^-$

→ **BOHR'S IDEA**

He proposed that electrons revolve in orbits in 2D or in plane & didn't give suitable theory

→ **SCHRODINGER**

He presented 3D model & Idea of orbitals

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n	PQN	$(2n^2)$	
1	K	$2(1)^2 = 2e^-$	
2	L	$2(2)^2 = 8e^-$	
3	M	$2(3)^2 = 18e^-$	
4	N	$2(4)^2 = 32e^-$	

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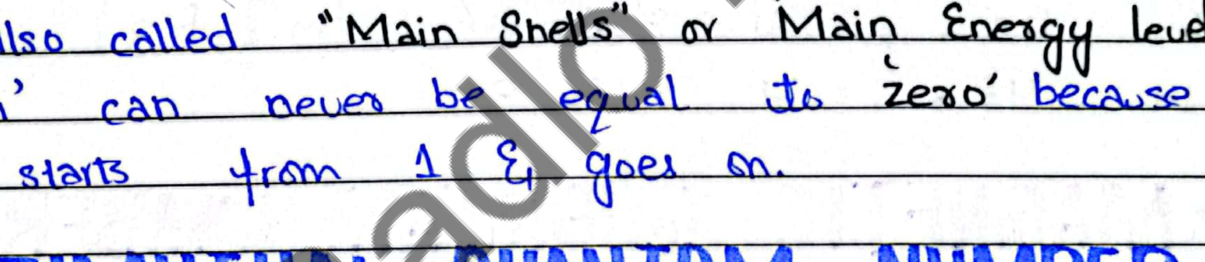
QUANTAM NO.

→ PRINCIPAL QUANTAM NUMBER

- It is denoted by 'n'
- It describes the energy levels or shells around the nucleus. formula for electrons = $2n^2$
  - → When n = 1, It is K shell
  - → When n = 2, It is L shell
  - → When n = 3, It is M shell
  - → When n = 4, It is N shell
- Also called "Main Shells" or "Main Energy levels"
- 'n' can never be equal to 'zero' because it starts from 1 & goes on.

→ AZIMUTHAL QUANTAM NUMBER

- It is also called "Angular Quantam Number"
- It is denoted by "l"
- It describes shape of "Sub-energy levels" or
- Sub-shells within main shells
- 4 Subshells are :-



- We start counting them from 0 to 3.

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→ RELATION BTW n and l

$l \geq n-1$ or $l = n-1$

- When $n=1$ (K shell) → 1s $l=0$
- When $n=2$ (L shell) → 2s 2p $l=0,1$
- When $n=3$ (M shell) → 3s 3p 3d $l=0,1,2$
- When $n=4$ (N shell) → 4s 4p 4d 4f $l=0,1,2,3$

→ EXAMPLES

In 2p, $n=2$ & $l=1$
In 3d, $n=3$ & $l=2$
In 4s, $n=4$ & $l=0$
In 4f, $n=4$ & $l=3$

$$\begin{bmatrix} s & 0 \\ p & 1 \\ d & 2 \\ f & 3 \end{bmatrix}$$

→ MAGNETIC QUANTANI NUMBER

- It is denoted by "m_l"
- It describes orbitals within Subshells
- ORBITALS :- The 3-dimensional region around the Nucleus where probability of finding an electron is maximum.

→ $-l \leq m \leq +l$ or $m = +l \rightarrow 0 \rightarrow +l$

When $l=0$ (s) → -0 to $+0$ $m_l = 0$
When $l=1$ (p) → -1 to $+1$ $m_l = -1, 0, +1$
When $l=2$ (d) → -2 to $+2$ $m_l = -2, -1, 0, +1, +2$
When $l=3$ (f) → -3 to $+3$ $m_l = -3, -2, -1, 0, +1, +2, +3$

→ So, s = 1 orbital, p = 3 orbitals, d = 5 orbitals & f = 7 orbitals

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Every orbital can hold only '2' electrons

- S → 1 orbital (2 electrons)
- p → 3 orbital (6 electrons)
- d → 5 orbital (10 electrons)
- f → 7 orbitals (14 electrons)

It also explains effect of an orbital in the magnetic field.

- s → spherical & not deflected
- p → deflected in 3 directions
- d → deflected in 5 directions
- f → deflected in 7 directions

Magnetic quantam number determines orientation of orbital.

→ ELECTRON SPIN QUANTAM NUMBER

- It is denoted by "ms"
- This number describes the motion of an electron within orbit
  - Possible value $ms = \pm \frac{1}{2}$
- Electron moves ↑ $+\frac{1}{2}$ Anti-Clockwise motion
- electron moves ↓ $-\frac{1}{2}$ Clockwise motion

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TO FIND QUANTAM NUMBERS

→ $2p^5$

- $n = 2$
- $l = 1$
- $m_l = 0$
- $m_s = \frac{-1}{2}$

$\overset{\uparrow\downarrow}{-1}$, $\overset{\uparrow\downarrow}{0}$, $\overset{\uparrow}{+1}$

(Since last electron is in 0)

(Since direction of last electron is down)

→ $3d^7$

- $n = 3$
- $l = 2$
- $m_l = -1$
- $m_s = +\frac{1}{2}$

$\overset{\downarrow\uparrow}{-2}$, $\overset{\downarrow\uparrow}{-1}$, $\overset{\downarrow}{0}$, $\overset{\downarrow}{+1}$, $\overset{\downarrow}{+2}$

(last electron is in -1 electron)

(position or dir of last electron is in upward dir)

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AUF BAU PRINCIPLE

→ DEFINITION

Electrons fill the orbitals of lowest energy levels before occupying higher energy levels

→ NAME ORIGIN

It's not the name of a scientist but comes from a **german word** which means "**to build**"

→ ORDER

Electrons will fill in the order of increasing Energy level in this form:-

$s < p < d < f$

ENERGY OF ORBIT

→ Energy of orbital $\propto n + l$

"n" is Shell number or Quantam number

"l" is orbital / Sub-Shell number or Azimuthal Quantam

→ EXAMPLES

In 3s & 4p

$n = 3$	$n = 4$
$s = 0$	$p = 1$
So $n + l = 3$	$n + l = 5$

- Electron will fill in 3s first

→ SAME (n+l)

In 3p & 4s

$n = 3$	$n = 4$
$p = 1$	$s = 0$
So $n + l = 4$	$n + l = 4$

- Electron will fill in 3p by considering lower "n" value

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→ ENERGY OF ORBITALS

1s
2s 2p
3s 3p 3d
4s 4p 4d
5s 5p
6s

$1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p < 5s$

PAULI EXCLUSION Principle

→ DEFINITION

Each orbital can accomodate 2 electrons with opposite spin.

→ EXAMPLE

$1s^2 \Rightarrow \uparrow\downarrow$

↳ $\uparrow$ $\left(+\frac{1}{2}\right)$ anticlockwise

↳ $\downarrow$ $\left(-\frac{1}{2}\right)$ clockwise

Different spin Quantam numbers

→ NOT SAME SET OF 4 QUANTAMS

No two Electrons in an atom have the same set of 4 quantam numbers.

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→ EXAMPE OF OXYGEN

$O_2 = 1s^2, 2s^2, 2p^4$

s	0	p	1	d	2
f	3				

$\boxed{\uparrow\downarrow}$ $\boxed{\uparrow\downarrow}$ $\boxed{\uparrow\downarrow \mid \uparrow \mid \uparrow}$

2px 2py 2pz

(1)

- ✓ $n = 2$
- ✓ $l = 1$ (−1, 0, 1) x y z
- ✓ $m_l = -1$
- ✗ $m_s = +\frac{1}{2}$

- ✓ $n = 2$
- ✓ $l = 1$ (−1, 0, 1) x y z
- ✓ $m_l = -1$
- ✗ $m_s = -\frac{1}{2}$

→ All 3 Quantam numbers of both electrons are equal but not 4th thus we conclude:-

→ The two electrons have not the same set of 4 Quantam numbers.

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HUND'S RULE

DEFINITION

Every orbital in a subshell is singly filled with one orbital before any orbital is doubly filled

SPIN

All Electrons in singly filled orbital have the same spin

EXAMPLE

Oxygen = 8 → $1s^2, 2s^2, 2p^4$

$\boxed{\uparrow\downarrow}$ $\boxed{\uparrow\downarrow}$ $\boxed{\uparrow\downarrow}\boxed{\uparrow}\boxed{\uparrow}$

TRAITS

- talks about pairing of electrons in orbitals
- Electrons tend to remain upaired as far possible

COMMON MISTAKES

$\boxed{\uparrow}$ $\boxed{\downarrow}$ $\boxed{\uparrow}$ ✗ (Direction Mistake)

$\boxed{\uparrow}$ $\boxed{\uparrow}$ $\boxed{\uparrow}$ ✓

$\boxed{\uparrow\downarrow}\boxed{\uparrow}\boxed{}$ ✗ (Double filling)

$\boxed{\uparrow\downarrow}\boxed{\uparrow}\boxed{\uparrow}$ ✓

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We can also do :-

↑	↑↓	↑

as they belong to same orbital & have same energy

→ **EXAMPLE**

Fe (26) = $1s^2, 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$

So, :- $1s^2$ ↑↓ $2s^2$ ↑↓ $2p^6$ ↑↓ ↑↓ ↑↓ $3s^2$ ↑↓ $3p^6$ ↑↓ ↑↓ ↑↓

$4s^2$ ↑↓ $3d^6$ ↑↓ ↑ ↑ ↑ ↑

BY ZOHAA FAISAL

RADIUS DERIVATION

DERIVATION OF RADIUS OF AN ORBIT

→ INTRODUCTION

Bohr derived expression for the calculation of radius of "nth" orbit of an atom of hydrogen or ions like He^{+1}, Li^{+2} etc

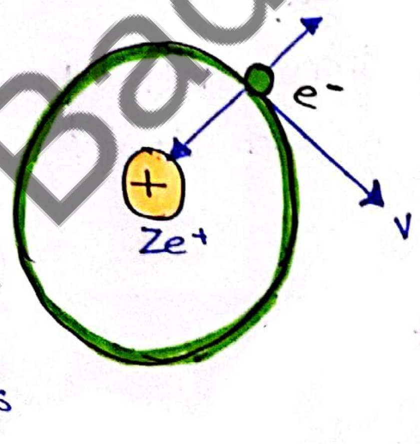
→ EXPLANATION

let us consider an atom having electron "e^-" moving around the nucleus having charge Ze^+, where Z is the atomic number & "e" shows proton.

→ DIAGRAM

→ Electrostatic force/centripetal force = $\frac{Ze^2}{4\pi E_o r^2}$

→ Pulling towards the centre or nucleus



→ Extra points

→ Centrifugal force $= \frac{mv^2}{r}$

→ Pulls outwards from centre

→ velocity is always tangent

→ MATHEMATICAL DERIVATION

let 'm' be the mass, 'r' is the radius of the orbit and 'v' is the velocity of the revolving electron → $\left[\frac{mv^2}{r}\right]$

Now, Electrostatic force or Coulomb's force of attraction is given as:-

$$F_E = \frac{Ze^+e^-}{4\pi E_o r^2}$$

$$F_E = \frac{Ze^2}{4\pi\varepsilon_0 r^2} \rightarrow (i)$$

Since, by using Coulomb's Law

$$F = \frac{K q_1 q_2}{r^2}$$

$$K = \frac{1}{4\pi\varepsilon_0}$$

$q_1 = e$, $q_2 = e^-$

$$F = \frac{e^+ e^-}{4\pi\varepsilon_0 r^2}$$

Z → represent atomic number

→ **PERMITIVITY**

Where, ε_0 is the vacuum permitivity constant with value

$8.8 \times 10^{-12}\ C^2 J^{-1} m^{-1}$

→ the permission or access to pass attractive forces trough a medium

→ **CENTRIFUGAL FORCE**

Centrifugal force acting on the moving electron will be

$$F_c = \frac{mv^2}{r} \rightarrow (ii)$$

→ **COMPARING OF EQUATIONS**

During motion of electron both forces become equal & opposite to each other,

So by comparing,

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

$$mv^2 = \frac{Ze^2}{4\pi\varepsilon_0 r} \rightarrow (x)$$ [will also be used in Energy derivation]

Rearranging equation, (to separate r)

$$r = \frac{Ze^2}{4\pi\varepsilon_0 mv^2} \rightarrow (III)$$

from eq 3, by removing constants, we conclude

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

→ more the radius, smaller velocity & vice versa.

→ ANGULAR MOMENTUM

Moment - arm × Force = torque

Moment arm × linear momentum = Angular momentum

$r \times mv = L$

$L = mvr$ (Angular momentum)

According to Neil Bohr,

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

$$v = \frac{nh}{2\pi mr} \quad \text{(Separating } v\text{)}$$

Taking square on both sides,

$$(v)^2 = \left(\frac{nh}{2\pi mr}\right)^2 \rightarrow v^2 = \frac{n^2h^2}{4\pi^2m^2r^2}$$

$$v^2 = \frac{n^2h^2}{4\pi^2m^2r^2} \rightarrow \text{eq (iv)}$$

putting eq (iv) in eq (iii)

$$r = \frac{Ze^2}{4\pi E_0 mv^2} \rightarrow \text{(iii)}$$

$$r = \frac{Ze^2}{\cancel{4\pi} E_0 \cancel{m}\left(\frac{n^2h^2}{\cancel{4\pi^2}\cancel{m^2}r^2}\right)}$$

$$r = \frac{Ze^2}{\frac{E_0 n^2h^2}{\pi m r^2}}$$

$$r = Ze^2 \div \frac{E_0 n^2h^2}{\pi m r^2}$$

$$\cancel{r} = Ze^2 \times \frac{\pi m r^{\cancel{2}}}{E_0 n^2 h^2}$$

$$1 = Ze^2 \times \frac{\pi m r}{\epsilon_o n^2 h^2}$$

$$\epsilon_o n^2 h^2 = Ze^2 \pi m r$$

$$\frac{\epsilon_o n^2 h^2}{Ze^2 \pi m} = r$$

$$r = \frac{\epsilon_o n^2 h^2}{Ze^2 \pi m}$$ (Again Separating r)

$$r_n = \frac{\epsilon_o n^2 h^2}{Ze^2 \pi m}$$ → (v) [n shows number of radius & variable]

Eq 5 shows radius of nth orbit of an atom.

→ **RADIUS OF ORBIT OF HYDROGEN ATOM**

$$r_n = \frac{\epsilon_o n^2 h^2}{Ze^2 \pi m}$$ For hydrogen $Z = 1$

$$r_n = \frac{\epsilon_o h^2}{Ze^2 \pi m} \times n^2$$ (except n all are constants)

$$r_n = a_o \times n^2$$ (replacing constants with a_o

$$a_o = 0.529 \times 10^{-10} m$$ [Unit called Angstrom is used for 10^{-10}]

$$= 0.529 A^o$$ (Angstrom)

Eq becomes

$$r_n = 0.529 A^o \times n^2$$

$$r_n = n^2 \times 0.529 A^o$$

↳ (vii)

→ the formula to find radius of Hydrogen atom

FOR ANY ATOM

$$r_n = 0.529 \frac{n^2}{Z} A^o$$

[Z = atomic no
n = no of orbit]

→ CONCLUSION

As $\boxed{r_n = n^2 \times 0.529 A^\circ}$

Putting the value of "n" as 1, 2, 3, 4, 5 the radius of orbits of hydrogen atom are:-

* $n = 1 \Rightarrow r_1 = (1)^2 \times 0.529 A^\circ \Rightarrow r = 0.529 A^\circ$

* $n = 2 \Rightarrow r_2 = (2)^2 \times 0.529 A^\circ \Rightarrow r_2 = 2.11 A^\circ$

* $n = 3 \Rightarrow r_3 = (3)^2 \times 0.529 A^\circ \Rightarrow r_3 = 4.75 A^\circ$

* $n = 4 \Rightarrow r_4 = (4)^2 \times 0.529 A^\circ \Rightarrow r_4 = 8.4 A^\circ$

* $n = 5 \Rightarrow r_5 = (5)^2 \times 0.529 A^\circ \Rightarrow r_5 = 13.32 A^\circ$

→ COMPARISON OF VECTOR

The comparison of radii shows that the distance between orbits of Hydrogen atom goes on increasing as we move from 1st orbit to higher orbits. The orbits are not equally spaced

$$r_2 - r_1 < r_3 - r_2 < r_4 - r_3 <$$

Second orbit is 4 times away from the nucleus than first orbit is, then 3rd orbit is Nine times away & Similarly, the 4th orbit is sixteen times away.

→ r is inversely proportional Speed (v)

→ larger the radius, lower will be speed

- $r_2 = 4r_1$ [4 times of 1st orbit]
- $r_3 = 9r_1$
- $r_3 = 16r_1$

→ Mercury takes less time than Earth to complete one orbit due to its less distance from Sun.

Date

DISCHARGE TUBE EXPERIMENT

DEFINITION / INTRODUCTION

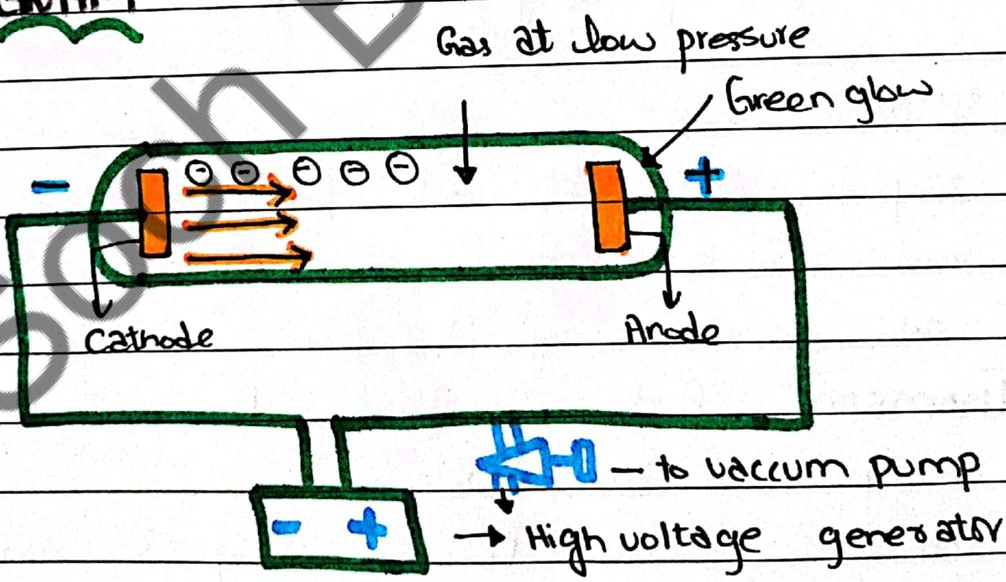
" An experiment called Discharge tube experiment which consisted of 2 metal electrodes and Electricity was passed with changing pressure & voltage which resulted in Discovery of "Cathode rays" or "Electrons" "

INSTRUMENTATION / CONSTRUCTION

It consists of following :-

- Gas discharge tube
- 2 metallic electrodes (cathode & anode)
- Gas or air at desired pressure
- Vaccum pump

DIAGRAM



Date

WORKING

- In the beggining electric current wass passed through gas tube at ordinary pressure
- Gas was not affected at high potential of 5000 Volts
- Pressure was reduced to **0.01 torr** and (through Vaccum pump) & voltage was increased to **5000-10,000 Volts.**
- The glow appeared before will disappear

OBSERVATION

- It was observed that at low pressure **0.1 torr** and High potential, the gas becomes the conductor Current starts to flow through the gas and gas starts to emit light
- "**Neon Sign**" is the modern example of discharge tube.
- When the pressure is reduced even further upto **0.01 torr**, emission of light by the gas ceased.

CONCLUSION

- Certain rays were given out from cathode & travel towards anode. Such rays were called "cathode rays" because they originate from "cathode"
- **JJ Thomson** first identified the electrons in cathode ray tube in **1887.**
- Many other scientists like Faraday & Crooks studied effects of passing electric current through gas

Date ____

X-RAYS

DEFINITION

"Electromagnetic radiations of very short wavelength (0.1 - 20 Å) produced when rapidly moving electrons collide with heavy metal anode in the discharge tube are called x-rays."

DISCOVERY

Wilhelm Roentgen (1895) accidentally discovered that if Cathode rays are pointed to fall on a heavy metal target, there are produced some penetrating short wavelength rays which were called x-rays

PROPERTIES

- They travel in straight line & are not deflected by electric or magnetic field
- They are invisible to the eyes but can affect the photographic plate
- They have high penetrating power and frequency
- The frequency depends on atomic number of anode
- Frequency ranges from 3×10^{16} to 3×10^{19} Hz
- Wavelength = 0.01 to 10 nm. or 0.04 Å - 0.08 Å

Date

→ USES

- They are used in the study of crystal structure
- They are used as a diagnostic tool in medicine and as treatment for cancer
- Detection of dental cavities, bone fractures & to differentiate between hard & soft tissue
- To check luggage of passengers at airport
- To detect flaws (cracks) non-destructively in metal castings
- Used in Security purposes, medical radiography
- They can also ionize gases