ATOMIC STRUCTURE

Discovery Of Electron:
OR
Discharge Tube Experiment:

- Electron was discovered by J.J. Thomson in 1886.
- Apparatus consists of discharge Tube.

★ **Discharge Tube:**

- Glass tube filled with a gas having two electrodes and vaccum pump is called discharge tube.

- These electrodes are connected with high voltage source i.e; 5000 – 10000 volts. Exact voltage required depends upon length of the tube and pressure inside the tube.
- When pressure is reduced to 0.01 Torr, glow is dissappeared and flourescence is observed. This flourescence is due to "Cathode Rays". Colour of the flourescence depends upon the composition of glass.

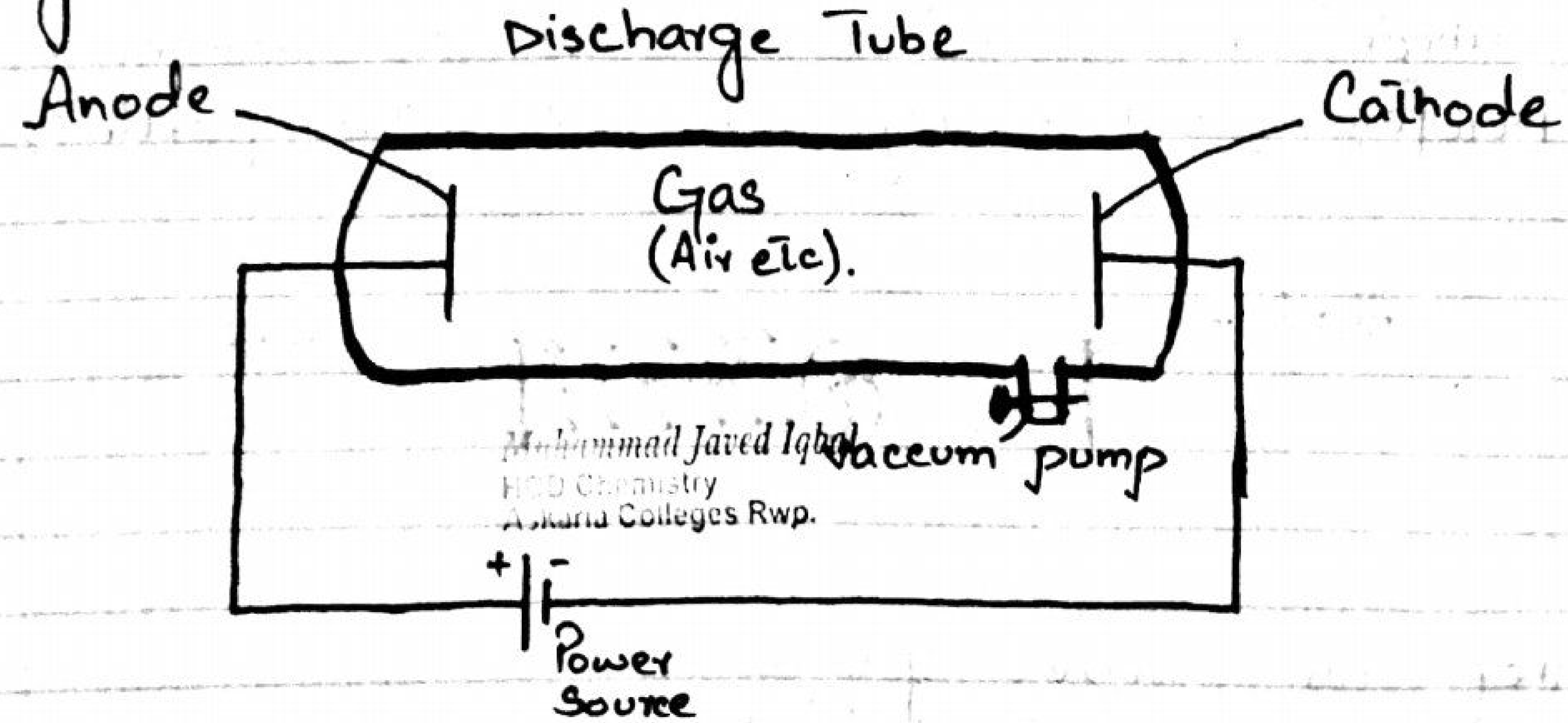


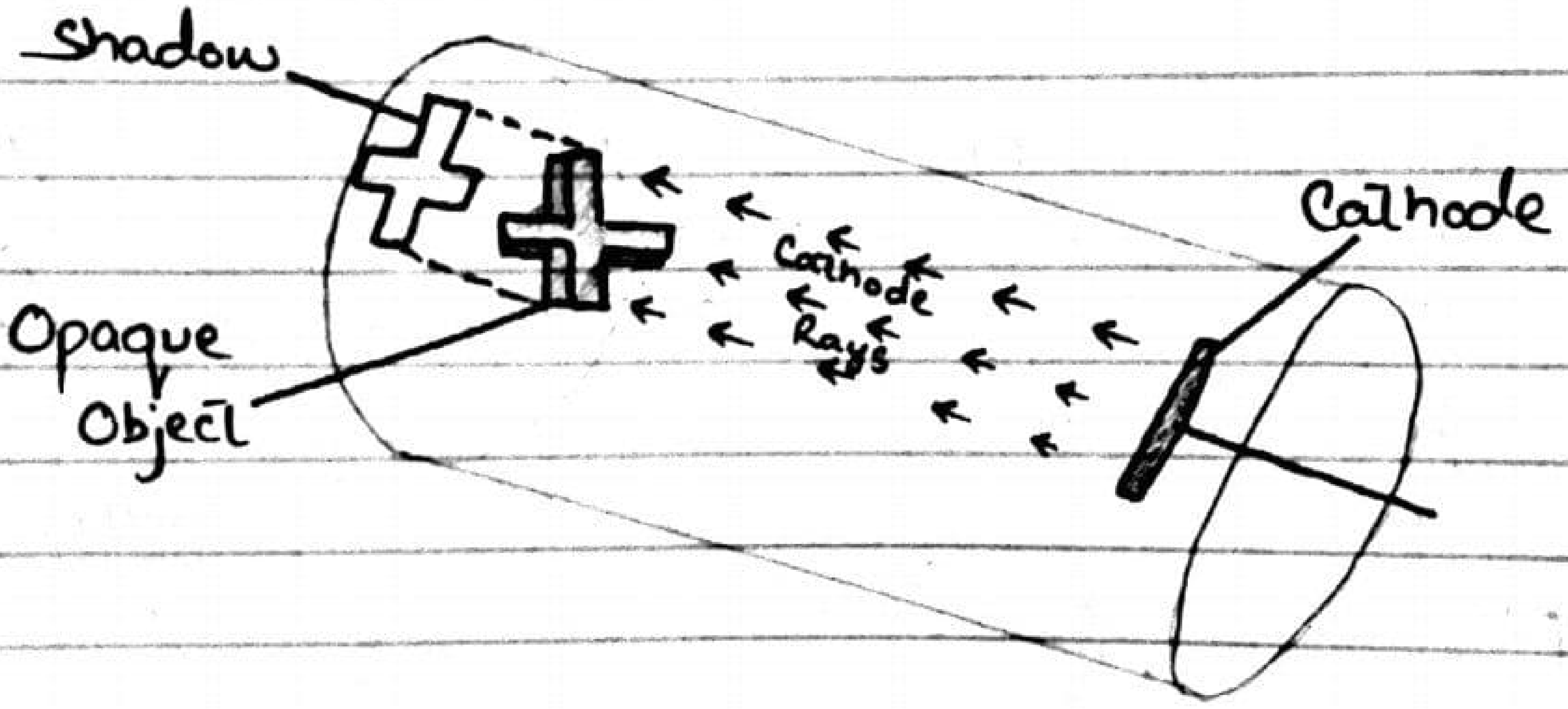
Figure: Structure Of Discharge Tube.

Properties of Cathode Rays:-

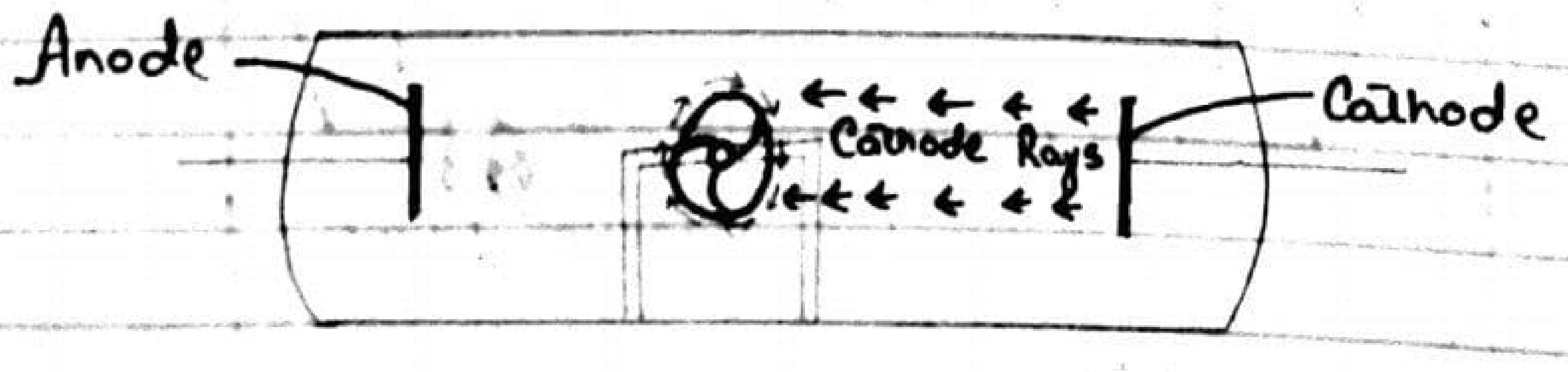
i- When cathode rays are passed through electric field, they are deflected towards +ve pole, which shows that they are -vely charged.

ii- When they are passed through the magnetic field, they are deflected perpendicular to the line, joining north and south pole.

iii- When an opaque object is placed in their path, they produce shadow of that object, showing that they travels in a straight line.



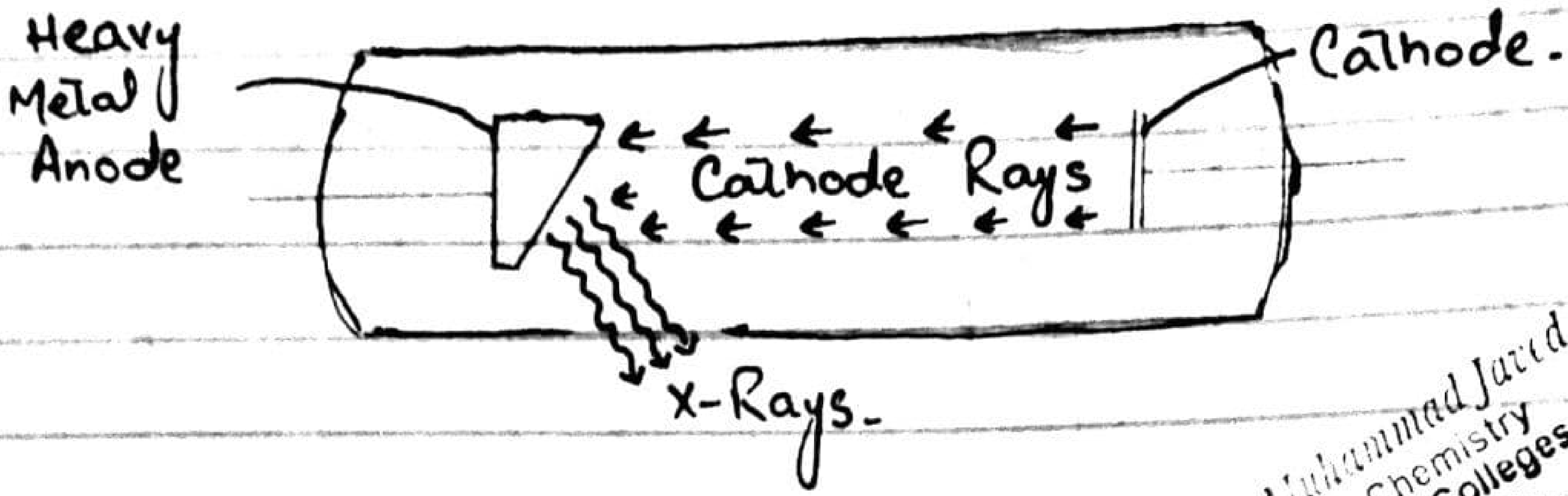
iv- When small paddle wheel is placed in their path, it goes on rotating, showing that cathode rays have mass, velocity and momentum. Therefore, these rays are also called particles.



v- They can ionize gases.

vi- They have reducing effect in a chemical reaction.

vii. They produce X-Rays, when collide with heavy metal Anode.



viii. They can increase the temperature of striking object.

ix. They can penetrate through the thin foil (sheet) of Aluminium (Al) or Gold (Au).

x. e/m value of cathode rays does not depends upon nature of a gas.

xi. Cathode rays are called electron because e/m value of these rays is equal to $\bar{e}$.

Determination of e/m Value of electron:

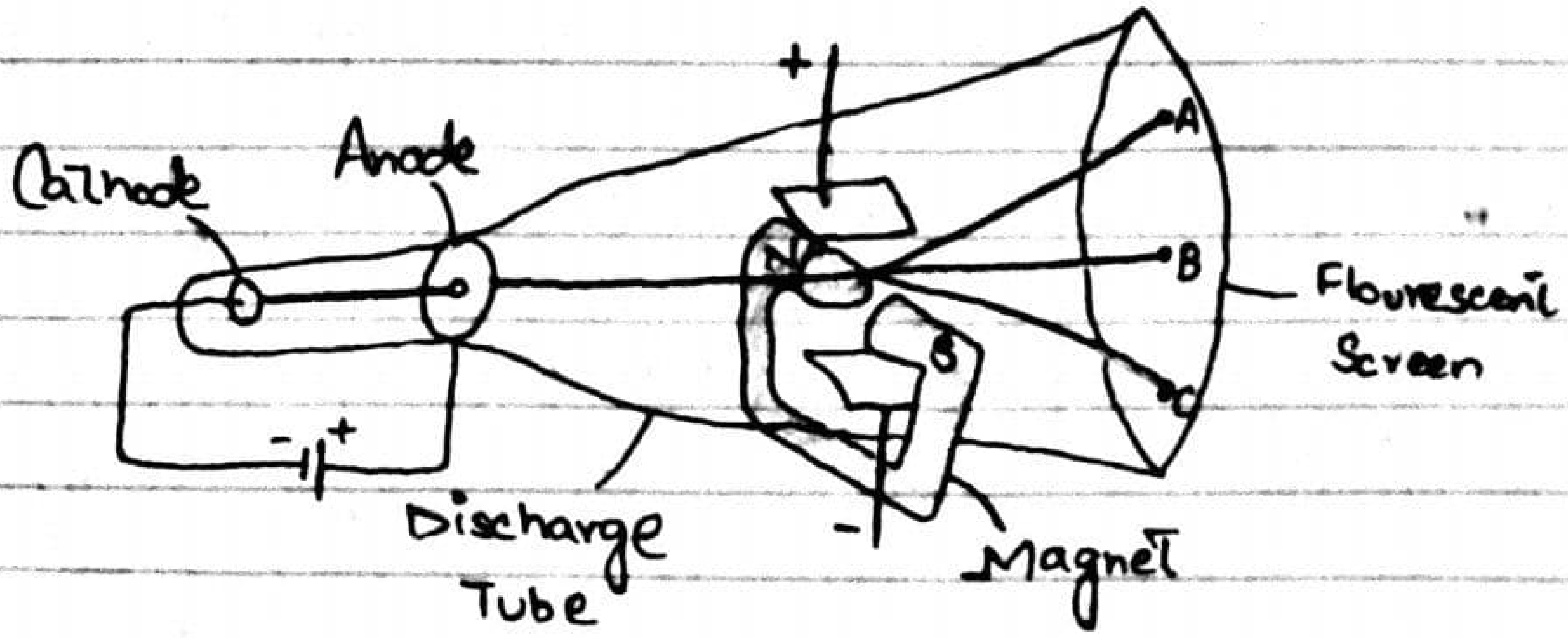
e/m value of é was determined by J.J. Thomson in 1897.

- Apparatus consists of discharge tube. Cathode rays are passed through electric and magnetic fields, which are perpendicular to each other.

Experiment:

In the begining, current is provided, and both fields i.e, electric and magnetic fields are off, the electrons from cathode rays strick the flouresecent screen at B'. Then under the effect of electric field, they strike at point A. Similarly, they strike at point C under the influence of magnetic field only. Now electric and magnetic fields were adjusted in such away that electrons again strike at point B.

In this way, by comparing the strength of two fields, he determined the e/m value of an electron which is 1.7588×10^{11} coulombs Kg^{-1}. This means that 1 Kg of electrons have 1.7588×10^{11} coulombs of charge.



Cathode Rays in Electric And Magnetic Fields.

Determination of Charge On Electron:
OR
MilliKan's Oil Drop Method:

Charge on $\bar{e}$ was determined by MilliKan in 1909.

Apparatus Consists of "Metallic Chamber filled with air, having two plates A and A_1."

The upper plate have small holes.

The pressure of air was adjusted by a vaccum pump.

Two plates "A" and "A_1" were woking as two electrodes, "A" was anode while "A_1" was cathode.

Experiment:

MilliKan created a fine spray of oil droplets by an atomizer. Few droplets entered the holes of plate "A", Then the hole was closed. An arc lamp was used to illuminate (روشن کرنا) the space b/w two electrodes (A & A_1). The droplet fell under the action of gravity. The velocity (V_1) of the droplet was determined depending upon its weight, with the help of a Microscope, adjusted with the Chamber.

$$V_1 \propto m \times g \longrightarrow (1)$$

where "m" is the mass of droplet and "g" is acceleration due to gravity.

After that, the air b/w two electrodes was ionized by X-Rays. The droplet under observation took up an electron and got Charged. Then current was supplied to electrodes which generated an electric field having a strength "E". The droplet moved upwards against gravitational force with a velocity "V_2".

$$V_2 \propto E \cdot e - m \times g.$$

where "E" is strength of electric field & e is charge of $\bar{e}$.

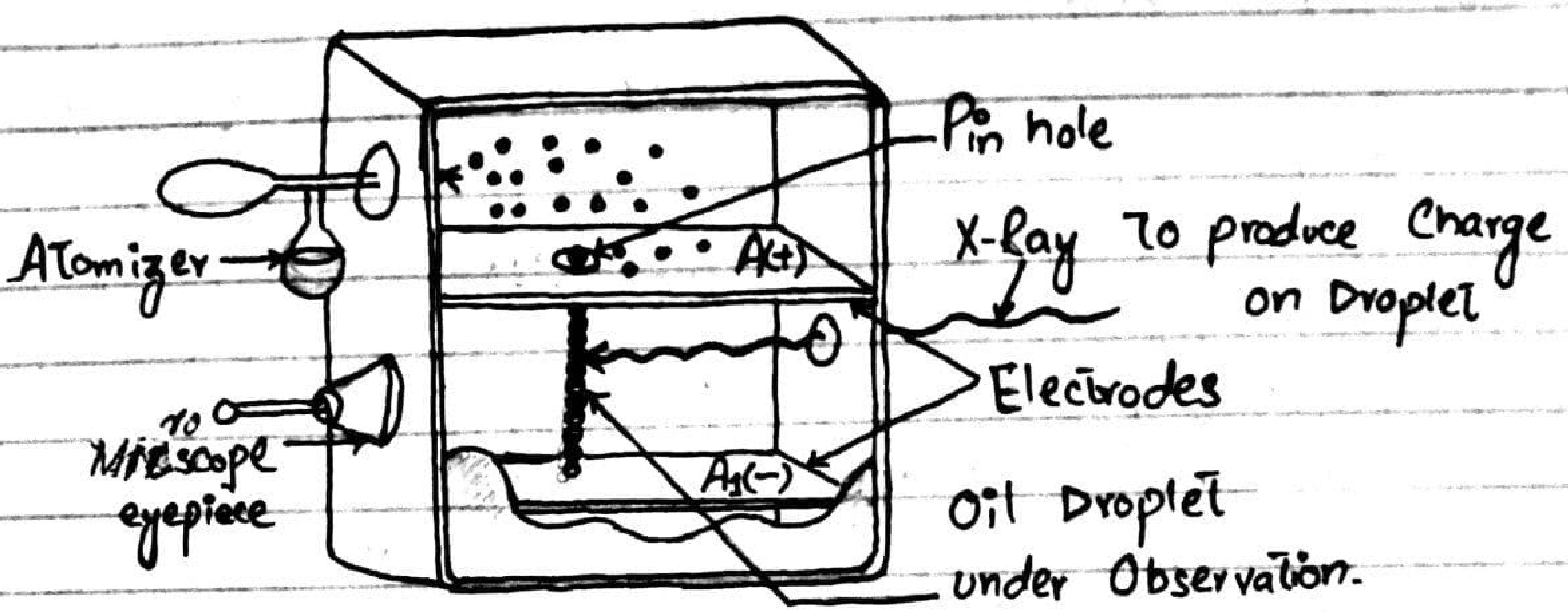
and whole "Exe" is called "upward driving Force" Through which drop moved upward.

Dividing Eq. (2) by (1)

$$\frac{V_1}{V_2} = \frac{m \times g}{Exe - mg}$$

If "V_1", "V_2" & "E" are Known, mass of $\bar{e}$ can be determined by varying the electric field in such away that the droplet is suspended in the chamber. Hence "e" can be calculated which is 1.6022×10^{-19} Coulombs.

Verification Through Faraday's Law:-



Millikan's Oil Drop Experiment

Determination of Mass of an Electron:-

We know that

$$\frac{e}{m} = 1.7588 \times 10^{11} \text{ Coulomb Kg}^{-1}.$$

$\therefore$ $\bar{e} = 1.6022 \times 10^{-19}$ Coulomb.

so;

$$\frac{1.6022 \times 10^{-19}}{m} = 1.7588 \times 10^{11}$$

$$m = \frac{1.6022 \times 10^{-19} C}{1.7588 \times 10^{11} C Kg^{-1}}$$

$$m = 9.1098 \times 10^{-31} Kg.$$

Mass of electron is much less than mass of Hydrogen: or Proton

$$\text{Mass of Hydrogen} = \frac{1.008 \times 10^{-3} \text{ Kg mol}^{-1}}{6.02 \times 10^{23} \text{ atom mol}^{-1}}$$

$$= 1.67 \times 10^{-27} \text{ Kg atom}^{-1}.$$

Discovery of Proton:-
OR
Discovery of +ve rays OR Canal Rays:-

Proton was discovered by Goldstein in 1886.
Apparatus consists of discharge tube having perforated (چھید دار) cathode.

How +ve rays are produced?

s: when cathode rays i.e, $\bar{e}$ collide with gaseous molecules, gaseous molecules are ionized into +ve ions, These +ve ions are called +ve rays or canal rays (They are called "canal rays" because they are passed through the hole of cathode.)

e.g;

$$H_2 \longrightarrow \underset{\text{(Protons)}}{2H^+} + e^-$$

Properties of +ve Rays:-

i- They are deflected in electric and magnetic field showing that they are +vely charged.

ii- They are called "Canal Rays" because they are passed through the holes of cathode.

iii- They travel opposite to cathode rays.

iv- They produce flash on Zinc Sulphide (ZnS) plate.

v- Their e/m value depends upon nature of a gas filled in discharge tube.

vi- e/m (charge to mass ratio) value of +ve rays is always less than that of cathode rays, because they are heavier than that of cathode rays (electron).

vii- Mass of proton is 1836 times heavier than that of electron.

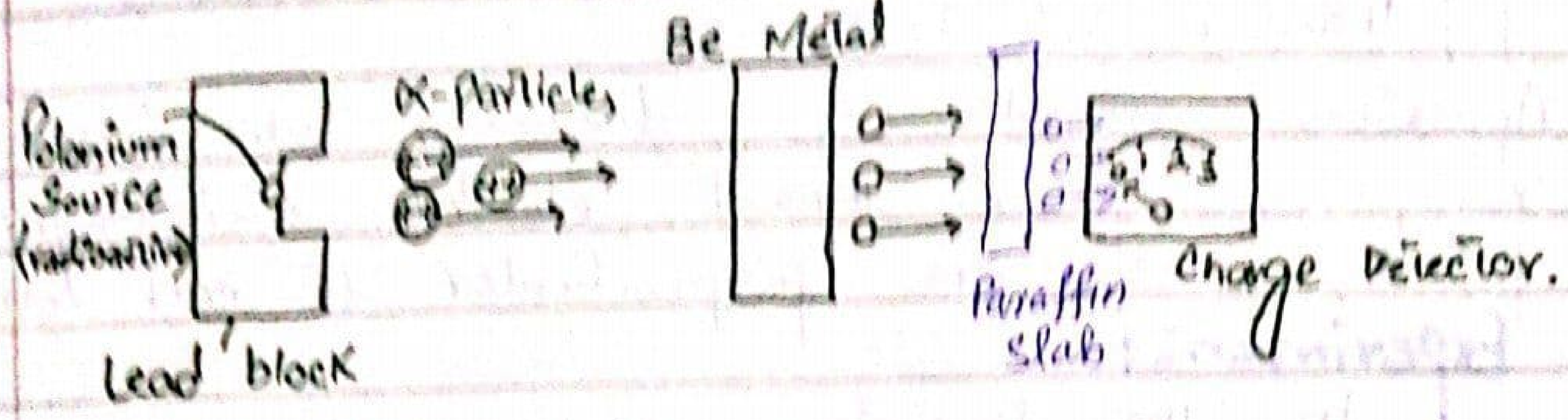
viii- Highest e/m value of +ve rays is obtained, when Hydrogen gas is filled in discharge tube.

Discovery of Neutron:-

- Neutron was discovered by "James Chadwick" in 1932.
- He was awarded noble prize in the field of Physics in 1935.
- Reaction of his experiment is as follows;

He take a source like Polonium (Po) or Radium (Ra), and placed it in a lead block. These are radioactive elements, which produce α-particles. He bombarded (بمباری) these α-particles on Berillium (Be) metal. After some time, the nature of Be metal was changed and it was converted into Carbon. He also observed an unknown particle, which has no ~~charged~~ charge but have a unit mass, i.e 1. He named this particle as "neutron".

$${}_{2}He^4 + {}_4Be^9 \longrightarrow {}_6C^{12} + {}_0n^1$$



Properties of Neutrons:

i. Free neutron is decay (ٹوٹ جانا) into electron, proton and neutrino.

$${}_0n^1 \longrightarrow {}_{+1}P^1 + {}_{-1}e^0 + {}_0n^0 \text{(neutrino)}$$

ii. They can not ionize gases.

iii. They are penetrating particles.

iv. They are not deflected in electric and magnetic field, shows they have no charge.

v. They can expel proton from paper, water, paraffin, and cellulose.

vi. Neutron having energy 1.2 MeV (Mega electron volt) are called fast ${}_0n^1$ (neutron) and ${}_0n^1$ (neutron) having energy less than 1 eV are called slow neutrons. Slow neutron is more effective for nuclear fission reaction.

vii. They are used as a projectile in nuclear reaction. They are used in the treatment of cancer. Fast ${}_0n^1$ produce α-particles from nucleus of nitrogen atom.

$${}_0n^1_{(fast)} + {}_7N^{14} \longrightarrow {}_5B^{11} + {}_2He^4 \text{(α-particles)}.$$

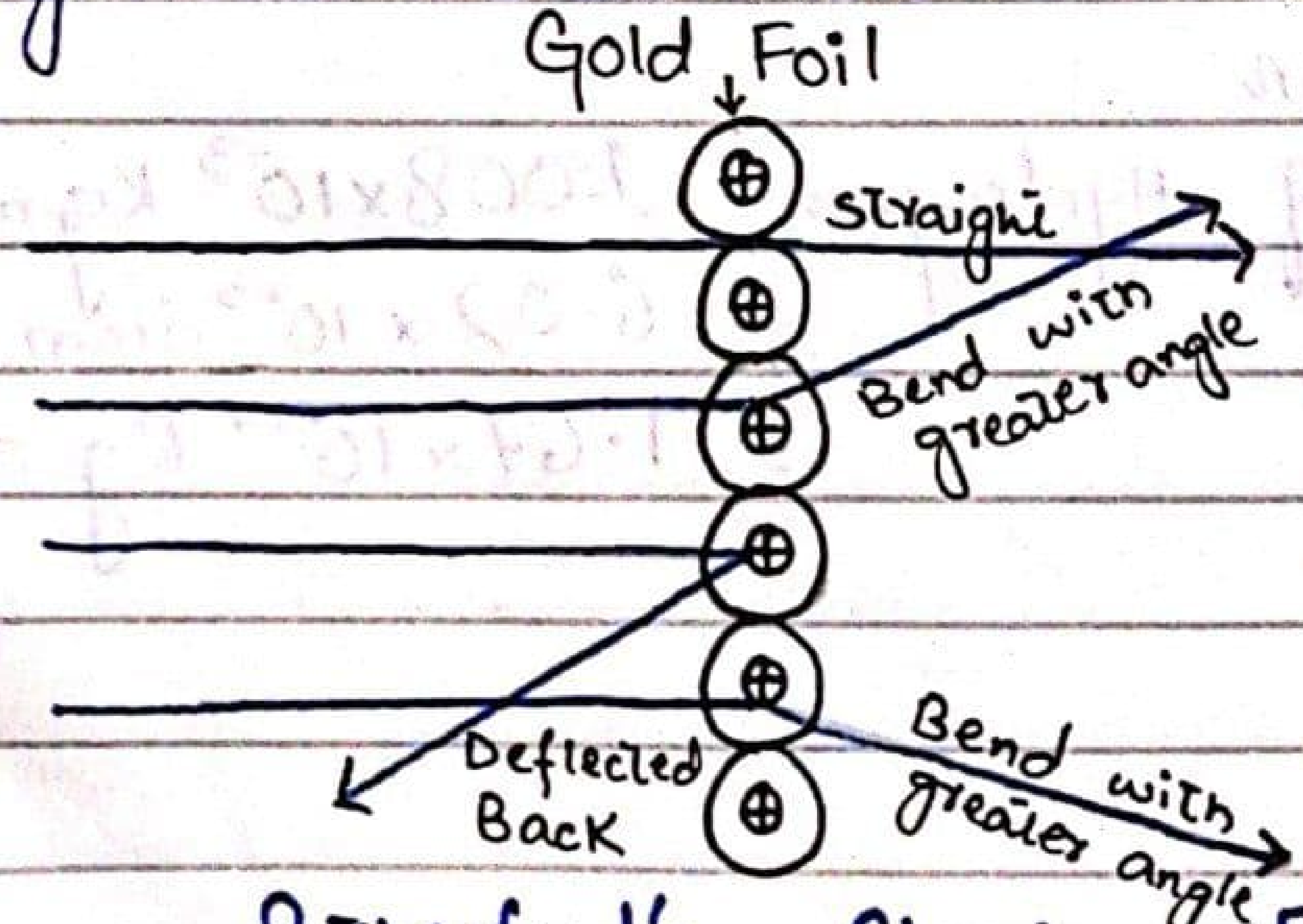
When slow ${}_0n^1$ collide with Copper, γ-radiations are produced.

$${}_0n^1_{(slow)} + {}_{29}Cu^{65} \longrightarrow {}_{29}Cu^{66} + h\nu \text{(γ-radiations)}$$

$${}_{29}Cu^{66} \longrightarrow {}_{30}Zn^{66} + {}_{-1}e^0 \text{(β-particles)}.$$

Discovery Of Nucleus :- (1910-1911)
(Rutherford's Atomic Model)

In 1911, Rutherford perform classic experiment, He produce α-particles from radio-active elements like Po or Ra. These α-particles are passed through a thin foil of gold, having thickness of 0.00004 cm. He observed that some particles are passed while some are deflected back through an angle greater than 90°.



Rutherford's Classic Experiment.

On the basis of these Observations, he proposed an atomic model, which is very similar to our solar system.

Conclusions (Postulates of Rutherford's Atomic Model):-

i. Central part of the atom is "massive", which is called "Nucleus".

ii. Nucleus is +vely charged due to presence of proton.

iii. Electron revolve around the nucleus just like planets around the sun.

iv. Centripetal Force is equal to electrostatic force.

v. No. of proton present in the nucleus is equal to no. of electron in the planetary

vi. Very small volume is occupied by nucleus.

Defects (نقائص):-

i. This model is based on laws of motion and laws of gravitation, which could be applied on neutral body, not on charged body.

ii. If ē emmit energy continuously during revolving, ultimately it should fall in the nucleus.

iii. If ē emmit energy contineously, its spectrum should be contineous, but it is always discontineous.

Properties of Fundamental Particles:

Particle	Charge/Coulomb	Relative Charge	Mass/Kg.	Mass (a.m.u)	Occurance
Proton	$+1.602\times10^{-19}$	$+1$	1.6727×10^{-27}	1.0073	In nucleus
Neutron	0	0	1.6750×10^{-27}	1.0087	In nucleus
Electron	-1.602×10^{-19}	-1	9.1095×10^{-31}	5.4858×10^{-4}	outside the nucleus.

Bohr's Atomic Model:-

Neil Bohr, An English Chemist, in 1913, removed the defects of Rutherford's Atomic Model. He made an extensive use of Planck's Quantum Theory and proposed his own atomic model.

Postulates:

i- Electrons revolve around the nucleus in definite energy levels called Orbits or shells.

ii- A quantum number is assigned to each orbit.

iii- Electrons does not radiate energy as long as it remains in its orbit. when ē jumps from lower orbit to higher, it absorbs energy. On the other hand, energy is emitted (losed) when ē jumps from higher to lower.

iv Electron is bound to remain in one of the orbit, not b/w the two orbits because angular momentum of an orbit is quantize (same).

v- Angular momentum of an ē is integral multiple of $h/2\pi$.

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

where;

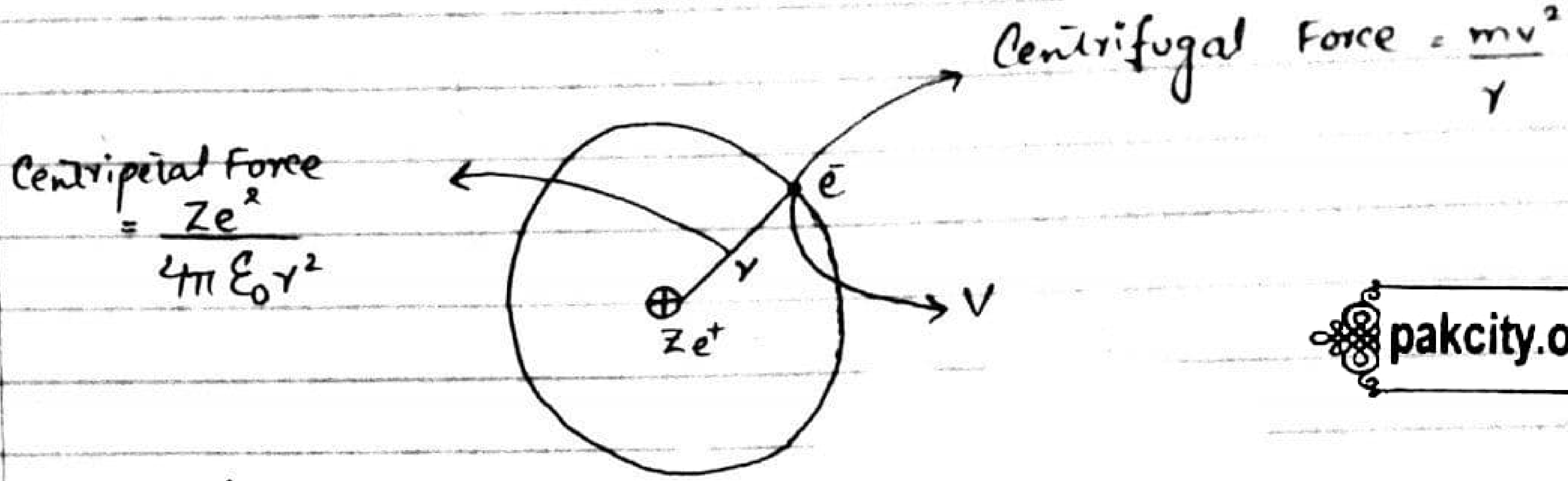
$n = 1, 2, 3, \ldots$

$h =$ Planck's Constant $= 6.625\times10^{-34}$ Js.

v.v.v. imp*

Applications of Bohr's Atomic Model:-

1- Derivation of Radius of An Orbit of An Atom: (Radius of Revolving $\bar{e}$ in n^{th} Orbit):



where;

Z = Atomic no.
e^+ = Charge on Proton.
e^- = " " Electron.
m = Mass of Electron.
V = Velocity of Electron.
r = Radius of an Orbit.

According to Coulomb's Law;

$$F \propto \frac{Ze^+ \cdot e^-}{r^2}$$

$$F = K \cdot \frac{Ze^2}{r^2}$$

$$F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Ze^2}{r^2} \qquad \because K = \frac{1}{4\pi\varepsilon_0}$$

where; "ε_0" = Permitivity Const. = $8.84 \times 10^{-12}\ C^2 J^{-1} m^{-1}$.

During revolving of $\bar{e}$;

$$\frac{Ze^2}{4\pi\varepsilon_0 r^{\cancel{2}}} = \frac{mv^2}{\cancel{r}}$$ (means centripetal force is equal to centrifugal force).

$$r = \frac{Ze^2}{4\pi\varepsilon_0 mv^2} \rightarrow (1) \qquad \left(\because r \propto \frac{1}{v^2}\right)$$

According To Bohr;

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

$$v = \frac{nh}{2\pi mr}$$

$$v^2 = \frac{n^2h^2}{4\pi^2 m^2 r^2} \quad (\because \text{squaring both sides})$$

Put value of "v^2" in ①;

$$\cancel{r} = \frac{Ze^2 \cdot \cancel{4}\pi^{\cancel{2}} \cdot m^{\cancel{2}} \cdot r^{\cancel{2}}}{\cancel{4\pi} \varepsilon_0 \cancel{m} n^2 h^2}$$

$$r = \frac{n^2h^2\varepsilon_0}{Ze^2\pi m}$$

$$r = \frac{n^2}{Z}\left(\frac{h^2\varepsilon_0}{e^2\pi m}\right)$$

$$r = \frac{n^2}{Z}(a^\circ) \quad \because \left(a^\circ = \frac{h^2\varepsilon_0}{e^2\pi m}\right)$$

$$r = \frac{n^2}{Z}(0.529\times10^{-10}m) \quad \because \frac{h^2\varepsilon_0}{e^2\pi m} = 0.529\times10^{-10}m.$$

$$r = \frac{n^2}{Z}(0.529\,Å) \quad \because 10^{-10}m = 1\,Å$$

For 'H', $Z = 1$

$$r = n^2(0.529\,Å)$$

$n = 1$, $r_1 = (1)^2(0.529\,Å) = 0.529\,Å$

$n = 2$, $r_2 = (2)^2(0.529\,Å) = 2.11\,Å$

$n = 3$, $r_3 = (3)^2(0.529\,Å) = 4.75\,Å$

$$r_2 - r_1 < r_3 - r_2 < r_4 - r_3 < \text{-------}$$

It means, as we go away from the nucleus, radius gap b/w The orbit goes on increasing.

V.V. imp*

Derivation of Energy of an orbit:
(Derivation of Energy of revolving $\bar{e}$ in n^{th} orbit):

During revolving of $\bar{e}$ in an orbit, Total energy is the sum of K.E and P.E.

$$E_{Total} = K.E + P.E \longrightarrow (1)$$

$$= \frac{1}{2}mv^2 + \left(-\frac{Ze^2}{4\pi\varepsilon_o r}\right)$$

$$E_n = \frac{1}{2} \times \frac{Ze^2}{4\pi\varepsilon_o r} - \frac{Ze^2}{4\pi\varepsilon_o r}$$

$$= \frac{Ze^2}{4\pi\varepsilon_o r}\left(\frac{1}{2} - 1\right)$$

$$E_n = \frac{Ze^2}{4\pi\varepsilon_o r}\left(-\frac{1}{2}\right)$$

$$E_n = -\frac{Ze^2}{8\pi\varepsilon_o r}$$

putting the value of 'r' from "Radius Derivation",

$$E_n = -\frac{Ze^2 . \cancel{\pi} . m . Ze^2}{8\cancel{\pi}\,\varepsilon_o n^2 h^2 \varepsilon_o}$$

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

$$= -\frac{Z^2}{n^2}\left(\frac{e^4 m}{8\varepsilon_o^2 h^2}\right)$$

$$E_n = -\frac{Z^2}{n^2}\left(2.178 \times 10^{-18} J\right) \qquad \because \frac{e^4 m}{8\varepsilon_o^2 h^2} = 2.178 \times 10^{-18} J$$

For 'H', $Z = 1$,

$$E_n = -\frac{2.178 \times 10^{-18}}{n^2} J$$

$$E_n = -\frac{2.178 \times 10^{-18}}{n^2 . 1000} \times 6.02 \times 10^{23},$$

$$\boxed{E_n = -\frac{1313.315}{n^2} KJ/mol}$$

when;

$n = 1, \quad E_1 = \dfrac{-1313.315}{(1)^2} = -1313.315 \text{ KJ/mol.}$

$n = 2, \quad E_2 = \dfrac{-1313.315}{(2)^2} = -328.325 \text{ KJ/mol.}$

$n = 3, \quad E_3 = \dfrac{-1313.315}{(3)^2} = -145.92 \text{ KJ/mol.}$

$n = \infty, \quad E_\infty = \dfrac{-1313.315}{(\infty)^2} = 0 \text{ KJ/mol.}$

$$E_2 - E_1 > E_3 - E_2 > E_4 - E_3 > \text{-----}$$

It means, as we go away from the nucleus, energy increases, but energy gap b/w the orbit goes on decreasing.

<u>Ionization energy of Hydrogen:</u>

$$I.E = E_\infty - E_1$$
$$= 0 - (-1313.315)$$
$$I.E = 1313.315 \text{ KJ/mol.}$$

Planck's Quantum Theory:-

This Theory was proposed by Max Planck, in 1900, To explain emission and absorption of radiation.

Postulates:

According To this Theory;

i- Energy emitted or absorbed by a body is always discontineous.

ii- Energy is emitted or absorbed in The form of wave packets called "Quanta". In case of Light, These wave packets are called Photons.

iii- **FREQUENCY:-**

No. of waves passing Through a point per second is called frequency. IT is denoted by "ν".

Energy is related To frequency by;

$$E = h\nu \longrightarrow (1)$$

where;

E = Energy
h = Planck's Constant = 6.625×10^{-34} Js.
ν = Frequency.

Eq. (1) shows that, Energy is directly proportional To Frequency.

iv- **Wave Length:-**

Distance b/w adjacent Crest or Trough is called wave length. IT is denoted by "λ".

wave length and Frequency are related as;

$$c = \nu\lambda \longrightarrow (2)$$

where;

C = velocity of light ($3\times10^8\ ms^{-1}$).

From eqs. (2);

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

Therefore; eqs. (1) can be written as

$$E = h\frac{c}{\lambda} \longrightarrow (3)$$

It shows that Energy and wavelength are inversly proportional.

v- **Wave Number:-**

No. of waves per unit length is called wave no. It is denoted by "$\bar{\nu}$."

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

Eq. (3) can be written as;

$$E = hc \times \frac{1}{\lambda}$$

$$E = hc\bar{\nu} \longrightarrow (4)$$

It shows that Energy and wave no. are directly proportional.

3. Derivation of Wave No. of Photon ($\bar{\nu}$):

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

$$\Delta E = E_2 - E_1$$

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

$$\Delta E = \frac{Z^2 e^4 m}{8\varepsilon_0^2 h^2}\left(-\frac{1}{n_2^2} + \frac{1}{n_1^2}\right)$$

$$\Delta E = \frac{Z^2 e^4 m}{8\varepsilon_0^2 h^2}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

For 'H', $Z = 1$

$$\Delta E = \frac{e^4 m}{8\varepsilon_0^2 h^2}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\Delta E = K\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$\therefore K = \frac{e^4 \cdot m}{8\varepsilon_0^2 h^2}$

$$\boxed{\Delta E = 2.178 \times 10^{-18}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)}$$

$\therefore K = 2.178 \times 10^{-18}$

also;

$$\Delta E = h\nu$$

$$h\nu = \frac{e^4 m}{8\varepsilon_0^2 h^2}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\boxed{\nu = \frac{2.178 \times 10^{-18}}{h}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)}$$

$$\nu = c\bar{\nu}$$

$$\bar{\nu} c = \frac{e^4 m}{8\varepsilon_0^2 h^3}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\bar{\nu} = \frac{e^4 m}{8\varepsilon_0^2 h^3 c}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\bar{\nu} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) \qquad \therefore R = \frac{e^4 m}{8\varepsilon_0^2 h^3 c}$$

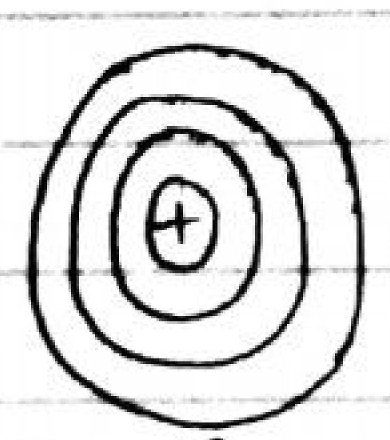
$$\boxed{\bar{\nu} = 1.09678 \times 10^7 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)} \qquad \because R = 1.09678 \times 10^7$$

where; "R" is called "Rydberg's Constant".

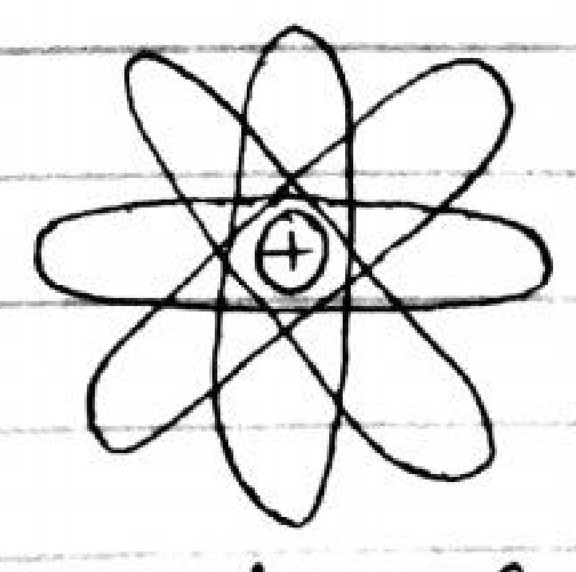
Defects of Bohr's Atomic Model:-

i- Bohr's atomic model can only explain spectrum of mono-electronic system. i-e;
H, He^+, Li^{+2},
But it can not explain multi-electronic or poly-electronic system. i-e;
He, Li, Be.

ii- According to Bohr, e^- revolve around the nucleus in circular path, but according to modern research, e^- revolve around the nucleus in elliptical form in three dimensional way.



Bohr's Concept



Modern Concept.

iii- Bohr's atomic model can not explain zeeman and stark effect.

Zeeman Effect:
when excited hydrogen atom is placed in magnetic field, each spectral line is splitted into a fine line. This effect is called zeeman effect

Example 2.6 :-

How Much Energy is required To make electron of H-atom To jump from n=2 To n=4.

Solution:

$$\Delta E = E_{final} - E_{initial}$$

Here;

n = 2 (initial) & n = 4 (final)

So;

$$\Delta E = K\left[\frac{1}{n_4^2} - \frac{1}{n_2^2}\right]$$

$$= K\left[\frac{1}{16} - \frac{1}{4}\right]$$

$$= 2.179\times10^{-18}\left[-\frac{3}{16}\right]$$

$$\Delta E = -4.086\times10^{-19} J$$

SPECTRUM:- [This Topic is not included in Text book, Only for Concept.]

When light is passed Through the prism, it is splitted into fine lines, each fine line has different wave length and different Colour. This band of colours is called Spectrum.

When white/visible light is passed through The prism, it is splitted into different wavelength correspond To a different Colour, This band of Colours is called Spectrum.

Reigion of Spectrum:-

1. Cosmic Rays
2. Gamma Rays
3. X-Rays
4. Ultra-Violet radiations
5. Visible Region
6. Infra-Red Region
7. Micro-Waves
8. Radio Waves

increasing Wavelength
increasing Frequency
increasing Energy

Types of Spectrum:-

There are Two Types of Spectrum:

1. Contineous Spectrum.
2. Dis-Contineous / Line / Atomic Spectrum.

Contineous Spectrum:-

Type of Spectrum in which one colour is merged (ملنا) into another and boundary line b/w the colours can not be marked, is called Contineous Spectrum.

e.g; Spectrum of Rainbow, Prism etc.

Discontineous / Line / Atomic Spectrum:-

Type of Spectrum in which one colour can not be merged into another and boundary line b/w the colours can be marked, is called Discontineous Spectrum. It is the property of an atom, Therefore, it is called Atomic Spectrum.

e.g; Hydrogen Spectrum.

This type is further divided into Two Types:

i- Atomic Emission Spectrum.
ii- Atomic Absorption Spectrum.

Atomic Emission Spectrum	Atomic Absorption Spectrum
→ Type of spectrum in which bright lines are separated by dark spaces, is called Atomic Emission Spectrum	→ Type of Spectrum in which dark lines are separated by bright spaces is called Atomic Absorption Spectrum.

imp*

Hydrogen Spectrum :-

Hydrogen Spectrum is an example of atomic spectrum, when hydrogen gas is filled in a discharge tube, bluish light is emitted, when it Observed with the help of Spectrometer, five spectral Series are obtained.

1. Lyman Series (Ultra-Violet Region)
2. Balmer Series (Visible Region)
3. Paschen Series (Infra-Red Region)
4. Brackett Series (" " ")
5. Pfund Series (" " ")

Lyman Series :-

$n_1 = 1$

$n_2 = 2, 3, 4, 5, 6, 7, \ldots$

where; n = no. of Orbit

Balmer Series :-

$n_1 = 2$

$n_2 = 3, 4, 5, 6, 7, \ldots$

Paschen Series :-

$n_1 = 3$

$n_2 = 4, 5, 6, 7, \ldots$

Brackett Series :-

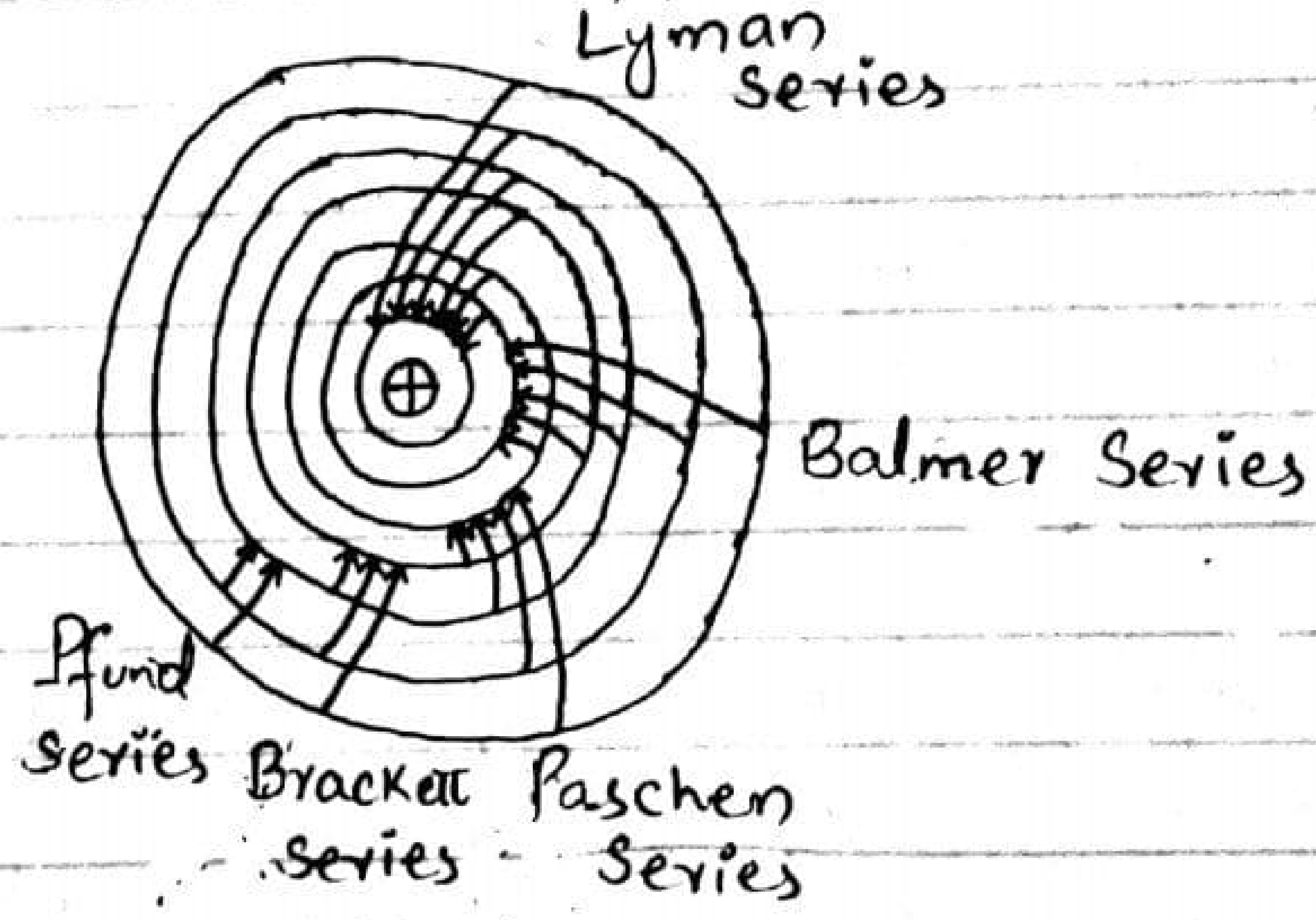
$n_1 = 4$

$n_2 = 5, 6, 7, \ldots$

Pfund Series :-

$n_1 = 5$

$n_2 = 6, 7, \ldots$



Explanation Of Hydrogen Spectrum On The basis Of Bohr's Theory :-

The first spectral lines were discovered by Lyman and Balmer in 1887. No satisfactory reason became available till 1913. Bohr, in 1913, proposed the atomic model and gave the following explanation.

When current is passed through the hydrogen gas in the discharge tube, the molecules of hydrogen breaks into atoms. These atoms absorb energy from electric spark. The electrons of hydrogen atoms are excited to high energy levels. The high energy orbit to which the electron migrate depend upon the amount of energy absorbed by the electron.

These excited electrons being unstable come back to one of the lower energy levels. The electrons may come to the lowest energy levels. In this way they emitt energy, which they had absorbed. Lyman Series is produced when the electrons jump from $n = 2, 3, 4, 5, \ldots$ to $n = 1$. In Balmer series, the electrons from $n = 3, 4, 5, 6, \ldots$ come back to $n = 2$.

We calculate the various lines of Lymen, Balmer, Paschen, Brackett and Pfund series from Bohr's wave equation.

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

where;

1.09678 is Rydberg's Constant.

Lymen Series:-

First Line:

$n_1 = 1 \quad , \quad n_2 = 2$

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

$$\bar{\nu} = 82.26 \times 10^5 \; m^{-1}.$$

Second Line:

$n_1 = 1 \quad , \quad n_2 = 3$

$$\bar{\nu} = 1.09678 \times 10^7 \left(\frac{1}{(1)^2} - \frac{1}{(3)^2}\right]$$

$$\bar{\nu} = 97.60 \times 10^5 \; m^{-1}.$$

Third Line:

$$n_1 = 1 \quad , \quad n_2 = 4$$

$$\bar{\nu} = 1.09678 \times 10^7 \left[\frac{1}{(1)^2} - \frac{1}{(4)^2} \right]$$

$$\bar{\nu} = 102.70 \times 10^5 \ m^{-1}$$

Limiting Line:

$$n_1 = 1 \quad , \quad n_2 = \infty$$

$$\bar{\nu} = 1.09678 \times 10^7 \left[\frac{1}{(1)^2} - \frac{1}{(\infty)^2} \right]$$

$$\bar{\nu} = 109.678 \times 10^5 \ m^{-1}.$$

This limiting line shows that the energy difference b/w the first level and the infinite (∞) level is the ionization energy of the hydrogen atom. All these lines of Lymen series have close values. They appear in the form of group. These values of wave numbers lie in the ultra-violet region.

Balmer Series:-

First Line (Hα line):

$$n_1 = 2 \quad , \quad n_2 = 3$$

$$\bar{\nu} = 1.09678 \times 10^7 \left[\frac{1}{(2)^2} - \frac{1}{(3)^2} \right]$$

$$\bar{\nu} = 15.234 \times 10^5 \ m^{-1}.$$

Second Line (Hβ line):

$$n_1 = 2 \quad , \quad n_2 = 4$$

$$\bar{\nu} = 1.09678 \times 10^7 \left[\frac{1}{(2)^2} - \frac{1}{(4)^2} \right]$$

$$\bar{\nu} = 20.566 \times 10^5 \ m^{-1}.$$

Third Line (H_γ line):

$n_1 = 2$, $n_2 = 5$

$$\bar{\nu} = 1.09678 \times 10^7 \left[\frac{1}{(2)^2} - \frac{1}{(5)^2} \right]$$

$$\bar{\nu} = 23.05 \times 10^5 \ m^{-1}$$

Limiting Line:

$n_1 = 2$, $n_2 = \infty$

$$\bar{\nu} = 1.09678 \times 10^7 \left[\frac{1}{(2)^2} - \frac{1}{(\infty)^2} \right]$$

$$\bar{\nu} = 27.421 \times 10^5 \ m^{-1}.$$

All these lines are very close to each other and apper in the form of group of lines. These lines lies in the visible region.

Paschen Series:-

First Line:

$n_1 = 3$, $n_2 = 4$

$$\bar{\nu} = 1.09678 \times 10^7 \left[\frac{1}{(3)^2} - \frac{1}{(4)^2} \right]$$

$$\bar{\nu} = 5.3310 \times 10^5 \ m^{-1}.$$

Second Line:

$n_1 = 3$, $n_2 = 5$

$$\bar{\nu} = 1.09678 \times 10^7 \left[\frac{1}{(3)^2} - \frac{1}{(5)^2} \right]$$

$$\bar{\nu} = 7.799 \times 10^5 \ m^{-1}$$

Limiting Line:

$n_1 = 3$, $n_2 = \infty$

$$\bar{\nu} = 1.09678 \times 10^7 \left[\frac{1}{(3)^2} - \frac{1}{(\infty)^2} \right].$$

$$\bar{\nu} = 12.187 \times 10^5 \ m^{-1}.$$

These are the group of lines appear close to each other in infra-red region.

Brackett Series:

First Line:

$n_1 = 4 \quad , \quad n_2 = 5$

$$\bar{\nu} = 1.09678 \times 10^7 \left[\frac{1}{(4)^2} - \frac{1}{(5)^2}\right]$$

$$\bar{\nu} = 2.45 \times 10^5 \ m^{-1}.$$

Second Line:

$n_1 = 4 \quad , \quad n_2 = 6$

$$\bar{\nu} = 1.09678 \times 10^7 \left[\frac{1}{(4)^2} - \frac{1}{(6)^2}\right]$$

$$\bar{\nu} = 3.808 \times 10^5 \ m^{-1}.$$

Limiting Line:

$n_1 = 4 \quad , \quad n_2 = \infty$

$$\bar{\nu} = 1.09678 \times 10^7 \left[\frac{1}{(4)^2} - \frac{1}{(\infty)^2}\right]$$

$$\bar{\nu} = 6.855 \times 10^5 \ m^{-1}.$$

Pfund Series:

First Line:

$n_1 = 5 \quad , \quad n_2 = 6$

$$\bar{\nu} = 1.09678 \times 10^7 \left[\frac{1}{(5)^2} - \frac{1}{(6)^2}\right]$$

$$\bar{\nu} = 1.340 \times 10^5 \ m^{-1}.$$

Second Line:

$n_1 = 5 \quad , \quad n_2 = 7$

$$\bar{\nu} = 1.09678 \times 10^7 \left[\frac{1}{(5)^2} - \frac{1}{(7)^2}\right]$$

$$\bar{\nu} = 2.148 \times 10^5 \ m^{-1}.$$

Limiting Line:

$n_1 = 5 \quad , \quad n_2 = \infty$

$$\bar{\nu} = 1.09678 \times 10^7 \left[\frac{1}{(5)^2} - \frac{1}{(\infty)^2}\right]$$

$$\bar{\nu} = 4.387 \times 10^5 \ m^{-1}.$$

Planck's Quantum Theory:-

This Theory was proposed by Max Planck, in 1900, to explain emission and absorption of radiation.

Postulates:

According to this Theory;

i- Energy emitted or absorbed by a body is always discontineous.

ii- Energy is emitted or absorbed in the form of wave packets called "Quanta". In case of Light, these wave packets are called Photons.

iii- **FREQUENCY:-**

No. of waves passing through a point per second is called frequency. It is denoted by "ν".

Energy is related to frequency by;

$$E = h\nu \longrightarrow (1)$$

where;

E = Energy

h = Planck's Constant = 6.625×10^{-34} Js.

ν = Frequency.

Eq. (1) shows that, Energy is directly proportional to Frequency.

iv- **Wave Length:-**

Distance b/w adjacent Crest or Trough is called wave length. It is denoted by "λ".

Wave length and Frequency are related as;

$$c = \nu\lambda \longrightarrow (2)$$

where;

C = velocity of light $(3\times10^{8}\ ms^{-1})$

From eqs. ②;

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

Therefore; eqs. ① can be written as

$$E = h\frac{c}{\lambda} \longrightarrow ③$$

It shows that Energy and wavelength are inversly proportional.

v. **Wave Number:-**

No. of waves per unit length is called wave no. It is denoted by "$\bar{\nu}$."

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

Eq. ③ can be written as;

$$E = hc \times \frac{1}{\lambda}$$

$$E = hc\bar{\nu} \longrightarrow ④$$

It shows that Energy and wave no. are directly proportional.

Example Solution :-

Example 2.7:

A Photon of Light with energy $10^{-19}J$ is emitted by a source of light.

a. Convert this light into the wave length, frequency, and wave no. of photon in m, Hz & m^{-1}.

b. Convert this energy of Photon into ergs and Calculate the wave length in cm, frequency in Hz and wave no. in cm^{-1}.

Solution:

a- Given:

Energy of Photon = 10^{-19} J

$\lambda = ?$, $\nu = ?$, $\bar{\nu} = ?$

$\nu = ?$

$E = h\nu$

$\nu = \frac{E}{h} = \frac{10^{-19}}{6.625\times10^{-34}} = 0.151\times10^{15}\ s^{-1} = 1.51\times10^{15} s^{-1}$

$\lambda = ?$

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

$\lambda = \frac{c}{\nu} = \frac{3\times10^{8}}{1.51\times10^{15}} = 1.98\times10^{-6}$ m

$\bar{\nu} = ?$

$\bar{\nu} = \frac{1}{\lambda} = \frac{1}{1.98\times10^{-6}} = 0.50\times10^{6}\ m^{-1} = 5\times10^{5} m^{-1}$

b- Given;

Energy of Photon = 10^{-19} J

1 J = 10^{7} ergs

$E = 10^{-19}\times10^{7}$ ergs $= 10^{-12}$ ergs.

$h = 6.625\times10^{-34}$ J s $= 6.625\times10^{-27}$ ergs.

$\nu = \frac{E}{h} = \frac{10^{-12}}{6.625\times10^{-27}} = 1.51\times10^{14}\ s^{-1}$.

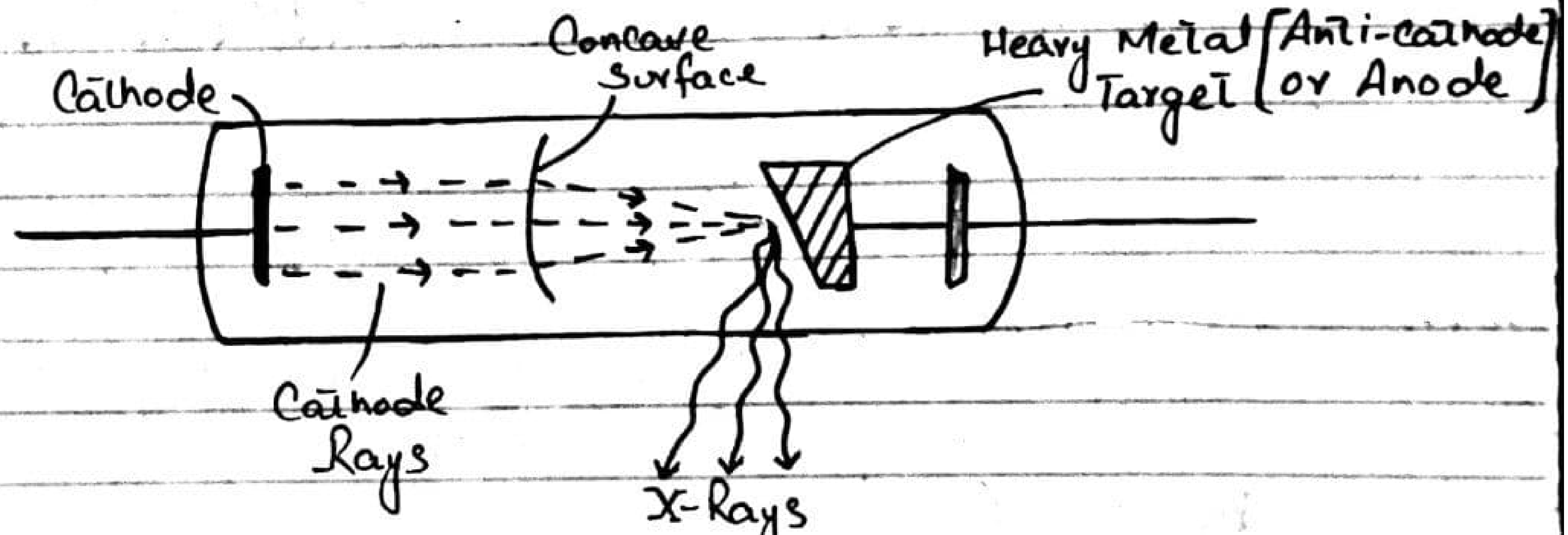
$\lambda = \frac{c}{\nu} = \frac{3\times10^{8}}{1.51\times10^{14}} = 1.98\times10^{-4}$ cm.

$\bar{\nu} = \frac{1}{\lambda} = \frac{1.51\times10^{14}}{1.98\times10^{-4}} = 5\times10^{3}$ cm^{-1}.

X-Rays :-

In 1895, Wilhelm Roentgen discovered that when high energy electrons collide with metal anode, highly penetrating radiations are produced. Roentgen called them X-Rays.

When $\bar{e}$ is suddenly stopped, energy is released in the form of electromagnetic waves. In the discharge Tube, the electrons produced by a heated tungeston filament are accelerated by high voltage, when they strike with metal target, X-rays are emitted.



Frequency of X-rays (energy of x-rays) depends on the nature of target metal. Every Metal has its own Characteristics x-rays.

X-Rays And Atomic No. :-

Mosely, in 1913-14 perform experiments with different target metals (About 38 Metals) and Conclude that energy of x-rays depends on the no. of protons in the nucleus of target metal. This no. is called Atomic No.

Types Of X-Rays:-

There are two Types of X-Rays.

i. K-Series X-Rays.
ii. L-Series X-Rays.

K-Series:-
X-Rays which are shorter in wave length are called K-Series X-Rays.

L-Series:-
X-Rays which are longer in wave length are called L-series X-Rays

→ wave length of X-Rays become shorter with increasing atomic no. of target metal.

Moseley's Law:-

According to this law, frequency of X-Rays is directly proportional to square of atomic no. of metal target.

Mathematically;

$$\sqrt{\nu} = a(Z-b)$$

where;

ν = frequency of X-Rays
Z = Atomic no.
'a' & "b" = Constants, depending on nature of Metal target.

Uses Of X-Rays:-

i. X-Rays are used to photograph interior of Objects
ii. They are used to assist in setting a person's broken Arm (Medical use).
iii. They are used to determine the internal structure

of Crystals. This Process is Known as X-Ray diffraction technique.

Quantum Numbers And Orbitals :-

Quantum Numbers :-

A set of numbers which are used to explain behaviour of electron in an orbital is called, Quantum numbers.

There are four Quantum numbers;

i. Principal Quantum No. (n)
ii. Azimuthal Quantum No. (l)
iii. Magnetic Quantum No. (m)
iv. Spin Quantum No. (s)

First three Quantum no. are derived from Schrodinger wave equation. The Fourth Quantum no. is due to spin of an electron.

Schrodinger wave equation is :

Points:-

i- Energy of an electron is quantize in an Orbit.

ii- Energy of two electrons is different, they exist in different region.

iii- **Heisenburg's Uncertanity Principle:-**

Possibility of an electron never zero even at large distance.

& "It is impossible to measure position as well as momentum of an $\bar{e}$ exactly and simultaneously."

1. **Principal Quantum No. (n):-**

It is denoted by 'n'.

where;

$n = 1, 2, 3, 4, ----$

value of 'n' describes the following;

i- Size of Orbit.

ii- Energy of Orbit.

iii- Nature of Orbit / Shell.

iv- No. of electrons in Shell.

Value of 'n' is directly Proportional to size and energy of orbital.

e.g;

1s, 2s.

Energy of 2s orbital is higher than 1s. similarly; size of 2s is also bigger than 1s.

n	Orbit	$2n^2$ = No. of $\bar{e}$	Orbitals
1	K	$2(1)^2 = 2$	s
2	L	$2(2)^2 = 8$	s, p
3	M	$2(3)^2 = 18$	s, p, d
4	N	$2(4)^2 = 32$	s, p, d, f

2. Azimuthal Quantum No. (l):-

It is denoted by "l".

where;

$l = 0, 1, 2, 3, ----$ and $n = 1$

Azimuthal quantum no. describes the following

i- Shape of Orbital.
ii- No. of electron in Orbital.
iii- Nature of Orbital.
iv- Energy of Orbital.

l	Orbitals	Shapes Of Orbitals	$2(2l+1) = \bar{e}$
0	s	Spherical	$2[2(0)+1] = 2$
1	p	Dumbbel	$2[2(1)+1] = 6$
2	d	Sausag (Double Dumbbel)	$2[2(2)+1] = 10$
3	f	Complicated Dumbbel	$2[2(3)+1] = 14$

This Quantum no. Also explains the energy of an Orbital.

$2s, \quad E = n+l = 2+0 = 2$

$2p, \quad E = n+l = 2+1 = 3$

Magnetic Quantum No. (m) :-

It is denoted by "m".

where;

$m = 0, \pm 1, \pm 2, \pm 3, ----, \pm l$

Relationship b/w "m" and "l" is;

$m = 2l + 1$

Magnetic Quantum no. describes;

i- Orientation of Orbital
ii- No. of degenerate Orbitals.

Orbitals	l	m	No. of degenerate Orbitals
s	0	0	1
p	1	-1, 0, +1	3
d	2	-2, -1, 0, +1, +2	5
f	3	-3, -2, -1, 0, +1, +2, +3	7

4. Spin Quantum No. (s) :-

It is denoted by "s".

where;

$$s = \pm \frac{1}{2}$$

It defines the spin of the electron in an orbital, which may be anti-clockwise or clock-wise. If spin is anticlockwise, then $s = +\frac{1}{2}$, and is denoted by "↑". If spin is clock-wise, then $s = -\frac{1}{2}$, and is denoted by '↓'.

Concept Of Shells And Sub-Shells (Orbitals):

Orbit:

Circular path around the nucleus of an atom is called Orbit or Shell.

Names Of Orbits are;

K-Shell (It Contains 2 electrons max.)

L-Shell (It Contains max. 8 electrons)

M-Shell (It Contains max. 18 electrons)

N-Shell (It Contains max. 32 electrons)

Orbitals:

Region around the nucleus where, there is maximum posibility of finding an electron, i.e; 95%, is called Orbital or sub-shell.

Node or Nodal Plane:

Node or Nodal plane is that region where electron density is zero.

The term Orbital should not be confused with the term Orbit as used in the Bohr's Theory. The orbital can't be regarded as spread of Charge surrounding the nucleus. This is often called as electron Cloud.

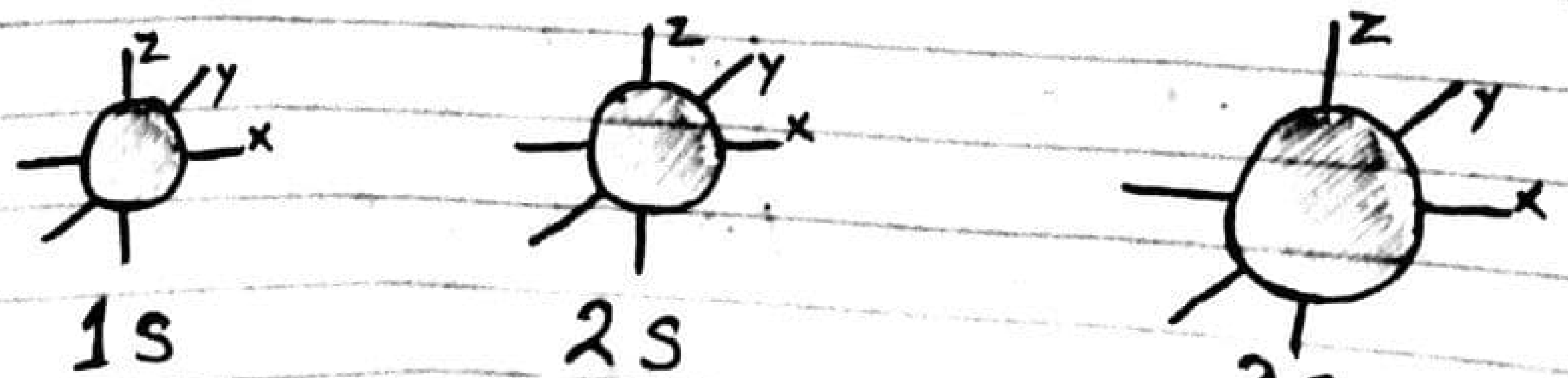
Types of Orbitals:-

There are four types of Orbitals:

i- s- Orbital
ii- p- orbital
iii- d- Orbital
iv- f- Orbital

1- s- Orbital:

It has maximum 2 electrons with opposite spin. It is spherically symmetrical in shape. Its size increases when 'n', i.e; Principal Quantum no. increases.



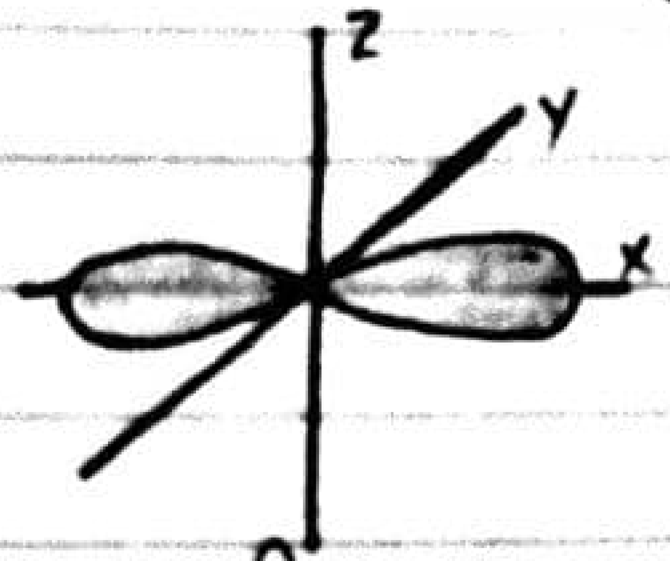
1s   2s   3s

2. P-orbital :-

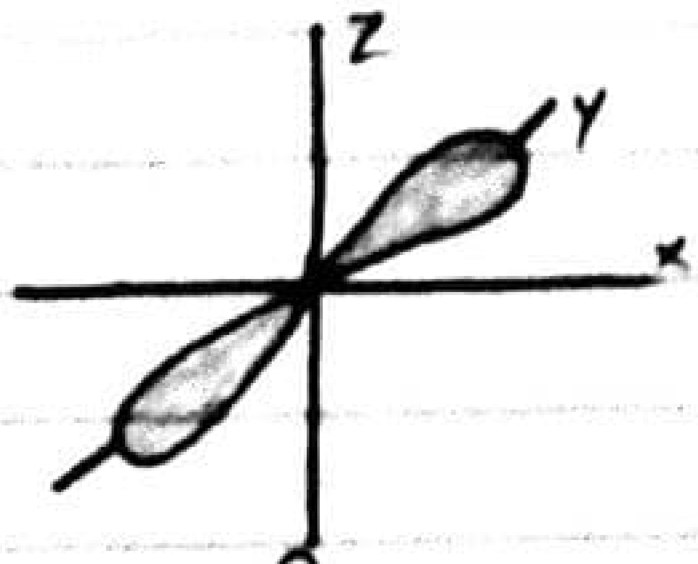
It has maximum 6 electrons. It is dumbbel in shape. It has three degenerate orbitals, i.e; P_x, P_y, P_z.

★ **Degenerate Orbitals :-**

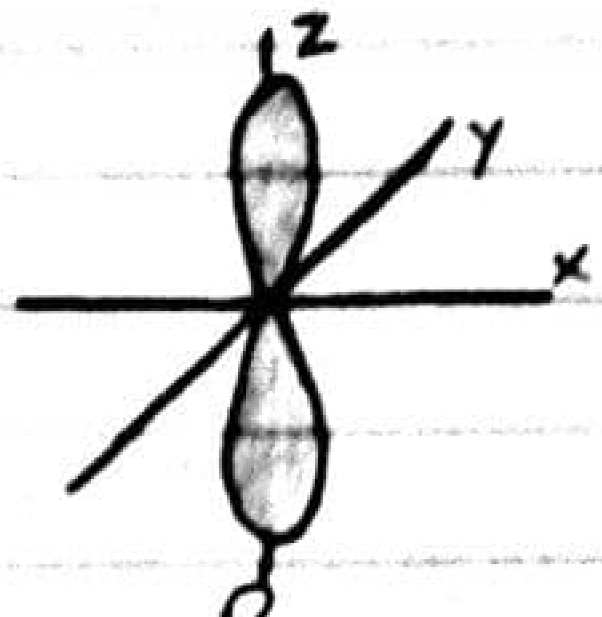
Orbitals have equal energy are called degenerate Orbitals.



P_x



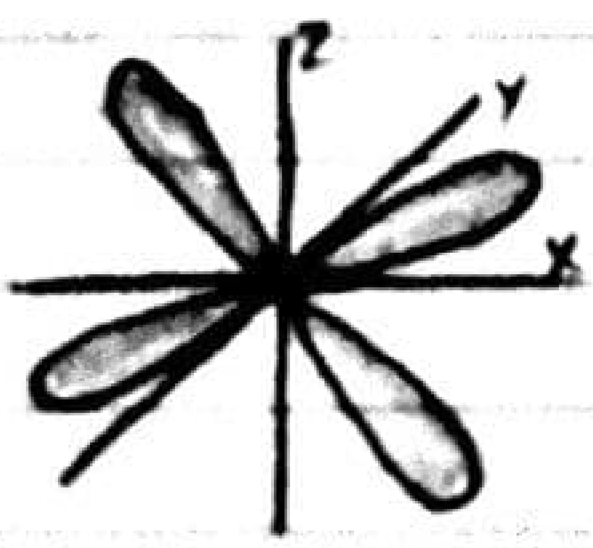
P_y



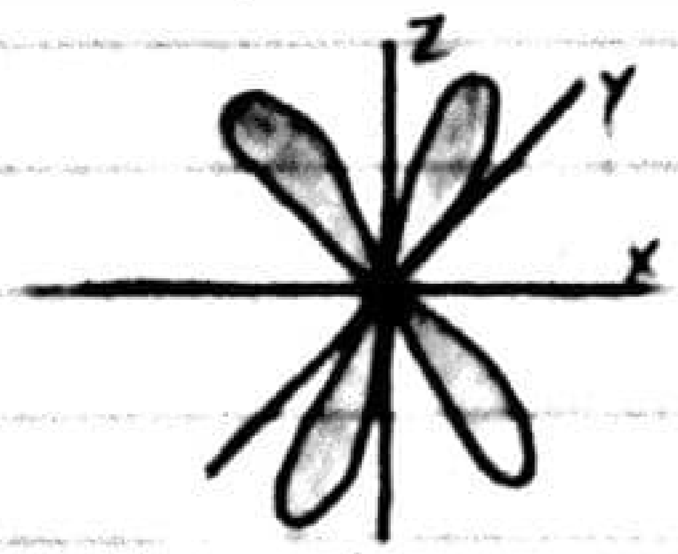
P_z.

3. d- Orbital :-

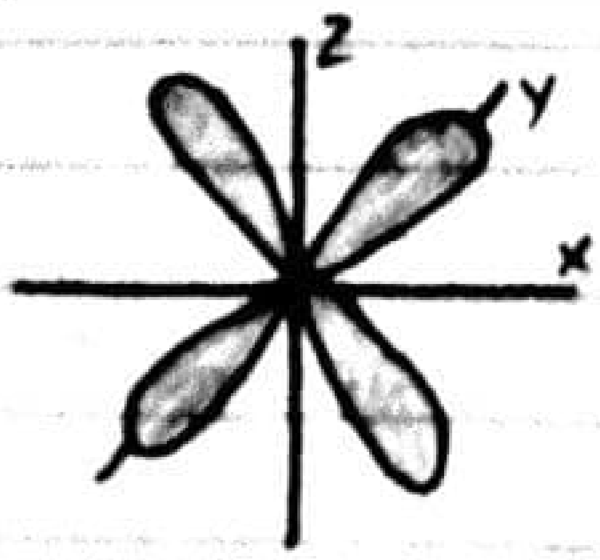
It has maximum 10 electrons. It is double-dumbble or sausag in shape. It has 5 degenerate orbitals, i.e; d_{xy}, d_{yz}, d_{xz}, $d_{x^2-y^2}$, d_{z^2}. They are not identical in shape. first four orbitals contains four lobs where last one i.e; d_{z^2} contains only two lobes.



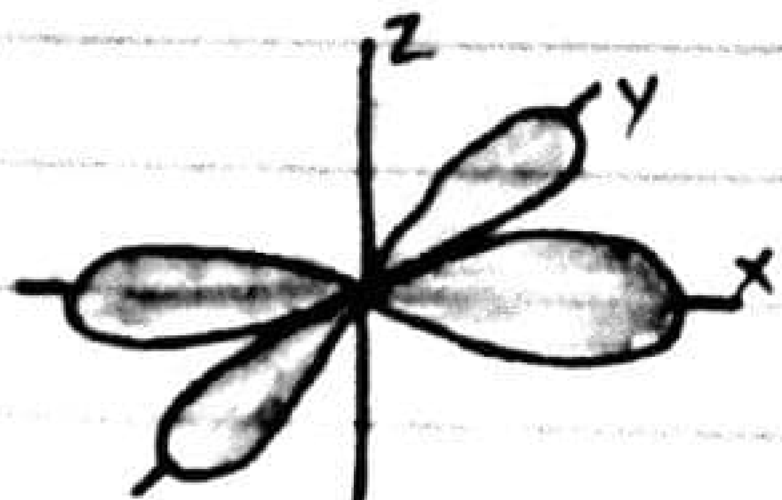
d_{xy}



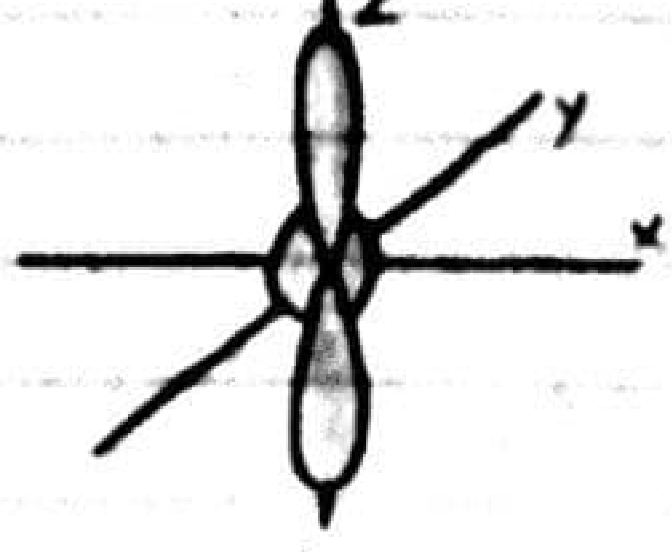
d_{yz}



d_{xz}



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



d_{z^2}

4. **f- Orbital:-** It has maximum 14 electrons. It is complicated (Complicated dumbbel) in shape. It has 7 degenerate Orbitals.

Example Solution:-

Example 2.8:
Describe the allowed combinations of the n, l and m quantum numbers when n = 4.

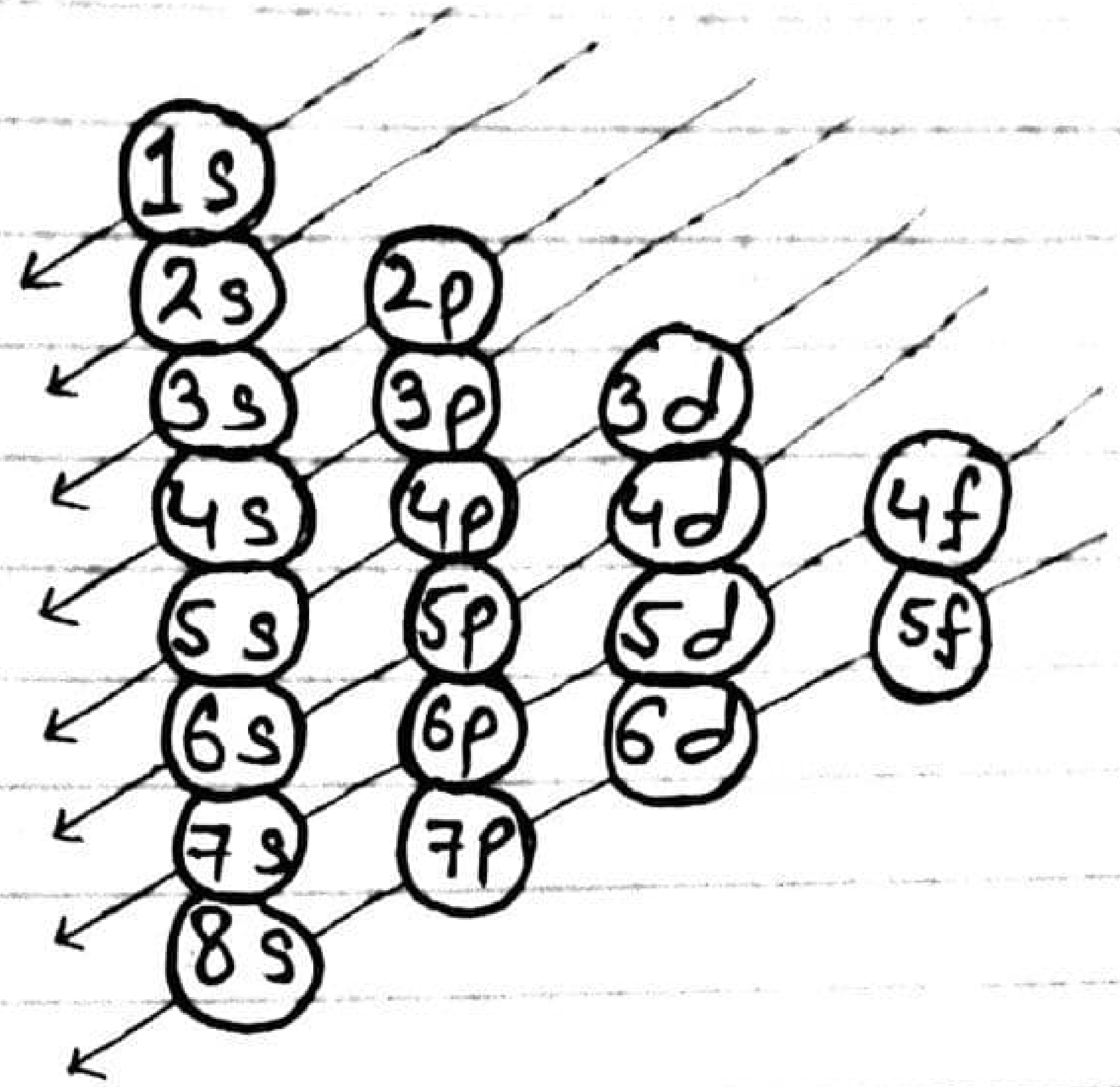
Solution:
The allowed Combinations are

n	l	m
4	0	0
	1	-1, 0, +1
	2	-2, -1, 0, +1, +2
	3	-3, -2, -1, 0, +1, +2, +3

ELECTRONIC CONFIGURATIONS:-

The representation of filling of electrons in different Orbitals of an atom is called its electronic Configuration.

n + l Rule:-
According to this rule, electrons are placed in subshell, by increasing order of their n+l value. If two orbitals have same value of n+l, then orbital having low value of 'n' will be filled first.



e.g; ${}_{20}Ca = 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2$

${}_{87}Fr = 1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10}, 4p^6, 5s^2, 4d^{10}, 5p^6, 6s^2, 4f^{14}, 5d^{10}, 6p^6, 7s^1.$

Rules For Distribution Of ELECTRON:-

There are three rules for distribution of electron in energy sublevels:

(i- Auf-Bau Principle:-
(ii- Pauli's Exclusion Principle-
(iii- Hund's Rule-

1. Auf-Bau Principle:-

According to this principle, electrons are placed in sub-shells by increasing order of their energy levels. It means that electrons are first placed in orbital of lowest energy level. e.g;

1s, 2s, 2p, 3s, 3p, 4s, - - - -

2. Pauli's Exclusion Principle:-

According to this principle, no two electrons in an orbital have same value of four quantum no., i.e; they always have different spin quantum no.

e.g;

for $1s^{2}$

For 1^{st} $\bar{e}$

$n = 1$
$l = 0$
$m = 0$
$s = +\frac{1}{2}$

For 2^{nd} $\bar{e}$

$n = 1$
$l = 0$
$m = 0$
$s = -\frac{1}{2}$

3. Hund's Rule:-

According to this rule, if degenerate orbitals are available, then $\bar{e}$ are placed in separate orbitals, with the same spin.

e.g;

$_7N = 1s^{2}, 2s^{2}, 2P_x^{1}, 2P_y^{1}, 2P_z^{1}$

$_8O : 1s^{2}, 2s^{2}, 2P_x^{2}, 2P_y^{1}, 2P_z^{1}$

$_9F : 1s^{2}, 2s^{2}, 2P_x^{2}, 2P_y^{2}, 2P_z^{1}$

Example Solutions:

Example 2.9:

Pick the orbital with the lower energy from each of the given pairs.

(a) 3d, 4s (b) 2p, 3s (c) 3d, 4s (d) 3d, 4p

Solution:

Applying $n+l$ rule;

a-

For 3d, $n=3$, $l=2$, $n+l=5$

For 4s, $n=4$, $l=0$, $n+l=4$

So; 4s-orbital will be filled first because it has lower energy than 3d.

b-

For 2p, $n=2$, $l=1$, $n+l=3$

For 3s, $n=3$, $l=0$, $n+l=3$

As both orbitals have same value of $n+l$, Therefore; 2p will fill first because it has lower value of "n".

c-

For 3d, $n=3$, $l=2$, $n+l=5$

For 4s, $n=4$, $l=0$, $n+l=4$

4s orbital will be filled first be filled first because it has low energy.

d-

For 3d, $n=3$, $l=2$, $n+l=5$

For 4p, $n=4$, $l=1$, $n+l=5$

3d orbital will be filled first because it has lower value of "n".

Example 2.10:-

Write down the electronic Configuration of $_{19}K$ and $_{20}Ca$.

Solution:

$_{19}K$. $1s^1, 2s^2, 2p^6, 3s^2, 3p^6, 4s^1$

$_{20}Ca$. $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2$

Example 2.11:-

Write the electronic Configuration of $_{21}Sc$, $_{25}Mn$, $_{30}Zn$.

solution:

$_{21}Sc$. $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^1$.

$_{25}Mn$: $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^5$.

$_{30}Zn$: $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^2, 3d^{10}$.

Example 2.12:

From the Following, Pick the impossible cases,
$6s^2, 6p^8, 6s^7, 3d^{11}$.

Solution:

s contains max. 2 electrons.
p " " 6 " .
d " " 10 " .

$6s^2, 6p^8, 6s^7, 3d^{11}$.

So; impossible Cases are
$6p^8, 6s^7, 3d^{11}$.

Magnetic Properties:

1. Para-Magnetic Substances:

Substance which is attracted in magnetic field, due to the presence of unpaired electron, is called para-magnetic substance. These substances are more reactive.

e.g; Na, H, Fe, O_2 etc.

2. Dia-Magnetic Substances:

Substances which are weakly repelled in magnetic field due to the presence of pairs of electron are called dia-magnetic substances. These are less reactive.

e.g; He.

Conceptual Questions:

Q. In Discharge tube, −ve rays are called cathode rays, but +ve rays are not called anode rays, why?

Ans. In discharge tube, −ve rays are called cathode rays because they emitted from cathode. But +ve rays are not called anode rays, this is because they are not emitted from anode but they are produced by the ionization of gas present in discharge tube.

However, these rays are called Canal Rays. This is because, they pass through the hole of cathode.

EXERCISE

Q1. Choose the Correct Answer.

i- (c)
ii- (d)
iii- (b)
iv- (b)
v- (d)
vi- (d)
vii- (d)
viii- (c)
ix- (d)
x- (c)
xi- (b)

The options of these four parts given in the book are wrong. We have correct them.

Q2. Short Question Answers.

i- How Mass of electron can be calculated from e/m ratio and Charge?

Ans. Determination Of Mass of Electron:

$$\frac{e}{m} = 1.7588 \times 10^{11}\ C/Kg \rightarrow (1)$$

$$e = 1.6022 \times 10^{-19}\ C$$

put value of "e" in (1)

$$\frac{1.6022 \times 10^{-19}}{m} = 1.7588 \times 10^{11}$$

$$m = \frac{1.6022 \times 10^{-19}\ \cancel{C}}{1.7588 \times 10^{11}\ \cancel{C}/Kg}$$

$$\boxed{m = 9.1 \times 10^{-31}\ Kg}$$

EXERCISE

Q1. Choose the Correct Answer.

i- (c)
ii- (d)
iii- (b)
iv- (b)
v- (d)
vi- (d)
vii- (d)
viii- (c)
ix- (d)
x- (c)
xi- (b)

The options of these four parts given in the book are wrong. We have correct them.

Q2. Short Question Answers.

i- How Mass of electron can be calculated from e/m ratio and Charge?

Ans. Determination of Mass of Electron:

$$\frac{e}{m} = 1.7588 \times 10^{11}\ C/Kg \rightarrow (1)$$

$$e = 1.6022 \times 10^{-19}\ C$$

put value of "e" in (1)

$$\frac{1.6022 \times 10^{-19}}{m} = 1.7588 \times 10^{11}$$

$$m = \frac{1.6022 \times 10^{-19}\ \cancel{C}}{1.7588 \times 10^{11}\ \cancel{C}/Kg}$$

$$\boxed{m = 9.1 \times 10^{-31}\ Kg}$$

ii. How does Moseley's law help in the production of X-Rays?

Ans. **X-Rays:**

In 1895, Wilhelm Roentgen accidently discovered X-rays.

When cathode rays i.e; electrons collide with heavy metal anode, high penetrating radiations are emitted, which are called X-rays.

Contribution of Moseley:

In 1913-14, Moseley, a student of Rutherford, performed same experiment by using 38 metals, and discovered atomic no. On the basis of this experiment, he proposed a law.

Moseley's Law:

According to this law, frequency of X-rays is directly proportional to square of atomic no.

Mathematically;

$$\sqrt{\nu} = a(Z - b)$$

This mathematical form is called Moseley's law.

where;

'a' and 'b' are constants

ν = frequency of X-rays

Z = Atomic no.

iii- Which Quantum no. is also Called Sub-shell Quantum no. ?

Ans. Azimuthal Quantum no. is also called sub-shell Quantum no.

Azimuthal Quantum No. :-

It is denoted by "l".

where ;

$l = 0, 1, 2, 3, ----$ and $n = 1$.

Azimuthal Quantum no. describes

i- Shape of Orbital.

ii- No. of $\bar{e}$ in Orbital.

iii- Nature of Orbital.

iv- Energy of Orbital.

l	Orbital	Shape	$2(2l+1) = \bar{e}$
0	s	Spherical	$2[2(0)+1] = 2$
1	p	Dumbble	$2[2(1)+1] = 6$
2	d	Double-Dumbble	$2[2(2)+1] = 10$
3	f	Complicated Dumbble	$2[2(3)+1] = 14$

It also explains the energy of Orbital;

$2s$, $E = n+l$, $E = 2+0 = 2$

$2p$, $E = n+l$, $E = 2+1 = 3$

iv. What is the Difference b/w Orbit & Orbital?

Ans:

Orbit	Orbital
1. Circular path around the nucleus of an atom is called orbit.	1. Region around the nucleus where there is max. chance of finding an $\bar{e}$ i.e 95%, is called Orbital.
2. Name of Orbits are: K $(2\bar{e})$, L $(8\bar{e})$, M $(18\bar{e})$, N $(32\bar{e})$	2. Name of Orbitals are: s $(2\bar{e})$, p $(6\bar{e})$, d $(10\bar{e})$, f $(14\bar{e})$
3. Electrons are placed in an orbit by following formula: $\bar{e} = 2n^2$	3. Electrons are placed in an orbital by following formula: $\bar{e} = 2(2l+1)$

v. What is relationship b/w

a. Energy and wavelength.

b. frequency and wavelength.

Ans. a. Energy and wavelength are related as:

$$E = \frac{hc}{\lambda}$$

It means; they are inversly related.

b. Frequency and wavelength are related as:

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

It mean; they are inversly proportional.

x. Why is 4s orbital lower in energy than 3d orbital?

Ans. According to $n+l$ rule, e^- are placed in sub-shell by increasing order of their $n+l$ value. If two orbitals have same $n+l$ value, then $\bar{e}$ is filled in the subshell having low value of "n".

$4s$, $n+l = 4+0 = 4$
$3d$, $n+l = 3+2 = 5$

So, electron will first filled in 4s orbital because its energy is lower than 3d orbital.

xi. Write electronic Configuration of:

i. ${}_{25}Mn^{+2}$

${}_{25}Mn^{+2}$ = $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^0, 3d^5$.

ii. ${}_{30}Zn^{+2}$

${}_{30}Zn^{+2}$ = $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^0, 3d^{10}$

iii. Cd^{+2}

${}_{24}Cd^{+2}$ = $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^0, 3d^4$,

iv. ${}_{13}Al^{+3}$

${}_{13}Al^{+3}$ = $1s^2, 2s^2, 2p^6$,

xii. what is n+l rule?

Ans. According to this rule, $\bar{e}$ are placed in sub-shell by increasing order of their n+l value. If two orbitals have same n+l value, then orbital having low energy of "n" will be filled first.

xiii.

Ans: See Theory.
(Measurement of e/m value of Electron).

xiv. Diagram shows the canal rays passing through perforated Cathode.

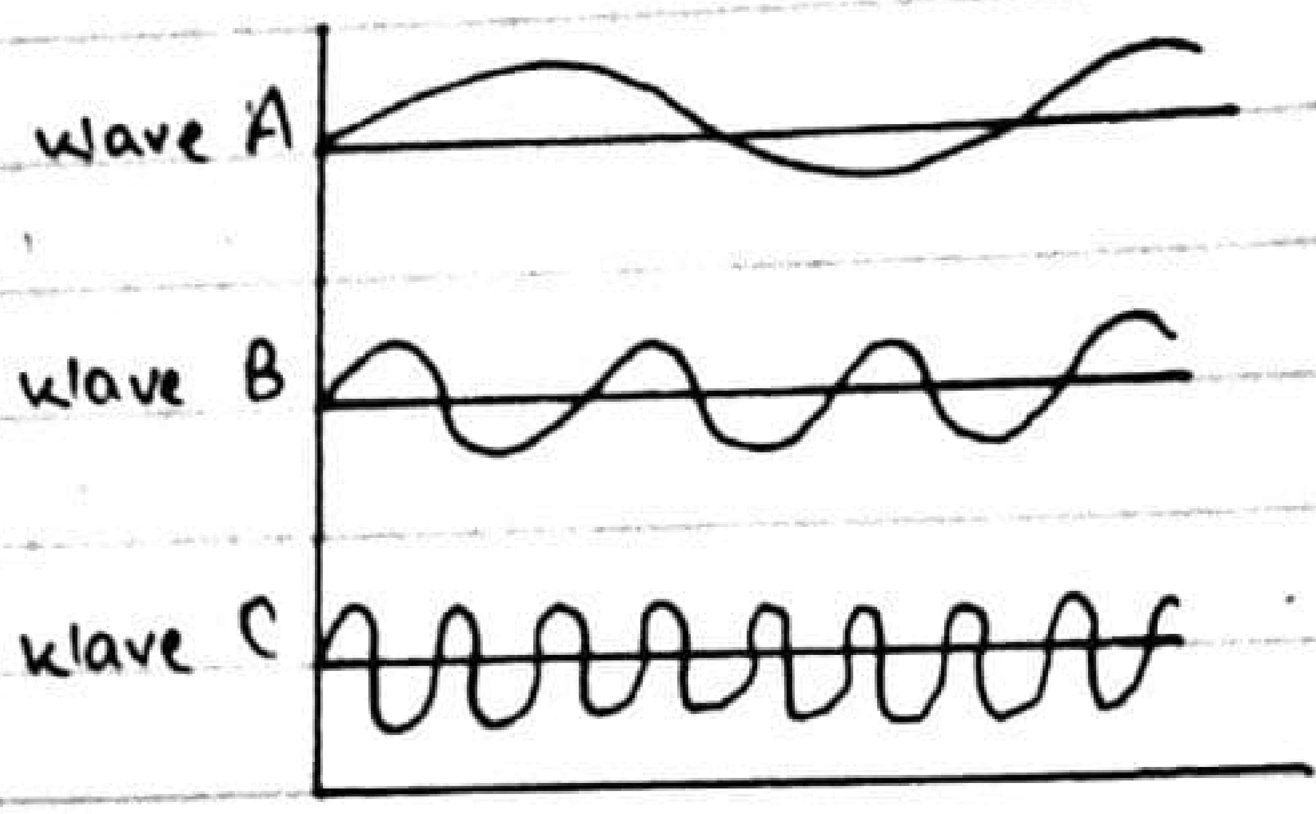
a. Name the apparatus and its use.
b. Voltage required.
c. Function of vaccum Pump.

Ans. a.
Apparatus consists of Discharge tube having perforated Cathode. It is used for the production of Cathode Rays.

b.
5000 – 10,000 voltage is required to follow current through gas.

c.
Vaccum pump is used to reduce the pressure of gas present in discharge tube.

xv.



a. which wave have higher Frequency?
b. which wave have longest wavelength?
c. Define i. Frequency ii. Wave length.
d. what is frequency of B as compared to C?

Ans. a.
Wave C have higher Frequency.

b.
Wave A have longest wavelength.

c.

Frequency:
No. of waves passing through a point per second is called Frequency. It is denoted by "ν".

Wave Length:
Distance b/w adjacent crests or trough is called wavelength. It is denoted by "λ".

d.
Wave B have lowest frequency than wave C, Because wave B has longest wave length than wave C.

xvi- Point Out Defects of Bohr's Atomic Model. How these defects are partially covered by Dual nature of electron and Heisenburg's Uncertainity Principle.

Ans- **Defects of Bohr's Atomic Model:**

i- Bohr's atomic model can only explain spectrum of mono-electronic system. i.e; H, He^{+}, Li^{+2}. But it can't explain multi-electronic system. i.e; He, Li, Be.

ii. According to Bohr, $\bar{e}$ revolve around the nucleus in circular path, but according to modern research, e^{-} revolve around the nucleus in elliptical form in three-dimensional way.

iii- This atomic model can't explain zeeman and stark effect.

Zeeman Effect

When an excited hydrogen atom is placed in magnetic field, each spectral line is splitted into a fine line. This effect is called Zeeman effect.

Stark Effect

When an excited hydrogen atom is placed in electric field, each spectral line is splitted into a fine line. This effect is called Stark effect.

Heisenburg's Uncertainity Principle:-

iv- According to Bohr, $\bar{e}$ revolve around the nucleus in an orbit having specific velocity and radius, but according to **Heisenburg's uncertainity principle**, it is impossible to measure position as well as momentum of an $\bar{e}$ exactly and simultaneously.

xvii. Calculate the energy of $\bar{e}$ of hydrogen atom in orbit with value $n = 3$.

$$E_n = -2.178\times10^{-18} \cdot \frac{Z^2}{n^2}$$

For 'H', $Z = 1$

$$E_n = -2.178\times10^{-18} \cdot \frac{(1)^2}{n^2}$$

For $n = 3$

$$E_n = -2.178\times10^{-18} \cdot \frac{(1)^2}{(3)^2}, \quad \boxed{E_n = -2.42\times10^{-19}\ J}$$

xviii. See Theory (Example 2.7).

xix. Bohr's Equation for radius of n^{th} Orbit is

$$r_n = \frac{\varepsilon_0 h^2 n^2}{\pi e^2 m}$$

a. when $\bar{e}$ moves from $n=1$ to $n=2$, Calculate radius Change.

b. what is the distance travelled by $\bar{e}$ from $n=8$ to $n=3$?

Ans. a.

when $n = 1$

$$r_n = n^2(0.529\ \text{Å})$$
$$= (1)^2(0.529\ \text{Å})$$
$$r_1 = 0.529\ \text{Å}$$

when $n = 2$

$$r_n = n^2(0.529\ \text{Å})$$
$$= (2)^2(0.529\ \text{Å})$$
$$r_2 = 2.11\ \text{Å}.$$

Now;

$$r_2 - r_1 = 2.11\ \text{Å} - 0.529\ \text{Å}$$
$$r_2 - r_1 = 1.581\ \text{Å}$$

b.

when $n = 8$

$$r_n = n^2(0.529\ \text{Å})$$
$$= (8)^2(0.529\ \text{Å})$$
$$r_8 = 33.856\ \text{Å}$$

when $n = 3$

$$r_n = n^2(0.529\ \text{Å})$$
$$= (3)^2(0.529\ \text{Å})$$
$$r_3 = 4.75\ \text{Å}$$

Now;

$$r_8 - r_3 = 33.85 - 4.75$$
$$r_8 - r_3 = 29.1\ \text{Å}.$$