

Atomic Structure

Quantum Nos.

(1) Principal Q. No. (n) \rightarrow shell No.
or
orbit No.

(2) Azimuthal Q. No. or secondary or subsidiary or angular Q. No. (l)

\Rightarrow Values of l can be $0, 1, 2 \dots n-1$

n	n	l
	1	0
	2	0, 1
	3	0, 1, 2
	4	0, 1, 2, 3

$l \rightarrow$ type of subshell present in a shell

l	subshell	} spectral terms
0	s \rightarrow sharp	
1	p \rightarrow principal	
2	d \rightarrow diffused	
3	f \rightarrow fundamental	

\rightarrow value of l gives the orbital angular momentum

$$L = \sqrt{l(l+1)} \frac{h}{2\pi}$$

(3) magnetic Q. No. (m)

→ values can be $-l$ to $+l$ including zero

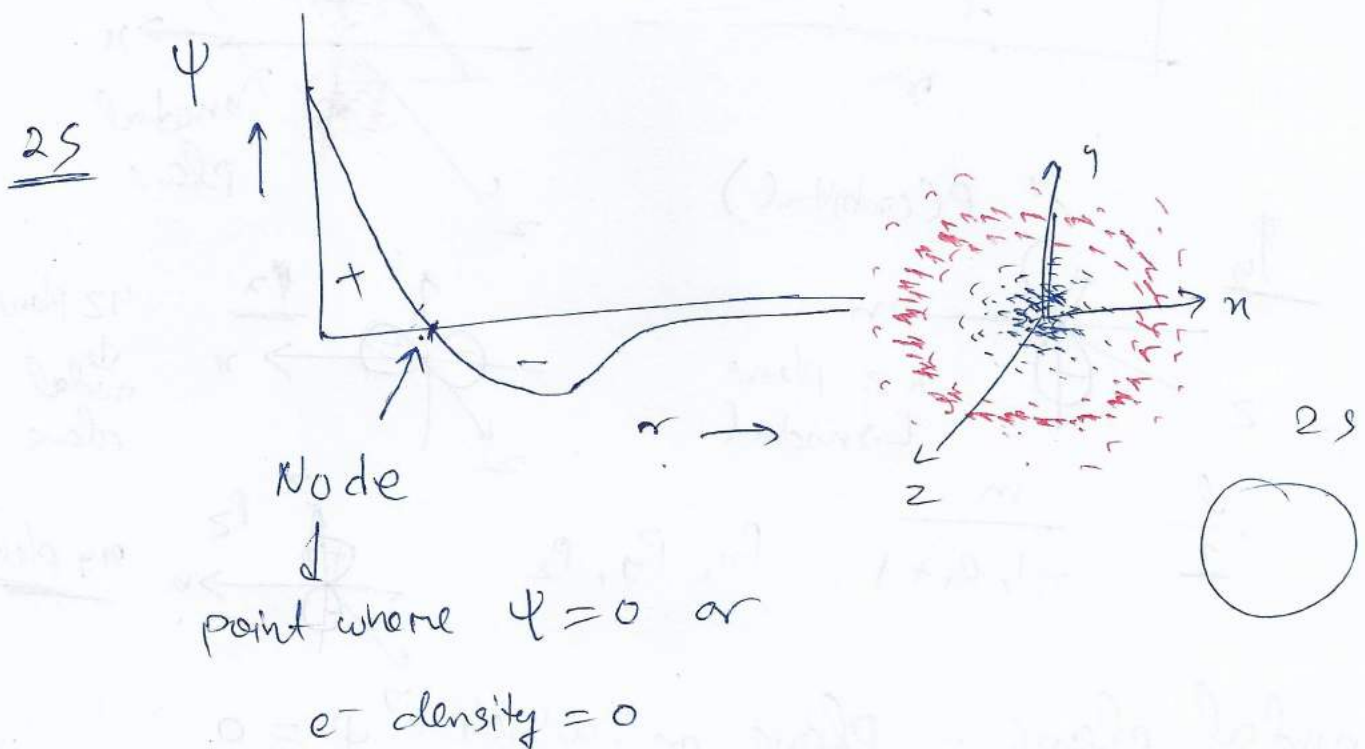
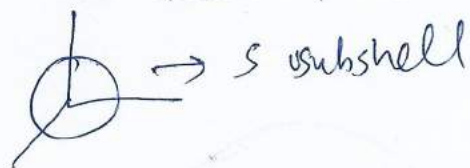
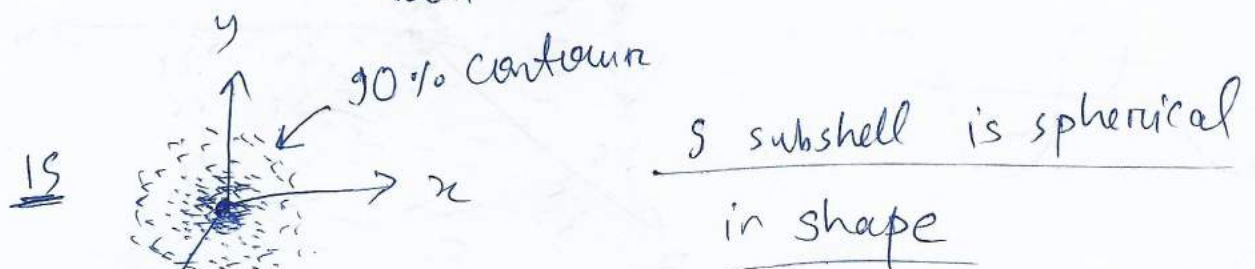
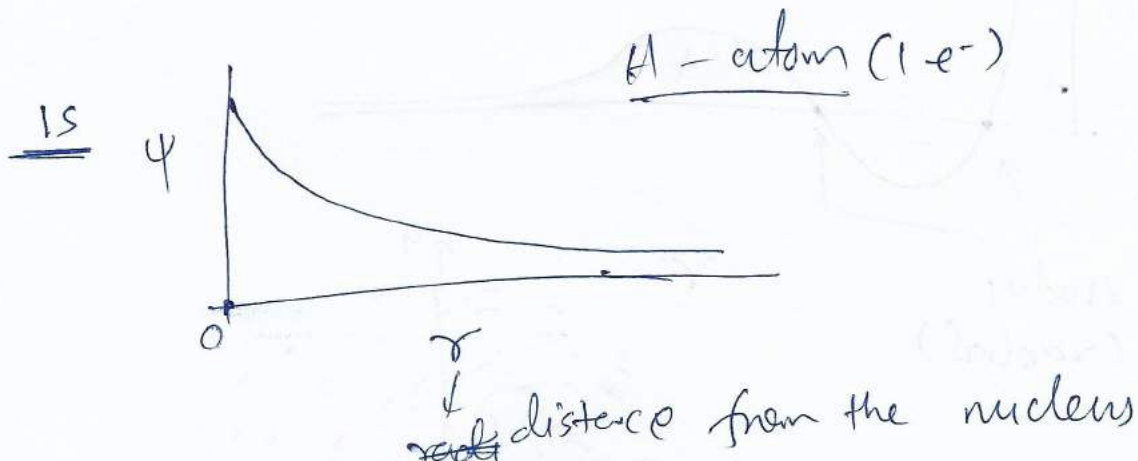
l	m	no. of m values
0	0	$1 = 2 \times 0 + 1$
1	-1, 0, +1	$3 = 2 \times 1 + 1$
2	-2, -1, 0, +1, +2	$5 = 2 \times 2 + 1$
3	-3 to +3	$7 = 2 \times 3 + 1$

for a particular l value there are total $2l+1$ m values

l	Subshell	m	orientations (orbitals)
0	s	0	1
1	p	-1, 0, +1	3 (p_x, p_y, p_z)
2	d	-2, -1, 0, +1, +2	5 ($d_{xy}, d_{yz}, d_{zx}, d_{x^2-y^2}, d_{z^2}$)
3	f	-3, to +3	7 orientations

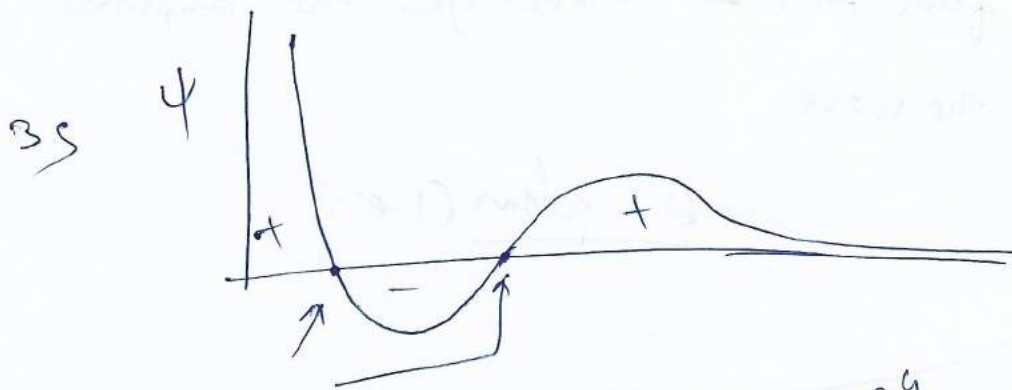
n	l	m	Subshell	n ↓
1	0	0	s	1s
2	0, 1	0 → s → 2s -1, 0, +1 → p → 2p ($2p_x, 2p_y, 2p_z$)		

Ψ (wave function) \rightarrow Gives you the amplitude of the wave

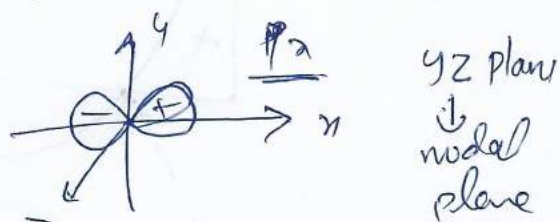
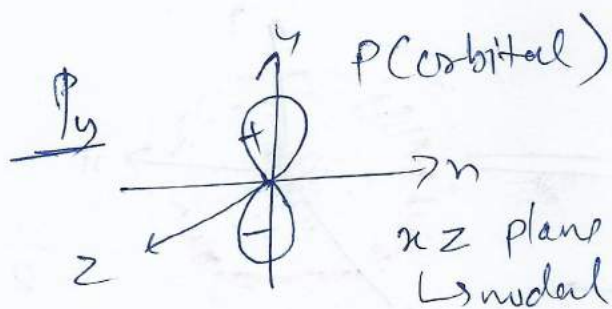
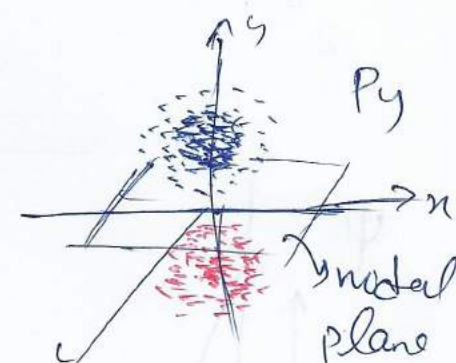
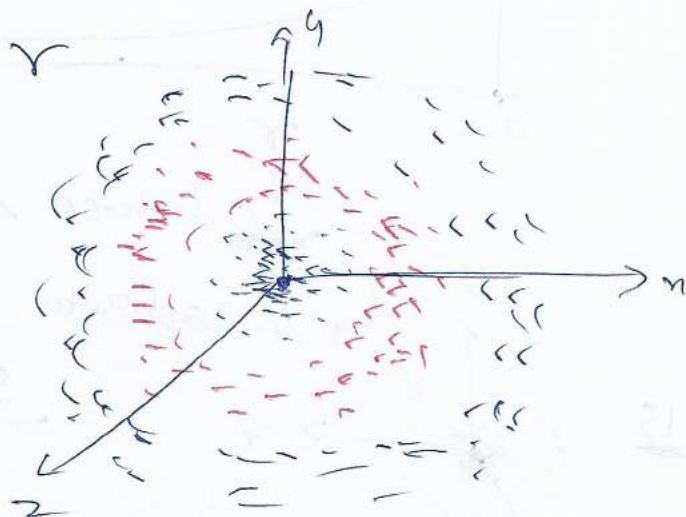
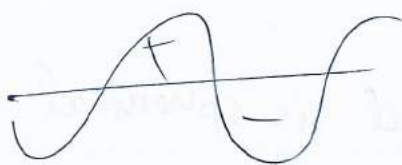


spherical or radial Node \rightarrow spherical surface on which $\Psi = 0$ or e^- density = 0

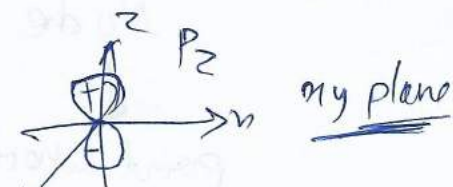
No. of radial Nodes = $n - l - 1$



nodes
(radial)



$$\frac{l}{1} \quad \frac{m}{-1, 0, +1} \quad P_x, P_y, P_z$$

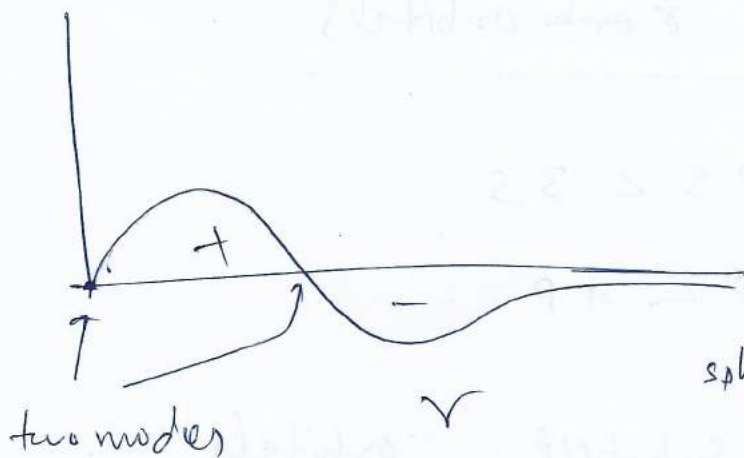


nodal plane = Plane on which $\psi = 0$

no. of nodal planes = l

3p

4



spherical nodes
= 1

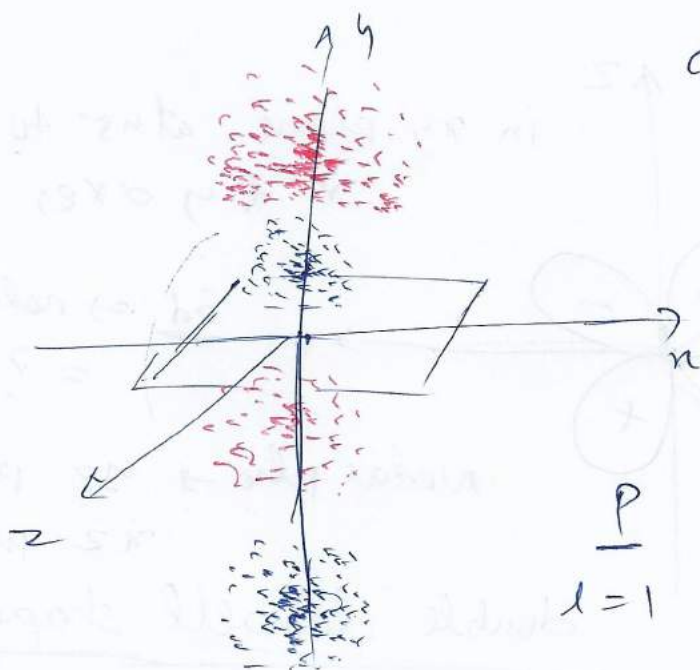
(spherical) radial nodes = $n - l - 1$

nodal planes = l

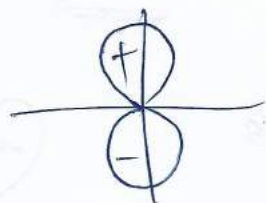
nodal planes
= 1

Total no. of nodes = $n - l - 1 + l$
= $n - 1$

3p



dumbbell shape



l
 $l = 1$

P_x	P_y	P_z
↓	↓	↓
-1	0	1
<u>m values</u>		

$\frac{l}{2}$ $\frac{m}{-2, -1, 0, +1, +2}$

$l \rightarrow$ shape of an orbital

$m \rightarrow$ tells the orientation of orbitals

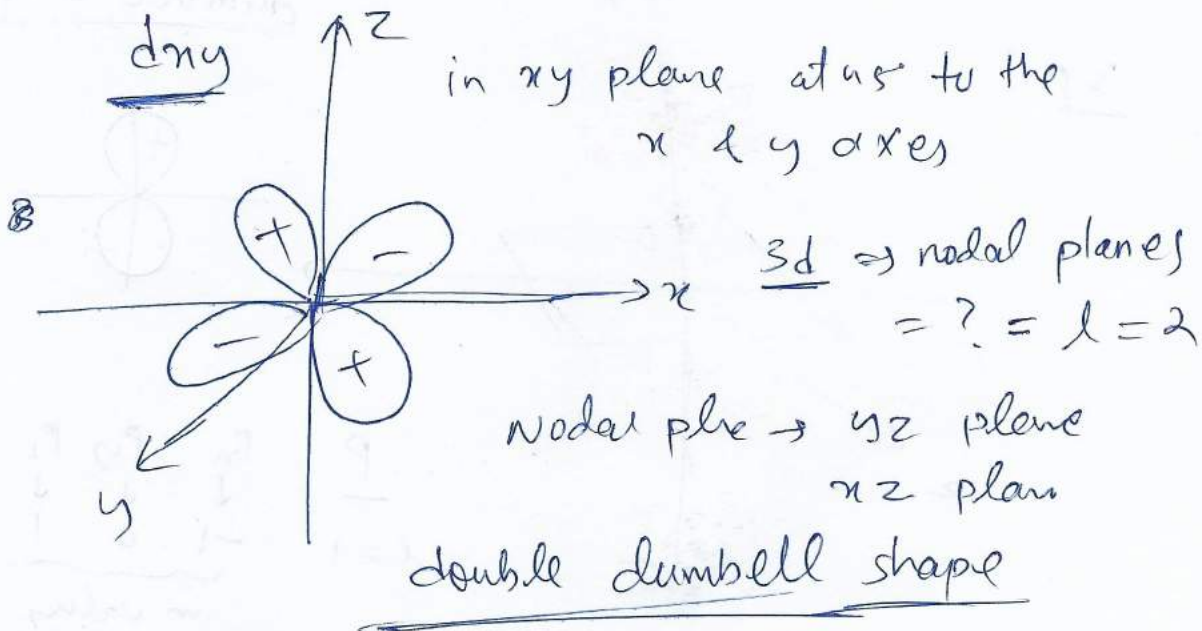
Size of s orbitals

$$1s < 2s < 3s \dots$$

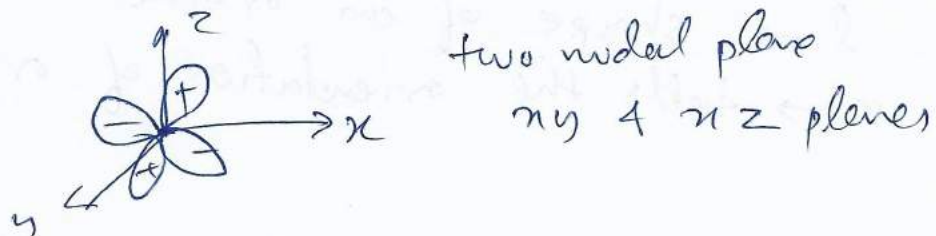
$$2p < 3p < 4p \dots$$

<u>shell</u>	<u>subshell</u>	<u>orbitals</u>
n	l	
1	0	1s
2	0 or 1 \rightarrow $2p_x, 2p_y, 2p_z$ \rightarrow 2s	

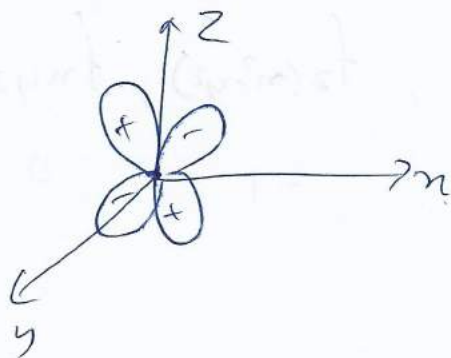
5 d orbitals or 5 orientations



d_{yz} \rightarrow in the yz plane at 45° to y & z

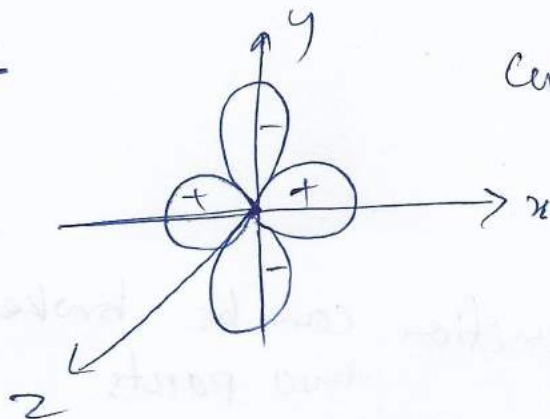


dxz \rightarrow in the xz plane at 45° to x & z axes



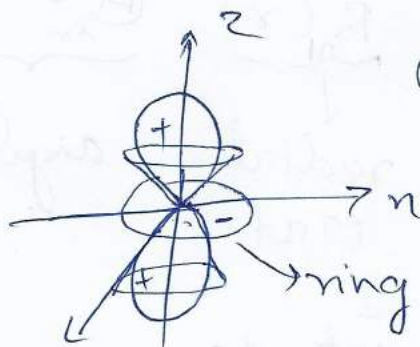
two nodal planes
 xy & yz planes

$dx^2 - y^2$



Cuts the x & y axes
has two nodal planes

dz^2



Cuts the z axis

$l=2$
 \Rightarrow two nodal planes

Q1 no. of spherical nodes = ?
 $= 3 - 2 - 1 = 0$

f \rightarrow 7 f orbitals \rightarrow complex shapes

d $\rightarrow l=2, m = -2, -1, 0, 1, 2$
 $\downarrow \quad \downarrow \quad \downarrow \quad \downarrow \quad \downarrow$
 $dxz \quad dyz \quad dxy \quad dx^2 - y^2 \quad dz^2$

f orbitals (7 f orbitals)

$$f_x(n^2-y^2), f_y(n^2-x^2), f_z(n^2-y^2), f_{xyz}, f_{z^3}, f_{yz^2}$$

$m \quad -3 \quad -2 \quad -1 \quad 0 \quad 1 \quad 2$

$$f_{xz^2}$$

$m \quad 3$

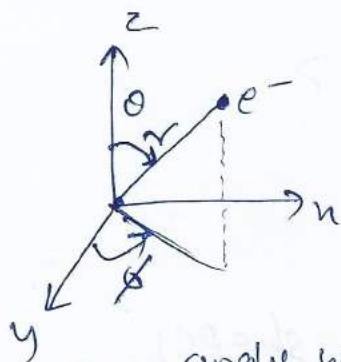
$\Psi \rightarrow$ wave function can be broken in to two parts

$$\Psi_{nlm}(r, \theta, \phi) = \underbrace{R_{nl}(r)}_{\text{radial part}} \underbrace{Y_{lm}(\theta, \phi)}_{\text{angular part}}$$

$r \rightarrow$ distance from the nucleus

\downarrow
represents the

e^- density w.r.t. to distance from nucleus



$\theta \rightarrow$ angle w.r.t. the z-axis

$$\theta \in [0, \pi]$$

$\phi \rightarrow$ angle of projection of r w.r.t. the y-axis

$$\phi \in [0, 2\pi]$$

$\Psi \rightarrow$ depends on n, l, m
Q. Nos.

$R(r) \rightarrow$ depends on n & l
Q. Nos.

angular part depends on l & m .

Radial part $R_{nl}(r)$

Examples of $R(r)$ for H like species

	n	l	$R_{nl}(r)$
1s	1	0	$2 \left(\frac{z}{a_0} \right)^{3/2} e^{-zr/a_0}$
2s	2	0	$\left(\frac{z}{2a_0} \right)^{3/2} \left(2 - \frac{zr}{a_0} \right) e^{-\frac{zr}{2a_0}}$
2p	2	1	$\frac{1}{\sqrt{3}} \left(\frac{zr}{2a_0} \right)^{3/2} \left(\frac{zr}{a_0} \right) e^{-zr/2a_0}$

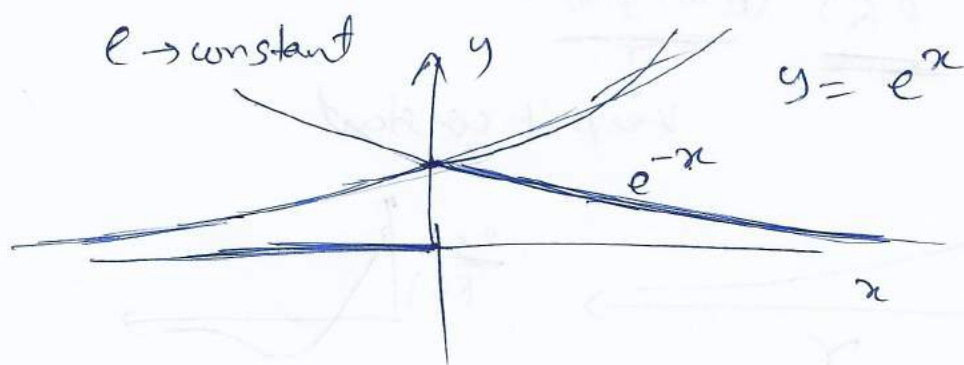
$z \rightarrow$ atomic No.

$a_0 \rightarrow$ radius of first bohr orbit

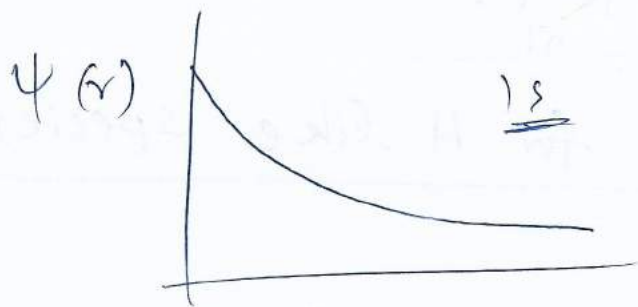
$r \rightarrow$ distance of e^- from the nucleus.

$R_{nl}(r) \rightarrow$ represents the distribution of e^- density as a function of distance r from the nucleus.

e^x or $e^{-x} \rightarrow$ Exponential functions



$$\begin{aligned} x \rightarrow \infty, y = e^\infty &= \infty \\ x \rightarrow -\infty, y = e^{-\infty} &= \frac{1}{e^\infty} \\ &= \frac{1}{\infty} \sim 0 \end{aligned}$$

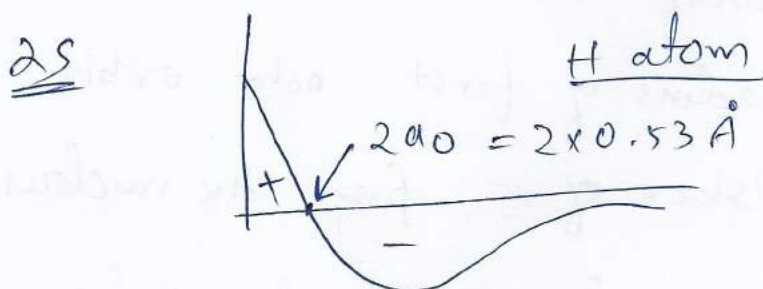


node is located where $R_{nl}(r) = 0$

$$\frac{2s}{2s} \quad 2 - \frac{2r}{a_0} = 0$$

$$r = \frac{2a_0}{2}$$

for $z=1$ (H atom) $\Rightarrow r = 2a_0$

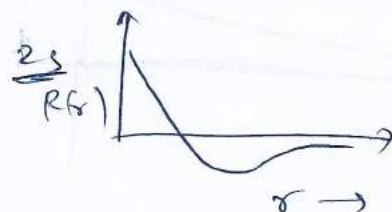
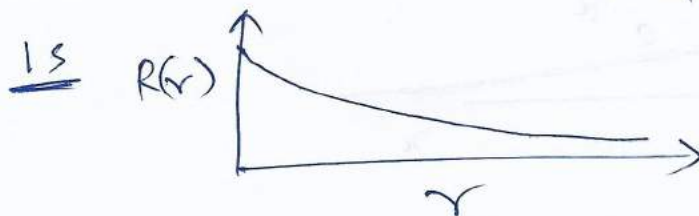


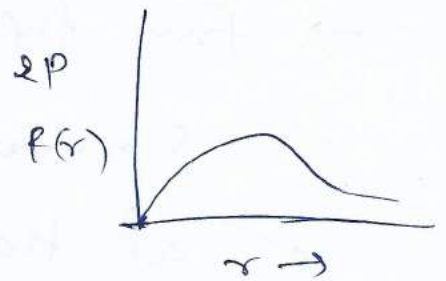
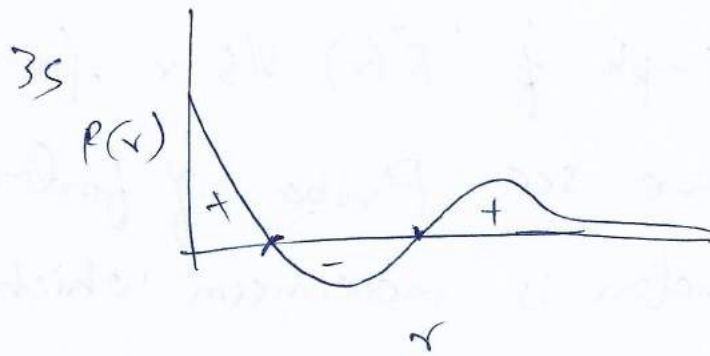
$\psi(r)$ v/s $r \rightarrow$ we have drawn

(i) Plot of Radial wave function ($R_{nl}(r)$)

w.r.t. r

$$\psi(r) = \underline{\underline{R(r)}} \underbrace{\Theta(\theta) \Phi(\phi)}_{\text{keep it constant}}$$





$\psi(r)$ & $R(r)$ have same shape

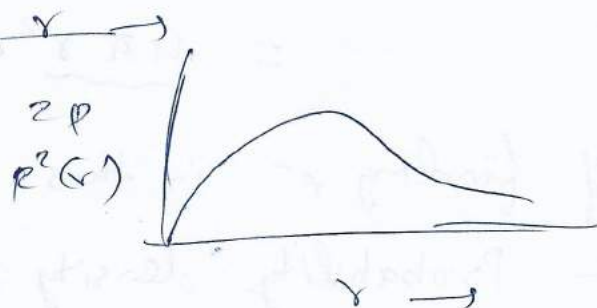
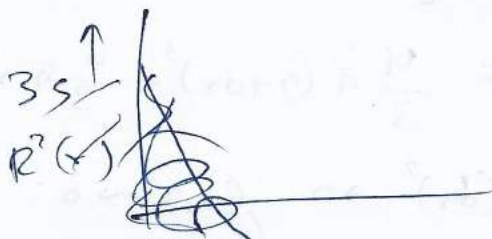
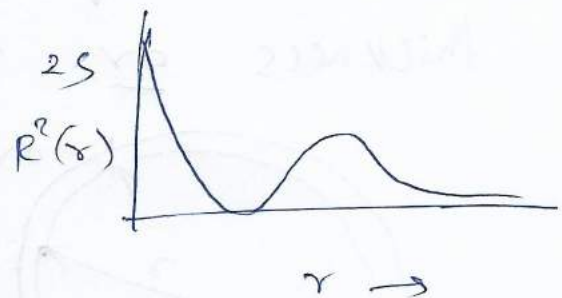
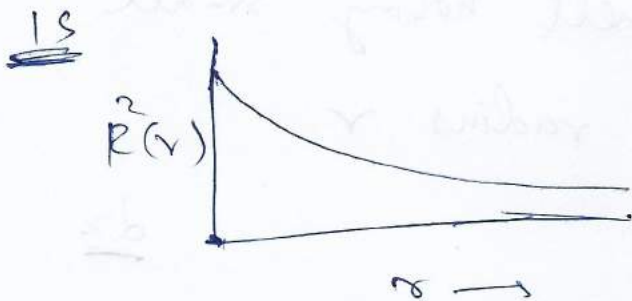
$R(r) = 0 \Rightarrow$ node

(2) Plot of Radial Probability Density ' R^2 '

$\psi^2 \rightarrow$ represents the probability

$R^2 \rightarrow$ represents the probability density

Probability per unit volume

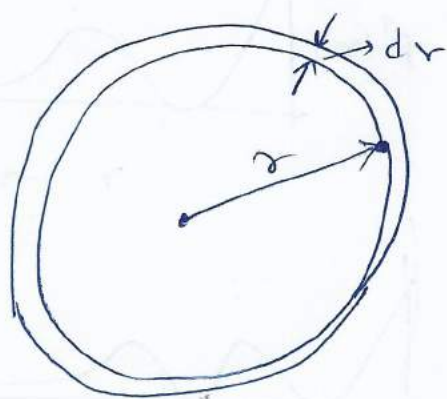


→ from the graph of $R^2(r)$ vs r for s orbital we see Proba. of finding e^- at the nucleon is maximum which is not possible

$R^2(r) \rightarrow$ Probability at a distance r from the nucleon



→ To ~~better~~ visualize the e^- cloud around the nucleus the $R^2(r)$ is multiplied by the volume of a shell having small thickness dr & radius r



volume of this shell

$$= \frac{4}{3} \pi (r+dr)^3 - \frac{4}{3} \pi r^3$$

$$(dr)^2 \rightarrow 0, (dr)^3 \rightarrow 0$$

$$= \underline{4\pi r^2 dr}$$

Probability of finding e^- in this shell

$$= \text{Probability density} \times \text{volume of the shell}$$

$$= \underbrace{R^2(r)} \times 4\pi r^2 dr$$

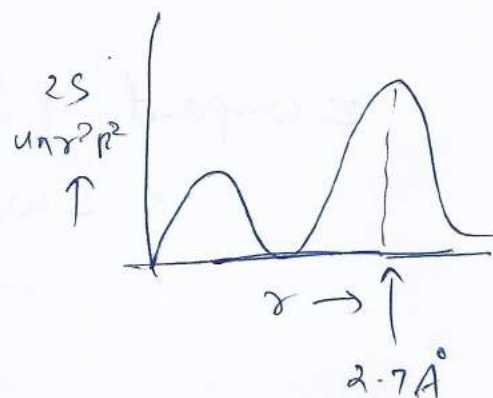
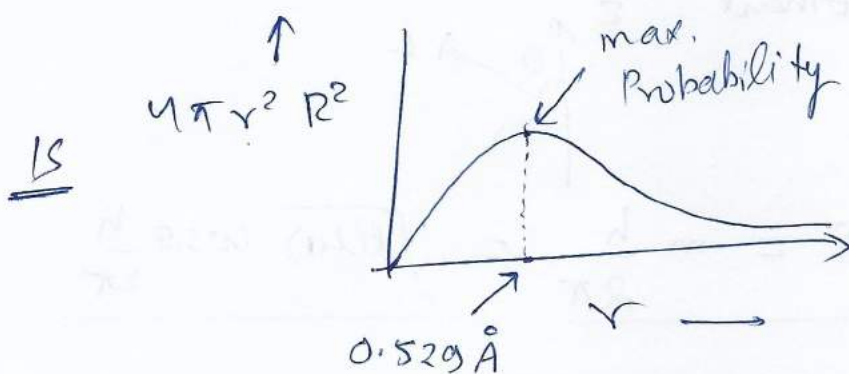
$$= \underbrace{P(r)} dr$$

Radial Probability function (RPF)

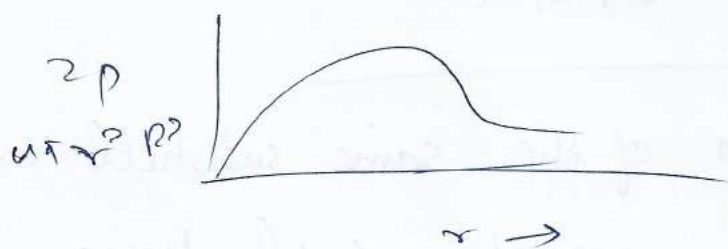
or

Radial Distribution function (RDF)

$$\underline{P(r) \propto r}$$

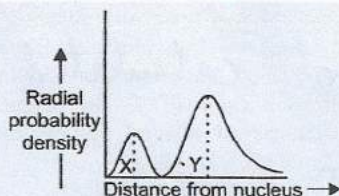


$$r=0 \Rightarrow 4\pi r^2 R^2 = 0$$



No. of peaks = $n - l$ in the graph
of $4\pi r^2 R^2$ vs r

Objective Questions



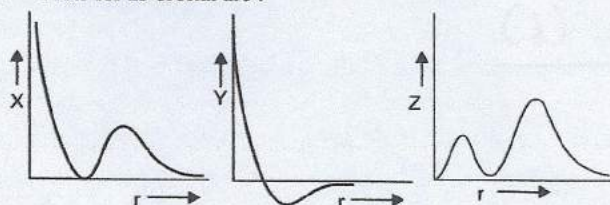
If the above radial probability curve indicates '2s' orbital, the distance between the peak points X, Y is :

- (a) 2.07 Å (b) 1.59 Å (c) 0.53 Å (d) 2.12 Å

[Ans. (a)]

[Hint : $X = 0.53 \text{ Å}$, $Y = 2.6 \text{ Å}$
 $Y - X = 2.6 - 0.53 = 2.07 \text{ Å}$]

2. Plots for 2s orbital are :



X, Y and Z are respectively :

- (a) R , R^2 and $4\pi r^2 R^2$ (b) R^2 , R and $4\pi r^2 R^2$
 (c) $4\pi r^2 R^2$, R^2 and R (d) R^2 , $4\pi r^2 R^2$ and R

[Ans. (b)]

[Hint : Y will be definitely 'R' because value of R cannot be negative, thus X will be R^2 and Z will be $4\pi r^2 R$. Z represents radial probability function; its value will be zero at origin]

3. The wave function (Ψ) of 2s is given by :

$$\Psi_{2s} = \frac{1}{2\sqrt{2\pi}} \left(\frac{1}{a_0} \right)^{1/2} \left\{ 2 - \frac{r}{a_0} \right\} e^{-r/2a_0}$$

At $r = r_0$, radial node is formed. Thus for 2s, r_0 in terms of a_0 is :

- (a) $r_0 = a_0$ (b) $r_0 = 2a_0$ (c) $r_0 = a_0/2$ (d) $r_0 = 4a_0$

[Ans. (b)]

[Hint : When $r = r_0$, $\Psi_{2s} = 0$, then from the given equation:

$$2 - \frac{r}{a_0} = 0$$

$$r = 2a_0$$

4. The wave function for 1s orbital of hydrogen atom is given by:

$$\Psi_{1s} = \frac{\pi}{\sqrt{2}} e^{-r/a_0}$$

where, a_0 = Radius of first Bohr orbit

r = Distance from the nucleus (Probability of finding the electron varies with respect to it)

What will be the ratio of probabilities of finding the electrons at the nucleus to first Bohr's orbit a_0 ?

- (a) e (b) e^2 (c) $1/e^2$ (d) zero

[Ans. (d)]

[Hint : For 1s orbital, probability of finding the electron at the nucleus is zero.]

5. The radial wave equation for hydrogen atom is :

$$\Psi = \frac{1}{16\sqrt{\pi}} \left(\frac{1}{a_0} \right)^{3/2} [(x-1)(x^2-8x+12)] e^{-x/2}$$

where, $x = 2r/a_0$; a_0 = radius of first Bohr orbit.

The minimum and maximum position of radial nodes from nucleus are :

- (a) $a_0, 3a_0$ (b) $\frac{a_0}{2}, 3a_0$ (c) $\frac{a_0}{2}, a_0$ (d) $\frac{a_0}{2}, 4a_0$

[Ans. (b)]

[Hint : At radial node, $\Psi = 0$

\therefore From given equation,

$$x-1=0 \text{ and } x^2-8x+12=0$$

$$x-1=0 \Rightarrow x=1$$

$$\text{i.e., } \frac{2r}{a_0} = 1; r = \frac{a_0}{2} \text{ (Minimum)}$$

$$x^2 - 8x + 12 = 0$$

$$(x-6)(x-2) = 0$$

$$\text{when } x-2=0$$

$$x=2$$

$$\frac{2r}{a_0} = 2, \text{ i.e., } r = a_0 \text{ (Middle value)}$$

$$\text{when } x-6=0$$

$$x=6$$

$$\frac{2r}{a_0} = 6$$

$$r = 3a_0 \text{ (Maximum)}$$

m (magnetic q. No.)

→ gives the z component of the orbital angular momentum

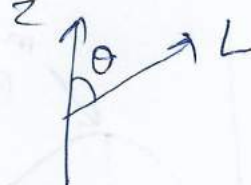
$$\text{Total Angular momentum} = \frac{n h}{2\pi}$$

$$\text{Orbital angular momentum} = \sqrt{l(l+1)} \frac{h}{2\pi} = L$$

(L)

$L_z \rightarrow z$ component

z component of L



$$= L \cos \theta = m \frac{h}{2\pi} = \sqrt{l(l+1)} \cos \theta \frac{h}{2\pi}$$

$$\Rightarrow \underline{m = \sqrt{l(l+1)} \cos \theta}$$

Characteristics of Orbitals


→ All orbitals of the same subshell in the absence of magnetic field have same energy i.e. they are degenerate



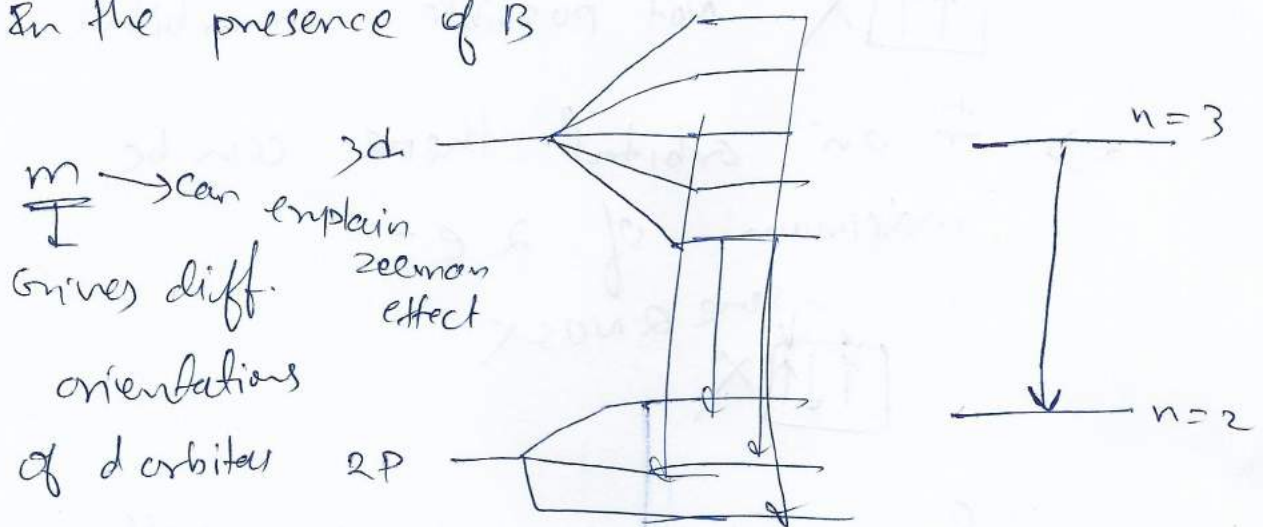
Energy → $d_{xy} = d_{yz} = d_{zx} = d_{x^2-y^2} = d_{z^2}$

• $\hookrightarrow P_x = P_y = P_z$

Zeeman effect \rightarrow splitting of spectral lines in the presence of magnetic field (B)

In the absence of B 

In the presence of B



(4) Spin Q. NO. (s)

\rightarrow spin of e^- around its own axis

(i) For clockwise spin $s = +\frac{1}{2}$ (\uparrow)

(ii) For anticlockwise spin $s = -\frac{1}{2}$ (\downarrow)

Pauli's Exclusion principle

\rightarrow No two e^- s in an atom can have the same value of all the four Quantum Nos.

max. capacity of a subshell = $2(2l+1)$
 each can have
 max $2e^-$

l

$$\begin{array}{c} -l \quad \dots \quad 0 \quad \dots \quad +l \\ \hline \quad \quad \quad \downarrow \quad \quad \quad \\ \quad \quad \quad 1 \quad \quad \quad \\ \hline = 2l+1 \rightarrow \text{orbitals} \end{array}$$

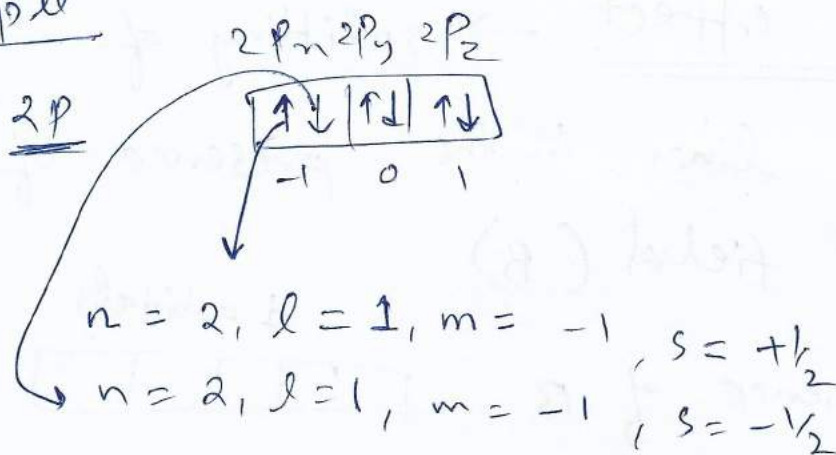
→ No. of subshells in a main energy shell = n


<u>n</u>	<u>l</u>	<u>No. of subshells</u>
1	0	1s = 1
2	0, 1	2s, 2p = 2
3	0, 1, 2	3s, 3p, 3d = 3
⋮		
n		<u>n subshells</u>

→ no. of orbitals in a main energy shell = n^2

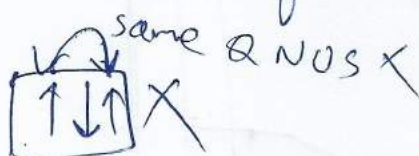
<u>n</u>	<u>l</u>	<u>no. of orbitals</u>
1	0	1s = 1
2	0, 1	2s, 2p _x , 2p _y , 2p _z = 4
3	0, 1, 2	3s, 3p _x , 3p _y , 3p _z , 3d _{xy} , 3d _{yz} , 3d _{xz} , 3d _{z^2} = 9

Example



 Not possible in an orbital

⇒ In an orbital there can be maximum of 2 e-



<u>l</u>	<u>max. capacity of subshells</u>
0	s → 2 e-
1	p → p_x, p_y, p_z → 6 e-
2	d → 5d orbitals → 10 e-
3	f → 7f orbitals → 14 e-

~~No.~~ No. of orbitals in a given subshell = $(2l+1)$

$l = 0 \Rightarrow s = 2 \times 0 + 1 = 1$ (1 s) sub No. of orbitals

$l = 1 \Rightarrow p \Rightarrow 2 \times 1 + 1 = 3$ (p_x, p_y, p_z)

$l = 2 \Rightarrow d \Rightarrow 2 \times 2 + 1 = 5$ ($d_{xy}, d_{yz}, d_{zx}, d_{x^2-y^2}, d_{z^2}$)

max. capacity of a main energy shell

$$= 2 \times \frac{n^2}{\text{no of orbitals}}$$

max. capacity of each orbital

$s \rightarrow$ spin angular momentum Q. No.

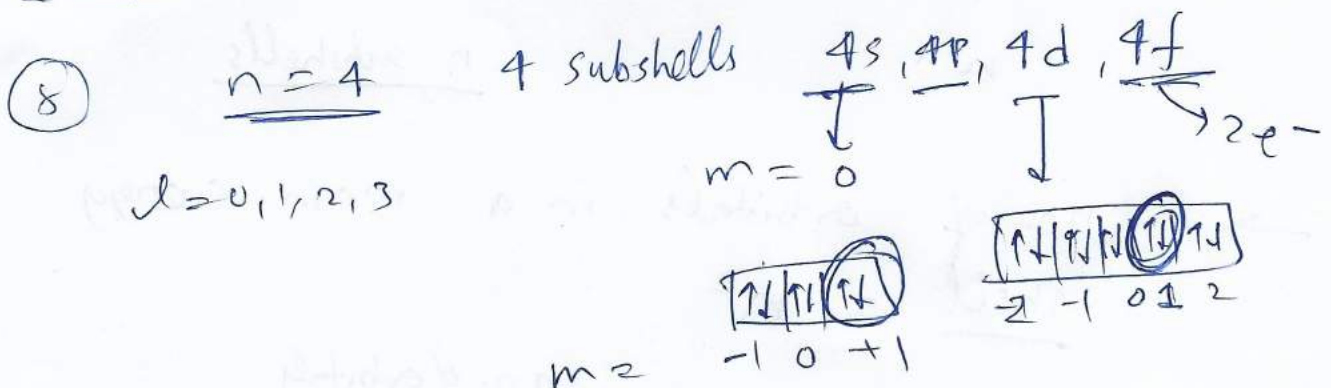
spin angular momentum $L_s = \sqrt{s(s+1)} \frac{h}{2\pi}$

where $s \rightarrow$ Spin of the Q. No. of the e^- ($\frac{1}{2}$)

for H atom e^- , $L_s = \sqrt{\frac{1}{2}(\frac{1}{2}+1)} \frac{h}{2\pi}$

$$s = \frac{1}{2} \quad = \quad \frac{\sqrt{3}}{2} \times \frac{h}{2\pi} \quad \left\{ \frac{h}{2\pi} = \hbar \right\}$$
$$= \frac{\sqrt{3}}{2} \times \hbar$$

Examples



Total = 6

Examples

① The orbital angular momentum of an electron in a d-orbital is?

Ans.

$$L = \sqrt{l(l+1)} \frac{h}{2\pi} = \sqrt{2(2+1)} \frac{h}{2\pi} = \sqrt{6} \frac{h}{2\pi}$$

② which of the following sets of quantum numbers is correct for an electron in 4f-orbital?

(a) $n = 4, l = 3, m = +4, s = +\frac{1}{2}$

(b) $n = 4, l = 4, m = -4, s = -\frac{1}{2}$

(c) $n = 4, l = 3, m = +1, s = +\frac{1}{2}$

(d) $n = 3, l = 2, m = -2, s = +\frac{1}{2}$

Ans.(c)

③ match the following:

(A) The number of sub-energy levels in an energy level (P) n^2

(B) The number of orbitals in a sub-energy level (Q) $3d$

(C) The number of orbitals in an energy level (R) $2l+1$

(D) $n=3, l=2, m=0$ (S) n

Ans. (A) \rightarrow (S), (B) \rightarrow (R), (C) \rightarrow (P), (D) \rightarrow (Q)

④ Which of the following is not possible?

(a) $n=2, l=1, m=0$

(b) $n=2, l=0, m=-1$

(c) $n=3, l=0, m=0$

(d) $n=3, l=1, m=-1$

Ans. (b)

⑤ What is the maximum number of electrons in an atom that can have quantum numbers $n=4, m_s = +1/2$?

(a) 4

(b) 15

(c) 3

(d) 1

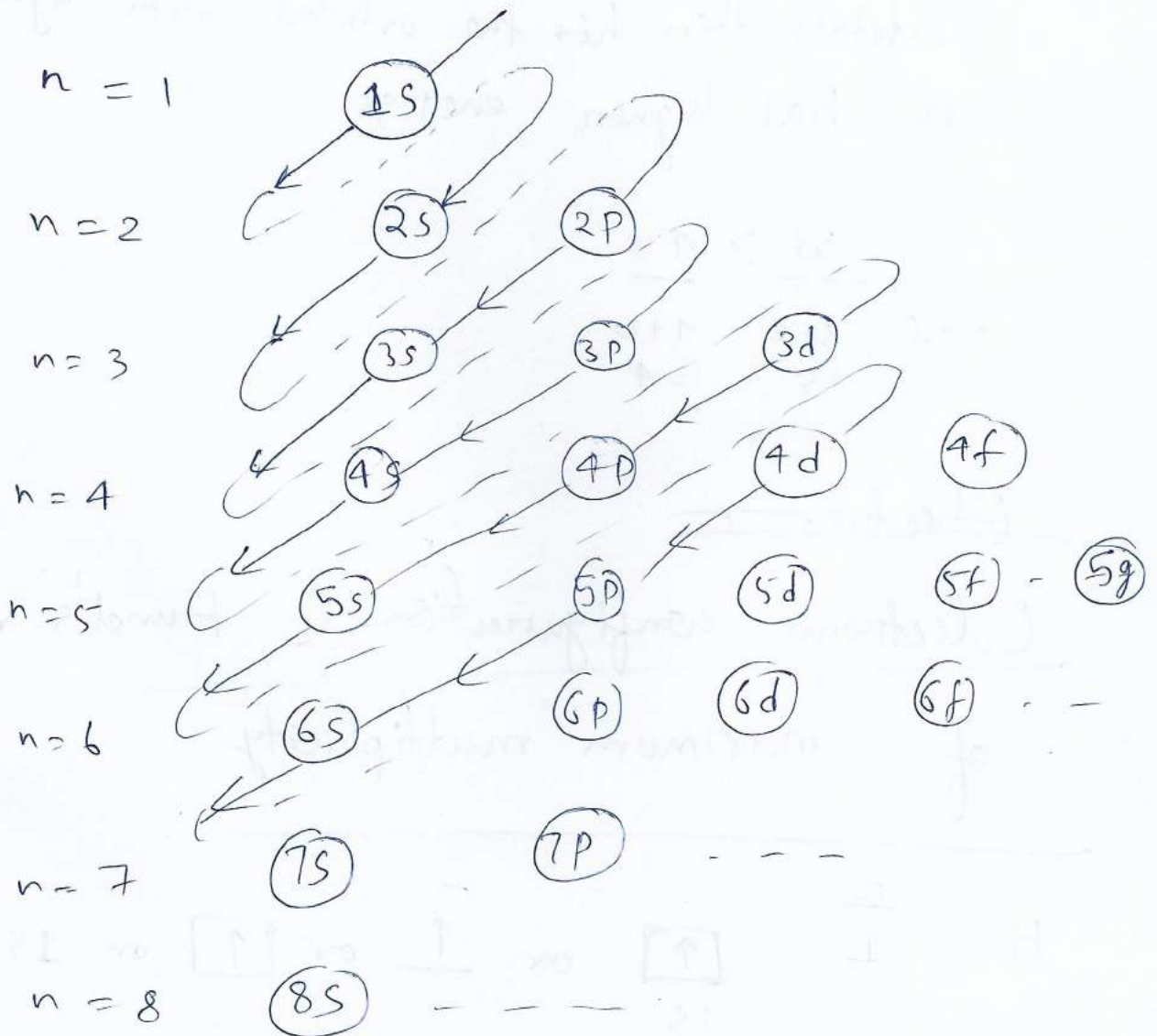
(e) 6

Ans. (e)

Aufbau Principle

→ Gives the energy order of various orbitals

→ German word means building up



Energy order

$1s < 2s < 2p < 3s < 3p < \underline{4s} < \underline{3d} < 4p < 5s \dots$

→ Increasing energy

→ rule which determines the energy order is called $(n+l)$ rule

(n+l) rule

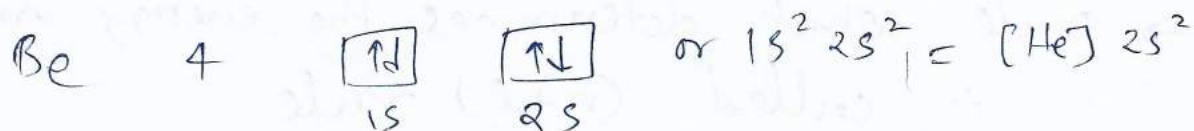
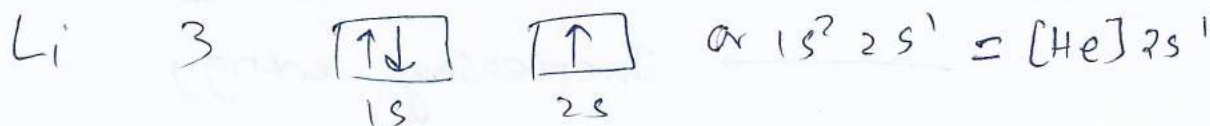
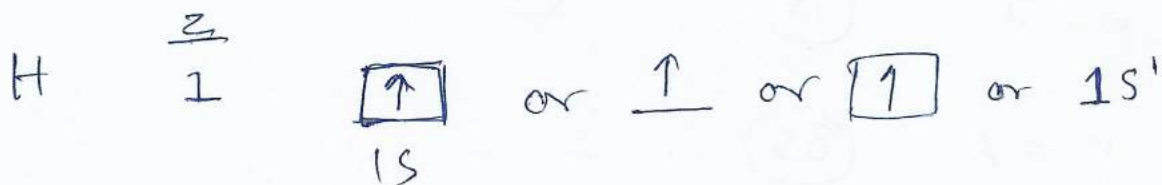
→ higher the value of $n+l$ higher is the energy of the orbital

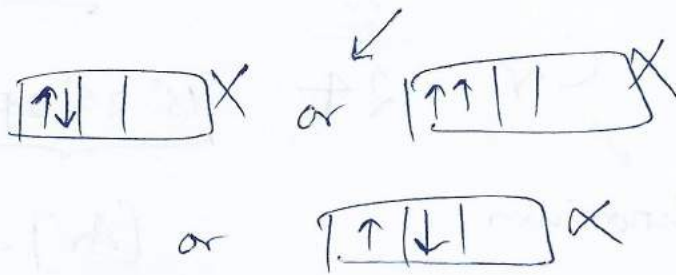
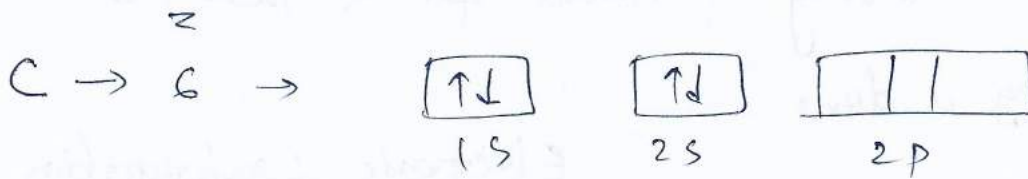
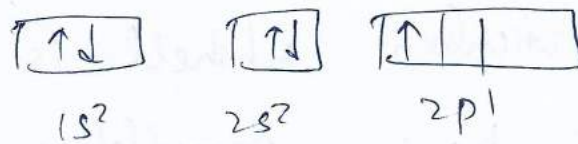
→ if $n+l$ is same for two different orbitals then the orbital with higher n has higher energy.

$$\begin{array}{ccc} \underline{3d} & > & \underline{4s} \\ n+l & 3+2 & 4+0 \\ & =5 & =4 \end{array}$$

~~Electric a~~

Electronic configuration & Hund's rule of maximum multiplicity



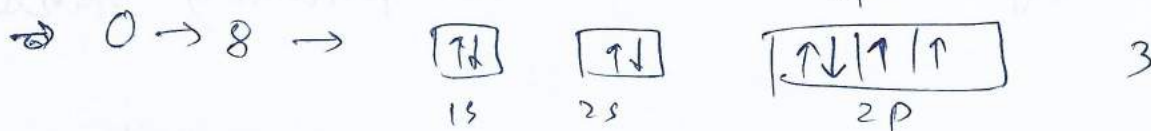
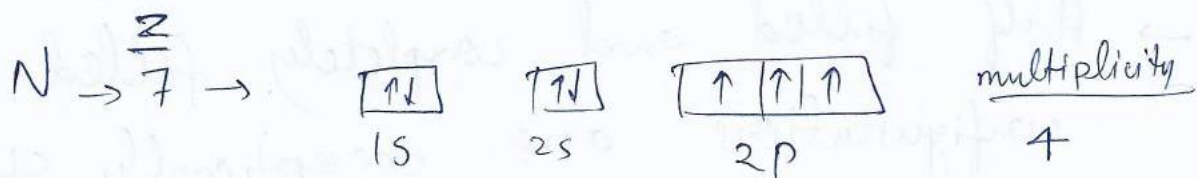


Hund's rule of maximum multiplicity

e^- are distributed among the orbitals of a subshell in such a way as to give the maximum no. of unpaired e^- with parallel spin

multiplicity = $2\Sigma S + 1$

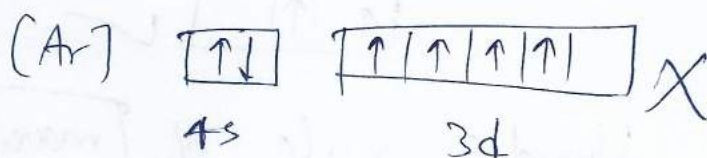
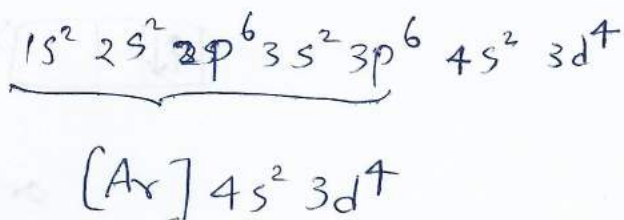
\checkmark
 should be maximum $\Sigma S = \text{total spin} = \underset{\substack{\downarrow \\ \text{no. of unpaired } e^-}}{n} \times \frac{1}{2}$



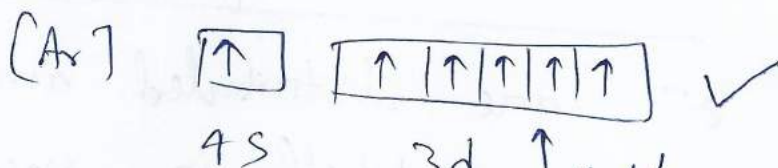
→ while writing the electronic configuration a particular subshell is filled singly with e^- having parallel spin & then the pairing is done

Electronic configuration

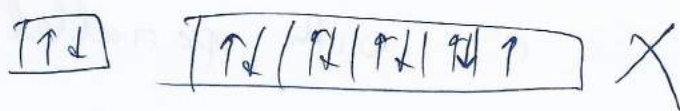
Cr $\frac{Z}{24}$
✓
Chromium



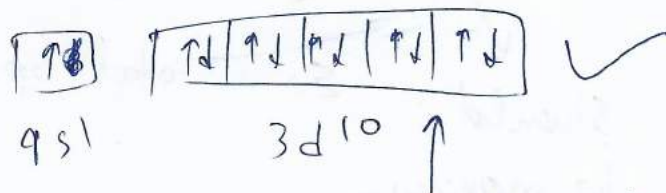
Correct



Cu $\frac{Z}{29}$ $(\text{Ar}) 4s^2 3d^9$ Half filled



correct $(\text{Ar}) 4s^1 3d^{10}$



↑
completely filled

→ Half filled and completely filled configurations are exceptionally stable

Explanation

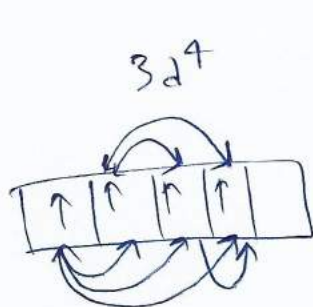
(i) Symmetry

⇒ half filled & completely filled configurations are more symmetric. Symmetry always leads to stability.

(ii) Exchange energy

→ wherever there is exchange between e^- there is energy released.

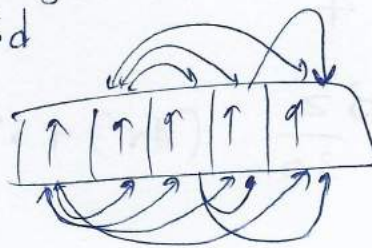
energy released ⇒ stability



$$3 + 2 + 1 = 6$$

↑
total exchange

$3d^5$



$$4 + 3 + 2 + 1 = 10$$

↑
total exchange

more exchanges

⇒ more stability

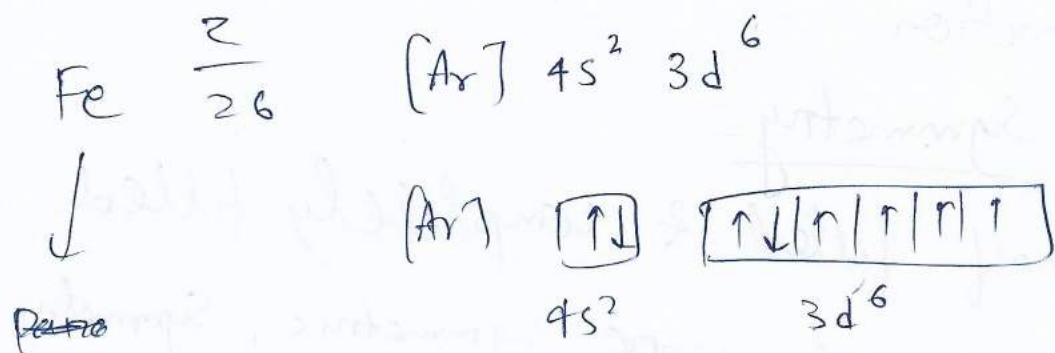
more energy is released

↳ lesser energy ⇒ more stability.

Paramagnetic material → material having

atoms with atleast one unpaired e^- .

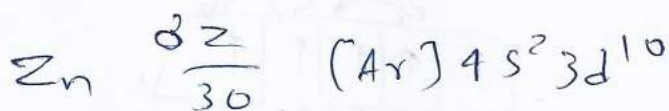
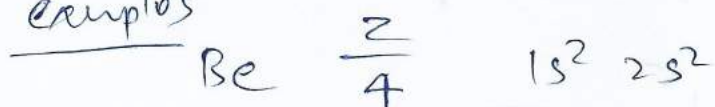
↳ weakly attracted by magnetic field



Fe metal is paramagnetic in nature has 4 unpaired e^-

Diamagnetic material (No attraction for magnetic field)
 \rightarrow has no unpaired e^-

examples



Magnetic moment (Determines the strength of magnetic nature of an atom)
 (μ)

$$\mu = \sqrt{n(n+2)} \quad \text{B.M.} \quad \begin{matrix} \nearrow \text{unit of } \mu \\ \nearrow \end{matrix}$$

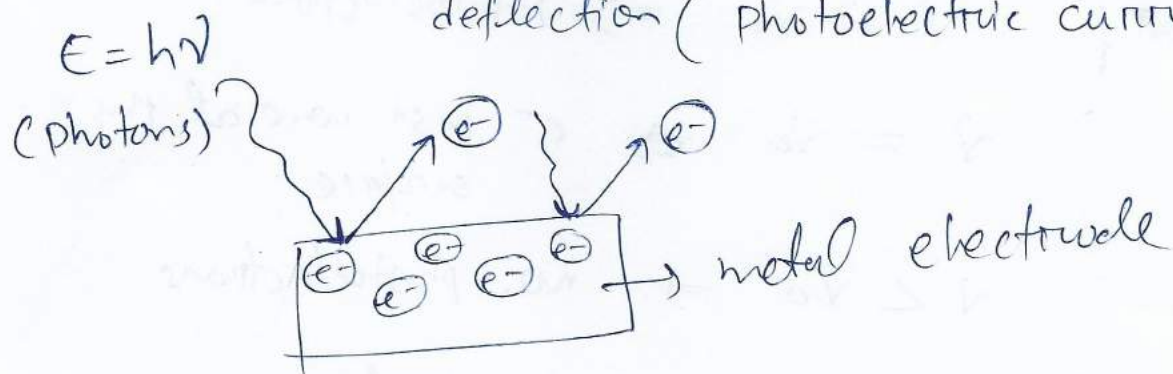
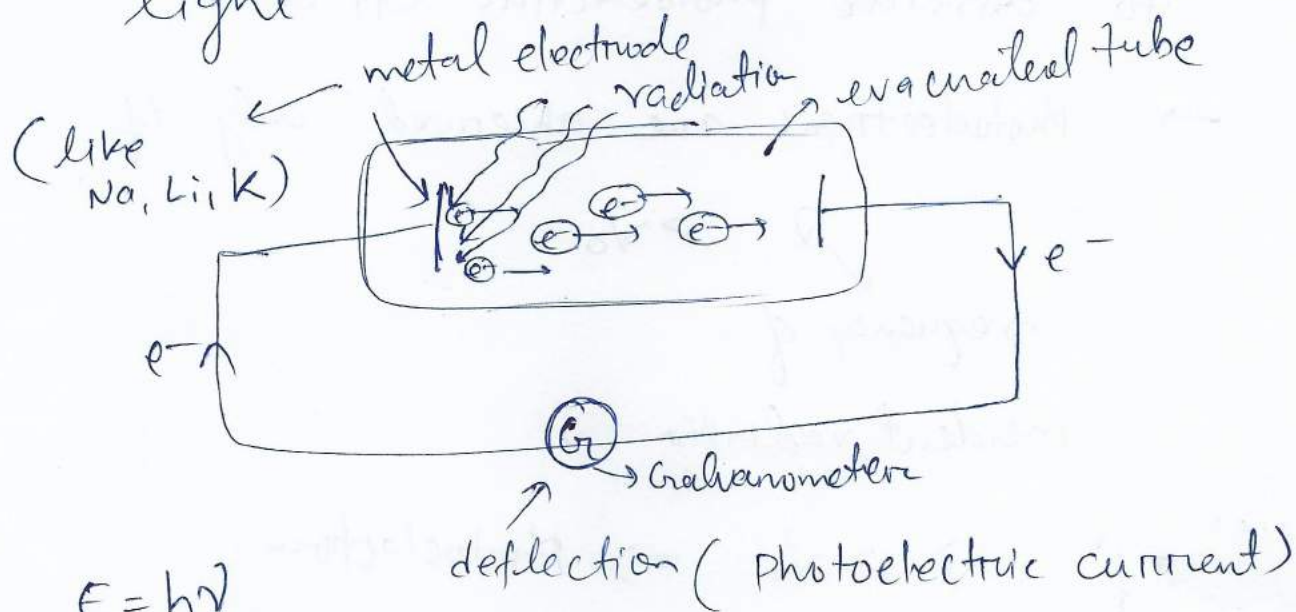
$n \rightarrow$ no. of unpaired e^- Bohr magneton.

$$1 \text{ B.M.} = \frac{eh}{4\pi mc}$$

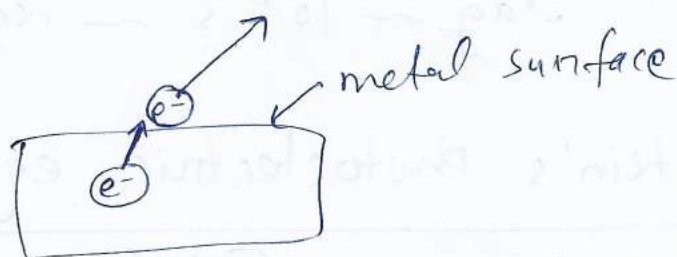
Properties Based on particle nature of e^-

(i) Photoelectric effect

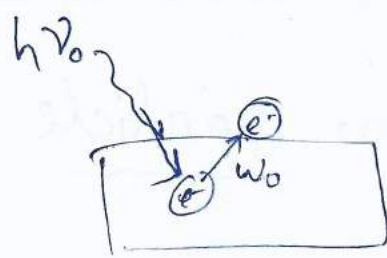
→ shows the particle nature of light



→ certain minimum frequency is required to observe photo electric effect



w_0 → work function → min. energy required to bring e^- from inside the metal on to the surface.



$$h\nu_0 = w_0$$

Threshold frequency \rightarrow min. frequency to observe photoelectric effect

\rightarrow Photoelectrons are observed only if

$\nu > \nu_0$
frequency of incident radiation

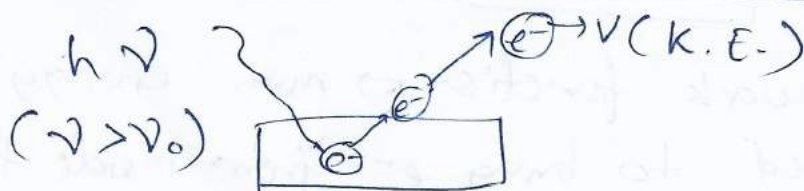
If $\nu > \nu_0 \Rightarrow$ photoelectron

$\nu = \nu_0 \Rightarrow e^-$ just come at the surface

$\nu < \nu_0 \rightarrow$ no. photoelectrons

\rightarrow Photoelectrons are observed as soon as light falls on the metal surface
lag $\sim 10^{-8}$ s \sim negligible

Einstein's photoelectric equation



$$h\nu = \underbrace{w_0}_{\text{work function}} + \underbrace{\frac{1}{2}mv^2}_{\text{K.E. of } e^-}$$

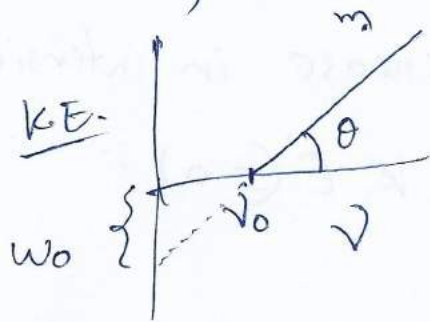
total energy

$$w_0 = h\nu_0$$

$$h\nu = h\nu_0 + \frac{1}{2}mv^2$$

If $\nu = \nu_0 \Rightarrow \text{K.E.} = 0$

$$\frac{\text{K.E.}}{y} = \frac{h\nu}{x} - \frac{w_0}{c} \rightarrow \text{intercept.}$$

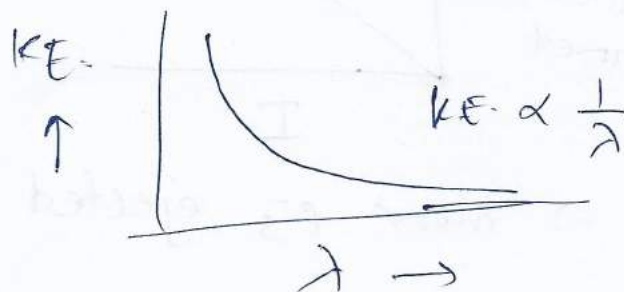


$$\text{slope} = \tan \theta = m = h$$

Slope

$$\text{K.E.} = \frac{hc}{\lambda} - h\nu_0 = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$$

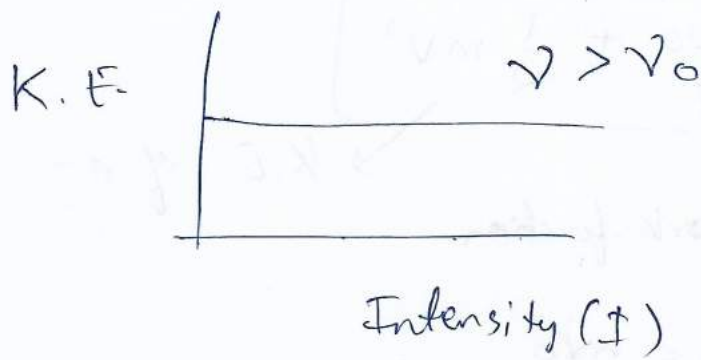
$$\text{K.E.} = hc \left(\frac{1}{\lambda} - \frac{1}{\lambda_0} \right)$$



Threshold wavelength

Intensity variation of K.E w.r.t. Intensity of light

$$\text{Intensity} \propto \text{no. of photons.}$$



$$K.E. = h\nu - h\nu_0$$

depends only on ν

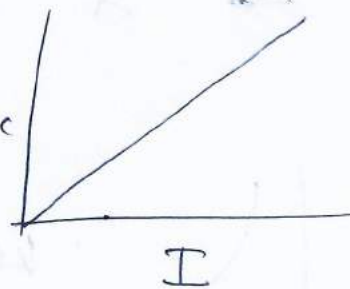
K.E. is independent of Intensity of light

→ if $\nu < \nu_0$, increase in intensity will have no effect on K.E. (≤ 0)

→ 1 photon ejects one e^-

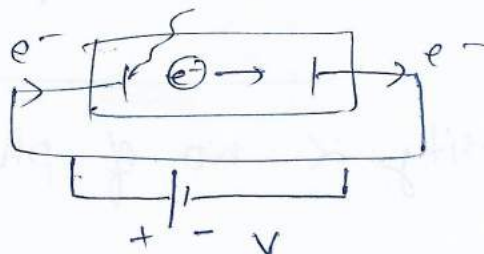
if $\nu > \nu_0$

photoelectric current

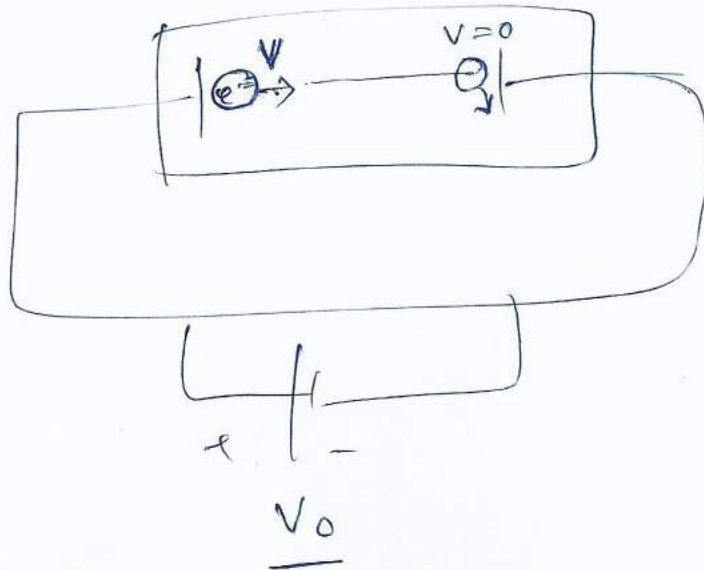


more photons \Rightarrow more e^- ejected

Stopping Potential (V_0)

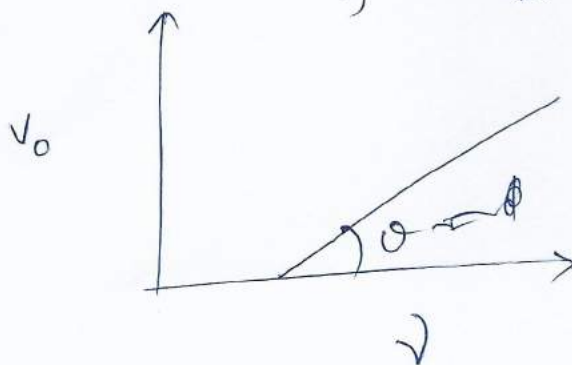


$V_0 \rightarrow$ minimum potential required to stop photoelectric emission
 or
 for zero photoelectric current



$$K.E. = eV_0 = h\nu - h\nu_0$$

$$\Rightarrow V_0 = \underbrace{\left(\frac{h}{e}\right)}_m \underbrace{\nu}_x - \underbrace{\frac{h\nu_0}{e}}_c$$



$$m = \text{slope} = \tan \theta = \frac{h}{e}$$

$$\text{intercept} = \frac{h\nu_0}{e} = \frac{w_0}{e}$$

* V_0 depends only on ν not on intensity of light used.