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12/07/17

Atomic Structure

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Democritus :- a Greek philosopher
atom $\Rightarrow$ "a-tomio" $\rightarrow$ indivisible / uncuttable

Dalton :-

- Matter is consist of small particles which is indivisible, called atom.
- Atom neither be created nor be destroyed.
- Atom of same element are same but atom of different element are different.
- Atom has mass
- Atom take part in Chemical reacⁿs.

Ques

Which of the following law of chemical combination is not proved by Dalton?

- ① law of mass conservation
- ② law of definite proportion
- ③ law of multiple proportion
- ✓ ④ Avogadro's law

Atomic Model :-

Thomson's Model : (Plum-Pudding Model)

- e^- are uniformly distributed in atom.
- atom is neutral.
- net +ve charge on atom $\approx$ net -ve charge on e^-
- mass of atom is uniformly distributed.

Drawback :-

- e^- are not stationary they are revolving around nucleus.

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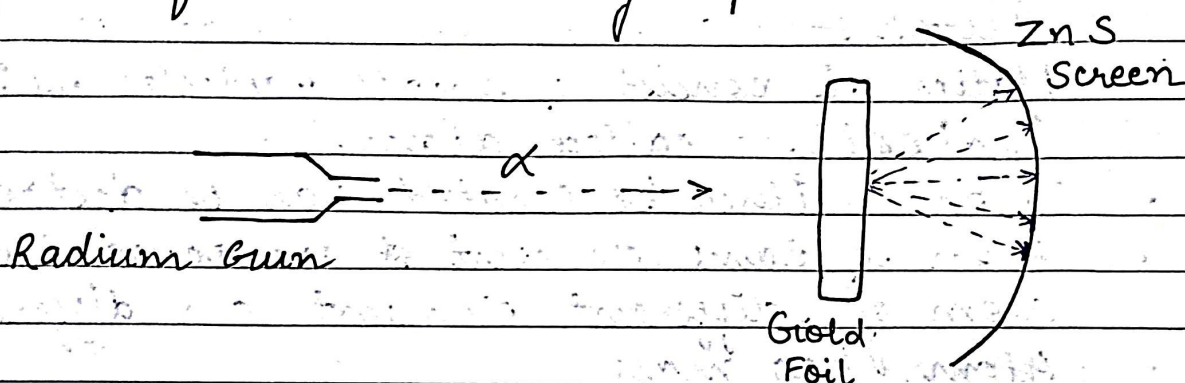
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- mass of atom is concentrated in nucleus.

Rutherford Model :-

Rutherford α -Scattering experiment :-

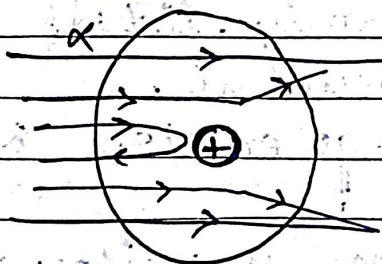


Observation :-

- ① Most of the α particles pass undeflected
- ② A few particles deflected at some angle
- ③ A very few (1 out of 20000) particles deflected at 180° .

Conclusion :-

- ① Most part of atom is vacant.
- ② Atom has some +ve charge in it.
- ③ +ve charge of atom is concentrated in nucleus.



$$\alpha = \text{He}^{++}$$

= +vely charged He ion

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Result :-

- Total +ve charge of atom is concentrated in nucleus.
- e^- are revolving around nucleus.
- mass of atom is concentrated at nucleus. Proton & neutrons are present in nucleus which is also called nucleons.

Size of nucleus is very small.

radius of atom (r_A) = 10^{-10} m

radius of nucleus (r_N) = 10^{-15} m

$$\frac{r_A}{r_N} = \frac{10^{-10}}{10^{-15}} = 10^5$$

$$r_A = 10^5 \times r_N$$

$$\frac{\text{Vol. of atom}}{\text{Vol. of nucleus}} = \frac{\frac{4}{3} \pi r_A^3}{\frac{4}{3} \pi r_N^3} = \frac{(10^{-10})^3}{(10^{-15})^3} = 10^{15}$$

$$\text{Vol. of atom} \approx 10^{15} \times \text{Vol. of nucleus}$$

Radius of Nucleus :-

$$R = R_0 (A)^{1/3}$$

$A \rightarrow$ mass no.

$R_0 =$ b/w 1.11×10^{-15} m to 1.44×10^{-15} m
generally = 1.2×10^{-15} m

Ques Calculate radius of Al ($A = 27$)

$$R = R_0 (A)^{1/3}$$

$$= 1.2 \times 10^{-15} (27)^{1/3}$$

$$= 3.6 \times 10^{-15} \text{ m}$$

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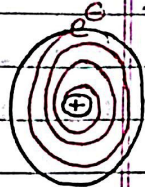
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Drawback :-

- He could not explain stability of atom.

Maxwell Electromagnetic Theory :-



Accⁿ to Maxwell, a moving charged particle lose its energy.

So a e^- moving in circular orbit will lose energy & its orbit become smaller & smaller and finally e^- falls in nucleus.

- He could not explain H-spectrum

Atomic Number ^(Z) :- It is no. which represent no. of protons in an atom.

For neutral atom

$$Z = \text{no. of proton} = \text{no. of } e^-$$

For charged atom

$$Z = \text{no. of proton} \\ = \text{no. of } e^- \text{ in charged atom} + \text{charge on atom}$$

$$\text{Na}^+ \rightarrow 11 = \text{no. of proton} = Z \\ \text{no. of } e^- = 10$$

$$Z = 10 + 1 = 11$$

$$\text{F}^- \text{ no. of proton} = 9 = Z$$

$$\text{no. of } e^- = 10$$

$$Z = 10 + (-1) = 9$$

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Mass Number : (A)

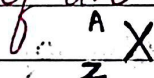
- no. of proton and neutron is called mass no.
- It is also kn as no. of nucleons (n+p)

$$A = n + p$$

$$A = n + z$$

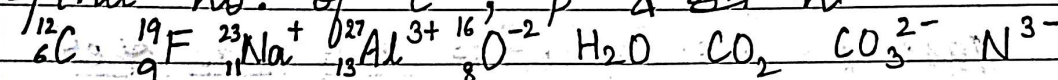
$$n = A - z$$

Representation of an element:-



Ques

find no. of e, p & ~~z~~ n



e	6	9	10	10	10	10	22	32	10
p	6	9	11	13	8	10	22	30	7
n	6	10	12	14	8	8	22	30	7

	SO_2	SO_3	H_2SO_4	SO_4^{2-}	S^{-2}	
		80	$2 + 32 + 64$ 98	$32 + 64 = 96$ 16 32		$\frac{48}{32}$ 80
e	32	40	49	50	18	
p	32	40	49	48	16	
n	32	40	47	46	16	

Fundamental Particle of Atom:-

Particle	discovered by	Charge			mass	
		esu	Coulomb	relative	amu	kg
Electron	J.J. Thomson	-4.8×10^{-10}	-1.6×10^{-19}	-1	0.00054	9.1×10^{-31}
Proton	Goldstein	$+4.8 \times 10^{-10}$	$+1.6 \times 10^{-19}$	+1	1.007	1.673×10^{-27}
Neutron	James Chadwick	0	0	0	1.008	1.675×10^{-27}

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$$\frac{e}{m} = \frac{1.6 \times 10^{-19}}{9.1 \times 10^{-31}} = 1.758820 \times 10^{11} \text{ C/kg}$$

$$m_e = \frac{1}{1837} \times m_p$$

$$\text{mass of moving } e^- = \frac{\text{rest mass of } e^-}{\sqrt{1 - \left(\frac{v}{c}\right)^2}}$$

$v \rightarrow$ vel. of e^-

$c \rightarrow$ speed of light

Ques Mass for moving $e^- = \frac{\text{rest mass of } e^-}{\sqrt{1 - \left(\frac{v}{c}\right)^2}}$ then

which statement is correct :-

- ✓ (1) If $v \uparrow$ mass of $e^- \uparrow$
- (2) If $v \downarrow$ mass of $e^- \uparrow$
- (3) mass remains constant.
- (4) can't be said

Ques If no. of e^- present in X^{+3} is 10 then Find no. of e^- & p in X , X^{+2} , X^{-2} .

	X^{+3}	X	X^{+2}	X^{-2}
e	10	13	11	15
p	13	13	13	13

Ques If no. of protons present in X^{+2} is 14 & its mass no is 32 then find no. of e^- , p & n in X^{+3} , X , X^{-2} ?

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	X^{+2}	X^{+3}	X	X^{-2}
e	12	11	14	16
p	14	14	14	14
n	18	18	18	18

Ques

An element has 31.7% more neutrons as compare to no. of protons then find symbol of element if its mass no. is 81.

~~$$n = \frac{31.7}{100} \times p$$~~

~~$$p = 0.317 \times n$$~~

~~$$n = 0.317 p + p$$~~

~~$$81 = p + 0.317 p$$~~

~~$$81 = 1.317 p$$~~

~~$$p = \frac{81}{1.317}$$~~

~~81~~
~~81~~

$$n = p + 31.7\% p$$

$$n = Z + 31.7\% Z$$

$$A = n + p$$

$$81 = Z + 31.7\% Z + Z$$

$$= 2Z + \frac{31.7}{100} Z$$

$$81 = 2.317 Z$$

$$Z = 34.95$$

~~81~~
~~35~~

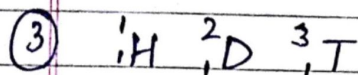
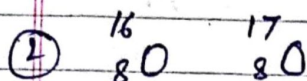
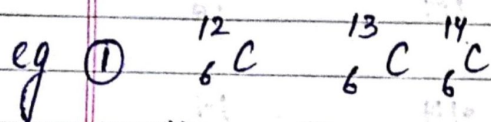
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समस्थानिक

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Isotope : Atoms which have same atomic number and different mass number.

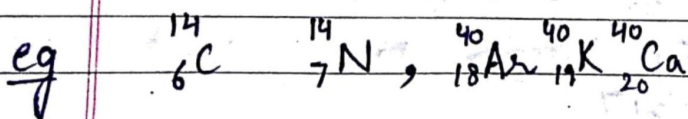


- Chemical Properties of isotopes are same. [Z = same]
- Physical Properties of isotope are different. (mass number different) i.e. - no. of e^- same

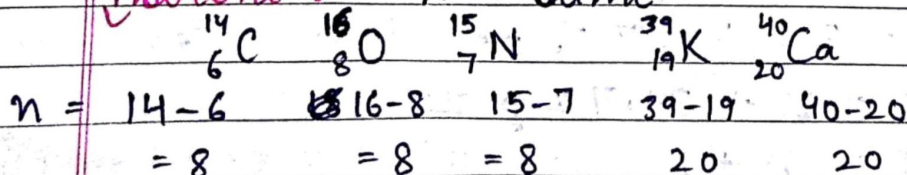
can't be separated by chemical properties and but can be separated by physical properties.

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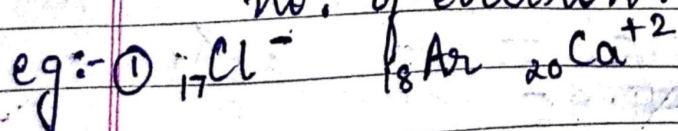
Z → different A → same



Isotone : n → same



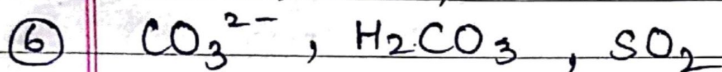
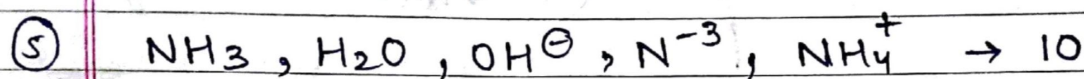
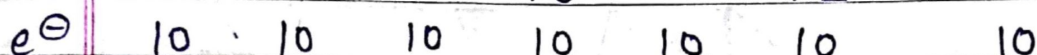
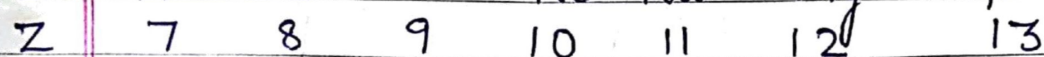
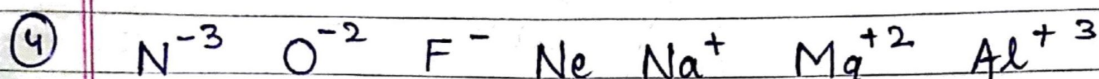
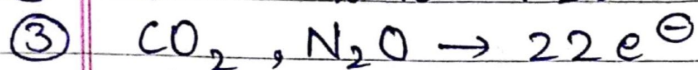
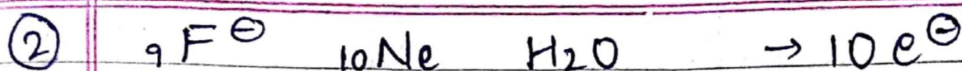
Isoelectronic : species which have same no. of electron.



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Isodiaphers :- which have same $(n-p)$ but $n-p \neq 0$

eg ①

	${}^{11}_5B$	${}^{13}_6C$
p	5	6
n	6	7
$n-p$	1	1 ✓

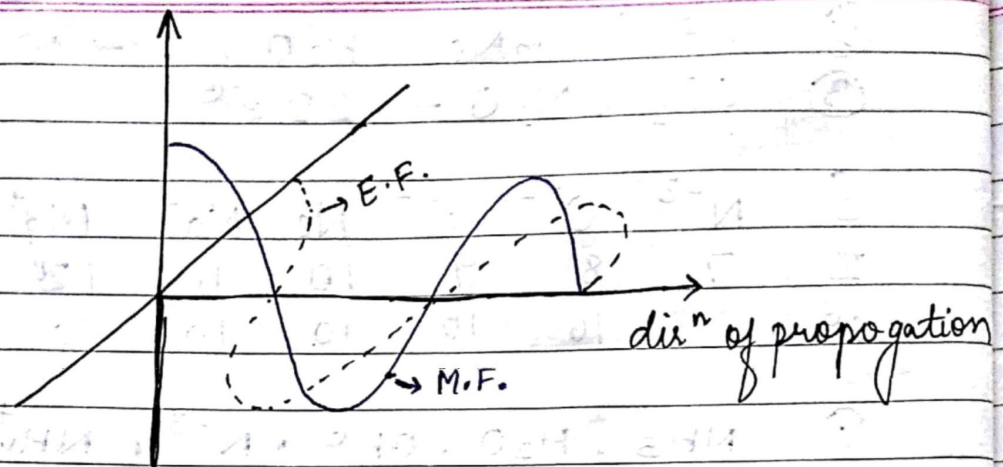
Isosters :- same no. of atom as well as same no. of $e^{\ominus}$.

	CO_2	N_2O	CO	N_2
atom	3	3	2	2
$e^{\ominus}$	22	22	14	14

Electromagnetic Radiation :-

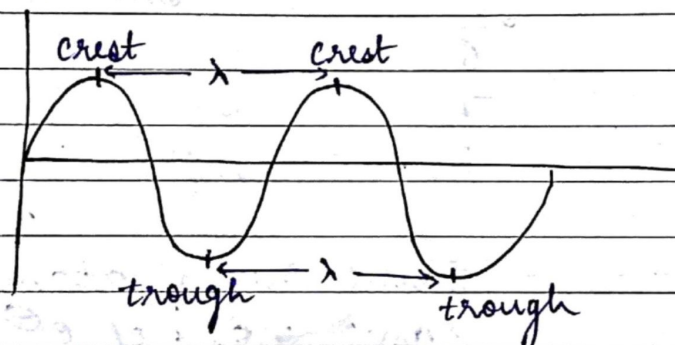
- Accⁿ to Maxwell, a char. accelerated charge particle produce electric and magnetifield.
- E.F. and M.F. are $\perp$ to each other & also $\perp$ to dirⁿ of propogation.
- E.M.R. donot require in any medium and they can ~~set~~ travel in vaccum with speed of light ($c = 3 \times 10^8 \text{ m/s}$)

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① Wavelength (λ) :-

It is distance b/w 2 nearest crest or trough.



② Wave Number ($\bar{\nu}$) - Nu

It is no. of waves in unit length.

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

Unit :- m^{-1} , cm^{-1} , etc

③ Frequency: (ν)

It is no. of wave passing through a point in one second.

Unit: s^{-1} or Hz

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(4) **Speed** : It is distance covered by wave in one second.

$$c = v\lambda$$

(4) Unit = m/s

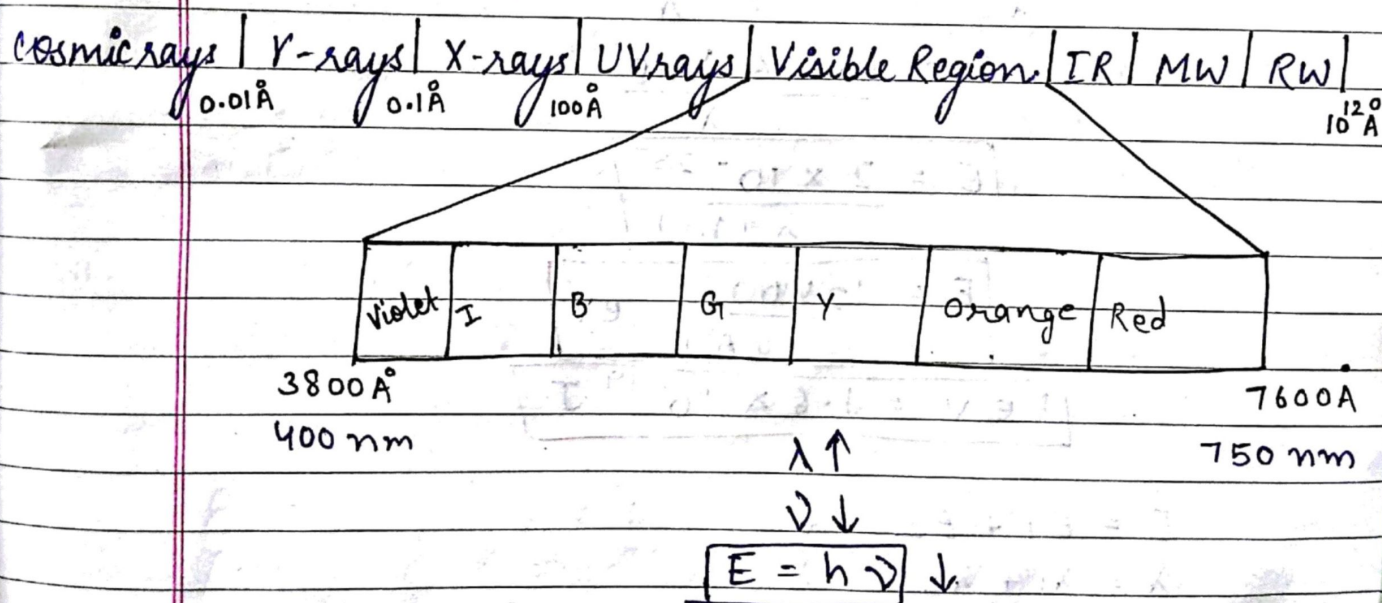
(5) **Time period** :

$$v = \frac{\lambda}{T}$$

Amplitude : (a)

It is the height of crest or trough.

E.M.R. Spectrum :-



Planck Quantum Theory :-

The radiant energy absorbed or emitted from a body not continuously but discontinuous in form of packets or quanta. In case of light, these packets are called photon.

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Energy of photon $\propto$ Frequency

$$E \propto \nu$$

$$E = h\nu$$

h = Planck's const

$$h = 6.62 \times 10^{-34} \text{ Js}$$

$$E = \frac{hc}{\lambda} = \text{Energy of 1 photon}$$

Energy of n photon

$$E = n \times h\nu = \frac{nhc}{\lambda}$$

$$E = h\nu, 2h\nu, 3h\nu \dots$$

$$E = 1.5 h\nu \quad \text{X}$$

$$E = \frac{hc}{\lambda} = \frac{6.62 \times 10^{-34} \times 3 \times 10^8}{\lambda}$$

$$E = \frac{19.86 \times 10^{-26}}{\lambda}$$

$$E = \frac{2 \times 10^{-25}}{\lambda (\text{m})}$$

$$E = \frac{12400}{\lambda (\text{\AA})} \text{ eV}$$

$$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$$

$$E = E_1 + E_2 \quad \checkmark$$

$$\lambda = \lambda_1 + \lambda_2 \quad \text{X}$$

$$\nu = \nu_1 + \nu_2 \quad \checkmark$$

$$E = E_1 + E_2$$

$$h\nu = h\nu_1 + h\nu_2$$

$$\frac{hc}{\lambda} = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2}$$

$$\frac{1}{\lambda} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$$

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Ques The wavelength of visible region exceeds from 400 nm to 700 nm then find in terms of frequency.

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

$$\nu \lambda = c$$

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

$$\lambda_1 = \frac{c}{\nu_1} \Rightarrow \nu_1 = \frac{c}{\lambda_1} \Rightarrow \nu_1 = \frac{3 \times 10^8}{400 \times 10^{-9}}$$

$$\Rightarrow \frac{3 \times 10^{17}}{400} = \frac{3}{4} \times 10^{15}$$

$$7.5 \times 10^{14} \text{ Hz} = \nu_1 = 0.75 \times 10^{15} \text{ Hz}$$

$$\nu_2 = \frac{c}{\lambda_2} \Rightarrow \nu_2 = \frac{3 \times 10^8}{700 \times 10^{-9}} = \frac{1000}{250} \times 10^{14} = 4 \times 10^{14} \text{ Hz}$$

Ques $\lambda = 250 \text{ \AA}$ Calculate

(1) ν (2) $\bar{\nu}$ (3) $E \text{ (J)}$ (4) $E \text{ (in eV)}$

$$(1) \quad \nu = \frac{c}{\lambda} = \frac{3 \times 10^8}{250 \times 10^{-10}} = \frac{300 \times 10^{16}}{250} = 1.2 \times 10^{16}$$

$$(2) \quad \bar{\nu} = \frac{1}{\lambda} = \frac{1}{250 \times 10^{-10}} = \frac{10^{10}}{250} = \frac{100}{250} \times 10^8 = \frac{20}{5} \times 10^7 = 4 \times 10^7$$

$$(4) \quad E = \frac{12400}{250} \text{ eV} = 49.6 \text{ eV}$$

$$\begin{array}{r} 5 \text{ } 49.6 \\ 250 \overline{) 12400} \\ \underline{1250} \\ 900 \\ \underline{875} \\ 250 \\ \underline{250} \\ 0 \end{array}$$

$$(3) \quad E = \frac{12400}{250} \times 1.6 \times 10^{-19} \text{ J} = 49.6 \times 1.6 \times 10^{-19} \text{ J} = 79.36 \times 10^{-19} \text{ J}$$

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Ques $E = 2.5 \text{ eV}$ calculate

① $E (\text{J})$ ② λ ③ ν ④ $\bar{\nu}$

$$\begin{array}{r} 3 \quad 2.5 \\ 1.6 \\ \hline 150 \\ 25 \times \\ \hline 400 \end{array}$$

$$E = 2.5 \text{ eV}$$

$$E = 2.5 \times 1.6 \times 10^{-19} \text{ J} = 4 \times 10^{-19} \text{ J}$$

$$E = \frac{hc}{\lambda} \rightarrow \lambda = \frac{hc}{E} = \frac{2 \times 10^{-25}}{4 \times 10^{-19}} = 0.5 \times 10^{-6} = 5 \times 10^{-7} \text{ m}$$

$$\nu = \frac{c}{\lambda} = \frac{3 \times 10^8}{5 \times 10^{-7}} = \frac{30 \times 10^{14}}{5} = 6 \times 10^{14} \text{ Hz}$$

$$\bar{\nu} = \frac{1}{\lambda} = \frac{1}{5 \times 10^{-7}} = \frac{10^7}{5} = \frac{10 \times 10^6}{5} = 2 \times 10^6$$

Ques Two radiation of wavelength $2000 \text{ \AA}$ & $4000 \text{ \AA}$ are given then calculate & compare their Energy?

$$E = \frac{12400}{\lambda (\text{\AA})}$$

$$\frac{E_1}{E_2} = \frac{\lambda_2}{\lambda_1}$$

$$E_1 = \frac{12400}{2000} = 6.2 \text{ eV}$$

$$E_2 = \frac{12400}{4000} = 3.1 \text{ eV}$$

$$E_1 > E_2$$

Ques find energy of photon one mole proton if λ for photon is $331 \text{ \AA}$

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$$E = \frac{hc}{\lambda} = \frac{0.02 \times 6.62 \times 10^{-34} \times 3 \times 10^8}{3.3 \times 10^{-10}}$$

$$\text{Energy of one photon} = E = 0.06 \times 10^{-18} \text{ J}$$

$$= 6 \times 10^{-18} \text{ J}$$

$$\text{Energy of one mole photon} = 6 \times 10^{-18} \times 6.022 \times 10^{23} \text{ J}$$

$$= 36.132 \times 10^{23-18} = 36.132 \times 10^5 \text{ J}$$

Ques A 100 watt bulb emits a radiation of wavelength 300 Å then find no. of photons emitted per sec.

$$P = \frac{E}{t}$$

$$100 = \frac{n hc}{\lambda t}$$

$$\frac{100 \lambda}{hc} = \frac{n}{t}$$

$$P = 100 \text{ watt}$$

$$= 100 \frac{\text{J}}{\text{s}}$$

$$\frac{n}{t} = \frac{100 \times 300 \times 10^{-10} \times 300}{6.62 \times 10^{-34} \times 3 \times 10^8}$$

$$\text{Energy of one photon} = \frac{50 \times 100 \times 10^{-10} \times 300}{2 \times 10^{-25}}$$

$$\frac{12400}{\lambda(\text{Å})} \text{ eV} = 41 \text{ eV}$$

$$= 50 \times 300 \times 10^{-10+25}$$

$$= 15 \times 10^3 \times 10^{15}$$

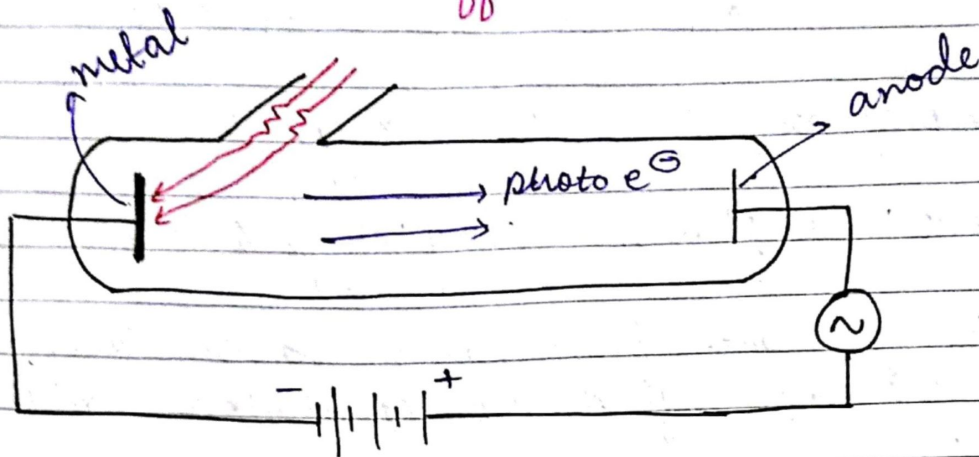
$$\frac{n}{t} = 15 \times 10^{18}$$

$$\text{no. of photons per hr} = \frac{100}{41 \times 1.6 \times 10^{-19}} \times 60 \times 60$$

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Photo - Electric Effect :-



- When photons of sufficient energy hits the metal surface then e^- comes out of the metal surface this is c/a P.E.E.
- There is no time lark b/w pt ~~emiss~~ striking of photon and emission of e^-
- no. of photo e^- emitted $\propto$ intensity of light.
- There is a characteristics minimum frequency required, called Threshold frequency.

Work function :- (W_0)

$$W_0 = h\nu_0$$

- Min. energy of photon required to remove a e^- is c/a work function.
- Kinetic Energy of e^- increases with ~~incre~~ increase in frequency of photon.

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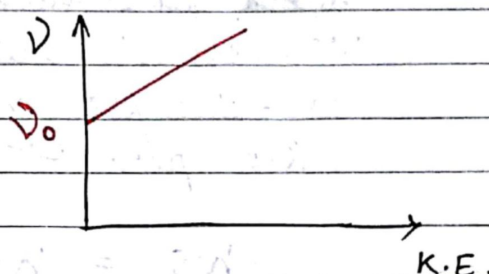
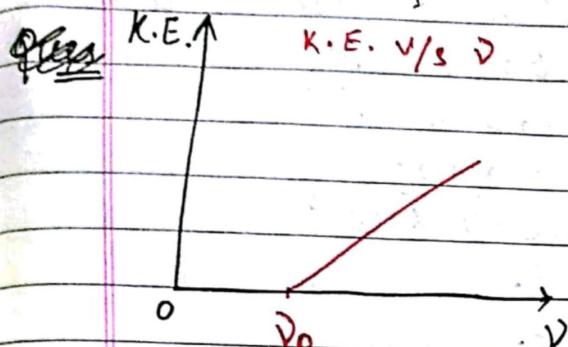
Intensity $\uparrow$ no. of photoe $^-$ $\uparrow$

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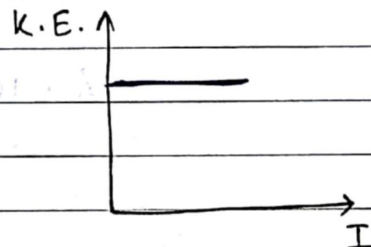
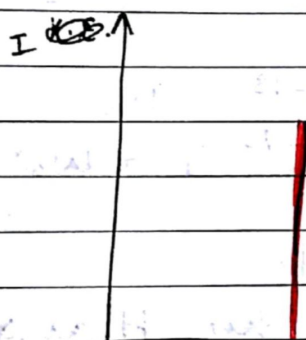
$$E = W_0 + K.E.$$

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

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



Ques II K.E. v/s Intensity (I)



Ques Threshold freq. for metal is 6×10^{15} Hz. If a photon of frequency 1×10^{16} Hz strike the metal surface then K.E. of e $^-$?

$$E = W_0 + K.E.$$

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

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

$$= h(\nu - \nu_0)$$

$$= h(1 \times 10^{16} - 6 \times 10^{15})$$

$$= h \times 10^{15} (4)$$

$$= 6.62 \times 10^{-34} \times 10^{15} \times 4 = 26.48 \times 10^{-19} \text{ J}$$

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Ques When a radiation of wavelength $331 \text{ \AA}$ strike the metal surface. Electrons are emitted with K.E. of $1.68 \times 10^5 \text{ J mol}^{-1}$. Then find the work function of metal & also find max^m wavelength required to remove an e^- .

$5.76 \times 10^{-18} \text{ J} = W_0$

$K.E. = E_{331} \text{ per mol} = 1.68 \times 10^5$

$K.E. \text{ per } e^- = \frac{1.68 \times 10^5}{6.022 \times 10^{23}}$

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

$$\frac{hc}{\lambda} = W_0 + K.E.$$

$$\frac{6.62 \times 10^{-34} \times 3 \times 10^8}{331 \times 10^{-10}} = W_0 + \frac{1.68 \times 10^5}{6.022 \times 10^{23}}$$

$$6 \times 10^{-18} - 0.24 \times 10^{-18} = W_0$$

$$5.76 \times 10^{-18} \text{ J} = W_0$$

Bohr Atomic Model :-

Note:- It is applicable for ~~to~~ H and H like species.

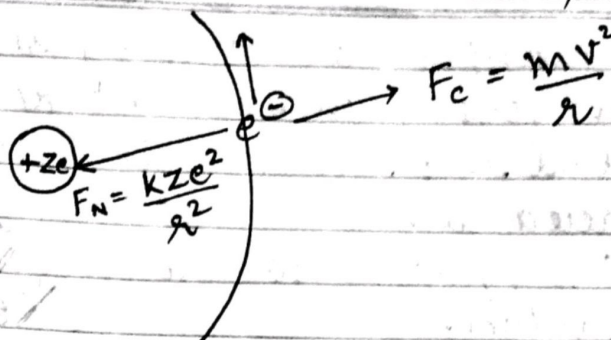
eg $H, He^+, Li^{2+}, Be^{3+}, Na^{10+}$ etc.

Postulate :-

- ~~nucleus~~ nucleus lies at centre of ~~proto~~ atom and ~~new~~ ~~in~~ n & p lies in it.
- e^- are revolving around nucleus in spherical path. These spherical circular paths ~~are~~ are c/a orbit and energy level.
- nuclear attractive force on e^- is balanced by centrifugal force.

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→ e^- revolves only in those orbit in which angular momentum is multiple of $\frac{h}{2\pi}$.

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

$n = 1, 2, 3, 4, \dots$

Ques which of the following angular momentum shows presence of e^- in an orbit.

- ☒ ① $\frac{h}{2\pi}$
 ☒ ② $\frac{3h}{2\pi}$
 ☒ ③ $\frac{5h}{\pi}$
 ☐ ④ $1.5 \frac{h}{2\pi}$
☐ ⑤ $\frac{7h}{4\pi}$
 ☐ ⑥ $1.25 \frac{h}{\pi}$
 ☐ ⑦ $3.5 \frac{h}{2\pi}$
 ☒ ⑧ $2.5 \frac{h}{\pi}$
☒ ⑨ $0.5 \frac{h}{\pi}$

$$\frac{1}{2} \frac{h}{\pi}$$

$$\frac{2.5 \times 255}{102}$$

Ques If angular momentum for $H (n=1)$ is x then find angular momentum for $Li^{+2} (n=1)$

- ☒ ① x
 ☐ ② $x/3$
 ☐ ③ $3x$
 ☐ ④ $2x$
 ☐ ⑤ $3x/2$

$$J_H = \frac{nh}{2\pi} = x$$

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

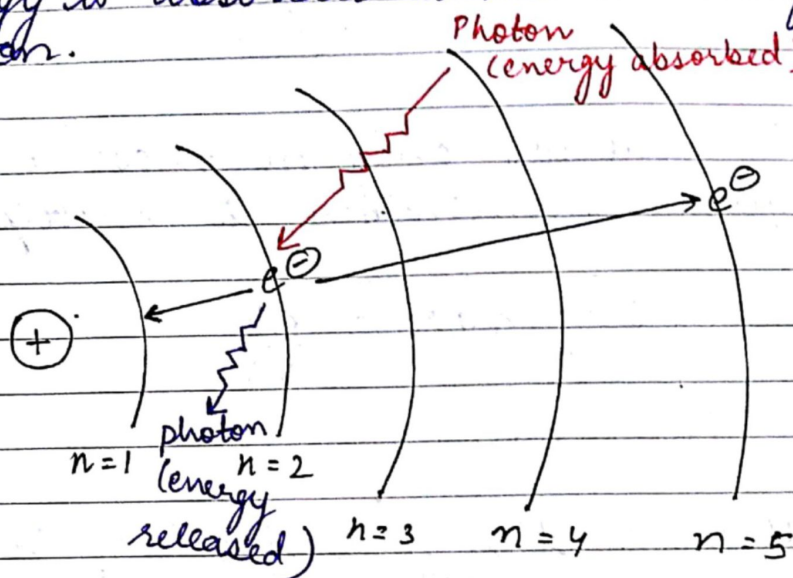
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→ Energy when energy is absorbed by an e^- it goes high energy level to lower energy level and when it comes back energy is released.

Energy is absorbed or released in form of photon.



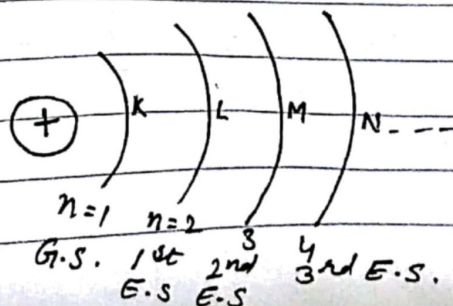
$n=1 \xrightarrow{h\nu} n=2 \xrightarrow{h\nu} n=5$ 2 Photons absorbed

$n=2 \xrightarrow{h\nu} n=4 \xrightarrow{h\nu} n=5 \xrightarrow{h\nu} n=7$
3 Photons absorbed

$n=6 \xrightarrow{h\nu} n=5 \xrightarrow{h\nu} n=3 \xrightarrow{h\nu} n=2$
3 Photons released

Ground State : Lowest energy level. ($n=1$)

Excited State : higher energy level $\neq$
 $n=2, 3, 4, \dots$



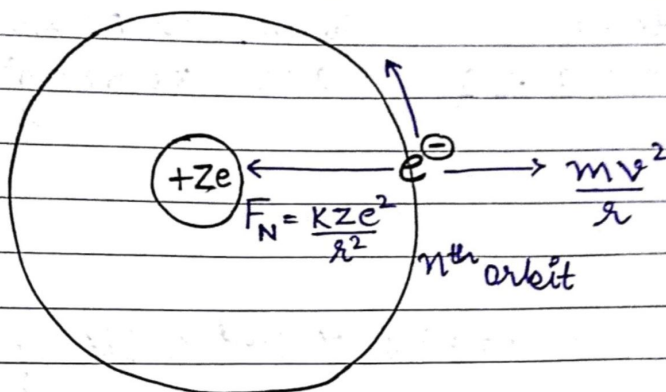
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Application of Bohr Model :-

1. Calculation of Radius :- r



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

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

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

$$v = \frac{nh}{2\pi r m}$$

$$\frac{kze^2}{r} = m \times \left(\frac{nh}{2\pi r m} \right)^2$$

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

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

$$k = 9 \times 10^9 \text{ Nm}^2/\text{C}^2$$

$$r = \frac{n^2 \times (6.62 \times 10^{-34})^2}{4 \times (3.14)^2 \times 9.1 \times 10^{-31} \times 9 \times 10^9 \times Z \times (1.6 \times 10^{-19})^2}$$

$$r = 0.529 \times 10^{-10} \frac{n^2}{Z} \text{ m}$$

$$r = 0.529 \frac{n^2}{Z} \text{ \AA}$$

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

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$$r = 0.529 \frac{n^2}{Z} \text{ \AA}$$

$$\begin{aligned} \text{diameter} &= 2r \\ &= 2 \times 0.529 \frac{n^2}{Z} \text{ \AA} \\ \text{Circumference} &= 2\pi r \\ &= 2 \times 3.14 \times 0.529 \frac{n^2}{Z} \text{ \AA} \\ A &= \pi r^2 \\ &= 3.14 \left(0.529 \frac{n^2}{Z} \right)^2 \text{ \AA}^2 \\ &\propto \frac{n^4}{Z^2} \end{aligned}$$

Ques Find the radius of 3rd orbit of H ?

$$r_1 = 0.529 \times \frac{n^2}{Z} \text{ \AA}$$

$$= 0.529 \times \frac{9}{1} = 4.761 \text{ \AA}$$

Ques If radius of 2nd orbit of H is 2.12 \AA then find radius of Li²⁺ for a same orbit ?

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

$$\frac{r_1}{r_2} = \frac{n_1^2}{n_2^2} \times \frac{Z_2}{Z_1}$$

$$\frac{2.12}{r_2} = \frac{4}{4} \times \frac{3}{1}$$

$$\begin{aligned} r_2 &= \frac{2.12}{3 \times 100} = \frac{2.12}{3 \times 100} = \frac{70.6}{100} \\ &= 70.6 \times 10^{-2} \text{ \AA} \\ &= 0.706 \text{ \AA} \end{aligned}$$

Ques If the radius of 2nd orbit of He⁺ is x pm then find radius of 3rd orbit of Be³⁺ ?

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$$\frac{r_1}{r_2} = \frac{n_1^2}{n_2^2} \times \frac{Z_2}{Z_1}$$

$$\frac{r}{r_2} = \frac{4}{9} \times \frac{4}{2}$$

$$\frac{r}{r_2} = \frac{16}{18}$$

$$\frac{9 \times 18 r}{8 \times 16} = r_2$$

$$r_2 = 1.1 \text{ } \mu\text{m}$$

Ques $r_1(\text{H}) : r_2(\text{H}) : r_3(\text{H})$

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

$$1 : 4 : 9$$

Q $r_1(\text{H}) : r_1(\text{He}^+) : r_1(\text{Be}^{3+})$

$$\frac{1}{1} : \frac{1}{2} : \frac{1}{4}$$

$$4 : 2 : 1$$

$r_2(\text{Li}^{2+}) : r_2(\text{He}^+) : r_2(\text{H})$

$$\frac{4}{3} : \frac{4}{2} : \frac{4}{1}$$

$$8 : 12 : 24$$

$$2 : 3 : 6$$

$r_3(\text{Li}^{2+}) : r_2(\text{He}^+) : r_1(\text{H})$

$$\frac{9}{3} : \frac{4}{2} : \frac{1}{1}$$

$$3 : 2 : 1$$

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$$r_2(\text{H}) : r_3(\text{He}^+) : r_4(\text{Li}^{3+})$$

$$6 \times \frac{4}{1} : \frac{9}{2} : \frac{16}{3}$$

$$24 : 27 : 32$$

$$r_5(\text{Na}^{10+}) = 0.529 \times \frac{5^2}{11}$$

$$= 0.529 \times \frac{25}{11} \text{ \AA}$$

$$\frac{r_3(\text{Be}^{3+})}{r_5(\text{Li}^{2+})} = \frac{9}{25} \times \frac{3}{4} = \frac{27}{100}$$

Ques If ratio of radius of 2 orbits of H atom is 1:4 then orbits may be

$$\frac{r_1}{r_2} = \frac{n_1^2}{n_2^2}$$

$$\frac{1}{4} = \frac{n_1^2}{n_2^2}$$

$$\frac{n_1}{n_2} = \frac{1}{2}$$

(i) K & L (2) K & M (3) L & N ~~(4) both (1) & (3)~~

$$\begin{array}{ccc} n=1 & n=2 & \\ \frac{n_1}{n_2} = \frac{1}{2} & \frac{1}{3} & \frac{2}{4} = \frac{1}{2} \end{array}$$

Ques Find radius of 2nd excited state in H?

$$n=3$$

$$r = 0.529 \times \frac{9}{1}$$

$$= 4.761$$

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Ques r of 3rd E.S. of He^+

$$r = 0.529 \times \frac{16}{2}$$

$$= 4.232 \text{ \AA}$$

Ques r of 2nd E.S. of Be^{3+}

$$r = 0.529 \times \frac{9}{4}$$

$$= \frac{4.761}{4} = 1.19 \text{ \AA}$$

Ques r 2nd E.S. of Li^{2+}

r 3rd E.S. of Be^{3+} =

$$\frac{r_1}{r_2} = \frac{0.529 \times \frac{4}{3}}{0.529 \times \frac{9}{4}} = \frac{3}{4}$$

2. Calculation of Velocity :-

$$F_N = \frac{kze^2}{r^2}$$

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

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

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

$$\frac{kze^2}{r} = (mv)v$$

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

$$mv = \frac{nh}{2\pi r}$$

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$$\frac{kze^2}{r} = \frac{nh}{2\pi r} \times v$$

$$v = \frac{2\pi kze^2}{nh}$$

$$v = 2.18 \times 10^6 \times \frac{z}{n} \text{ m/s}$$

$$v \propto \frac{z}{n}$$

Time Period

$$T = \frac{2\pi r}{v}$$

$$T \propto \frac{n^2/z}{z/n}$$

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

Frequency (ν)

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

$$\nu \propto \frac{z^2}{n^3}$$

Que
①

$$\frac{v_2(H)}{v_3(H)} = \frac{z_1}{z_2} \times \frac{n_2}{n_1} = \frac{1}{1} \times \frac{3}{2} = \frac{3}{2}$$

$$\textcircled{2} \quad \frac{v_1(H)}{v_1(Li^{2+})} = \frac{1}{3} \times \frac{1}{1} = \frac{1}{3}$$

$$\textcircled{3} \quad \frac{v_3(He^+)}{v_2(Be^{2+})} = \frac{2}{4} \times \frac{2}{3} = \frac{4}{12} = \frac{1}{3}$$

$$\textcircled{4} \quad \frac{T_1(He^+)}{T_3(He^+)} = \frac{1}{27} \times \frac{4}{4} = \frac{4}{108} = \frac{1}{27}$$

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$$(5) \frac{T_2(\text{Li}^{2+})}{T_3(\text{Be}^{3+})} = \frac{8}{27} \times \frac{16}{9} = \frac{2^7}{3^5}$$

$$(6) \frac{v_2(\text{H})}{v_2(\text{Be}^{3+})} = \frac{Z_1^2}{Z_2^2} \times \frac{n_2^3}{n_1^3} = \frac{1}{16} \times \frac{8}{8} = \frac{1}{16}$$

$$(7) \frac{v_3(\text{He}^+)}{v_2(\text{Li}^{2+})} = \frac{2^2/3^3}{3^2/2^3}$$

Radius

$$(1) r = 0.529 \times 10^{-10} \times \frac{n^2}{Z} \text{ m}$$

$$r = 0.529 \times \frac{n^2}{Z} \text{ \AA}$$

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

Velocity

$$(1) v = 2.18 \times 10^6 \frac{Z}{n} \text{ m/s}$$

$$v \propto \frac{Z}{n}$$

$$T.P. = \frac{2\pi r}{v}$$

$$= \frac{n^2/Z}{Z/n}$$

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

$$\text{Frequency } (\nu) = \frac{1}{T}$$

$$\nu = \frac{Z^2}{n^3}$$

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19/7/17

3.

Calculation of Energy :-

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

$$= \frac{1}{2} mv^2 - \frac{KZe^2}{r}$$

$$= \frac{KZe^2}{2r} - \frac{KZe^2}{r}$$

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

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

$$T.E. = -\frac{KZe^2}{2 \times \frac{n^2 h^2}{4\pi^2 m K Z e^2}}$$

$$T.E. = -\frac{2\pi^2 m K^2 Z^2 e^4}{n^2 h^2}$$

$$T.E. = -2.18 \times 10^{-18} \frac{Z^2}{n^2} \text{ J/atom}$$

$$1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$$

$$1 \text{ J} = \frac{1}{1.6 \times 10^{-19}} \text{ eV}$$

$$T.E. = -2.18 \times 10^{-18} \frac{Z^2}{n^2} \times \frac{1}{1.6 \times 10^{-19}} \text{ eV/atom}$$

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

$$T.E. = -2.18 \times 10^{-18} \frac{Z^2}{n^2} \times 6.022 \times 10^{23} \text{ J/mol}$$

$$T.E. = -1312 \frac{Z^2}{n^2} \text{ kJ/mol}$$

$$T.E. = -312 \frac{Z^2}{n^2} \text{ kcal/mol}$$

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

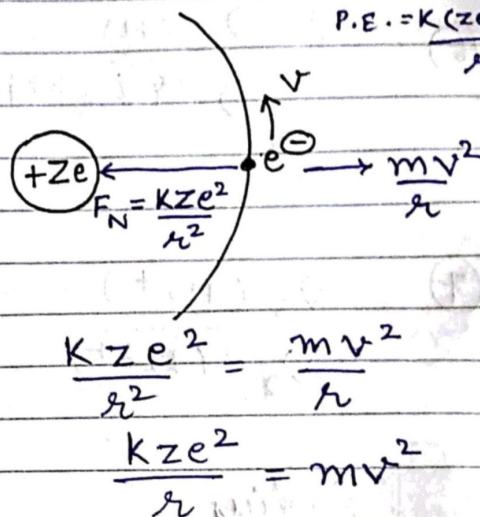
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$$F = K \frac{q_1 q_2}{r^2}$$

$$P.E. = \vec{F} \cdot d\vec{r}$$

$$P.E. = \frac{K q_1 q_2}{r}$$

$$P.E. = \frac{K (Ze)(-e)}{r}$$



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→ -ve sign of T.E. shows attraction force b/w nucleus and electron.

$$K.E. = \frac{KZe^2}{2n}$$

$$K.E. \propto \frac{1}{n}$$

$n \uparrow$ $K.E. \downarrow$

$$P.E. = -\frac{KZe^2}{n}$$

$$P.E. \propto -\frac{1}{n}$$

$n \uparrow$ $P.E. \uparrow$

$$T.E. = -\frac{KZe^2}{2n}$$

$$T.E. \propto -\frac{1}{n}$$

$n \uparrow$ $T.E. \uparrow$

$$T.E. = \frac{P.E.}{2} = -K.E.$$

H-atom

	T.E.	K.E.	P.E.
$n=1$	-13.6 eV	13.6	-2×13.6 eV
$n=2$	-3.4	3.4	-2×3.4
$n=3$	-1.51	1.51	-2×1.51
$n=4$	-0.85	0.85	-2×0.85
$n=5$	-0.54	0.54	-2×0.54
$n=6$	-0.38	0.38	-2×0.38
$n=\infty$	0 (max.)	0 (min.)	0 (max.)

$$E_2 - E_1 = -3.4 - (-13.6) = 10.2 \text{ eV}$$

$$E_3 - E_1 = -1.51 - (-13.6) = 12.09 \text{ eV}$$

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$$E_4 - E_3 = -0.85 - (-1.51) = -0.85 + 1.51 = 0.66$$

$$E_5 - E_4 = -0.54 - (-0.85) = -0.54 + 0.85 = 0.31$$

$$E_6 - E_5 = -0.38 - (-0.54) = -0.38 + 0.54 = 0.16$$

Ques which of the following statement is correct?

① $K.E. 1 > K.E. 2 > K.E. 3$ ✓

② $P.E. 1 < P.E. 2 < P.E. 3$

③ $T.E. 3 > T.E. 2 > T.E. 1$

④ all

Ques ① Energy E_3 (He^+) in kcal/mol

$$= -312 \times \frac{4}{9}$$

$$= -104 \times \frac{4}{3}$$

$$= -\frac{416}{3} = -137.$$

② E_2 (Li^{2+}) in KJ/mol = $-1312 \times \frac{3^2}{2^2}$ KJ/mol

③ E_3 (Be^{3+}) in eV/atom = $-13.6 \times \frac{4^2}{3^2}$

④ E_5 (Ne^{9+}) in J/atom = $-2.18 \times 10^{-18} \times \frac{10^2}{5^2}$

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$$\Delta E = E_{n_2} - E_{n_1} = -13.6 \times \frac{Z^2}{n_2^2} - \left(-13.6 \times \frac{Z^2}{n_1^2} \right)$$

$$\Delta E = -13.6 Z^2 \left[\frac{1}{n_2^2} - \frac{1}{n_1^2} \right]$$

Ques $E_2 - E_1$ for He^+

$$E_2 - E_1 = -13.6 \times \frac{2^2}{2^2} - \left(-13.6 \times \frac{2^2}{1^2} \right)$$

$$= -13.6 + 13.6 \times 4$$

$$= -13.6(1-4) = -13.6 \times -3 = 40.8$$

Ques $E_3 - E_2$ (Li^{2+})

$$E_3 - E_2 = -13.6 \times \frac{3^2}{3^2} - \left(-13.6 \times \frac{3^2}{2^2} \right)$$

$$E_4 - E_3 = -13.6 \times \frac{3^2}{4^2} - \left(-13.6 \times \frac{3^2}{3^2} \right)$$

$$= -13.6 \times \frac{9}{16} + 13.6 \times 9 = 13.6 \times 9 \left(\frac{1}{4} - \frac{1}{16} \right) = \frac{1}{4} - \frac{1}{16} = \frac{4-1}{16} = \frac{3}{16}$$

$$= \frac{-5}{-10} = \frac{5 \times 16 \times 9}{36 \times 10} = \frac{20}{10} = 2$$

Ques Calculate energy of 1st E.S. of Be^{3+} ?

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

$$= -2.18 \times 10^{-18} \times \frac{16}{4}$$

$$= -8.72 \times 10^{-18}$$

Ques Calculate ratio of energy of 1st E.S. & 2nd E.S. of Li^{2+} ?

$$\frac{E_2}{E_3} (\text{Li}^{2+}) = \frac{3^2}{3^2} \times \frac{3^2}{2^2} = \frac{9}{4}$$

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Ques ① If P.E. of H-atom is -6.8 eV then
K.E. ② T.E. ③ n ④ r

$$\begin{aligned} \text{① } T.E. &= -K.E. \quad \text{② } T.E. = \frac{P.E.}{2} \quad \text{③ } T.E. = -3.4 \\ &= -3.4 \text{ eV} \quad = \frac{-6.8}{2} \quad = -13.6 \times \frac{1}{n^2} \\ & \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad n^2 = \frac{-13.6}{-3.4} \\ & \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad \quad n = 2 \end{aligned}$$

$$\begin{aligned} \text{④ } r &= 0.529 \times \frac{n^2}{Z} \\ &= 0.529 \times \frac{2^2}{1} = 0.529 \times 4 = 2.116 \text{ \AA} \end{aligned}$$

AIPMT

Ques

If energy of 2nd orbit of H is -328 KJ/mol then calculate energy of 4th orbit.

$$\frac{E_2}{E_4} = \frac{-1312 \times \frac{1^2}{2^2}}{-1312 \times \frac{1^2}{4^2}}$$

$$\frac{-328}{E_4} = \frac{4^2}{2^2}$$

$$E_4 = -82 \text{ KJ/mol}$$

Ques

Energy of 1st E.S. of He^+ is x then find energy of 2nd E.S. of Li^{2+} x ② $x/2$ ③ $4x$ ④ $3x$

$$\frac{E_2(\text{He}^+)}{E_3(\text{Li}^{2+})} = \frac{-13.6 \times \frac{2^2}{2^2}}{-13.6 \times \frac{3^2}{3^2}} = \frac{1}{1}$$

$$E_3(\text{Li}^{2+}) = E_2(\text{He}^+) = x$$

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Energy

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$$(1) E = -2.18 \times 10^{-18} \frac{Z^2}{n^2} \text{ J/atom}$$

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

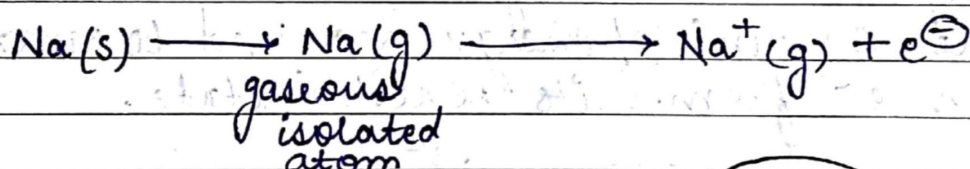
$$E = -1312 \times \frac{Z^2}{n^2} \text{ KJ/mol}$$

$$E = -312 \times \frac{Z^2}{n^2} \text{ kcal/mol}$$

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

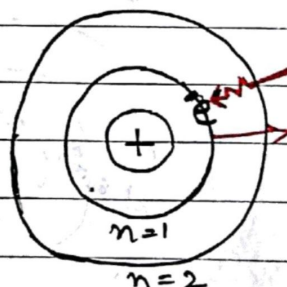
Ionisation Energy :-

The amount of energy required to remove an e^- from ground state of an isolated atom



H-atom

$$\begin{aligned} I.E. &= E_\infty - E_1 \\ &= 0 - (-13.6) \\ &= 13.6 \text{ eV} \end{aligned}$$



If 13.6 is given $\rightarrow e^-$ just comes out of atom
 10 eV $\rightarrow e^-$ not comes out
 15 eV $\rightarrow e^-$ comes out of atom with K.E.
 $(15 - 13.6) = 1.4 \text{ eV}$

Ques - Find I.E. for He^+ .

$$I.E. = -E_1 = -\left(-13.6 \times \frac{2^2}{1^2}\right) = 54.4 \text{ eV}$$

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AIPMT

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Ques

If 13.6 eV is needed to form H^+ from H then find amount of energy required to form Li^+ from Li?

 $H \rightarrow \alpha$
 $\rightarrow Z^2 \alpha$

$$I.E. = -E_1$$

$$= - \left(-13.6 \times \frac{3^2}{1^2} \right)$$

$$= + 13.6 \times 9 = 122.4$$

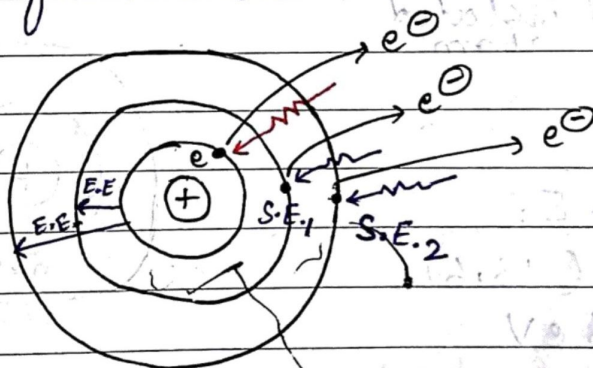
$$I.E. Li = 13.6 \times 9$$

$$\frac{13.6}{I.E. Li} = \frac{-E_1 H}{-E_2 Li} = \frac{1}{9}$$

$$I.E. Li = 13.6 \times 9 \quad \underline{\text{Ans}}$$

Separation Energy: (S.E.)

The amount of energy required to remove an e^- from its excited state.



H-atom

$$S.E.1 = E_{\infty} - E_{1st \text{ E.S.}} = E_{\infty} - E_2 = 0 - (-3.4)$$

$$= 3.4 \text{ eV}$$

$$S.E.2 = E_{\infty} - E_{2nd \text{ E.S.}} = E_{\infty} - E_3 = 0 - (-1.51)$$

$$= 1.51 \text{ eV}$$

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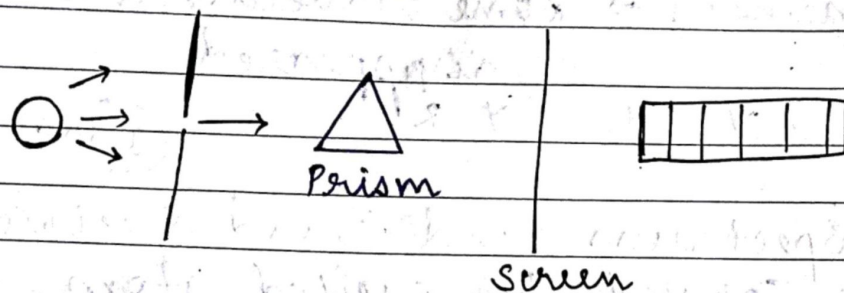
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Excitation Energy :-

Amount of energy required to excite an e^- from ground s. to higher energy level.

E. M. Spectrum :-

Spectra - appearance

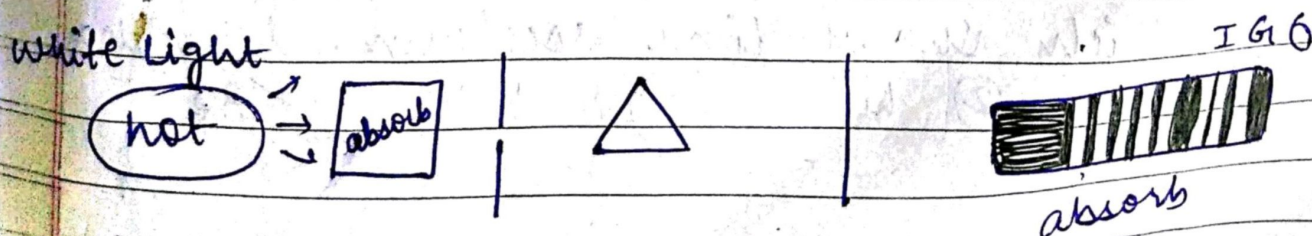
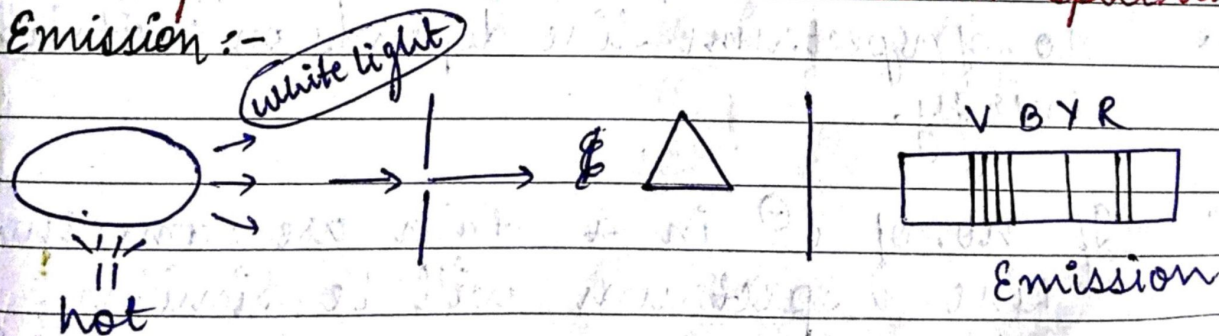


Monochromatic
mono $\rightarrow$ single
chromo $\rightarrow$ colour
 $\rightarrow$ single wavelength radiation

Type of Spectrum :-

1. **Absorption and Emission Spectrum :-**

Emission :-



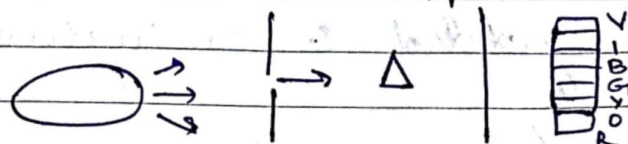
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2. Continuous & discontinuous Spectrum

Continuous all λ appear



V I B G Y O R, Sunlight, Rainbow.

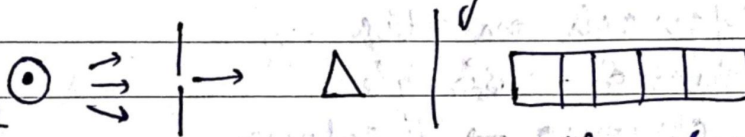
Discontinuous $\rightarrow$ some wavelength are disappeared

V B Y R (I G O)

3. Line Spectrum and Band Spectrum

Line :- Formed by excited atom

also known as fingerprint of element



line spectrum

Note :- line spectrum for each element is different.

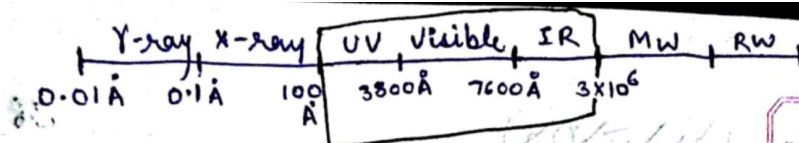
$\rightarrow$ no. of spectrum line depends on excitation energy.

$\rightarrow$ If no. of e^- in a atom are same then line spectrum will be similar.

Ques Which shows line spectrum like that H^+
 ① He ② Li^+ ③ H^+ ④ Be^{3+}

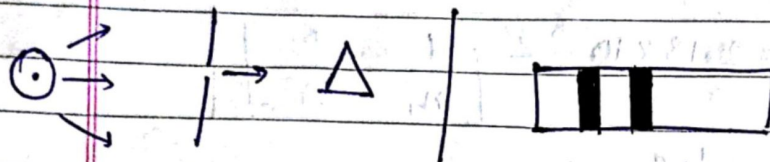
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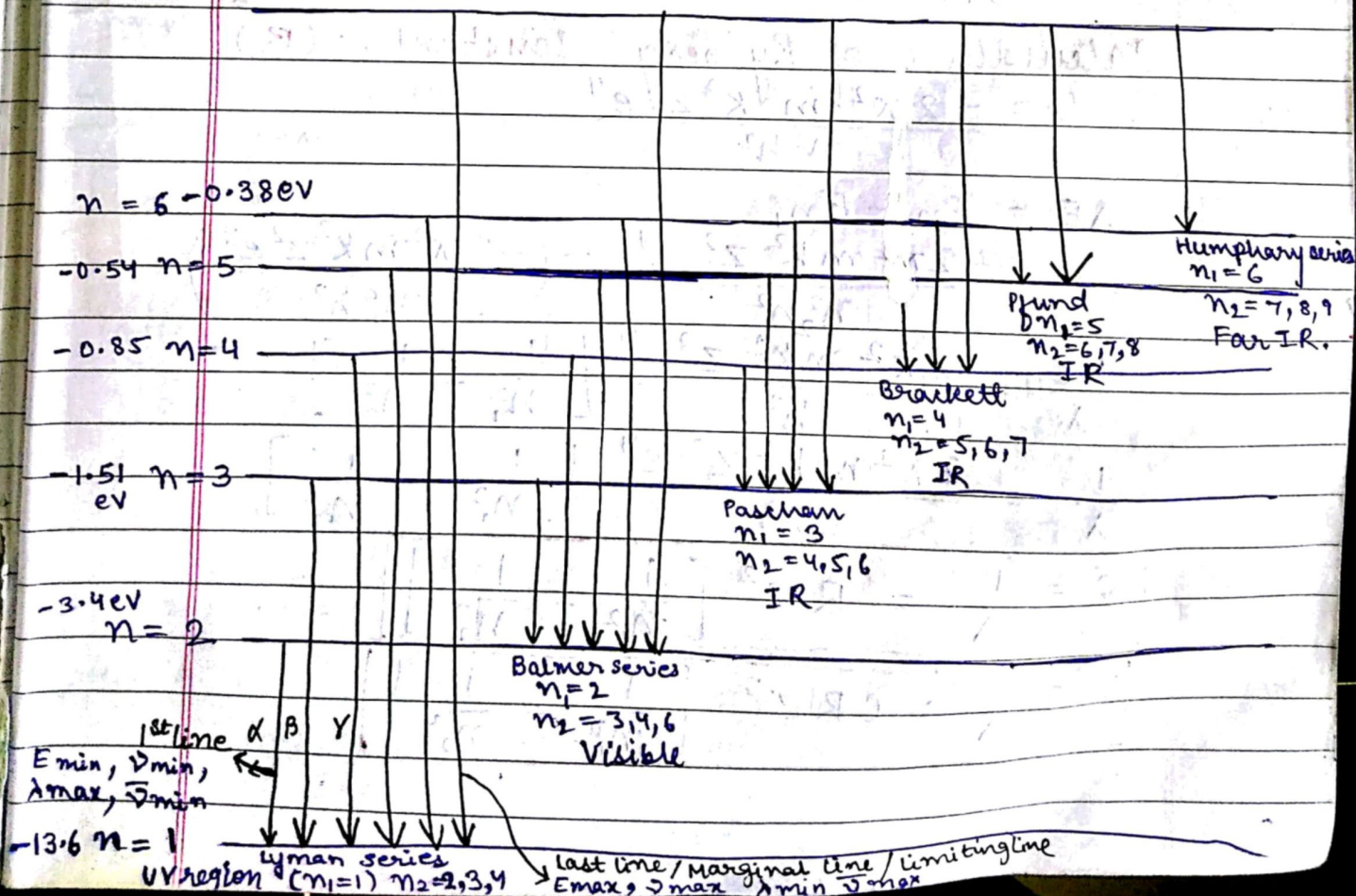
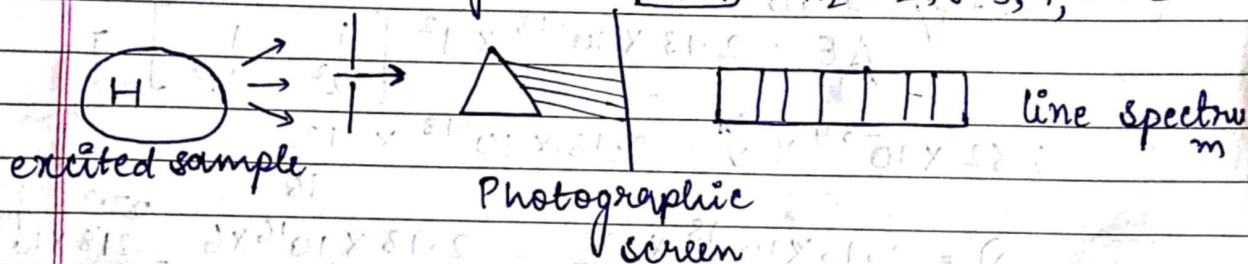
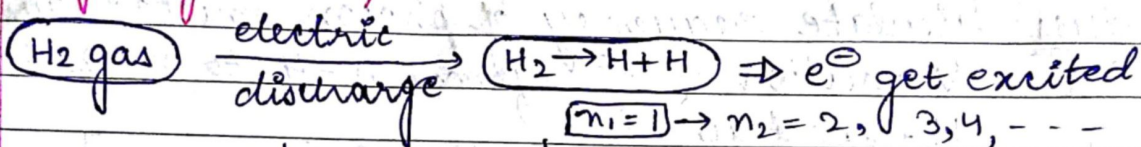
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Band spectrum :- formed by excited molecule



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Hydrogen - Spectrum :-



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$$n_1 > n_2$$

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Calculation of $\lambda, \nu, \Delta E$

$$\Delta E = E_{n_2} - E_{n_1} = 2.18 \times 10^{-18} Z^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right]$$

$$\Delta E = h\nu = \frac{hc}{\lambda}$$

Ques Calculate frequency of photon emitted during transition of e^- from $n=4$ to $n=2$ in H-spectrum?

$$\Delta E = 2.18 \times 10^{-18} \times 1^2 \left[\frac{1}{2^2} - \frac{1}{4^2} \right] \text{ J}$$

$$6.62 \times 10^{-34} \times \nu = 2.18 \times 10^{-18} \times \frac{12}{16}$$

$$\nu = \frac{2.18 \times 10^{-18} \times \frac{12}{16}}{6.62 \times 10^{-34}} = \frac{2.18 \times 10^{16} \times 6}{6.62 \times 8} = \frac{27.2 \times 10^{14} \times 6}{6.62 \times 8}$$

Calculation of Rydberg constant:- (R)

$$E = - \frac{2\pi^2 m k^2 Z^2 e^4}{n^2 h^2}$$

$$\Delta E = E_{n_2} - E_{n_1} = - \frac{2\pi^2 m k^2 Z^2 e^4}{n_2^2 h^2} - \left(- \frac{2\pi^2 m k^2 Z^2 e^4}{n_1^2 h^2} \right)$$

$$\frac{hc}{\lambda} = \frac{2\pi^2 m k^2 Z^2 e^4}{h^2} \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right]$$

$$\frac{1}{\lambda} = \frac{2\pi^2 m k^2 Z^2 e^4}{c h^3} \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right]$$

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

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

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$\lambda_{\max} \rightarrow$ 1st line

$\lambda_{\min} \rightarrow$ last line

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$$R \rightarrow 109678 \text{ cm}^{-1}$$

$$\rightarrow 109700 \text{ cm}^{-1} = 10970000 \text{ m}^{-1}$$

$$\rightarrow 912 \text{ \AA}$$

$$\frac{1}{R} = 912 \text{ \AA}$$

Ques 1 find $\lambda_{\max}$ & $\lambda_{\min}$ for Lyman series in H-spectrum.

Lyman series $\rightarrow \lambda_{\max}$
1st line
 $n_1 = 1$
 $n_2 = 2$

$\lambda_{\min}$
last line
 $n_1 = 1$
 $n_2 = \infty$

$$\frac{1}{\lambda_{\min}} = R(1)^2 \left[\frac{1}{1^2} - \frac{1}{\infty^2} \right]$$

$$\frac{1}{\lambda_{\max}} = R(1)^2 \left[\frac{1}{1^2} - \frac{1}{2^2} \right]$$

$$\frac{1}{\lambda_{\min}} = R$$

$$\frac{1}{\lambda_{\max}} = \frac{3R}{4} \Rightarrow \lambda_{\max} = \frac{4}{3R} = \frac{4 \times 912 \text{ \AA}}{3} = 1216 \text{ \AA}$$

$$\lambda_{\min} = \frac{1}{R} = 912 \text{ \AA}$$

Ques 2 $\lambda_{\max}$ (Balmer) = ? for H-spectrum
 $\lambda_{\min}$ (Balmer)

$\lambda_{\max} \rightarrow$ 1st line $n_1 = 2, n_2 = 3$

$\lambda_{\min} \rightarrow$ last $n_1 = 2, n_2 = \infty$

$$\frac{1}{\lambda_{\min}} = R(1)^2 \left[\frac{1}{2^2} - \frac{1}{\infty} \right] = R \left[\frac{1}{4} \right] = \frac{R}{4}$$

$$\lambda_{\min} = \frac{4}{R}$$

$$\frac{1}{\lambda_{\max}} = R(1)^2 \left[\frac{1}{2^2} - \frac{1}{3^2} \right]$$

$$\frac{\lambda_{\max}}{\lambda_{\min}} = \frac{36/5R}{4/R} = \frac{36 \times R}{5R \times 4} = \frac{9}{5}$$

$$\frac{1}{\lambda_{\max}} = R \left[\frac{1}{4} - \frac{1}{9} \right] = R \left[\frac{9-4}{36} \right] = R \left[\frac{5}{36} \right]$$

$$\lambda_{\max} = \frac{36}{5R}$$

$$\frac{\lambda_{\max}}{\lambda_{\min}} = \frac{9}{5}$$

Ques 3 Find $\lambda_{\max}$ for Li^{2+} in visible region?

$\lambda_{\max} \rightarrow$ 1st line $n_1 = 2, n_2 = 3$

$$\frac{1}{\lambda_{\max}} = R(3)^2 \left[\frac{1}{2^2} - \frac{1}{3^2} \right] = 9R \left[\frac{1}{4} - \frac{1}{9} \right]$$

$$= 9R \left[\frac{9-4}{36} \right] = 9R \left[\frac{5}{36} \right] = \frac{45R}{36}$$

$$\lambda_{\max} = \frac{36}{45 \times 912}$$

Ques 4 Find wavelength of 3rd line of Paschen series in He^+ spectrum.

$n_1 = 3$

$n_2 = 6$

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$$\frac{1}{\lambda} = R (2)^2 \left[\frac{1}{3^2} - \frac{1}{6^2} \right]$$

$$= R \times 4 \left[\frac{1}{9} - \frac{1}{36} \right]$$

$$= 4R \left[\frac{4}{9 \times 4} - \frac{1}{36} \right]$$

$$= 4R \times \left[\frac{3}{36} \right] = 3R$$

$$\frac{1}{\lambda} = \frac{R}{3}$$

$$\lambda = \frac{3}{R}$$

Ques 5 - λ 2nd line of Lyman series in Li^{2+} spectrum
 λ 3rd line of Balmer series in He^+ spectrum
 $n_1=1, n_2=3$ $\downarrow n_1=2, n_2=5$

$$= \frac{1}{\lambda_{\text{Li}^{2+}}} = \frac{\lambda_{\text{He}^+}}{\lambda_{\text{Li}^{2+}}} = R(2)^2 \left[\frac{1}{2^2} - \frac{1}{5^2} \right]$$

$$= \frac{4 \left[\frac{1}{4} - \frac{1}{25} \right]}{9 \left[\frac{1}{4} - \frac{1}{9} \right]} = \frac{4 \left[\frac{25-4}{100} \right]}{9 \left[\frac{9-4}{36} \right]}$$

$$= \frac{4 \left[\frac{21}{100} \right]}{9 \left[\frac{5}{36} \right]} = \frac{4 \times 21 \times 4}{9 \times 5 \times 100} = \frac{21}{250}$$

Ques ν_{max} (Balmer) $\rightarrow n_1=2, n_2=\infty = \frac{CR}{4}$

ν_{min} (Lyman) $\rightarrow n_1=1, n_2=2 = \frac{3CR}{4}$

$$\nu_{\text{max}} = \frac{c}{\lambda} = CR(1)^2 \left[\frac{1}{2^2} - \frac{1}{\infty} \right] = \frac{CR \times 4}{4 \times 3CR}$$

$$= CR \left[\frac{1}{4} \right] = \frac{CR}{4}$$

$$\nu_{\text{min}} = CR(1)^2 \left[\frac{1}{1^2} - \frac{1}{2^2} \right]$$

$$= CR \left[\frac{1}{1} - \frac{1}{4} \right] = CR \left[\frac{4-1}{4} \right] = \frac{3CR}{4}$$

Ques ν_{max} (Paschen) He^+ $\rightarrow CR(2)^2 \left[\frac{1}{3^2} - \frac{1}{\infty} \right]$

ν_{max} (Brackett) Li^{2+} $\rightarrow CR(3)^2 \left[\frac{1}{4^2} - \frac{1}{\infty} \right]$
 $n_1=3, n_2=\infty$ $\hookrightarrow n_1=4, n_2=\infty$

$$= \frac{4 \left[\frac{1}{9} \right]}{9 \left[\frac{1}{16} \right]} = \frac{4 \times 16}{9 \times 9} = \frac{64}{81}$$

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$n_1=1, n_2=2$
 $E_{min} \quad \lambda_{max} \quad \bar{\nu}_{min}$
 $E_{max} \quad \bar{\nu}_{max}$
 $n_1=2 \quad n_2=\infty$

Ques $\frac{\bar{\nu}_{min} \text{ (Lyman)}}{\bar{\nu}_{max} \text{ (Balmer) for Li}^{2+}} = \frac{3R/4}{9R/4} = \frac{3R \times 4}{9R \times 4} = \frac{1}{3}$

$\bar{\nu}_{min} = \frac{1}{\lambda} = R(1)^2 \left[\frac{1}{1^2} - \frac{1}{2^2} \right]$
 $= R \left[\frac{1}{1} - \frac{1}{4} \right]$
 $= R \times \frac{3}{4} = \frac{3R}{4}$

$\bar{\nu}_{max} = R(2)^2 \left[\frac{1}{2^2} - \frac{1}{\infty} \right]$
 $= R \times 4 \left[\frac{1}{4} \right] = \frac{4R}{4}$

Ques For which transition in H-spectrum wavelength will be same as that of He^+ in ~~spectrum~~ transition from $4 \rightarrow 2$.

$\lambda_H = \lambda_{He^+}$
 $\frac{1}{\lambda_H} = \frac{1}{\lambda_{He^+}}$
 $R(1)^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right] = R(2)^2 \left[\frac{1}{2^2} - \frac{1}{4^2} \right]$
 $\left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right] = \frac{4}{1} \left[\frac{1}{1} - \frac{1}{2^2} \right]$
 $\left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right] = \frac{3}{1} \left[\frac{1}{1} - \frac{1}{2^2} \right]$
 $\frac{1}{n_1^2} - \frac{1}{n_2^2} = \frac{3}{4}$
 $\frac{1}{n_1^2} = \frac{3}{4} + \frac{1}{n_2^2}$
 $\frac{1}{n_1^2} = \frac{3n_2^2 + 4}{4n_2^2}$
 $\frac{4n_2^2}{3n_2^2 + 4} = n_1^2$
 $n_1 = 1$
 $n_2 = 2$

Ques which transition will emit a photon of max^m wavelength in H-spectrum.

- ① $4 \rightarrow 2$
 ② $2 \rightarrow 1$
 ③ $3 \rightarrow 1$
 ④ $1 \rightarrow 3 \rightarrow$ absorption
- emission

Ques which of following transition will ^{absorption} require max^m frequency radiation in He^+ spectrum.

① $1 \rightarrow 3$
 ② $1 \rightarrow 2$
 ③ $4 \rightarrow 1$
 ④ $3 \rightarrow 1$

absorb

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Calculation of Number of Spectral lines:-
 Max.^m no. of lines when $e^{\ominus}$ comes out from higher energy level (n_2) to lower energy level (n_1)

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

higher energy level ~~to~~ (n) to G.S.
 $n_2 = n$, $n_1 = 1$

$$= \frac{(n-1)n}{2}$$

no. of lines in a spectral region = $n_2 - n_1$

Ques In H-spectrum $e^{\ominus}$ comes from 6th energy level to 1st energy level in multisteps find max.^m no. of spectral lines?

$$= \frac{n(n-1)}{2} = \frac{6(6-1)}{2} = 15$$

Ques An $e^{\ominus}$ comes from n^{th} energy level to G.S. & from form 21 spectral line Find n

$$21 = \frac{n(n-1)}{2}$$

$$42 = n^2 - n$$

$$n^2 - n - 42 = 0$$

$$n^2 - 7n + 6n - 42 = 0$$

$$n(n-7) + 6(n-7) = 0$$

$$n = 7$$

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Ques An electron comes from an E.S. to G.S. in multisteps & forms 15 spectral line. Initially it was in

① 6th E.S. ② 4th E.S. ③ 5th E.S. ④ 7 E.S.

$$\frac{n(n-1)}{2} = 15$$

~~$$n(n-1) = 30$$~~

~~$$n(n-1) = 6 \times 5$$~~

~~$$(n-6)$$~~

$$n(n-1) = 30$$

$$n^2 - n - 30 = 0$$

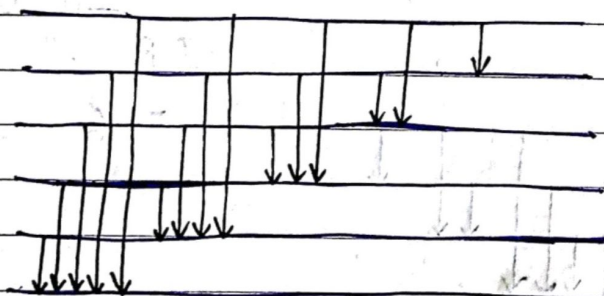
$$n^2 - 6n + 5n - 30 = 0$$

$$n(n-6) + 5(n-6) = 0$$

$$(n+5)(n-6)$$

$$n = 6$$

E.S. = $n-1 = 6-1 = 5^{\text{th}}$ Excited state



no. of spectral lines = 15

$$5 + 4 + 3 + 2 + 1 = 15$$

$$\textcircled{1} \quad \Delta E = \frac{hc}{\lambda} = h\nu = 2.18 \times 10^{-18} Z^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right]$$

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

$$\textcircled{3} \quad \nu = \frac{c}{\lambda} = c R Z^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right]$$

$$\textcircled{4} \quad \text{no. of spectral lines} = \frac{(n_2 - n_1)(n_2 - n_1 + 1)}{2}$$

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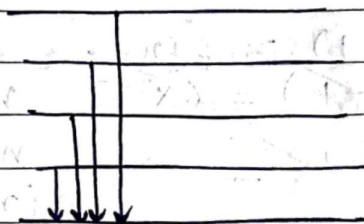
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Ques 6 → 2 H-spectrum Calculate

(i) total no of spectral line

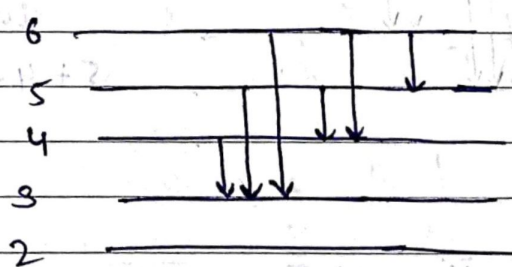
$$= \frac{(6-2)(6-2+1)}{2} = \frac{4 \times 5}{2} = 10$$

(ii) no. of spectral lines in visible region = 4



(iii) " " " " " in UV = 0

(iv) " " " " " IR = 6



Ques In H-spectrum 8 lines in Balmer series are formed then when an e^- from n^{th} orbit. Then n is

- ① 6 ② 8 ③ 10 ④ 7

$$8 = n_2 - 2$$

$$n_2 = 10$$

Ques 5 spectral lines are formed in visible region in H-spectrum when e^-

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comes from n^{th} E.S. ?

① Then find $n = ?$ 5

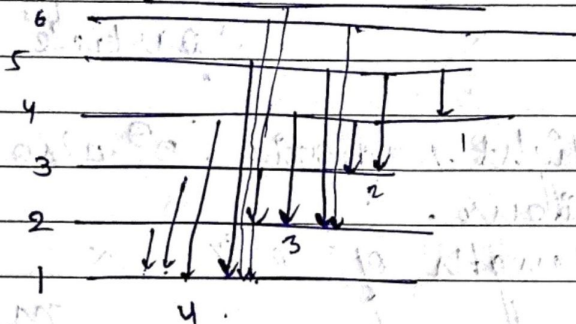
$$5 = n_2 - 2$$

$$n_2 = 7$$

② Find no. of spectral lines formed in Lyman series. = 6

$$n_1 = 1$$

$$n_2 = 7$$

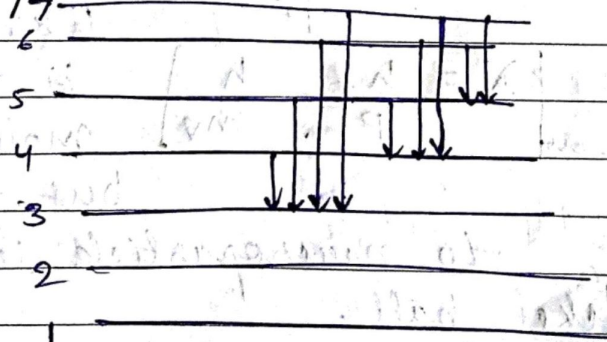


③ no. of spectral lines in IR = 9

$$7 - 3 = 4$$

$$7 - 4 = 3$$

$$7 - 5 = 2$$



Limitations :-

1. only applicable to single e^- species
2. $mvr = \frac{nh}{2\pi}$ → not explained
3. does not explain wave nature of e^-

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Wave Mechanical Model of Atom :-

1. Dual behaviour of e^- [debroglie concept]
2. Heisenberg.

1. Dual behaviour of e^- :-

dual behaviour of light $\rightarrow$ wave nature
eg - interference & diffraction
 $\rightarrow$ particle nature eg: photon

like light radiation e^- also have dual behaviour.

wavelength of $e^- \propto \frac{1}{\text{momentum}}$

$$\lambda \propto \frac{1}{p}$$

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

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

only applicable to micro particles like e^- , p , α , & atom, ion, molecules.

but not applicable to macroparticle like aeroplane, cricket ball.

$m \uparrow$

$\lambda \downarrow$

$v \uparrow$

$\lambda \downarrow$

$m \& v \uparrow$

$\lambda \downarrow$



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Case-I :- e^- have K.E.

$$K.E. = \frac{1}{2} m v^2$$

$$m K.E. = \left(\frac{1}{2} m v^2 \right) m = \frac{1}{2} m^2 v^2 = \frac{p^2}{2}$$

$$p = \sqrt{2m K.E.}$$

$$\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{\sqrt{2m K.E.}}$$

Case-II :- When a charge particle q is accelerated with potential.

$$K.E. = qV$$

$$\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{\sqrt{2m K.E.}} = \frac{h}{\sqrt{2mqV}}$$

Bohr Theory & deBroglie Concept :-
are to deBroglie

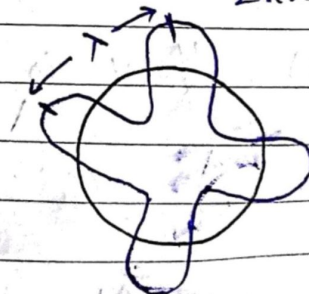
$$2\pi r = n\lambda$$

$$2\pi r = n \frac{h}{p}$$

$$2\pi r = n \frac{h}{mv}$$

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

$$2\pi\lambda = 4\lambda$$



Ques find no. of waves formed by e^- in 3rd & 6th orbit

$$n = 3$$

$$\text{wave} = 3$$

$$n = 6$$

$$\text{wave} = 6$$

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Ques Find ratio of wavelength of proton & α particle

(1) If momentum is same

$$\frac{\lambda_1}{\lambda_2} = \frac{\lambda_1}{\lambda_2} = \frac{h/p}{h/p} = \frac{p}{p} = 1:1$$

(2) If velocity is same

$$m_p = m_p$$

$$\alpha = 4m_p$$

$$\frac{\lambda_1}{\lambda_2} = \frac{h/m_1 v}{h/m_2 v} = \frac{m_2 v}{m_1 v} = \frac{m_2}{m_1}$$

$$= \frac{4m_p}{m_p} = \frac{4}{1}$$

(3) If K.E. is same

$$\frac{\lambda_1}{\lambda_2} = \frac{h/\sqrt{2m_1 K.E.}}{h/\sqrt{2m_2 K.E.}} = \frac{\sqrt{2m_2 K.E.}}{\sqrt{2m_1 K.E.}}$$

$$= \frac{\sqrt{4m_p}}{\sqrt{m_p}} = \frac{2}{1}$$

(4) If v is same

$$\lambda = \frac{h}{\sqrt{2mqv}}$$

$$\frac{\lambda_1}{\lambda_2} = \frac{\frac{h}{\sqrt{2mq_1 v}}}{\frac{h}{\sqrt{2mq_2 v}}} = \frac{\sqrt{2mq_2 v}}{\sqrt{2mq_1 v}}$$

$$= \frac{\sqrt{m_2 q_2}}{\sqrt{m_1 q_1}} = \frac{\sqrt{4m_p \times 2e}}{\sqrt{m_p \times e}}$$

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Ques Find ratio of wavelength of A & B

- (i) If momentum of A is 50% more than that of B
 (ii) If velocity of A is 20% less than that of B
 (iii) If mass of A is 25% more than B & velocity of A is 20% less than B
 (iv) If K.E. of A is 200% of B
 (v) If K.E. of A is 300% more than that of B.

(i) $P_B = x$ $P_A = \frac{50}{100} \times x + x = \frac{x}{2} + x = \frac{3x}{2}$

$$\frac{\lambda_A}{\lambda_B} = \frac{h/P_A}{h/P_B} = \frac{P_B}{P_A} = \frac{x}{\frac{3x}{2}} = \frac{2x}{3x} = \frac{2}{3}$$

(ii) $V_B = x$ $V_A = \frac{100-20}{100} \times x = \frac{80}{100} x = \frac{4x}{5}$

$$\frac{\lambda_A}{\lambda_B} = \frac{h/mV_A}{h/mV_B} = \frac{V_B}{V_A} = \frac{x}{\frac{4x}{5}} = \frac{5}{4}$$

(iii) $m_B = x$ $m_A = \frac{25}{100} x + x = \frac{x}{4} + x = \frac{5x}{4}$

$V_B = v$ $V_A = \frac{100-25}{100} \times v = \frac{75}{100} v = \frac{3}{4} v$

$$\frac{\lambda_A}{\lambda_B} = \frac{h/m_A V_A}{h/m_B V_B} = \frac{m_B V_B}{m_A V_A} = \frac{x \times v}{\frac{5x}{4} \times \frac{3}{4} v} = \frac{16xv}{15xv} = \frac{16}{15}$$

(iv) $K.E. B = x$ $K.E. A = \frac{200}{100} \times x = 2x$

$$\frac{\lambda_A}{\lambda_B} = \frac{h/\sqrt{2mK.E.A}}{h/\sqrt{2mK.E.B}} = \frac{\sqrt{K.E.B}}{\sqrt{K.E.A}} = \frac{\sqrt{x}}{\sqrt{2x}} = \frac{1}{\sqrt{2}}$$

(v) $K.E. B = x$ $K.E. A = \frac{300}{100} \times x + x = 3x + x = 4x$

$$\frac{\lambda_A}{\lambda_B} = \frac{h/\sqrt{2mK.E.A}}{h/\sqrt{2mK.E.B}} = \frac{\sqrt{K.E.B}}{\sqrt{K.E.A}} = \frac{\sqrt{x}}{\sqrt{4x}} = \frac{1}{2}$$

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Ques Find wavelength of e^- which is accelerated 1.5 V ?

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

$$\begin{array}{ccc} \downarrow & \downarrow & \downarrow \\ e^- & p & \alpha \\ \lambda = \frac{150}{\sqrt{V}} \text{ \AA} & \lambda = \frac{0.286}{\sqrt{V}} \text{ \AA} & \lambda = \frac{0.101}{\sqrt{V}} \text{ \AA} \end{array}$$

2. Heisenberg Principle :-

We can't measure exact position & velocity of e^- simultaneously.

$$\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$$

$$\Delta x \cdot m \Delta v \geq \frac{h}{4\pi}$$

$$\Delta x \cdot \Delta v \geq \frac{h}{4\pi m}$$

$\Delta x \rightarrow$ uncertainty in position

$\Delta p \rightarrow$ " " momentum

$\Delta v \rightarrow$ " " velocity

Ans

Ques Find uncertainty in velocity of an e^- if uncertainty in position is equal to uncertainty in momentum.

① $\frac{h}{2\sqrt{\pi}m}$ ② $\frac{h}{2\sqrt{\pi}m}$ ③ $\frac{1}{2m} \sqrt{\frac{h}{\pi}}$ ④ $\frac{1}{2} \sqrt{\frac{h}{\pi m}}$

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2.15

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$$\Delta x = \Delta p$$

$$\Delta x = m \Delta v$$

$$\Delta v = \frac{h}{4\pi m \Delta x}$$

$$= \frac{h}{4\pi m m \Delta v}$$

$$\Delta v^2 = \frac{h}{4\pi m^2} \Rightarrow \Delta v = \sqrt{\frac{h}{2m\pi}}$$

Ques Find uncertainty in velocity of particle in a distance of $0.1 \text{ \AA}$?

(i) $5.79 \times 10^6 \text{ m/s}$ (ii) $5.79 \times 10^7 \text{ m/s}$

(iv) $5.79 \times 10^8 \text{ m/s}$ (iv) $0.579 \times 10^6 \text{ m/s}$

$$\Delta x m \Delta v = \frac{h}{4\pi}$$

$$\Delta v = \frac{h}{4\pi m \Delta x}$$

$$\Delta v = \frac{6.6 \times 10^{-34}}{4 \times 3.14 \times 9.1 \times 10^{-31} \times 0.1 \times 10^{-10}} \\ = \frac{6.6 \times 10^{-34}}{4.71 \times 10^{-7}} = 47.$$

$$\Delta v = 6.6 \times 10^{-34+31+10}$$

$$= \frac{36.4 \times 0.314}{6.6 \times 10^{-3+10}}$$

$$= \frac{66 \times 10^6}{36.4 \times 0.314} \\ = 0.560$$

Ques Find uncertainty in position of an e^- moving with $3 \times 10^4 \text{ m/s}$ which is accurate upto 0.001% .

$$\Delta x m \Delta v = \frac{h}{4\pi}$$

$$v = 3 \times 10^4 \times 0.001 \\ = \frac{3 \times 10^4 \times 0.001}{100 \times 1000} = 0.3$$

$$\Delta x = \frac{h}{4\pi m \Delta v}$$

$$= \frac{6.6 \times 10^{-34}}{4 \times 3.14 \times 9.1 \times 10^{-31} \times 0.3}$$

$$= \frac{6.6 \times 10^{-34+31}}{36 \times 3.14 \times 0.3} = \frac{22 \times 10^{-3}}{36 \times 3.14}$$

$$= \frac{2.2}{0.1} = 22 \times 10^{-3}$$

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Ques Which of the following is correct

① $\Delta x = 0$ $\Delta p = \infty$

② $\Delta x = 0$ $\Delta p = 0$

③ $\Delta x = \infty$ $\Delta p = 0$

④ all

24/07/17

Quantum Numbers :-

→ It describes the position of an atom

1. Principal Quantum No. (n) :-

2. Azimuthal Quantum No. (l) :-

3. Magnetic Quantum No. (m) :-

4. Spin Quantum No. (s) when Whlenback &

1. Principal Quantum Number :- (n)

→ It describes shell or orbit.

n =	1	2	3	4	5	...
Shell =	K	L	M	N	O	...

→ It defines size or energy of orbit/shell.

$$r = 0.529 \frac{n^2}{Z} \text{ \AA}$$

$$r \propto n^2$$

$$n \uparrow r \uparrow$$

$$r_1 < r_2 < r_3$$

$$E = -2.18 \times 10^{-18} \frac{Z^2}{n^2} \text{ J/atom}$$

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

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$$E \propto -\frac{1}{n^2}$$

$$n \uparrow \Rightarrow E \uparrow$$

$$E_1 < E_2 < E_3$$

- angular momentum of an e^- in n^{th} orbit

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

- no. of subshells / suborbit in n^{th} shell = n
- max^m. no. of orbitals in n^{th} shell = n^2
- max^m. no. of e^- in n^{th} shell = $2n^2$

2. Azimuthal Quantum Number : (l)

- It describes subshell.
- Values of 'l' = 0 to $n-1$

$n=1$	$l=0$	s	$l=0$ s
$n=2$	$l=0$	s	$l=1$ p
$n=3$	$l=1$	p	$l=2$ d
	$l=0$	s	$l=3$ f
	$l=1$	p	$l=4$ g
	$l=2$	d	

- orbital angular momentum = $\sqrt{l(l+1)} \frac{h}{2\pi}$
- no. of orbital = $2l+1$
- max^m. no. of e^- = $2(2l+1)$

= $4l+2$ AIPMT-2012

Ques Max^m no. of e^- is represent by
 (i) $(4l+2)$ (ii) $4l-2$ (iii) $2l+1$ (iv) n^2

Solⁿ $l=0$
 $4 \times 0 + 2$
 $= 2$

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Subshell	l	no. of orbital $2l+1$	max. no. of e^-	orbital ang. moment $= \sqrt{l(l+1)} \frac{h}{2\pi}$
s	0	1	2	$= \sqrt{0(0+1)} \frac{h}{2\pi} = 0$
p	1	3	6	$= \sqrt{1(1+1)} \frac{h}{2\pi} = \sqrt{2} \frac{h}{2\pi} = \frac{h}{\sqrt{2}\pi}$
d	2	5	10	$= \sqrt{2(2+1)} \frac{h}{2\pi} = \sqrt{6} \frac{h}{2\pi} = \frac{\sqrt{3}h}{\sqrt{2}\pi}$
f	3	7	14	$= \sqrt{3(3+1)} \frac{h}{2\pi} = \sqrt{12} \frac{h}{2\pi} = \frac{2\sqrt{3}h}{2\pi} = \frac{\sqrt{3}h}{\pi}$

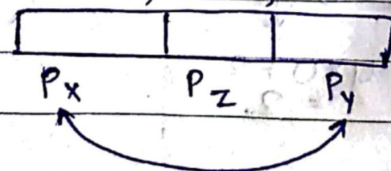
3. Magnetic Quantum No. :- (m)

It describes shape of and orientation of shell.

Value of m :- $-l \leq m \leq l$

total values of ' m ' for any ' l ' = $2l+1$

$n=1$	$l=0$	s	$m=0$	1s
$n=2$	$l=0$	s	$m=0$	2s
	$l=1$	p	$m = -1, 0, +1$	



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$n=3$	$l=0$	s	$m=0$
	$l=1$	p	$m = -1, 0, +1$
	$l=2$	d	$m = -2, -1, 0, +1, +2$
$d_{xy}, d_{xz}, d_{z^2}, d_{yz}, d_{x^2-y^2}$			

$n=4$	$l=0$	s	$m=0$
	$l=1$	p	$m = -1, 0, +1$
	$l=2$	d	$m = -2, -1, 0, +1, +2$
	$l=3$	f	$m = -3, -2, -1, 0, +1, +2, +3$

4. Spin Quantum Number (s) :-

- It describes the spin of the e^- .

Clockwise & anticlockwise

($+1/2$ or $-1/2$)

$\uparrow\downarrow$ ✓

$\uparrow\uparrow$ ✗

$\downarrow\downarrow$ ✗

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

$$= \sqrt{s(s+1)} \hbar$$

angular momentum

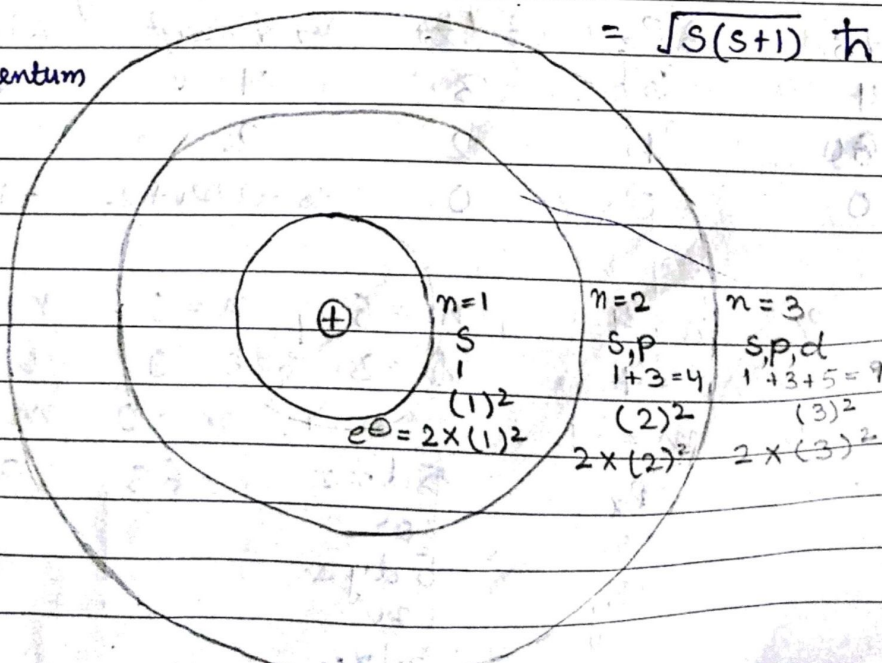
$$m_{\text{max}} = \frac{nh}{2\pi}$$

orbital angular momentum

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

spin angular momentum =

$$\sqrt{s(s+1)} \frac{h}{2\pi}$$



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Ques Find angular momentum
(i) 2s orbital orbital ang. mom.

$$\sqrt{l(l+1)} \frac{h}{2\pi} = 0 \quad mvr = \frac{2h}{2\pi} = \frac{h}{\pi}$$

(ii) 4p orbital

$$\sqrt{l(l+1)} \frac{h}{2\pi} \quad mvr = \frac{4h}{2\pi} = \frac{2h}{\pi} = \frac{h}{\sqrt{2}\pi}$$

(iii) 3rd orbit

$$\frac{nh}{2\pi} = mvr = \frac{3h}{2\pi}$$

Representation of orbital
 $n l^x$ ns^2

$n \rightarrow$ Principal Quantum no.

$l \rightarrow$ azimuthal

$x \rightarrow$ no. of e^-

$$\Psi_{nlm} = n l m$$

Ques Write Quantum Number for following

	4s	3P _z	3dz ²	4dx ² -y ²	6P _x
$n =$	4	3	3	4	6
$l =$	0	1	2	2	1
$m =$	0	0	0	-2 or +2	-1 or +1

<u>Ques</u>	$n = 3$	$n = 4$	$n = 5$	$n = 6$	$n = 3$
	$l = 0$	$l = 1$	$l = 2$	$l = 0$	$l = 2$
	$m = 0$	$m = -1$	$m = +1$	$m = 0$	$m = 0$
	3s	4P _x or 4P _y	5dxz or 5dyz or 5dx _{xy}	6s	3dz ²

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Ques which of the following set of Quantum No. is correct?

	n	l	m	s
①	2	0	0	$-\frac{1}{2}$
②	3	3	1	$+\frac{1}{2}$
③	4	-2	2	$-\frac{1}{2}$
④	5	4	-3	$+\frac{1}{2}$
⑤	3	4	-1	$-\frac{1}{2}$
⑥	6	2	-3	$+\frac{1}{2}$
⑦	5	3	2	$-\frac{1}{2}$

25/07/17

Ques find max. no. of orbitals and max. no. of e^- in following :-

(i) $n = 4$ ~~4, 3, 2, 1~~

$$\text{max. no. of orbitals} = n^2 = 16$$

$$e^- = 2n^2 = 2 \times 16 = 32$$

(ii) $n = 4$ $l = 3$

$$\text{Or.} \rightarrow 4^2 = 16$$

$$e^- \rightarrow 7 \times 2 = 14$$

(iii) $n = 3$ $l = 2$ $m = -2$ $3d$

$$\text{Or.} \rightarrow 1$$

$$e^- \rightarrow 2$$

(iv) $n = 5$ $l = 2$ $m = -1$ $s = +\frac{1}{2}$

$$5d$$

$$\text{Or} \rightarrow 1$$

$$e^- \rightarrow 1$$

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$\psi \rightarrow$ wave fn

$\psi^2 \rightarrow$ Probability of finding e^-

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Ques which of the following orbital is not possible

(i) 5s

(ii) 4d

~~(iii) 3f~~

(iv) 1p

(v) 2p

~~(vi) 2d~~

(vii) 1s

Ques for $n+l=5$ find max^m no. of

(i) Subshell = 3

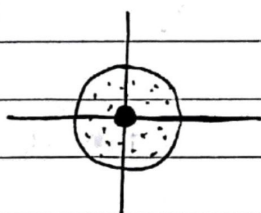
(ii) Orbitals = 9

(iii) e^- = 18

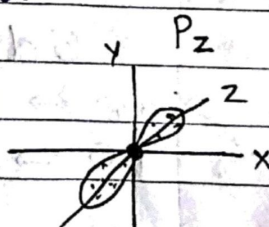
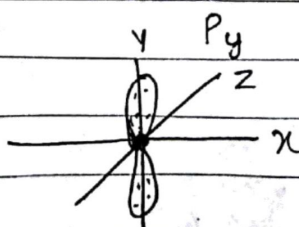
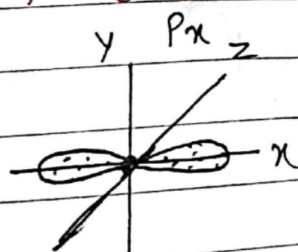
$n+l=5$	Orbital	e^-
$5+0 \rightarrow 5s$	1	2
$4+1 \rightarrow 4p$	3	6
$3+2 \rightarrow 3d$	5	10
$2+3 \rightarrow 2f$ X	9	18

Shapes of Orbitals :-

1. s-orbital :- Spherical



2. p-orbital :- dumb-bell

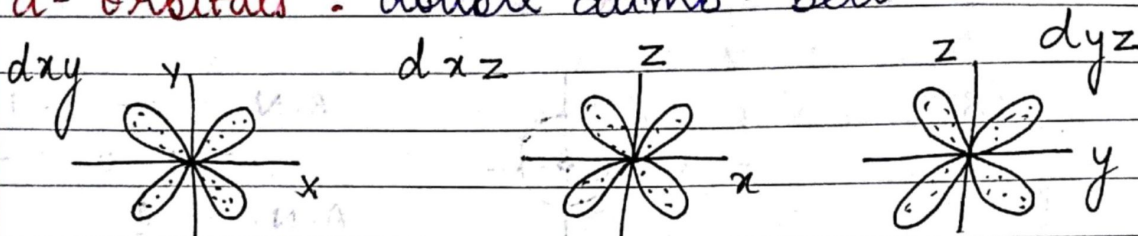


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3. d-orbitals : double dumb-bell



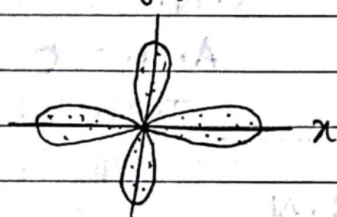
e^- density $\rightarrow xy$

xz

yz

$d_{x^2-y^2}$

d_{z^2}



4. f-orbitals : complicated

Node and Nodal Plane :-

Node : The region where probability of finding an e^- is zero.

~~ψ~~ $|\psi^2| = 0 \rightarrow \text{Node}$

$|\psi^2| = 1$ ~~max~~ max.^m probability of finding an e^-

Nodal Plane : The plane where probability of finding e^- is zero.

Radial Node :- Spherical Node

R.N. = ~~$n-l-1$~~ $n-l-1$

A.N. = l

total Node = R.N. + A.N. = $n-1$

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Orbitals and Node :-

1s



$$R.N. = n - l - 1$$

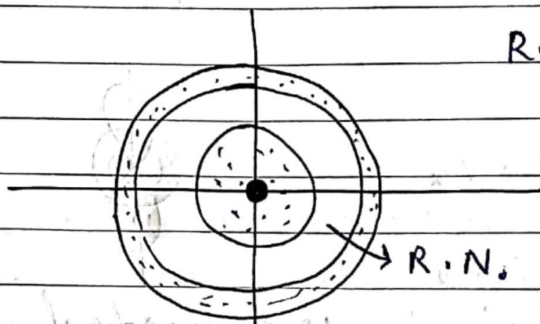
$$= 1 - 0 - 1 = 0$$

$$A.N. = l$$

$$= 0$$

$$T.N. = 0 + 0 = 0$$

2s

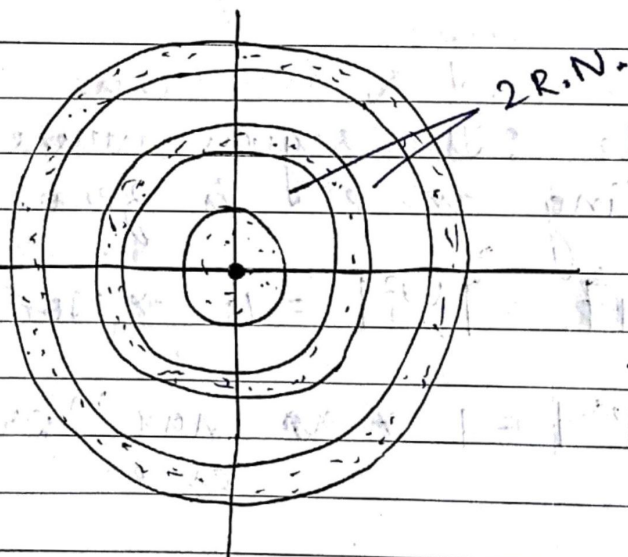


$$R.N. = 2 - 0 - 1 = 1$$

$$A.N. = 0$$

$$T.N. = 1$$

3s



$$R.N. = 3 - 0 - 1$$

$$= 2$$

$$A.N. = 0$$

$$T.N. = 2$$

P-orbital2p_x3p_x

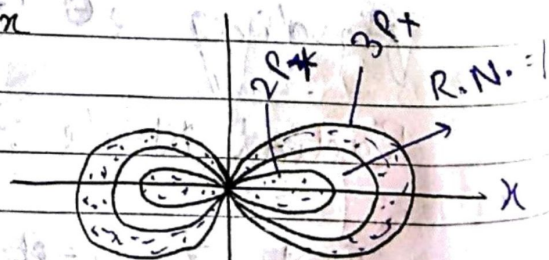
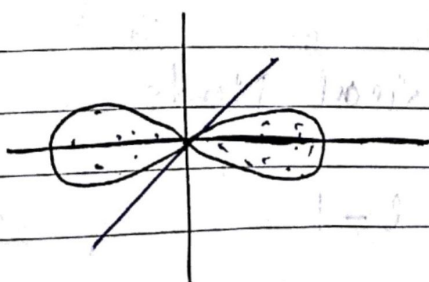
$$R.N. = 2 - 1 - 1$$

$$= 0$$

$$A.N. = 1$$

y z

$$T.N. = 1$$



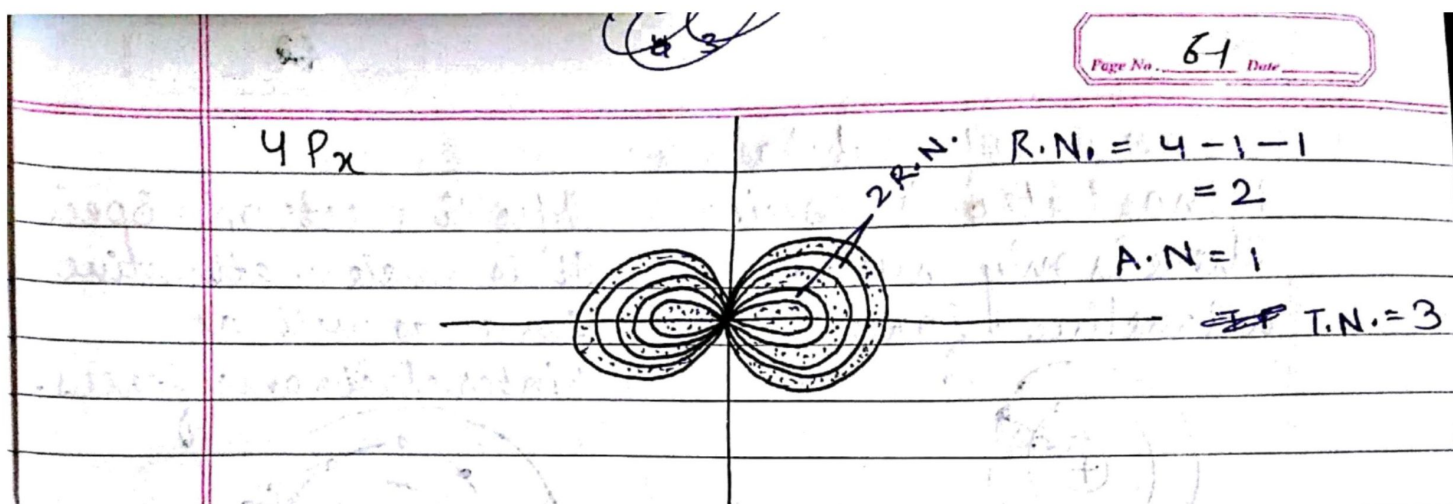
$$R.N. = 3 - 1 - 1 = 1$$

$$A.N. = 1 \rightarrow yz \text{ plane}$$

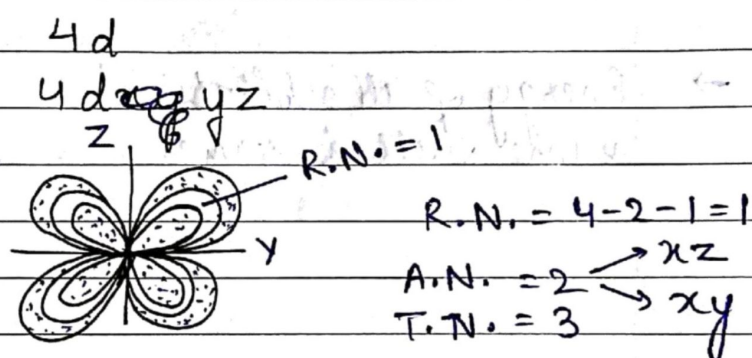
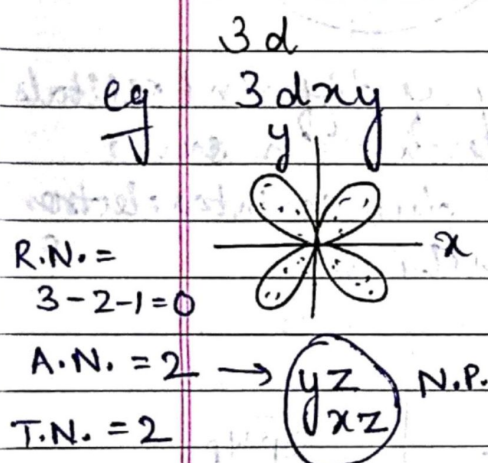
$$T.N. = 3 - 1 = 2$$

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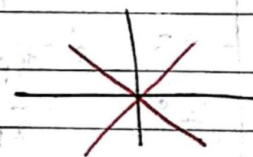
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d-orbital :-



~~$3d_{z^2}$~~ ~~$4d_{z^2}$~~ $4d_{x^2-y^2}$



$dz^2 \rightarrow$ conical Node

1.	$4f$	$R.N. = 4 - 3 - 1 = 0$	$A.N. = 3$	$T.N. = 0 + 3 = 3$
2.	$6s$	$= 6 - 0 - 1 = 5$	$A.N. = 0$	$T.N. = 5$
3.	$5p$	$= 5 - 1 - 1 = 3$	$A.N. = 1$	$T.N. = 4$
4.	$5d$	$= 5 - 2 - 1 = 2$	$A.N. = 2$	$T.N. = 4$
5.	$5f$	$= 5 - 3 - 1 = 1$	$A.N. = 3$	$T.N. = 4$

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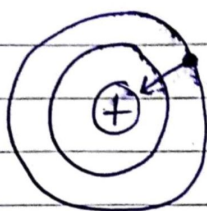
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Energy of orbitals :-

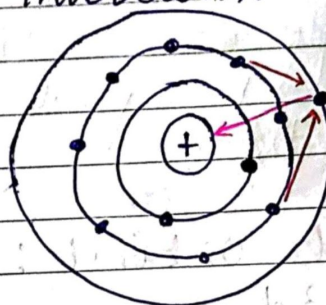
Mono electronic species

There is only nuclear attractive force



Multi electronic species

It is nuclear attractive force as well as interelectronic forces.



→ Energy of all orbitals in same shell is same

Energy of different orbitals is different in same shell due to interelectronic repulsion.

4s	4p	4d	4f
3s	3p	3d	
2s	2p		
1s			

4s	3d	4p
3s	3p	
2s	2p	
1s		

→ Energy only depends on principal quantum No.

$$1s < 2s = 2p < 3s = 3p = 3d$$

→ Energy depends upon 'n' as well as 'l'

→ **[n+l] rule**
 $(n+l) \downarrow E \downarrow$
 $(n+l) = \text{same } n \downarrow E \downarrow$

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

$$(n+l) \Rightarrow 1 \quad 2 \quad 3 \quad 3 \quad 4 \quad 4 \quad 5$$

Effective Nuclear Charge (Z_{eff}) :-

Due to shielding of outer shell e^- from nucleus by inner shell e^- , net +ve charge experienced by outer shell e^- from nucleus

$Z_{eff} \downarrow$ $l \uparrow$
Shielding Power $s > p > d > f$

for same subshell Energy $\downarrow$ as atomic no.
($Z_{eff} \uparrow$)

$$E_{2s}(H) > E_{2s}(Li) > E_{2s}(Na) > E_{2s}(K)$$

$n \rightarrow \text{const.}$

$$E \propto -Z^2$$

$$Z \uparrow E \downarrow$$

find max. no. of e^- which have $n = 3$
 $s = -1/2$

$$\text{Orbital } (3)^2 = 9$$

$$\text{total } e^- = 2n^2 = 2(3)^2 = 18$$

$$\begin{array}{cc} 9 & 9 \\ (+1/2) & (-1/2) \end{array}$$

¢

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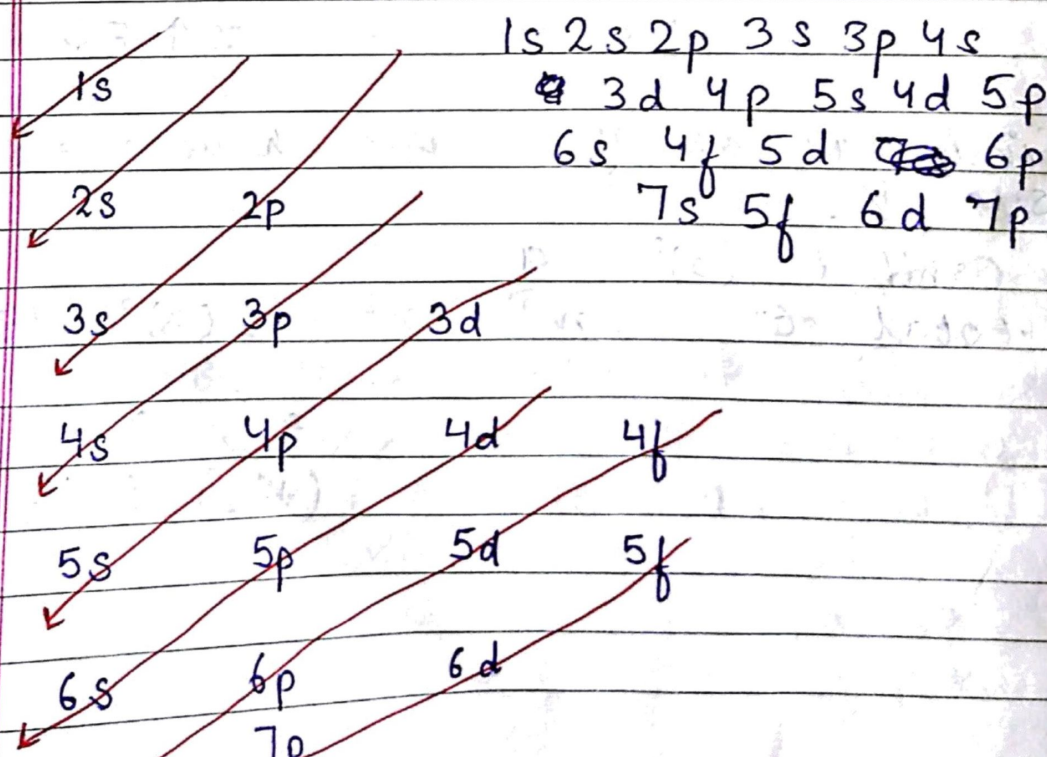
Filling of orbitals in an atom :-
It is based on Aufbau Principle

Pauli's Exclusion Principle Hund's max^m Multiplicity Rule Relative Energy of orbital

Aufbau Principle :-

Aufbau → German word
↳ "to build up"

- Accⁿ to Aufbau Principle, e^- are filled in orbitals in increasing order of energy.
- 1st e^- are filled in lower energy orbitals & then e^- are filled in higher energy orbitals.



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$n+l$ Rule :-

$n = 1, 2, 3, 4 \dots$

$K, L, M, N \dots$

$l = 0, 1, 2, 3$

s, p, d, f

$(n+l) \downarrow E \downarrow$

$(n+l) = \text{same } n \downarrow E \downarrow$

Pauli Exclusion Principle :-

It states that no two e^- have same quantum numbers.

or

Two e^- can be filled in orbitals but they must have opposite spin.

max. e^- in ' n ' shell = $2n^2$

$$\begin{array}{ccc} & n^2 & n^2 \\ & \swarrow & \searrow \\ S = +1/2 & & -1/2 \end{array}$$

Hund's Max.^m Multiplicity Rule :-

Accⁿ to hund, Pairing of e^- in orbitals of same subshell does not take place until each orbital of ^{that} subshell is singly occupied or half filled.

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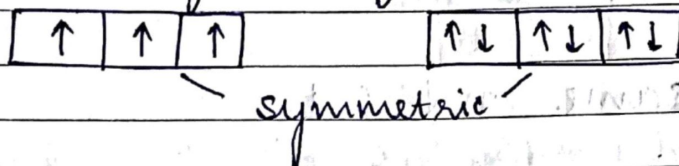
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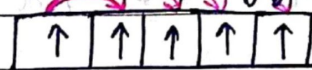
Pairing :-
 $s \rightarrow 2^{\text{nd}} e^-$
 $p \rightarrow 4^{\text{th}} e^-$
 $d \rightarrow 6^{\text{th}} e^-$
 $f \rightarrow 8^{\text{th}} e^-$

no. of exchange $\uparrow$
 energy released is
 more
 hence stability $\uparrow$

- Stability of half or full filled subshells.
- due to symmetry

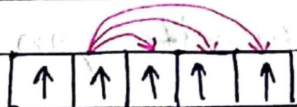


- due to energy exchange



$\rightarrow$ all have same energy
 $\rightarrow$ degenerate orbital

1st $e^- \rightarrow 4$ exchange

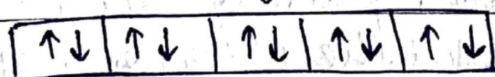


2nd $e^- \rightarrow 3$ exchange

3rd $e^- \rightarrow 2$ exchange

4th $e^- \rightarrow 1$ exchange

total exchange = 10



d^{10}

total exchange = 10 + 10 = 20

full filled $>$ half filled

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Electronic Configuration :-

- $\begin{matrix} \text{PS} \\ \text{ES} \end{matrix}$
- chemical behaviour
 - metal & non metal (MP/B.P)
 - inert gas non-reactive
 - halogen very-reactive
 - colour
 - Bond character $-$, $-$, $\equiv$, $\equiv$
 - solid, liquid, gas.

1 H	$1s^1$	$\uparrow$
2 He	$1s^2$	$\uparrow\downarrow$
3 Li	$[\text{He}] 2s^1$	$\uparrow$
4 Be	$[\text{He}] 2s^2$	$\uparrow\downarrow$
5 B	$[\text{He}] 2s^2 2p^1$	$\uparrow\downarrow$ $\uparrow$ $\square$ $\square$
6 C	$[\text{He}] 2s^2 2p^2$	$\uparrow\downarrow$ $\uparrow$ $\uparrow$ $\square$
7 N	$[\text{He}] 2s^2 2p^3$	$\uparrow\downarrow$ $\uparrow$ $\uparrow$ $\uparrow$
8 O	$[\text{He}] 2s^2 2p^4$	$\uparrow\downarrow$ $\uparrow\downarrow$ $\uparrow$ $\uparrow$
9 F	$[\text{He}] 2s^2 2p^5$	$\uparrow\downarrow$ $\uparrow\downarrow$ $\uparrow\downarrow$ $\uparrow$
10 Ne	$[\text{He}] 2s^2 2p^6$	$\uparrow\downarrow$ $\uparrow\downarrow$ $\uparrow\downarrow$ $\uparrow\downarrow$
11 Na	$[\text{He}] 2s^2 2p^6 3s^1$ or $[\text{Ne}] 3s^1$	$\uparrow$
12 Mg	$[\text{Ne}] 3s^2$	$\uparrow\downarrow$
13 Al	$[\text{Ne}] 3s^2 3p^1$	$\uparrow\downarrow$ $\uparrow$ $\square$ $\square$
14 Si	$[\text{Ne}] 3s^2 3p^2$	$\uparrow\downarrow$ $\uparrow$ $\uparrow$ $\square$
15 P	$[\text{Ne}] 3s^2 3p^3$	$\uparrow\downarrow$ $\uparrow$ $\uparrow$ $\uparrow$
16 S	$[\text{Ne}] 3s^2 3p^4$	$\uparrow\downarrow$ $\uparrow\downarrow$ $\uparrow$ $\uparrow$
17 Cl	$[\text{Ne}] 3s^2 3p^5$	$\uparrow\downarrow$ $\uparrow\downarrow$ $\uparrow\downarrow$ $\uparrow$
18 Ar	$[\text{Ne}] 3s^2 3p^6$	$\uparrow\downarrow$ $\uparrow\downarrow$ $\uparrow\downarrow$ $\uparrow\downarrow$

19 K $[\text{Ne}] 3s^2 3p^6 3d^0 4s^1$ $\Rightarrow$ $[\text{Ar}] 3d^0 4s^1$

$\begin{matrix} 3+2 \\ =5 \end{matrix}$
 $\begin{matrix} 4+0 \\ =4 \end{matrix}$

$\square$ $\square$ $\square$ $\square$ $\uparrow$

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20 Ca	[Ar] 3d ⁰ 4s ²	$\boxed{} \boxed{} \boxed{} \boxed{} \boxed{} \boxed{}$	$\uparrow\downarrow$
21 Sc	[Ar] 3d 3d ¹ 4s ²	$\uparrow $	$\uparrow\downarrow$
22 Ti	[Ar] 3d ² 4s ²	$\uparrow \uparrow $	$\uparrow\downarrow$
23 V	[Ar] 3d ³ 4s ²	$\uparrow \uparrow \uparrow $	$\uparrow\downarrow$
24 Cr	[Ar] 3d ⁴ 4s ²	[Ar] 3d ⁵ 4s ¹ (n+l) Rule Violate	
		$\uparrow \uparrow \uparrow \uparrow \uparrow $ half filled extra stability	
25 Mn	[Ar] 3d ⁵ 4s ²	$\uparrow \uparrow \uparrow \uparrow \uparrow $	$\uparrow\downarrow$
26 Fe	[Ar] 3d ⁶ 4s ²	$\uparrow\downarrow \uparrow \uparrow \uparrow \uparrow $	$\uparrow\downarrow$
27 Co	[Ar] 3d ⁷ 4s ²	$\uparrow\downarrow \uparrow\downarrow \uparrow \uparrow \uparrow $	$\uparrow\downarrow$
28 Ni	[Ar] 3d ⁸ 4s ²	$\uparrow\downarrow \uparrow\downarrow \uparrow\downarrow \uparrow \uparrow $	$\uparrow\downarrow$
29 Cu	[Ar] 3d ⁹ 4s ²	[Ar] 3d ¹⁰ 4s ¹ (n+l) Rule x	
		$\uparrow\downarrow \uparrow\downarrow \uparrow\downarrow \uparrow\downarrow \uparrow\downarrow $	$\uparrow$
30 Zn	[Ar] 3d ¹⁰ 4s ²	$\uparrow\downarrow \uparrow\downarrow \uparrow\downarrow \uparrow\downarrow \uparrow\downarrow $	$\uparrow\downarrow$

26 Fe	$1s^2$	$2s^2 2p^6$	$3s^2 3p^6 3d^6$	$4s^2$
	Per ultimate shell	Penultimate shell	Valence shell or Outermost shell or ultimate shell	

Ques e^- for an atom is $\rightarrow 2K \ 8L \ 9M \ \& \ 2N$ find

- ① atomic Number :- 21
- ② no. of e^- in s-subshell 8
- ③ no. of e^- in p-subshell 12
- ④ no. of e^- in d-subshell 1
- ⑤ no. of unpaired e^- 1

III

Ques In which of following Aufbau Principle is violated?

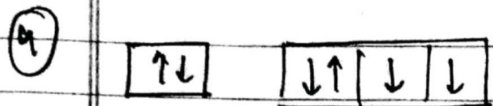
- ① $\uparrow\downarrow $
- ② $\uparrow\downarrow $

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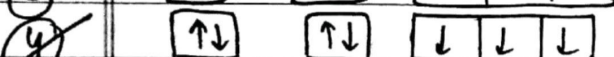
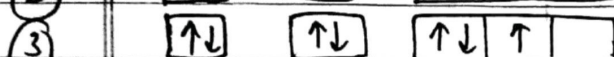
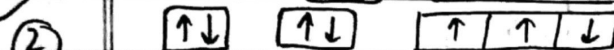
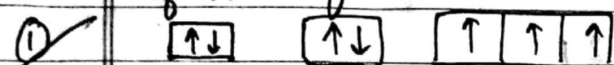
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2-Ne
3-Ar
OK



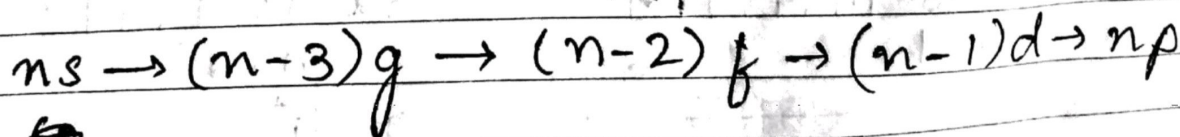
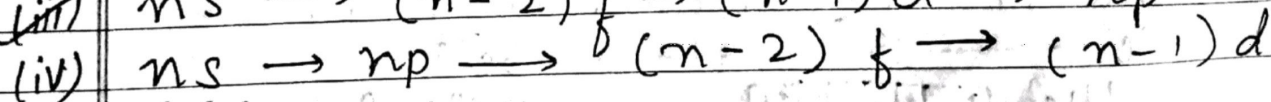
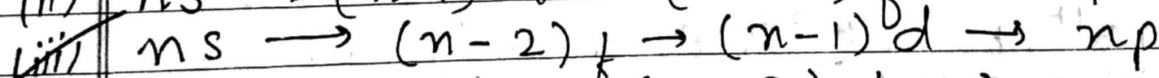
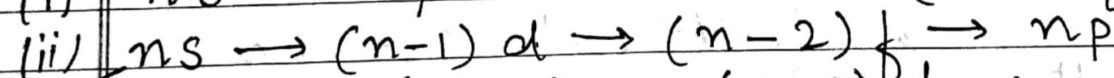
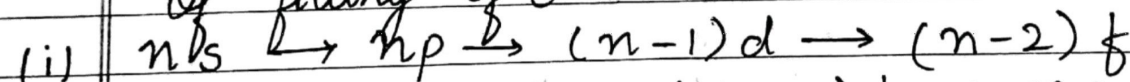
Ques Which of the following is correct e^- configuration of N



Ques Write 4 quantum no. of for valence e^- of Rubidium ($Z = 37$) ?
 1984
 AIPMT-2012
 JEE Main-2013

	n	l	m	s	5s ¹
1	5	1	0	$1/2$	
2	5	0	1	$-1/2$	
3	5	2	0	$+1/2$	
4	5	0	0	$-1/2$	

Ques For $n = 6$, which is correct sequence of filling of e^-



Ans

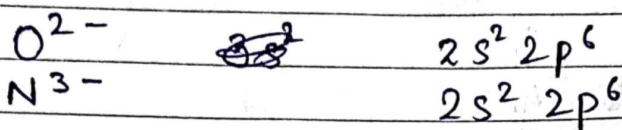
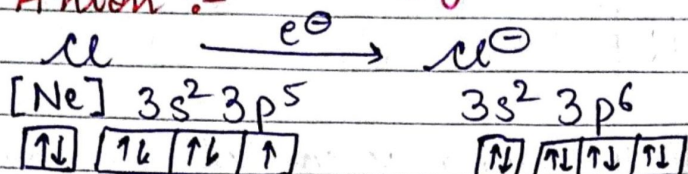
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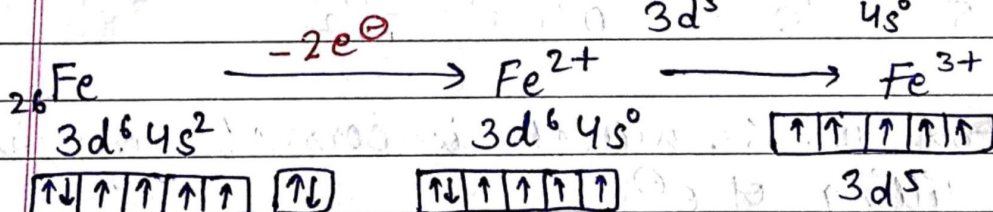
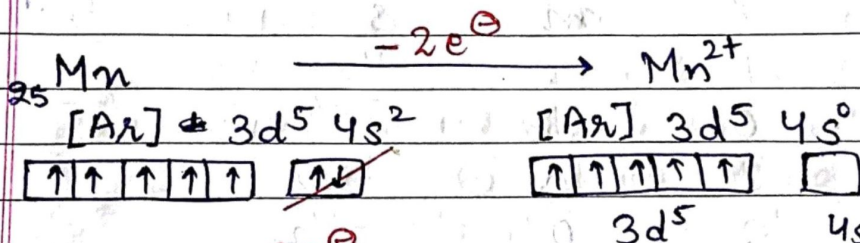
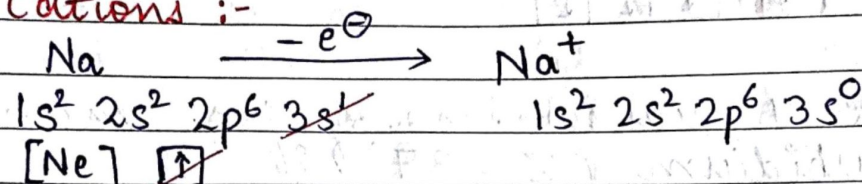
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Electronic Configuration of ions :-

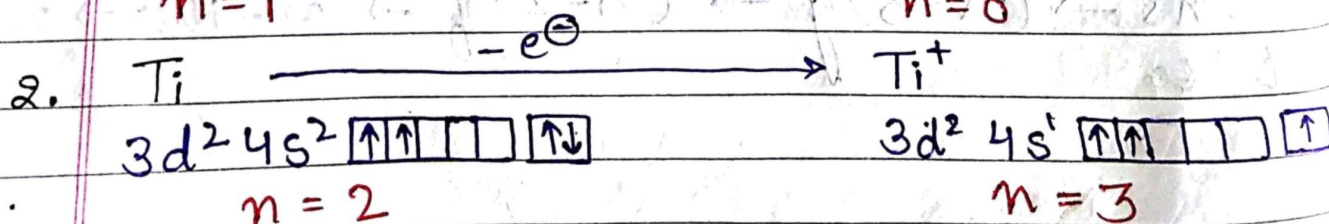
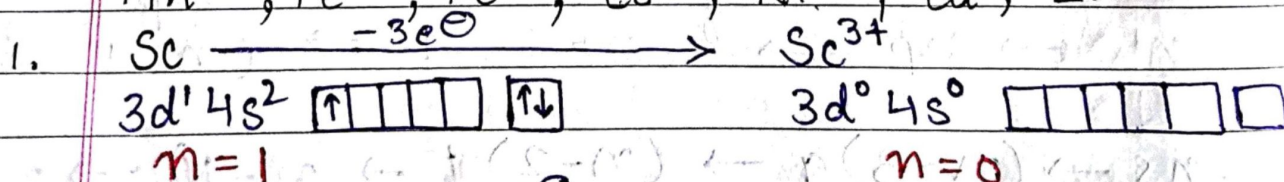
Anion :-



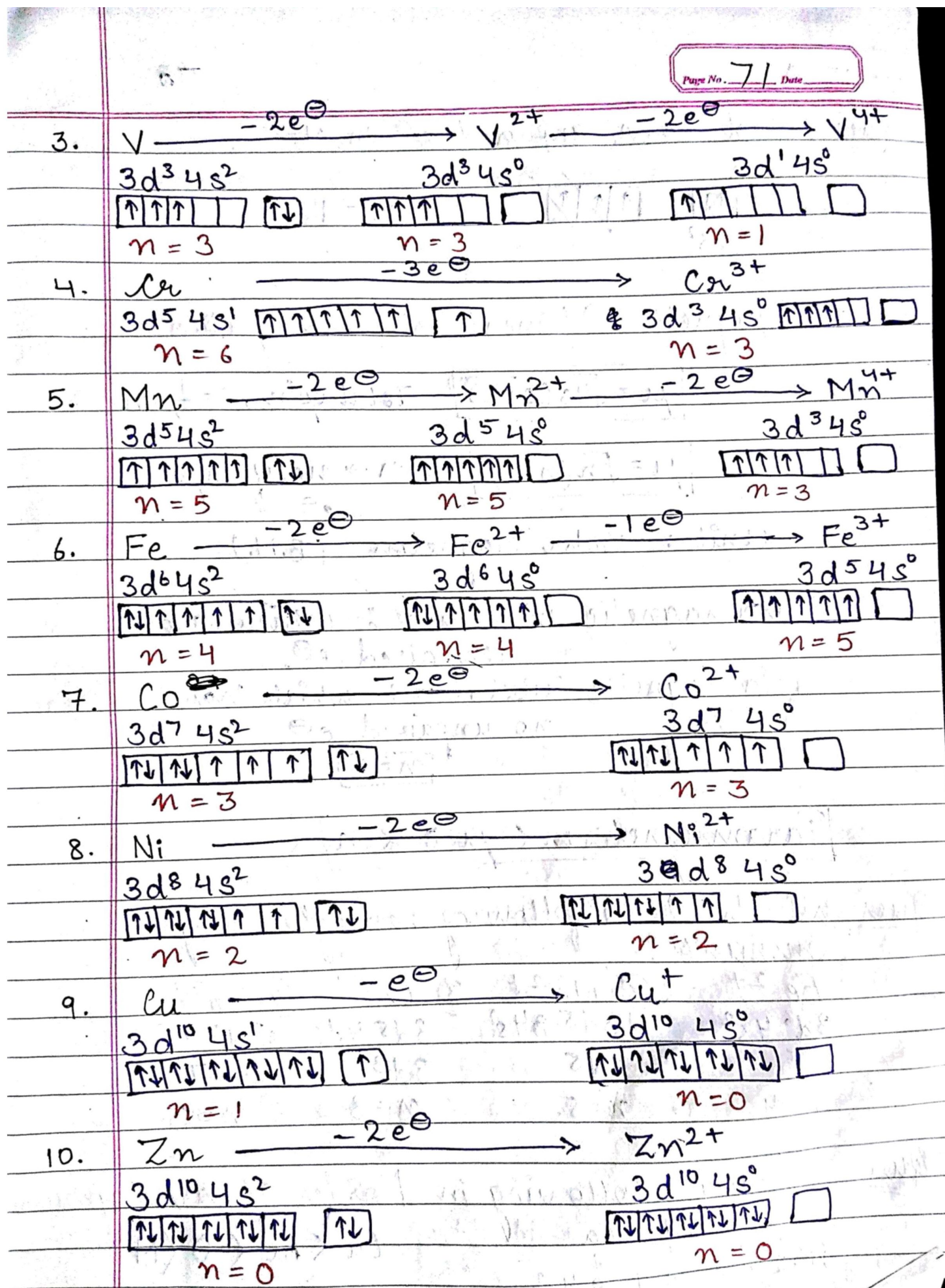
Cations :-

H.W.

Sc^{3+} , Ti^+ , V^{2+} , V^{4+} , Cr^{3+} , Mn^{2+} , Mn^{4+} , Fe^{2+} , Fe^{3+} , Co^{2+} , Ni^{2+} , Cu^+ , Zn^{2+}



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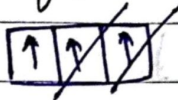
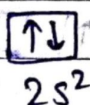
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Ques find no. of unpaired e^- in N^{2+} ? $n=1$ Magnetic Moment or Paramagnetism :-

$$\mu = \sqrt{4s(s+2)}$$

Total spin, $s = \frac{1}{2} \times n$

$$\mu = \sqrt{n(n+2)}$$

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

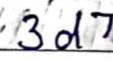
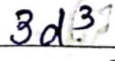
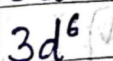
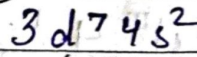
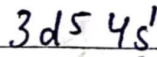
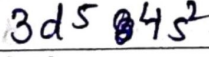
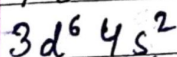
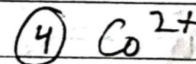
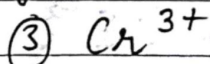
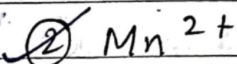
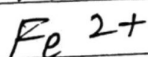
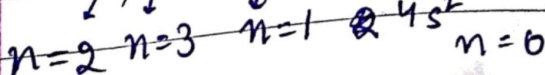
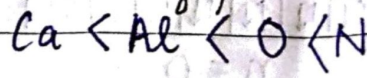
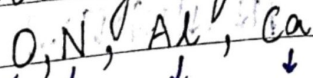
Unit :- Bohr Magnetron (B.M.)

Paramagnetic Substance :- which have unpaired e^- .Diamagnetic Substance :- which have no unpaired e^- .

$$\boxed{n=0}$$

Paramagnetism $\propto \mu \propto n$ Ques Which of the following has highest magnetic moment?

①

 $n=4$ $n=5$ $n=3$ $n=3$ QuesArrange following in $\uparrow$ order of paramagnetism

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H.W.

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QuesFind magnetic moment of elements which have at. no. $Z = 7, 24, 34$

$$Z = 7 \quad 1s^2 2s^2 2p^3 \quad n = 3 \quad \mu = \sqrt{3(3+2)} = \sqrt{3 \times 5} = \sqrt{15}$$

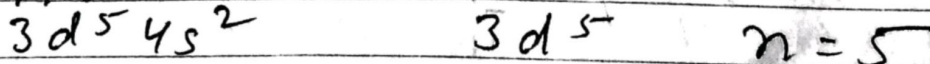
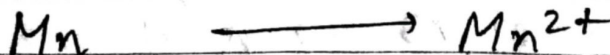
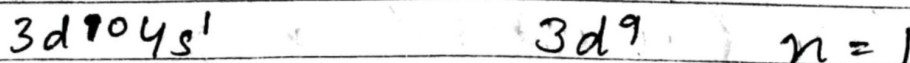
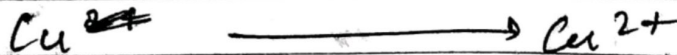
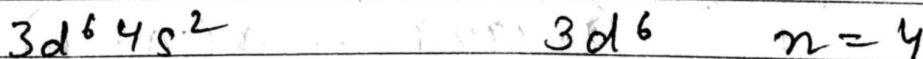
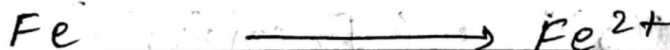
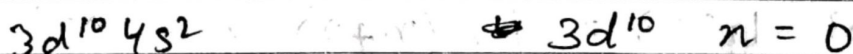
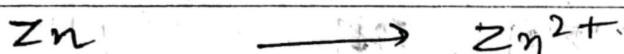
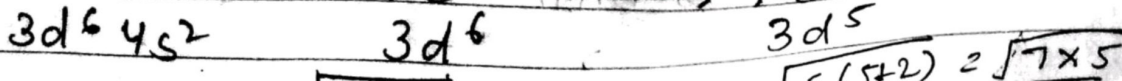
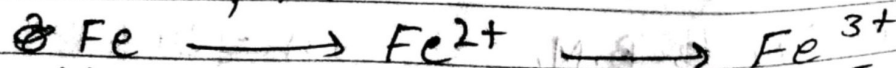
$$Z = 24 \quad [Ar] 3d^5 4s^1 \quad n = 6 \quad \mu = \sqrt{6(6+2)} = \sqrt{6 \times 8} = \sqrt{48} = 4\sqrt{3}$$

$$Z = 34 \quad [Ar] 3d^{10} 4s^2 4p^4 \quad n = 2 \quad \mu = \sqrt{2(2+2)} = \sqrt{2 \times 4} = \sqrt{8} = 2\sqrt{2}$$

Ques

which of the following has highest paramagnetism.

- ① $ZnSO_4 \cdot 6H_2O$ Zn^{2+}
- ② $FeSO_4 \cdot 6H_2O$ Fe^{2+}
- ③ $CuSO_4 \cdot 6H_2O$ Cu^{2+}
- ④ $MnSO_4 \cdot 6H_2O$ Mn^{2+}

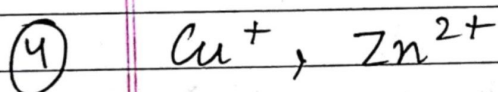
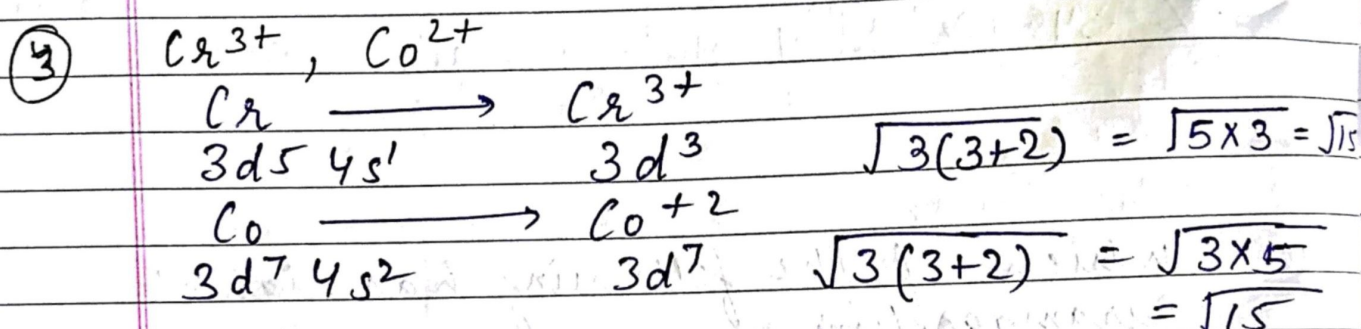
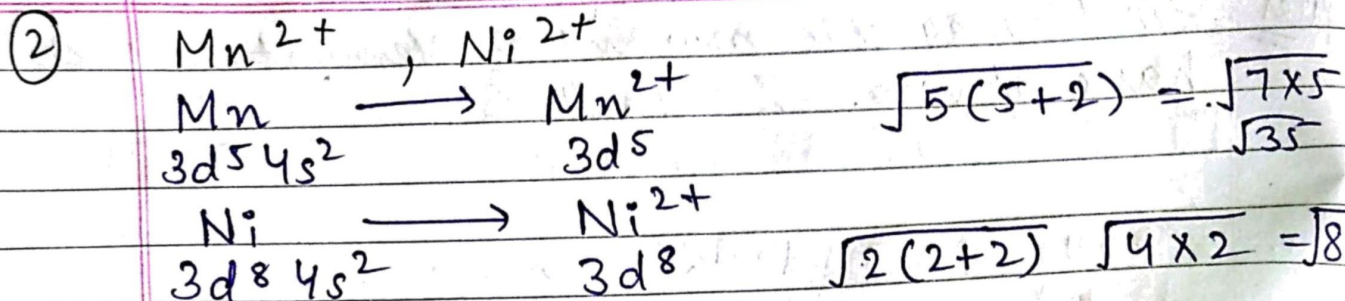
Ques $\mu = \sqrt{15}$ B.M. for which of the following pairs?(i) Fe^{2+}, Fe^{3+} 

$$\sqrt{(1+2)} = \sqrt{7 \times 5}$$

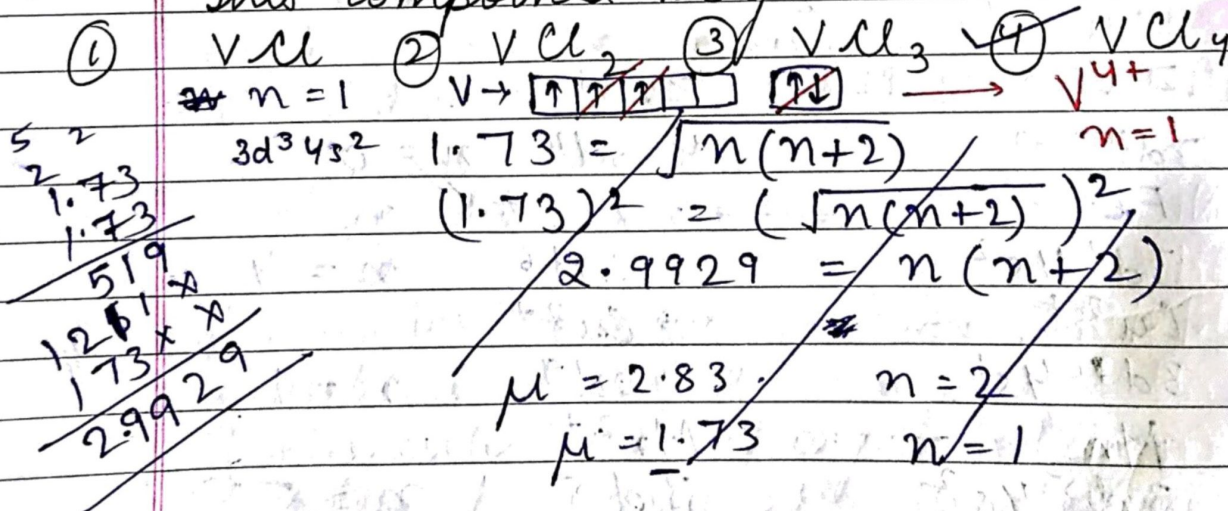
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Ques A compound of Vanadium has $\mu = 1.73$ B.M.
This compound may be



Ques For which of the following ion $\mu = 2.83$ B.M.

(i) Ti^{3+} (ii) Ni^{2+} (iii) Cr^{3+} (iv) Cu^{2+}

$\downarrow$ $3d^1 4s^0$ $n=1$ $\mu = 1.73$

$3d^8 4s^0$ $n=2$ $\mu = 2.83$ B.M.

$3d^3 4s^0$ $n=3$ $\mu = 3.87$

$3d^9 4s^0$ $n=1$ $\mu = 1.73$

$n=2$