Dated:

# ATOMIC STRUCTURE

MDCAT

1) Atom discovery:- Democritus suggested that there is no other particle smaller than atom that can not be further divided.

2) Postulates of John Dalton :-

1) Atom is smallest, indivisible particle.
2) It can not be created nor destroyed but can change it's form.
3) Atoms undergo chemical combinition to form molecules ; but as a whole, molecule is smallest identity that exists independently.
4) Atoms have same mass, size, properties etc if they're of elemen

3) Electron discovery:- JJ Thomson discovered electron.

1) It was discovered due to discharge tube experiment based on cathod ray.
2) The glass tube had 2 electrodes (+ve) and (-ve). The partic emitted from electron gun difflected and bent toward (+ve) side
3) This means that electrons have negative nature and so are attracted towards +ve anode.

4) Postulates of JJ Thomson :-

1) Atom is divisible in sub-atomic particles.
2) Atoms do differ in mass incase of Isotopes, and do have different properties.

5) Neil Bohr discovey:- Neil Bohr's atomic model further classified the atomic picture.

6) Postulates of Neil (Bohr :-

∴ Quanta = Packets of energy

1) His model was first approach to quantized energy levels or electronic shells with fixed energy.

(Point 5 - 7) Qs 2(i).

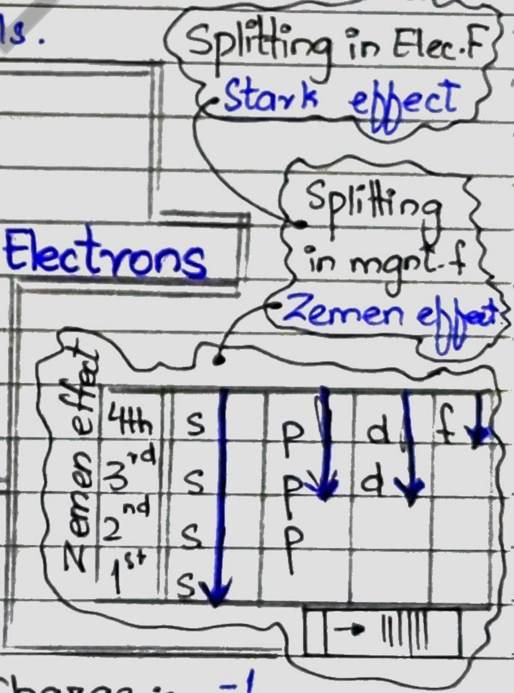
Dated:

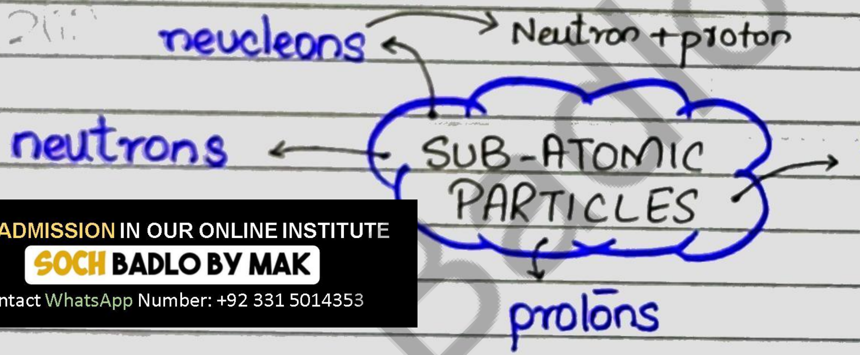
2) He calculated the radius of H-atom. (roughly $10^{-10}$)
3) energy of electrons in H-atoms.
4) The emmision of spectrum was explained.
5) Defects of Bohr's theory:-

When high resolution spectrophotometer were made, fine spectrum originated with splited spectral lines. These lines were splitting in electric /magnetic feild giving Spark & Zemen effect.

7) Contribution of Heisenberg:-

1) He discribed or formulated the principle of uncertainity; "It is not possible to know certain propeities of sub-atomic particles like position & speed simultaneouslly."
2) He gave rise to concept of subshells/orbitals.





## 1} ELECTRONS :-

→ Discovery :- JJ Thomson
→ Nature :- Negative
→ Charge :- $-1.6022 \times 10^{-19}$ C    Relative Charge :- -1
→ Location :- Shells of atom
→ Deflection in Ef :- Deflect towards +ve pole.
→ Mass :- $9.1095 \times 10^{-31}$ kg.

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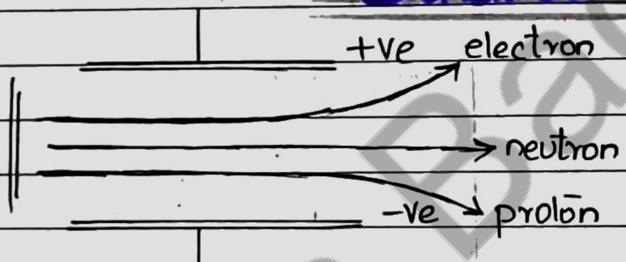
## PROTON :-

- → Discovery Goldstein
- → Nature Positive
- → Charge +1.0622 $\times 10^{-19}$ C → Relative charge. +1.
- → Location In nucleus
- → Deflection Towards -ve pole.
- → Mass 1.6727 $\times 10^{-27}$ kg (1836x more than $e^-$).

## NUETRON :-

- → Discovery Chad-wick
- → Nature Neutral
- → Charge No charge
- → Mass 1.6750 $\times 10^{-27}$ kg.
- → Location In nucleus
- → Deflection No deflection
- → Relative charge No charge

### → Behaviour in electric feild



- -ve electron ⟶ +ve pole
- +ve proton ⟶ -ve pole
- (∓) neutron ⟶ No deflection
- Share same velocity
- diveragance depend on velocity.

### → Atomic CHARACTERISTICS

Atomic no.
- No. of protons
- (Z) proton = electrons
- $N^7$ = 7 atomic no.

Mass no.
- No. of nucleons (neutrons + protons)
- (A) → P+N = A

anion = -ve = gain $e^-$.
$e^-$ no. = atomic no + charge
$Cl^{-1}$ = 17+1 = 18

- cation = + = lose $e^-$ • exp :- $Ca^{+2}$
- $e^-$ no. = Atomic no. − charge 20-2 = 18

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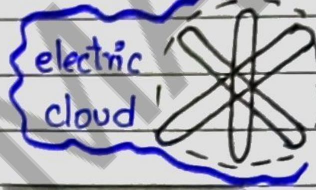
# Atomic Radius

Definition :- The average distance of nucleus from outermost valence electron is radius of an atom.



| TREND | REASON (Main group) |
|---|---|
| Periodic {L ⟶ R} Trend. | {Decrease} It decreases as the nucleur charge increases ; thus ; No. of electrons in valance shell increase which results in increase force of attraction by nucleus on valance $e^-$ causing size to shrink. |
| Group Trend [T ↓ B] | {Increases} It increases as the no. of shells increases and increase in sheilding effect. |

## TRANSITIONAL METALS :-

| TREND | REASON |
|---|---|
| Periodic Trend. L ⟶ R | Decrease to {Increase} electrons are in d-group. Initial behaviour of elements shows decrease in atomic radii. Then it becomes constant for few. & in last it increases.<br>Decrease → Greater force of attraction b/w nucleus & $e^-$s.<br>Increase → electrons repel each other. |
| Group Trend {T ↓ B} | In group trend it {Increase} as no. of shells increases and sheilding effect increases.<br>Qs 2(iv) |

| Atomic S | Period | Group |
|---|---|---|
| Main G. | Dec | Inc. |
| Transition | Dec → Inc | Inc. |

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# IONIC RADIUS :- Ion → Gain / Lose of electrons.

1) Cation : (+ve) Lose electrons and is of smaller size than parent.

2) Anion :- (-ve) Gain electron and is greater size than parent atom.

→ Trends are same as of main group elements. Qs 2(v)

# QUANTUM NUMBERS -

[Short / Long imp]
Qs 2(vii) (Q 3)

1) Brief Introduction :-

-- Set of 4 numerals to explain behaviour of electrons are Q.N.

-- By :- Schrodinger equation of wave.

-- To :- Used to determine location, shell, sub-shell, energy, rotation, size, distance from nucleus, shape, of electron of atom.

-- Numbers = 4.

# PRINCIPLE QUANTUM NUMBERS :- (n)

1) Importance :-

- → It express Bohr's shells in quantum form.
- → Depicts period no. in periodic table.
- → Atomic size (Greater the value of "n" greater the size).
- → Nature of shell (K, L, M, N ...)
- → Energy of shell $(E = n + l)$.
- → $n \neq 0$ → $n = 1, 2, 3 ..$
- → To predict no. of $e^-$ → $2n^2$.
- → n is alway +ve.
- ~~→ Maximum no. of sub shells in n → $n^2$.~~

| n | Energy level | Shell | Sub Shell | No. of $e^-$ = $2n^2$. |
|---|---|---|---|---|
| 1 | 1st E.L | K | s | $2(1)^2 = 2e^-$ |
| 2 | 2nd E.L | L | s p | $2(2)^2 = 8e^-$ |
| 3 | 3rd E.L | M | s p d | $2(3)^2 = 18e^-$ |
| 4 | 4th E.L | N | s p d f | $2(4)^2 = 32e^-$ |

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# AZIMUTHAL QUANTUM NUMBERS:-

Denoted by 'l'

1) Importance :-

- → Tells us about $e^-$'s subshell.
- → Shape of orbital (place where max $e^-$ can be found)
- → One shell may have more than one sub-shells.
- → It determine angulau momentum of $e^-$.
- → $l = 0, 1, 2, 3 \dots$
- → $l = n - 1$.
- → To find no. of $e^-$ in sub-shell → $2(2l+1)$.
- → Sub-shells cause fine spectral lines in spectrum.
- → position of $e^-$ (s, p, d, f) blocks in table.

| $l = n-1$ | Subshell | Shape of Subshell | $e^-$ in subshell |
|---|---|---|---|
| $l = 1-1 = 0$ | s (sharp) | sperical ○ | $2(2l+1)$ s → $2e^-$ |
| $l = 2-1 = 1$ | p (principle) | dumble ∞ | $2(2(1)+1) \rightarrow 6e^-$ |
| $l = 3-1 = 2$ | d (diffused) | double dumble ✤ siccor | $2(2(2)+1) \rightarrow 10e^-$ |
| $l = 4-1 = 3$ | f (fundamental) | Complex 3D | $2(2\times3+1) \rightarrow 14e^-$ |

# MAGNETIC QUANTUM NO. :- (m)

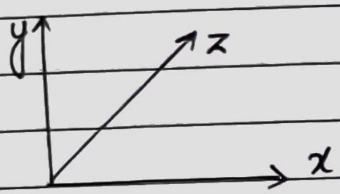
s = 0  p = 1
d = 2  f = 3

1) Importance :-

- → Zeeman effect (fine spectral lines into influence of magnetic feild) can be explained by MQN.
- → It is orientation quantum no.
- → m could be from negative integers to "0" to positive integers.
- → It shows deflection of $e^-$ in subshells in different directional axis.
- → Direction in degenerate orbit = Obt having space.
- → Deflection in different direction with same energy.

Dated:

| $l$ | Subshell | Degenerate Orbit $2l+1 = m$ | m values | Degenerate Orbit detail directions. |
|---|---|---|---|---|
| 0 | s | $2(0)+1 = 1$ | , 0 | s |
| 1 | p | $2(1)+1 = 3$ | -1 0 1 | $P_x$ $P_z$ $P_y$ |
| 2 | d | $2(2)+1 = 5$ | -2 -1 0 1 2 | $d_{xy}, d_{xz}, d_{yz}, d_{x^2y^2}, d_{z^2}$ |
| 3 | f | $2(3)+1 = 7$ | -3 -2 -1 0 1 2 3 | - |



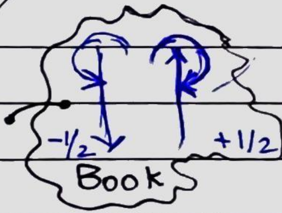
$P_x = -1$ $P_z = 0$ $P_y = 1$

$d_{xy} = -2$ $d_{xz} = -1$ $d_{xy} = 0$ $d_{x^2y^2} = 1$ $d_{z^2} = 2$

$s = 0$

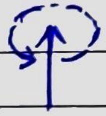
## SPIN QUANTUM NUMBERS:- (s)

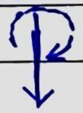
1) Importance:- (GoudSmith) Ds 2 (viii)



- → Indicates angular momentum of $e^-$.
- → Possible values of $s = +1/2, -1/2$.
- → Spin of $e^-$ in magnetic feild.
- → Always oppose in direction thus;

(↑) anticlock wsie → $-1/2$ (↓) clockwise $= +1/2$





- → $e^-$s in one orbitals ($d_{xy}$, $P_z$, $P_x$ etc...) have opposite spins.
- → Called as Self-rotation.

| Shell | Subshell | SQN | No. of $e^-$ in SHELL |
|---|---|---|---|
| K | s | $+1/2$ $-1/2$ | $2e^-$ |
| L | s | $+1/2$ $-1/2$ | $2e^-$ } |
|  | p | $P_x = \mp 1/2$ $P_y = \mp 1/2$ $P_z = \mp 1/2$ | $6e^-$ } $8e^-$ |
| M | s | $+1/2$ $-1/2$ | $2e^-$ } |
|  | p | $P_x = \mp 1/2$ $P_y = \mp 1/2$ $P_z = \mp 1/2$ | $6e^-$ } $e^- = 10e^-$ |
|  | d | $d_{xy} = \mp 1/2$ $d_{xz} = \mp 1/2$ $d_{yz} = \mp 1/2$ $d_{z^2} = \mp 1/2$ $d_{x^2y^2} = \mp 1/2$ | $10e^-$ |

Dated:

$1 \rightarrow$ SQN $\rightarrow +1/2$

PQN $\leftarrow$ $3p_x \rightarrow$ MQN $\rightarrow$ x-axis

n = 3 = M

AQN $\rightarrow$ p block $\rightarrow l = 1$

**Spectrum** :- Range of diff $\lambda / f / E$.

- From higher to lower shell → $e^-$ emitt energy.
- From lower to higher shell → $e^-$ absorbs.
- No. of spectral lines ∝ shell Numbers.
- $e^-$ occupy quantized energy levels.

**Spectrum** λ incr.

Greater f: cosmic — Short λ
Gamma
X-ray
UV ray
visible
Infrared
Microwave
radio wave. — Greater λ
Short f

frequency energy inc

Visible Spectrum

**Continuous**
- No marks
- No boundries
- Colors are mixed
- Cant be distinguish

**Line**
- Marks
- Boundaries
- Colors are seperate
- Can be distinguish

Atomic emission (emission spectrum)

Atomic absorption. (Absobtion spectrum).

Line Spectrum Analysis.

→ each elements has it's own emission spectrum (E.conf is also specific).

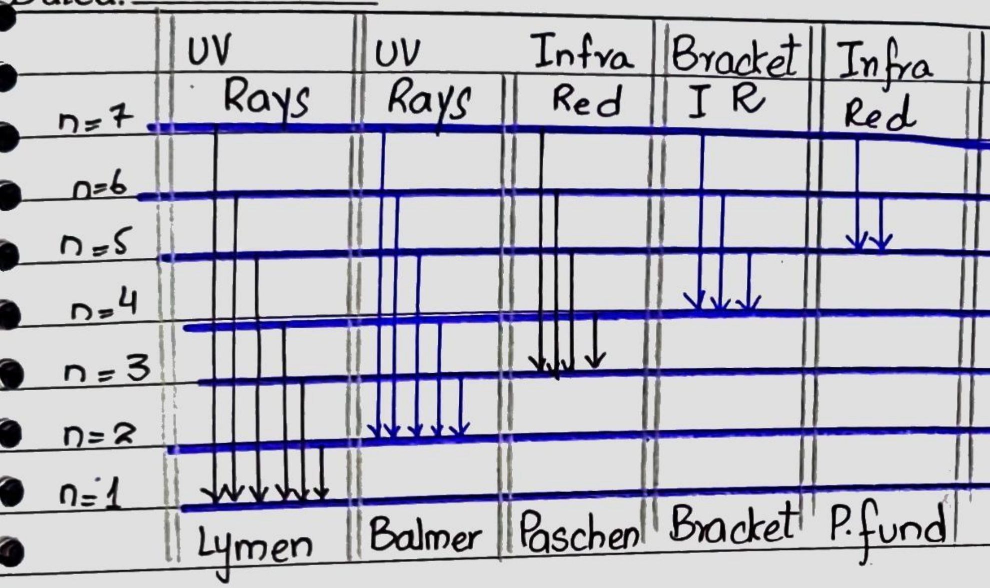
E. Configuation Deduction.

→ No. of lines on spectrum determines no of shells.

**Spectral Series** :- {LBPBP}

1) Lymen 2) Balmer 3) Paschen 4) Bracket
5) P.fund

Dated:



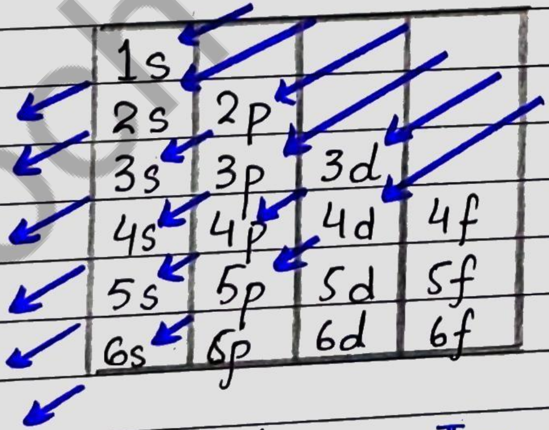
# "Rules for E.configurations" (Qs 5)

E.Configuration:- Arrangements of electrons around the nucleus.

1) Rule Auf Bau Principle :-

Arrangement ↓ increasing energy

"The electrons are filled to the orbitals of lowest energy sequence OR Electrons are distributed in sub-shells in order of increasing energy. firstly, low energy orbitals are filled then higher ones.



→ Auf Bau Rule :-

∴ 1s, 2s 2p, 3s 3p, 4s, 3d, 4p, 5s, 4d, 5p, 6s.

s=2 p=6
d=10 f=14

→ Example :-

Mg=12 $1s^2, 2s^2\ 2p^6, 3s^2$.

Exceptional 3 elements They are stable (fully $\overset{10}{\text{filled}}$) > half $\overset{5}{\text{filled}}$ & unstable at partial fillings. (1 2 3 4 6 7 8 9)

Dated:

Ususual conf of Copper = 29 =

$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^9$ → Unstable

Now d will gain $1e^-$ from 4s to gain stability.

Thus ; $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^{10}$ → Stable

## 2) Rule for energy = n+l

Qs 2(ix)

"It states higher the value of n+l , the higher the energy will be."

OR

"Orbital having least value of n+l will be filled first."

example :- 1) 5s → n = 5 l = 0

E = 5 = n+l = 5+0

2) 4p ⇒ n = 4 p = 1 → n+l = 4+1 = 5 → E = 5

3) 2p ⇒ n = 2 p = 1 → n+l = 2+1 = 3 → E = 3.

NOTE: In case of same energy like 5s & 4p = 5 then lower "n" will be filled first like "4p".

## 3) Pauli Exclusion Rule :-

It states :- that in an atom no two electrons can have same set of quantum no. atleast / must be their spin no. will be different.

→ $1s^2$

$e_1 = n = 1 \longleftrightarrow e_2 = n = 1$

$l = s = 0 \longleftrightarrow l = s = 0$

$m = 0 \longleftrightarrow m = 0$

$s = +1/2 \xleftrightarrow{\text{Different}} s = -1/2$

spinning / opposite

Dated:

## 4) Hund's Rule :-

Statements :- If the orbitals are available to be filled then $e^-$ will occupy each orbital single rather than pairing up with any other $e^-$. Thus, their spin will be same as paired $e^-$ have opposite spin but single electrons may have same directional spin.

example :- $1s^2\ 2s^2\ 2p^3$. $= p = 3e^-$.

→ P has 3 directions $m = -1, 0, 1$ ; thus $P_x, P_y, P_z$.

| | | |
|---|---|---|
| $e_1 = P_x$ | $e_2 = P_y$ | $e_3 = P_z$.. |
| +1/2 ↑ | +1/2 ↑ | +1/2 ↑ |

## DETERMINATIONS

- E.C of neutral atom = Atomic No. $7^{(N)} \rightarrow 1s^2\ 2s^2\ 2p^3$.
- E.C of ~~positive~~ anion = Atomic no. $7(N) \rightarrow (N\cancel{7})^{-3} \longrightarrow (1s^2\ 2s^2\ 2p^6.)^*$
  (Add in valence shell)
- EC of cation = Atomic no. 11 $\rightarrow (Na)^{+1} \longrightarrow (1s^2\ 2s^2\ 2p^6)^*$
  (Remove from valence shell).

- Repulsion force of $e^-$ :- $e^-$ will exerts force of repulsion as are of same charges placed in same orbital. When their orbitals will be changed then repulsion will be minimum.
- Orbital energy :- orbitals of low energy are filled first. The nucleus exerts more energy on $e^-$ near/close to it.
- Spin repulsion :- $e^-$ having same spin, will repel each other. overcome this either hund's rule is used or $e^-$ of opposite are placed together.

Dated: ________

# SHAPE OF ORBITALS :-

**Orbital :-** The region in space where the probability of finding an electron is maximum.

**Node / Nodal plane :-** The region is space where the probability of finding electron is minimum / zero.

## 1) S-orbital :-

① Maximum electrons = $2e^-$.
② It has 3D spherical shape (tennis ball).
③ The size of s-orbital increases as value of n-increses.

1s○ < (2s) < (3s) < ....n.

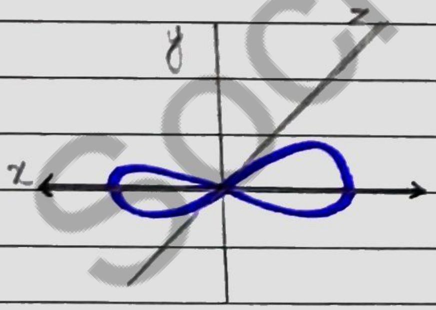
④ It doesn't deflect in magnetic feild as $m = 2(l)+1 = 1$.
⑤ Thus $m = 0$ only (value of $m = 0$) (directional $m = 1$).

## 2) P- orbital :-

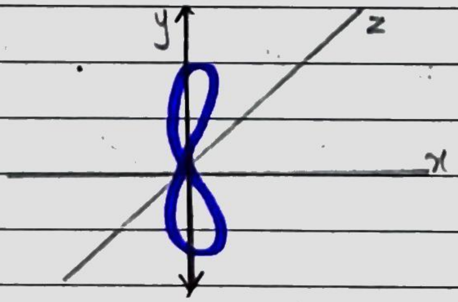
① It can have maximum $6e^-$.
② It have 2 lobes.
③ It's shape is dumble like.
④ It show 3 directional diflection is magnetic feild.

$m = 2(1)+1 = 3 \rightarrow +1, 0, 1 \quad (P_x, P_y, P_z)$

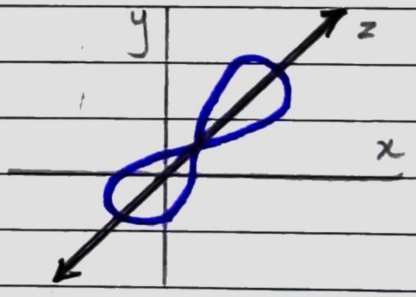
⑤ The dumble of axis will be drawn on it's own axis.



$P_x$



$P_y$



$P_z$

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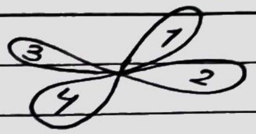


# 3) d - Orbital :-

① It can have 10e⁻.

② It's shape is like double dumble, suasage, session, clover le

③ It has 4 lobes.

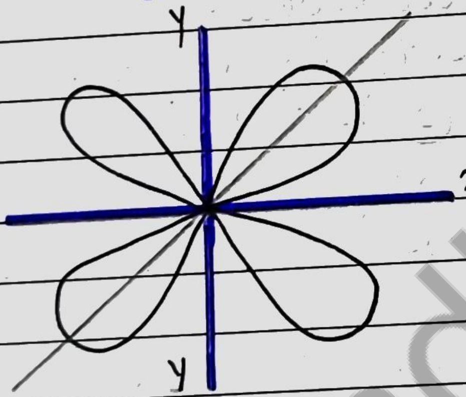
④ It's deflection is in 5 different direction ;
$m = 2(2)+1 = 5$ = -2, -1, 0, 1, 2 ; dxy, dxz, dyz, $dx^2y^2$, d

⑤ The shape will be drawn in b/w of 2-axis (at inte

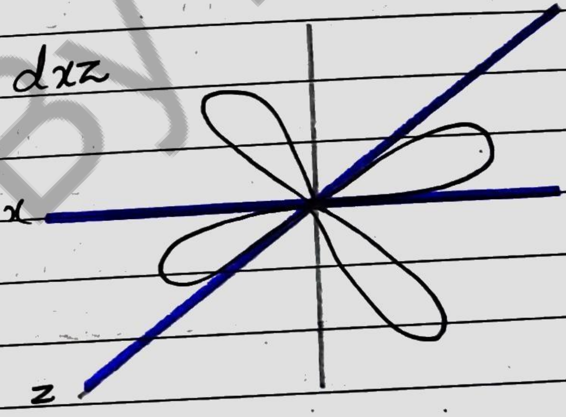
⑥ If there is $n^2$ then shape will be drawn twice on

⑦ for $dx^2-y^2$ the shape will be on the axis.

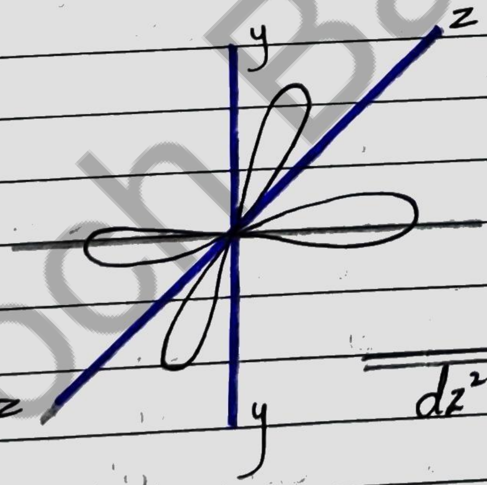
dxy



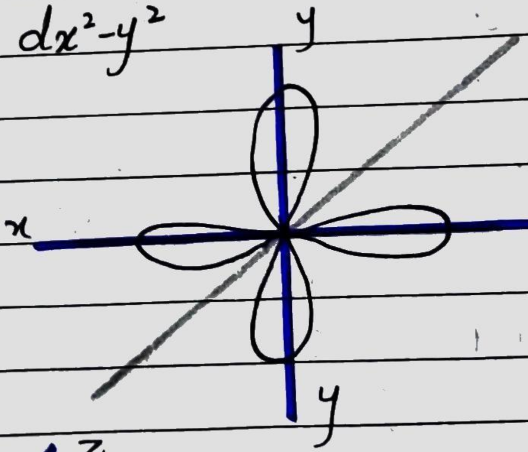
dxz



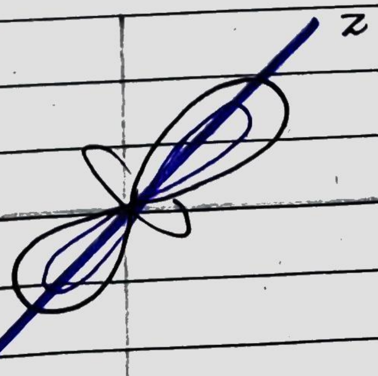
dyz



$dx^2-y^2$



$dz^2$



Dated:

## 4) f- Orbital :-

① It can have maximum $14e^-$

② It can deflect into 7 directions, $m = 2(3)+1 = 7$.

③ It has complicated complex shape.

## (Q4) ⟹ MASS SPECTROMETRY

Mass Spectrometer :- Instrument used to measure exact mass isotope and their relative abundance is mass spectrometer.

Technique mass spectrometry :- Technique in which mass spectromete s used to determine, ① Isotopes ② Abundance of Isotopes % ③ Relative atomic mass ④ Molecular mass. ⑤ Molecular Structu

Types :- ① Aston ② Dempster (solid).

Principle :- To find m/e ratio ;

- Sample → Vapour → Ion → EF → MF → m/e.

Isotopes of an element are seperated on the basis of their mass to charge m/e ratio & record in form of peaks on graph.

WORKING :-

a) Vapourization :- Substance to analyze is converted into vapours state by application of $10^{-6} - 10^{-7}$ torr pressure.

) Ionization :- High energy electrons (EI) at ionizing source will change gaseous vapours into +ve gaseous ions.

c) Electric feild effect :- High voltages are applied to +ve gaseous ions (500- 2000 V) which will accelerate them.

d) Magnetic feild effect :- The accelerated ions are directed mass analyzer by deflection due to magnetic feild effect.

- It seperates ions based on m/e ratio.
- $m/e = \frac{H^2 r}{E}$

r = radius

H = Strength of MF

E = Strength of EF.

e) Detection :- Ion Collector / electrometer / detector ; records the time taken by each ion to reach for calculation of m/e.

→ Ion having definite m/e are collected in ion collector.

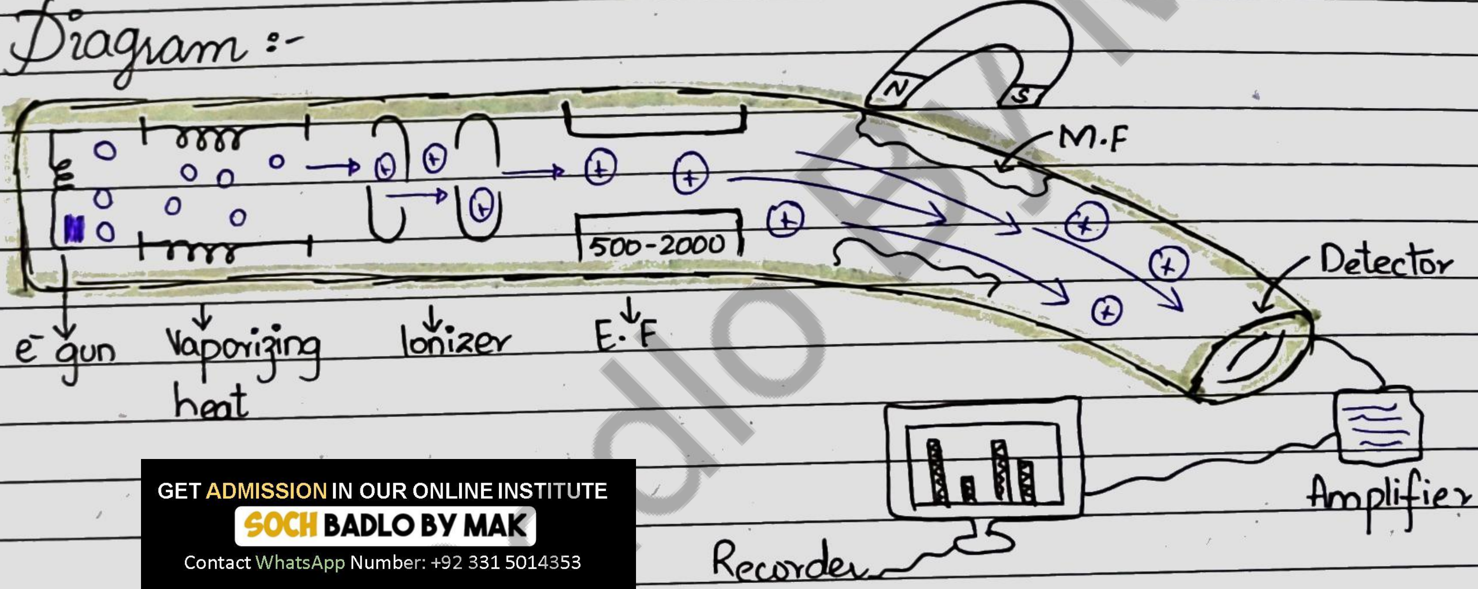
→ It produces different values of current.

→ Heavy ions have more current value & high peak.

f) Amplifier :- It increases current to put it in graph and record it.

g) Recorder :- It record & illustrate graph.

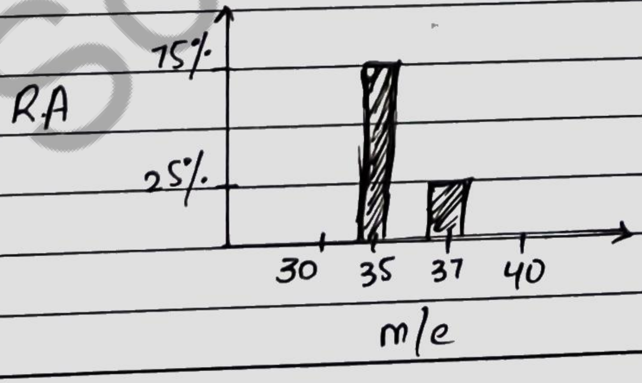
## Diagram :-



## GRAPH :-

The graph is plotted between m/e at x-axis (abscissa) and relative abundance at y-axis (ordinate).

for chlorine :-



Info ;
Isotopes = 2
Iso 1 = 35 – 75%.
Iso 2 = 37 – 25%.

Dated: ____________

## Formula for numericals :-

Avrg. atomic mass = (Mass no. x Na) + (Mass no. x Na) / 100.

Na = natural abundance.

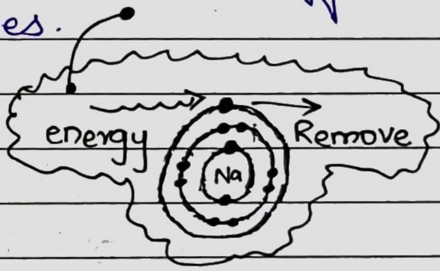
$$\text{Avrg A of } Cl^- = (35 \times 75) + (37 \times 25) / 100$$
$$= 35.5 \text{ amu.}$$

## → IONIZATION ENERGY (Qs 6)

Definition :-

The minimum energy needed to remove the outermost electron from gaseous isolated atom.

Gaseous Compulsion :- Gaseous state compulsion is due to nature of solid & liquid of transfer of energy. Thus, when the energy will given they will distribute among themselves.



Example :- $Na \rightarrow Na^+ + 1e^-$ (496 KJ/mol)

| TRENDS | REASON |
|---|---|
| Group T ↓ B decrease | Along group it decreases due to increase in sheilding effect as it becomes difficult for nucleus to hold on valence electrons, and less energy is needed. |
| Period. L → R Increases | Along period it increases as the nuclear charge increases and force effect increase that holds electrons tightly. Atomic size decrease Thus more energy is needed to remove electrons. |

Dated:

Exception in periodic trend:- As the group 3A along period occupy energy of $z(np^1)$ and losing one electron is easier thus ionization energy decreases.

② As the group V̄A along period occupy more electrons which is half sub-shell ocupation thus it is stable and ionization increases to remove them. $(np^3)$

| → fully filled | > half filled | > Partial filled |
|---|---|---|
| Most stable | stable | Unstable. |
| • $p = 6$ | $p = 3$ | $p = 1, 2, 4, 5$ |
| • $d = 10$ | $d = 5$ | $d = 1, 2, 3, 4, 6, 7, 8,$ |

## FACTORS :-

① Nuclear Charge:- Ns $2(xi)$

• As nuclear charge increase force of attraction by nucleus increases thus ionization energy increases.

• As nuclear charge is described by
$C = kq_1q_2/r^2$.

P
•- N.C $\propto$ IE
•- A.R $\propto$ 1/IE
•- S.E $\propto$ 1/IE
•- S.R $\propto$ 1/IE

② Atomic radii :-

① Atomic radii decreases along period thus ionization also increases due to increase in charge.

② Atomic radii increases along group thus ionization dec

③ Sheilding effect:-

① Increase in sheilding effect along group decreases ionization energy as nuclear attraction becomes weak.

② It remains constant along period thus no effect o

Dated:

④ Spin Repulsion :-

① When p is half filled, $e^-$ repel each other which excites or increase there energy, made easy to remove thus, ionization decreases.

②/

→ Big gap shows inner $e^-$ are removed thus more energy is needed.

## FREE RADICALS :-

•) A free radicals is an atom that bears unpaire or lone electrons in valance shell.

•) It is reactive, activated, bearing dot in structure

•) $Cl_2 \longrightarrow \dot{Cl} - \dot{Cl}$

## Deduction of position based on periodic table :- (Ionization energy).

① Trends :-

→Group : IE decreases.

→Period : IE increases except of few exception.

② Periodic table Organization :-

→ Same IE elements are grouped in same column. & chemi properties can also be determined.

## MODERN MATERIALS :-

"Semi-conductors" are materials that possesses characte like metal as well as non-metal.

- Valance-band :- Describes energy level of $e^-$ in a valance shel excites and move out of atom.
- Conduction-band :- Area where excited $e^-$ went. Elect need energy to go to conduction band.

Dated:

- Metals :- No energy is needed for e⁻ to move to conduband from valance band.
- Non metals :- Need so much energy to move to electrical conducting band from valance band, that's why they usually dont conduct electricity.
- Semi-conductor :- Energy is provided to move from valance band to conduction band through a hole-pair by process "excitation".

- Types of Semi-conductor ;

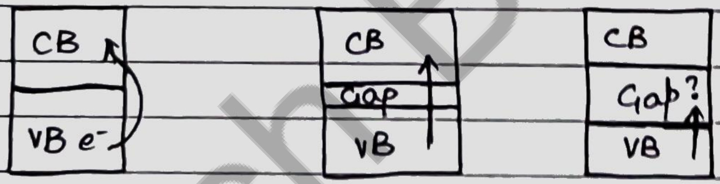
e⁻ More to cond-bar by leaving valence band +ve

1) Intrinsic :- Pure semi conductor , Si & Ge.
2) Extrisic :- They are made intentionally to enhance conductivity.

→ Trivalent or petravalent electrons are used to for silicon enhancement.

→ In $10^6$ atoms of Si , 1 atom of either Boron or P is added This process is "doping". And impurity is "dopet".

Application : Transisters , gates etc..



Conductor Semi-C Insulator

- Semi-C will absorb energy and then it moves to CB from VB after covering Gap of band.

- Insulators have gap and high amount of energy is needed to cover it by excited e⁻. Thus, insulators can not conduct it.

- $$\text{Band Gap} \propto \frac{1}{\text{conductivity}}.$$

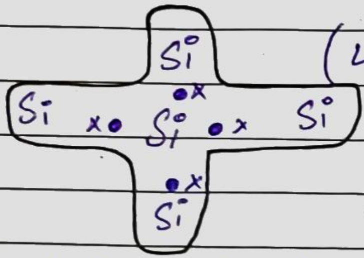
Dated:

- Semiconductor elect activity can be controlled by increasing or decreasing temperature.

S-subshell bond = sigma σ bond.

- Silicon : 14 : $\underbrace{1s^2}_{(2e^-)}$ $\underbrace{2s^2\ 2p^6}_{8e^-}$ $\underbrace{3s^2\ 3p^2}_{4e^-}$

$n=1$ $n=2$ $n=3$



(4-sigma σ bonds.)

→ Valence bond $e^- = 4e^-$

Molecular orbital Theory

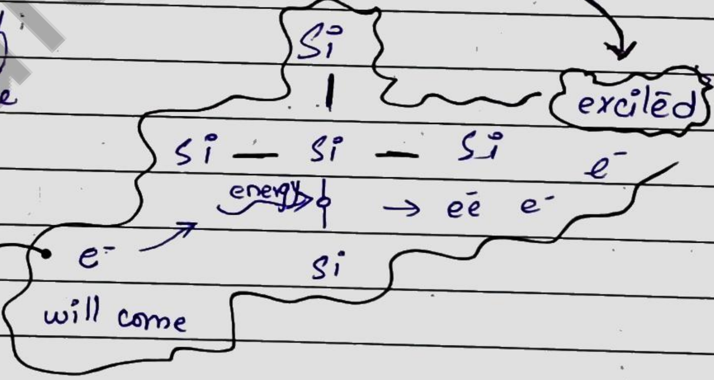
↓

Bonding ↓ $VBe^-$

Antibonding ↓ $CBe^-$

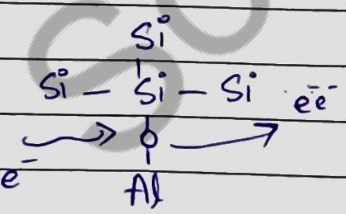
→ energy is given to Si-bonds, $e^-$ excites and move to region of excited $e^-$ leaving a hole-space at behind. Another $e^-$ will come to take place.

→ Thus $e^-$ movement indicates start of conduction.



## Dopant (Al, P)

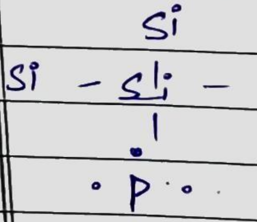
p-type



creates hole & conductivity

junction PN Controls amont of $e^-$ passing.

n-type



extra $e^-$ & generate conuduction.