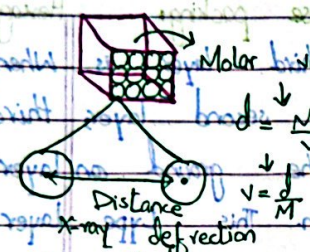
By using equation

$n\lambda = 2d\sin\theta$

2) Molar volume:

It is determine by the density of the crystal.

$V = \frac{M}{d}$



Ch # 05

Structure of Atom.

Atom is derived from Latin word "Atmos" which meaning indivisible.

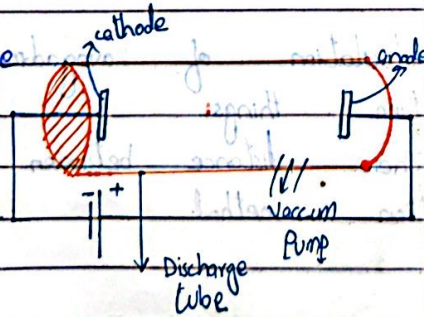
According to modern study atom is divisible particle.

Discovery of cathode rays:

Construction:

A discharge tube made up of glass.

Have two electrode one is connected through negative terminal is called cathode and other is connected through the positive terminal of battery which is called anode.



* A vaccum pump which reduce the pressure.
* A battery.

Working:

Q. Why it is necessary to reduce the pressure inside the discharge tube to produce cathode rays?

At atmospheric pressure the gas molecule cause the hinderance in the path of cathode rays. Either we apply 50000V, no cathode rays produce. When we use vaccum pump to reduce the pressure to 0.01 torr, a continuous glow is produced which is actually cathode rays.

We apply 5000 – 100000V potential (energy) difference between electrode.

Dependence of cathode rays:

Cathode rays is only depend on the nature of

gass.

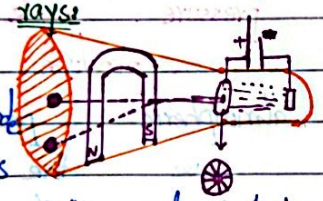
2#. Why cathode rays does not depend upon the nature of gase.

Cathode rays are actually electrons. Nature of electron in all the gases are same. So cathode rays which is produced (by) from these electrons is also same.

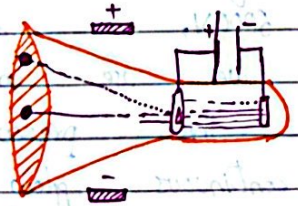
That's why; cathode rays does not depend upon the nature of gas.

Properties of cathde rays:

1) J=perrin applied magnetic field on cathode rays. These cathode rays deflects from point '1' and strike at point '2'.



J.J Thomson apply electric field the cathode rays move toward the positive plate. This experiment shows that cathode rays have negative charge.

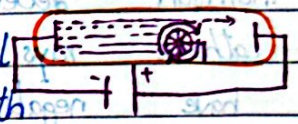


How can you justify that cathode rays move in a straight line?

When an opaque object placed in the path of cathode. It produce shadow. Which shows that cathode rays move in a straight line.

2) Explain that cathode rays have momentum?

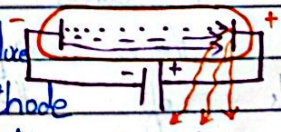
When a paddle wheel placed in the path of cathode rays. These cathode rays drived the paddle wheel. It's shows that cathode rays have mass and velocity, or simply momentum.



5) When cathode rays strike with discharge tube, it produce green flurisence. When we place a crystal of Alumina produced red light, a stone of tin produced yellow light.

6) When cathode rays fall on the object. They increase the temperature of object.

7) Cathode rays can produce X-rays. (which) When cathode rays strike on anode which is made up of high atomic number.



8) Cathode rays can pass through a

thin foil of gold.

9) Cathode rays can cause chemical change. Because they have reducing effect.

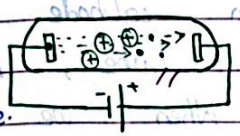
10) J.J Thomson determine the e/m value of cathode rays which shows that they have negative charge.

McQs

Stoney firstly given the name to cathode rays, electron.

Discovery of canal rays:

For discovery of cathode rays we used perforated cathode.



Why positive rays called canal rays?

When electric current is applied some rays are produced which move away from anode. These rays passed through hole or canals of cathode. It seems that these rays are produced from canals of cathode. That's why these rays are called canal rays.

Reason for production of canal rays:

In the discharge tube there are many molecules of gas. One cathode ray strike with the molecule of gas. The molecules of gas is ejected by these cathode rays. The molecule of gas contain positive charge which move toward the negative plate (cathode) and passed through the canal of cathode and produce light when strike with the walls of container.

$M + e^- \rightarrow M + 2e^-$

Properties of canal rays:

(1) They show deflection when applied electric and magnetic field.

(2) Canal rays move in a straight line away from anode.

(3) When these rays strike on ZnS plate. It produce flash of light.

(4) These rays are 1836 time havier than the electron.

Q. Justify that e/m value of canal rays is smaller than the cathode rays?

e/m is the ratio between charge to mass.

We know that canal rays are

1836 time haviar than the electron. That's why e/m value of canal rays is smaller than the cathode rays.

Q# Explain; e/m value of hydrogen is highest among all the elements?

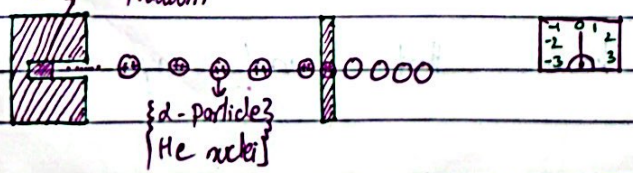
Hydrogen atom have lowest mass among all the elements. e/m value is inversly proportional to the mass. That's why due to this reason, e/m value of hydrogen is highest among all the elements.

Discovery of neutron:

Long time it is considered that atom is only consist of proton and electron. But Rutherford claimed that atom have some other particle except electron and proton, which have no charge (neutral) and the mass of that particle is equal to the mass of proton.

Experiment:

Chadwick discover neutron by following experiment;



$_2He^4 + {}_4Be^9 \longrightarrow {}_6C^{12} + {}_0n^1$

α-particle is He nuclei which is produced from polonium or radium. Strike on Be plate. After striking with Be-plate some rays/particles are produce which have no charge but have high penetration power.

Properties of neutron:

Q# Write the equation for decay of neutron?

(1) On the decay of one neutron, it produce proton, electron and neutrino.

Equation:

$${}_0n^1 \longrightarrow {}_1P^1 + {}_{-1}e^0 + {}_0n^0$$

(2) They cannot ionize the gas.

(3) They have high penetration power.

(4) When neutron strike on paraffin or water they produce high speed proton.

Q# What is the difference between fast neutron or slow neutron?

Fast neutron:

(5) Those neutron which have energy 1.2MeV is called fast neutron.

Slow neutron:

Those neutron which have energy 1eV is called slow neutron. Slow neutron is more effective and use in nuclear fission reaction.

(6) When neutron is passed through Nitrogen gas. The gas is converted into Boron and α-particle.

$$_0^1n + {}_7^{14}N \longrightarrow {}_5^{11}B + {}_2^4He$$

2. How Cu is converted into Zn and give the use of this reaction?

When neutron is strike with $_{29}^{65}Cu$ it change into $_{29}^{66}Cu$ and produce Y-rays. $_{29}^{66}Cu$ is unstable and change into $_{30}^{66}Zn$ and produce B-rays.

$$_0^1n + {}_{29}^{65}Cu \longrightarrow {}_{29}^{66}Cu + \text{Y-rays}$$

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

Uses:

These Y-rays and B-particles are used for the treatment of cancer.

Measurement of e/m values

e/m is determine by J.J Thomson.

Construction:

It is consist of;

- Discharge tube
- Electric field
- Magnetic field
- Two electrode ie; cathode and anode
- Screen or display

Working:

When electrode connected through battery cathode rays are produce.

When no electric and magnetic field applied a spot is formed at point "P_1".

When only electric field is applied the cathode rays deflected upward / toward the positive plate, and strike at point "P_2".

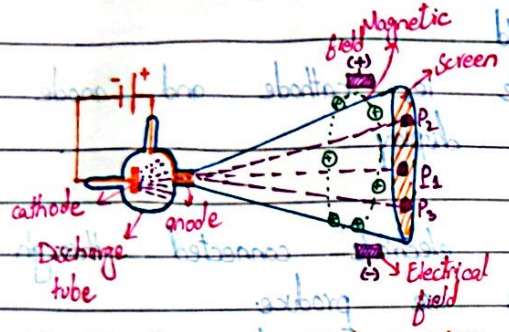
When only magnetic field is applied the cathode rays deflected downward and strike at point "P_3".

Now apply both electric and magnetic field. And adjust the strength of both fields that these rays are strike at point "P".

Compare the electric and magnetic field and determine the e/m value. The e/m value is 1.7588×10^{11} colombs kg^{-1} for

cathode rays:

It means if we take 1kg of electron than the charge will be 1.7588 coulombs.



Measurement of charge on Electron Millikan's Oil Drop method:

Millikan's was the first scientist who determine the charge on electron.

Construction:

The apparatus is consist of

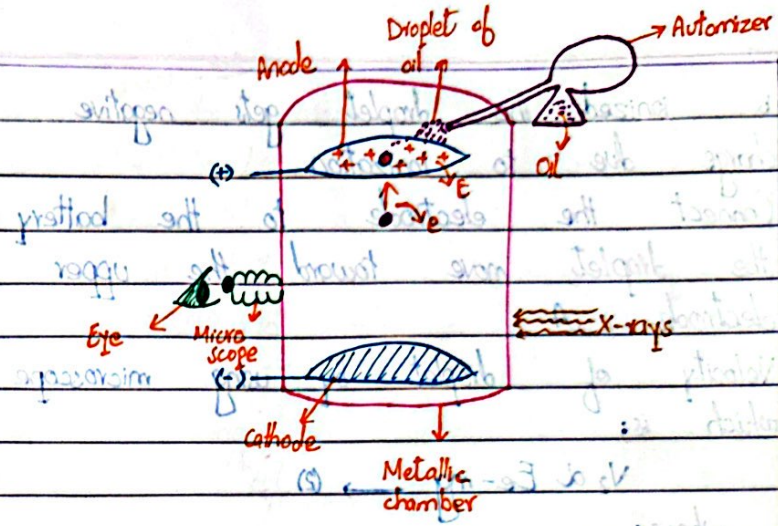
A metallic chamber

Two electrode A and A'. A or anode have small hole.

Automizer, which is used for spray of oil in the metallic chamber.

A microscope which is used to see the droplet.

X-rays used to ionize the droplet.



Working:

Adjust the pressure inside the metallic chamber and by using automizer we spray the oil in the metallic chamber.

When only one or two oil droplet pass through the hole of anode then close the hole.

The droplet move downward due to force due to gravity.

$v_1 \propto mg \longrightarrow (i)$

where;

m = mass of droplet

g = acceleration due to gravity.

Passed the X-rays in the metallic chamber. The gas inside the metallic chamber

is ionized. The droplet gets negative charge due to ionization. Connect the electrode to the battery the droplet move toward the upper electrode A.

Velocity of droplet by using microscope which is;

$$V_2 \propto Ee - mg \longrightarrow (2)$$

where;

E = electric current / field

e is charge on electron

m is mass of droplet

g is acceleration due to gravity

Dividing both equation (1) and (2)

$$\frac{V_1}{V_2} = \frac{mg}{Ee - mg}$$

Adjust the electric field in such a way that the droplet suspend and measure the mass of droplet by using of electric field.

Amount of charge:

The charge on electron is 1.59×10^{-19} C which is determine by Millikan. Now according to recent study the charge on electron is 1.60×10^{-19} C.

Q# Determine the mass of electron by using e/m value and charge value?

We know that e/m value is equal to 1.7588×10^{11} coulombs kg^{-1}.

$$e/m = 1.7588 \times 10^{11}$$

By rearranging the above equation

$$m = e/1.7588 \times 10^{11} \quad \because e = 1.60 \times 10^{-19} C$$

$$m = \frac{1.60 \times 10^{-19}}{1.7588 \times 10^{11}}$$

$$m = 9.108 \times 10^{-31} \text{ kg}$$

The mass of electron is 9.108×10^{-31} kg.

Relative properties of fundamental particles:

The fundamental particles are electron, proton and neutron.

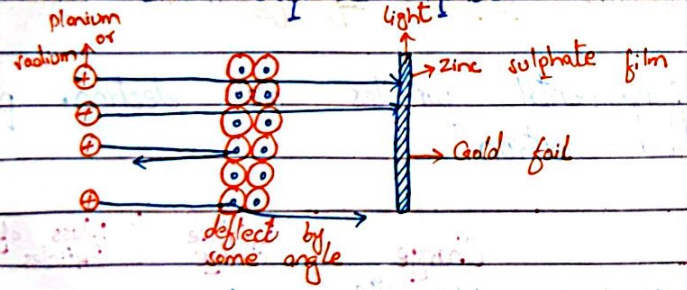
	Charge	Relative charge	Mass of Particles (amu)
Electron	-1.60×10^{-19} C	-1	5.4858×10^{-4}
Neutron	0	0	1.0087
Proton	$+1.60 \times 10^{-19}$ C	+1	1.0073

Ruther ford atomic model:

Ruther Ford perform an experiment to determined the structure of atom.

Experiment

Ruther ford use the gold foil whose width is 0.00004cm. He bombarded alpha particles on gold foil. Alpha particles is produced from polonium and radium. He used ZnS plate or photographic film for detection of alpha particle. Light is produced when alpha particles strike on zinc sulphate plate.



Observation:

He noted that most of the alpha particles goes straight without any deflection. It shows that most of the part atom is empty.

Some alpha particles deflected by some angle. It shows that nucleus have positive charge.

Some alpha particles rebounce back. It shows that nucleus is dense or hard.

Planatry model:

Rutherford resembles his model to the planatry system. Nucleus is present at the centre and appropriate number of electron revolve around the nucleus. In an atom number of electron is equal to the number of proton. Atom is nutral.

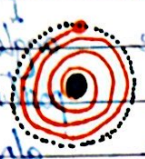
IMP

Deflects of Rutherford atomic theory:

IMP Write the deflects of Rutherford atomic theory?

Electron revolves around the nucleus continuously and nucleus should attract the electron and electon revolve around the nucleus with decreasing distance from (electron) the nucleus. And ultimately electron fall in the nucleus and atom collaps, but in real it

not happen.



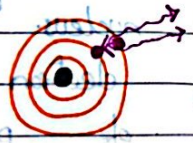
Plank's quantum theory:

Purpose.

Plancks quantum theory. Energy released or absorbed in the form of packet which is known as quantum. But in the case of light these packets of energy is known as photon.

Postulates:

(1) Atom is not released energy continuously. Atom emits energy in the form of quantum. Light emits energy in the form of photon.



The amount of energy is directly proportional to frequency.

$E \propto \nu$ $\quad \nu = Mvv$

$E = h\nu$

where h is plancks constant and it value is 6.63×10^{-34} Js.

2) Define frequency and give its unit?

Define:

The number of waves passing through a certain point is called frequency. $\left(\frac{1}{\lambda}\right)$

Units:

Hz, s^{-1}, etc.

Representation:

"ν"

3) Energy is inversly proportional to the wavelength which can be explain as follows;

$E = h\nu$ $\quad \therefore c = \nu\lambda$

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

By putting the value of "ν"

$E = h\left(\frac{c}{\lambda}\right)$

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

4) Define wavelength and give its unit?

Define:

The (adjacent) distance between two adjacent crust or trough is called wavelength.

Representation:

"λ"

Unit:

nm, pm, Å, etc.

where

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

We know that

$E = \frac{hc}{\lambda} = hc\left(\frac{1}{\lambda}\right)$

$E = hc\bar{\nu}$

where

$\bar{\nu}$ = wave number "c"

Q#* Define wave number and write its unit?

Def:

The number of waves present per unit length or in 1m is called wave number.

Representation:

"$\bar{\nu}$"

Unit:

m^{-1}, A^{-1}, cm^{-1}, etc.

Note:

($E \propto \frac{1}{\lambda}$ ∴ E is inversly proportional to the λ

$E \propto \nu$ = E is directly proportional to the ν

$E \propto \bar{\nu}$ ∴ E is directly proportional to the $\bar{\nu}$.)

Bohar's Atomic Model:

Bohar atomic model is based on planck's quantum theory.

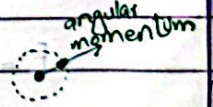
(1) Electron revolve in a circular path which have specific energy. So each orbit have quantized energy

(2) Atom cannot release energy or absorbed energy when an electron in same orbit. Energy is released or absorbed when an electron move from one orbit to another orbit.

(3) When an electron move from inner orbit to outer orbit, the electron absorbed energy. When an electron move from outer orbit to inner inner orbit, the electron released energy / energy is released. He used to determine the amount of energy he used planckes equations,

$\Delta E = E_2 - E_1 = h\nu$

(4) Each electron revolve around the nucleus in a specific angular momentum. The angular momentum is "mvr."



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

where;

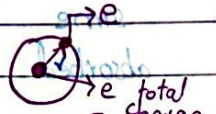
"n" is the number of shell.

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

The angular momentum of different shells is $\frac{nh}{2\pi}, \frac{h}{2\pi}, \frac{2h}{2\pi}, \frac{3h}{2\pi}, \frac{4h}{2\pi}, \ldots\ldots$

Q# Derive the radius of an atom.

We take an atom of hydrogen.



→ The distance between the nucleus and electron is "r". ∴ z = no. of "P".

Charge on electron is "e".

Total charge in the nucleus in "ze".

Mathematically:

According to coloumbs' law;

$$F = k\frac{Zee}{r^2}$$

$$\therefore F = k\frac{ze^2}{r^2} \qquad \because k = \frac{1}{4\pi\varepsilon_0}$$

$$\therefore F = \frac{ze^2}{4\pi\varepsilon_0 r^2} \longrightarrow (1)$$

where;

ε_0 is permitivity in space. Its value is $8.85 \times 10^{-12}\ C^2 J^{-1} m^{-1}$.

Electron revolves around the nucleus due to centripetal force.

$$F = \frac{mv^2}{r} \longrightarrow (2)$$

By comparing equation (1) & (2)

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

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

$$r = \frac{ze^2}{4\pi\varepsilon_0 mv^2} \longrightarrow (3)$$

According to above equation; velocity of electron is higher when the radius of an atom decrease.

According to angular momentum;

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

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

By taking square

$$v^2 = \frac{n^2h^2}{4\pi^2m^2r^2} \quad \therefore$$

By putting the value of "v" in equation (3)

$$r = \frac{ze^2}{4\pi\varepsilon_0 m\left(\frac{n^2h^2}{4\pi^2m^2r^2}\right)} \quad \therefore$$

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

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

$$1 = \frac{ze^2 \pi m r}{\varepsilon_0 n^2 h^2}$$

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

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

For hydrogen atom the value of $\frac{\varepsilon_0 h^2}{\pi m z e^2} = 0.529 \times 10^{-10} m \Rightarrow 0.529\ \text{Å}$

$$r = 0.529\, n^2\ \text{Å}$$

The values of radius of hydrogen atom.

$\therefore n = 1$

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

$\therefore n = 2$

$r_2 = 0.529(2)^2\ \text{Å} \Rightarrow 0.529(4)\ \text{Å}$

$r_2 = 2.11\ \text{Å}$

$\therefore n = 3$

$r_3 = 0.529(3)^2\ \text{Å} \Rightarrow 0.529(9)\ \text{Å}$

$r_3 = 4.75\ \text{Å}$

$\therefore n = 4$

$r_4 = 0.529(4)^2\ \text{Å} \Rightarrow 0.529(16)\ \text{Å}$

$r_4 = 8.4\ \text{Å}$

From above calculated value

$r_2 - r_1 = 1.581$

$r_3 - r_2 = 2.64$

$r_4 - r_3 = 3.65$

$r_2 - r_1 < r_3 - r_2 < r_4 - r_3 < \ldots\ldots$

Derivation of energy:

We know that

Total energy = K.E + P.E

$E = K.E + P.E$

Derivation of K.E:

We know that

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

By replacing the value of mv^2;

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

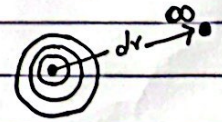
$$K.E = \frac{1}{2}\left(\frac{ze^2}{4\pi\varepsilon_0 r}\right)$$

$$K.E = \frac{ze^2}{8\pi\varepsilon_0 r}$$

Derivation of P.E:

As we know that

$W = F.dr$



$$W = \frac{ze^2}{4\pi\varepsilon_0 r^2} \cdot dr$$

We know that work done is known as P.E

$$P.E = \frac{ze^2}{4\pi\varepsilon_0 r^2} \cdot dr$$

By integrating

$$P.E = \int_{\infty}^{r} \frac{ze^2}{4\pi\varepsilon_0 r^2} \cdot dr \Rightarrow \frac{ze^2}{4\pi\varepsilon_0} \int_{\infty}^{r} \frac{dr}{r^2}$$

$$P.E = \frac{ze^2}{4\pi\varepsilon_0} \left| \frac{2-1}{r^{2-1}} \right|_{\infty}^{r} \Rightarrow \frac{ze^2}{4\pi\varepsilon_0} \left| \frac{1}{r} \right|_{\infty}^{r}$$

$$P.E = \frac{ze^2}{4\pi\varepsilon_0}\left(\frac{-1}{r}\right) \Rightarrow \frac{-ze^2}{4\pi\varepsilon_0 r} \qquad \because = \frac{1}{\infty} - \frac{1}{r}$$

$$\therefore = 0 - \frac{1}{r}$$

$$\therefore = -\frac{1}{r}$$

Total energy = K.E + P.E

By putting the values of K.E & P.E

$$\text{Total energy} = \frac{-ze^2}{4\pi\varepsilon_0 r} + \frac{ze^2}{8\pi\varepsilon_0 r}$$

$$= \frac{ze^2}{8\pi\varepsilon_0 r} - \frac{ze^2}{4\pi\varepsilon_0 r}$$

$$= \frac{ze^2}{4\pi\varepsilon_0 r}\left(\frac{1}{2} - 1\right)$$

$$= \frac{ze^2}{4\pi\varepsilon_0 r}\left(\frac{1-2}{2}\right)$$

$$= \frac{ze^2}{4\pi\varepsilon_0 r}\left(\frac{-1}{2}\right)$$

$$= \frac{-ze^2}{8\pi\varepsilon_0 r}$$

We know that

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

$$E = \frac{-ze^2}{8\pi\varepsilon_0\left(\frac{\varepsilon_0 n^2 h^2}{ze^2\pi m}\right)}$$

$$E = \frac{-ze^2(ze^2\pi m)}{8\pi\varepsilon_0^2 n^2 h^2}$$

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

For hydrogen atom the value of constant $\frac{ze^4 m}{8\varepsilon_0^2 h^2}$ is 2.178×10^{-18} J

By replacing the value of constant

$$E = -2.178 \times 10^{-18}\left(\frac{1}{n^2}\right) \text{ J}$$

This is in joule. For conversion of this energy from joule into KJmole^{-1}.

$$E = -\frac{2.178 \times 10^{-18} \times 6.02 \times 10^{23}}{1000}\left(\frac{1}{n^2}\right)\frac{\text{kJ}}{\text{mole}}$$

$$E = -1313.31\left(\frac{1}{n^2}\right) \text{kJmole}^{-1}$$

When

$\therefore n = 1$

$$E_1 = -1313.31\left(\frac{1}{(1)^2}\right) \Rightarrow -1313.31 \text{ KJmole}^{-1}$$

$\therefore n=2$

$E_2 = 1313.31 \left(\frac{1}{(2)^2}\right) \Rightarrow -328.32 \text{ kjmole}^{-1}$

$\therefore n=3$

$E_3 = 1313.31 \left[\frac{1}{(3)^2}\right] \Rightarrow -145.92 \text{ kjmole}^{-1}$

$\therefore n=4$

$E_4 = 1313.3 \left[\frac{1}{(4)^2}\right] \Rightarrow -82.02 \text{ kjmole}^{-1}$

$\therefore n=\infty$

$E_\infty = 1313.31 \left[\frac{1}{(\infty)^2}\right] \Rightarrow 0 \text{ kjmole}^{-1}$

Now;

$E_2 - E_1 = -328.32 + 1313.31 \Rightarrow 984.99 \text{ kjmole}^{-1}$

$E_3 - E_2 = -145.92 + 328.32 \Rightarrow 182.4 \text{ kjmole}^{-1}$

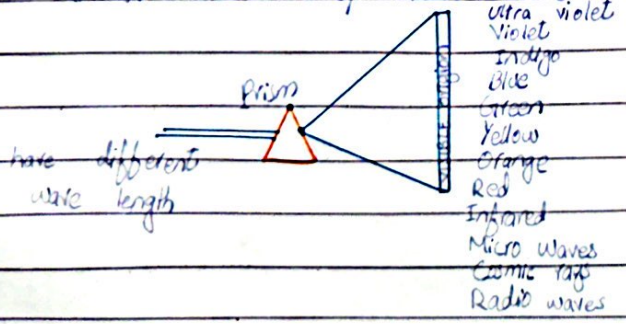
$E_4 - E_3 = -82.02 + 145.92 \Rightarrow 63.9 \text{ kjmole}^{-1}$

Hence;

$E_2 - E_1 > E_3 - E_2 > E_4 - E_3 > \ldots\ldots$

Spectrum:

The visual display of white light into different components when it is passed through the prism is known as spectrum.



Vib Gyor

Explaination:

White light is pass through the prism. It divides into different components. The light bends according to their wave length. The light whose wavelength is shorter is bend larger and vice-versa.

→ The spectrum of white light have visible region. Visible region have seven visible colours ie; violet, Indigo, Blue, Green, yellow, Orange and Red.

→ Above the violet colour some components are present which are; Ultra violet, X-rays and γ-rays are present.

→ Below the red colour Infrared, Micro waves, Cosmic rays and radio waves are present.

Types:

There are two types of spectrum;

* Continuous Spectrum
* Line Spectrum

Continuous Spectrum:

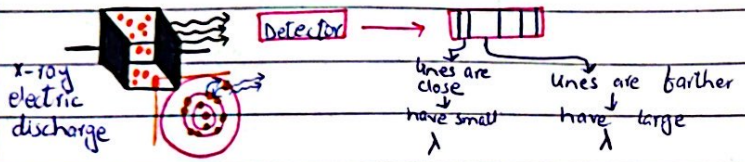
The type of spectrum in which boundary cannot be drawn between different colours/components is

called continuous spectrum.

e.g
Rainbow

* **Line Spectrum:**

The type of spectrum in which lines are separated to each other at a specific distance is called line spectrum.



e.g
- In sodium atom yellow lines are separated at a specific distance.
- The spectrum of hydrogen atom have lines of different colours which is separated at a specific distance.

Formation/Production:

Q: What is the origin of Line spectrum?

When a substance is heated or provide electric discharge the electrons of the substance excite and when these electron dexcite and emit energy which is pass through from detector and line spectrum are formed.

Note:

In spectrum, where the lines are close to each other their wavelength is smaller and vice-versa.

Atomic Emission Spectrum: (Difference) IMP Q

Defination:

The type of spectrum in which while lines are formed on black background is called atomic emission spectrum.

Explination:

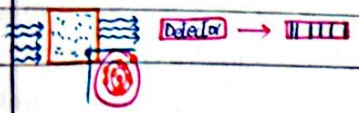
When a substance is heated or provide electric discharge the electron of substance excite and when the electron dexcite and it emit the energy which is pas though from dectector and atomic emission spectrum are formed.

Atomic absorption spectrum:

Defination:

The type of spectrum in

which dark lines are formed on white background is called atomic absorption spectrum.



Explanation:

When we pass the white light in the sample of a substance specific wavelength are absorbed and remaining wavelength of light pass through the detector and atomic absorption spectrum are formed.

Hydrogen Spectrum:

Q# Write the name of spectral lines of hydrogen atom?

Lyman Series (Ultra violet region)
Balmer Series (Visible region) — IMP MCQs
Paschen Series (I.R region)
Brackett Series (I.R region)
Phund Series (I.R region)

Origion of hydrogen Spectrum:

Q# What is the origion of hydrogen Spectrum?

Fill the discharge tube with hydrogen gas then apply electric discharge. On applying electric discharge excitation occur. On dexcitation hydrogen gas emit blue light which pass thrugh the detector and spectrum are formed.

	n_1	n_2
L.S	1	2, 3, 4, 5, ... ∞
B.S	2	3, 4, 5, 6, ... ∞
P.S	3	4, 5, 6, 7, ... ∞
Brackett.S	4	5, 6, 7, 8, ... ∞
P.S	5	6, 7, 8, 9, ... ∞

When,

$n_1 = (1)$; $n_2 = 2$

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

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

$$\bar{v} = 1.09678 \times 10^7 \left(\frac{1}{1} - \frac{1}{4}\right)$$

$$\bar{v} = 1.09678 \times 10^7 \left(\frac{4-1}{4}\right)$$

$$\bar{v} = 1.09678 \times 10^7 \left(\frac{3}{4}\right)$$

$$\bar{v} = 822585$$

$$\bar{v} = 8.2 \times 10^5 \, m^{-1}$$

$n_1 = 1 \; ; \; n_2 = 3$

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

$\bar{v} = 1.09678 \times 10^7 \left(\frac{1}{1} - \frac{1}{9}\right)$

$\bar{v} = 1.09678 \times 10^7 \left(\frac{9-1}{9}\right)$

$\bar{v} = 1.09678 \times 10^7 \left(\frac{8}{9}\right)$

$\bar{v} = 974915$

$\bar{v} = 974.915 \times 10^5 m^{-1}$

$n_1 = 1 \; ; \; n_2 = 4$

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

$\bar{v} = 1.09678 \times 10^7 \left(\frac{1}{1} - \frac{1}{16}\right)$

$\bar{v} = 1.09678 \times 10^7 \left(\frac{16-1}{16}\right)$

$\bar{v} = 1.09678 \times 10^7 \left(\frac{15}{16}\right)$

$\bar{v} = 102.82312.5$

$\bar{v} = 102.82 \times 10^5 m^{-1}$

$n_1 = 1 \; ; \; n_2 = \infty$

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

$\bar{v} = 1.09678 \times 10^7 \left(\frac{1}{1} - 0\right)$

$\bar{v} = 1.09678 \times 10^7 (1-0)$

$\bar{v} = 1.09678 \times 10^7$

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

$n_1 = 2 \; ; \; n_2 = 3$

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

$\bar{v} = 1.09678 \times 10^7 \left(\frac{1}{4} - \frac{1}{9}\right)$

$\bar{v} = 1.09678 \times 10^7 \left(\frac{9-1}{36}\right)$

$\bar{v} = 1.09678 \times 10^7 \left(\frac{5}{36}\right)$

$\bar{v} = 1523365.5$

$\bar{v} = 15.2 \times 10^5 m^{-1}$

$n_1 = 2 \; ; \; n_2 = 4$

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

$\bar{v} = 1.09678 \times 10^7 \left(\frac{1}{4} - \frac{1}{16}\right)$

$\bar{v} = 1.09678 \times 10^7 \left(\frac{4-1}{16}\right)$

$\bar{v} = 1.09678 \times 10^7 \left(\frac{3}{16}\right)$

$\bar{v} = 2056462.5$

$\bar{v} = 20.5646 \times 10^5 m^{-1}$

$n_1 = 2 \; ; \; n_2 = 5$

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

$\bar{v} = 1.09678 \times 10^7 \left(\frac{1}{4} - \frac{1}{25}\right)$

$\bar{v} = 1.09678 \times 10^7 \left(\frac{25-4}{100}\right)$

$\bar{v} = 1.09678 \times 10^7 \left(\frac{21}{100}\right)$

$\bar{v} = 2303238$

$\bar{v} = 23.0 \times 10^5 m^{-1}$

$n_1 = 2 \; ; \; n_2 = \infty$

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

$\bar{v} = 1.09678 \times 10^7 \left(\frac{1}{4} - 0\right)$

$\bar{v} = 1.09678 \times 10^7 \left(\frac{1}{4}\right)$

$\bar{v} = 2741950$

$\bar{v} = 2741 \times 10^5 m^{-1}$

Calculation of Wave number:

We know that

$$E_1 = \frac{-Z^2e^4m}{8\varepsilon_0^2 n_1^2 h^2}$$

$$E_2 = \frac{-Z^2e^4m}{8\varepsilon_0^2 n_2^2 h^2}$$

We know that

$$\Delta E = E_2 - E_1$$

By putting the values of E_2 & E_1

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

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

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

We know that $\frac{Z^2e^4m}{8\varepsilon_0^2 h^2} = 2.178 \times 10^{-18}$

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

Calculation of frequency

$$\Delta E = h\nu$$

Putting the value of ΔE in eq (i)

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

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

Calculation of wave no.

$$c = \nu\lambda$$

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

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

Putting the value of frequency in eq (ii)

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

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

By putting the values of all the constants and we get 1.09678×10^7

$\frac{Z^2e^4m}{8\varepsilon_0^2 h^3 c}$ is known as Ryberg constant

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

Deflects of Bohar atomic model:

M.IMP

Q#: Write any two deflects of Bohar atomic model?

1) Bohar atomic model is only applicable for monoelectronic system but not applicable for polyelectronic system.
2) When spectral lines are seen through the high resolving spectrometer. This spectral lines is further divide into several fine lines.
3) One quantum no. is not sufficient to describe the location of electron.
4) Bohar atomic model tell electron moves

in a circular path or in one plane but actually electron move in three dimensionally.

4) When spectral lines are placed under electric or magnetic field, it divides into several fine lines.

Q# What is zeeman and Stark effect?

Zeeman effect:

When spectral lines are placed under magnetic field then it divides/splits into several fine lines is called zeeman effect.

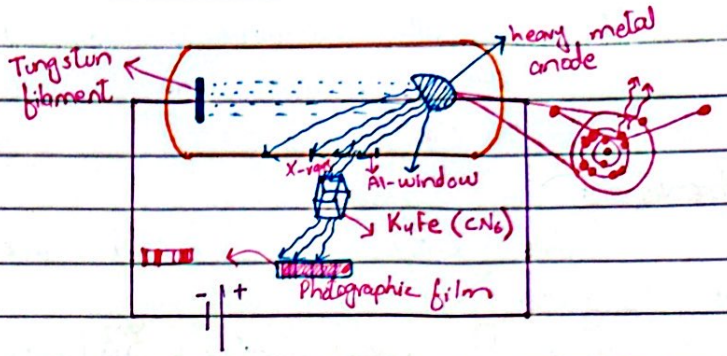
Stark effect:

When spectral lines are placed under electric field then it divides into several fine lines is called starks effect.

X-rays:

Q# Define x-rays, how it is produce?

When electron are strike on heavy metal anode than high energetic waves are produce which is known as X-rays.



Q# What is the origion of x-rays?

When electric current is provided to heated tungsten fibment it produce electron. These electron strike on heavy metal anode and they produce x-rays.

Explaination:

X-rays produce in every direction. A small portion is passed through the Al-Window. These rays are strike/collide on $K_4(Fe(CN)_6)$ crystal and x-rays are differected then these rays fall on photographic film it produce line spectrum. The x-rays have two types of waves such as K_α, K_β, L_α, L_β .....

Mosely Work:

Mosely works on x-rays.

IMP MCQs

He studied 38 elements from Al to Gold. He studied the wavelength from 1.04 Co. 8 Å.

Observation:

① The x-rays is divided into two groups:
- one have shorter wavelength
- other have longer wavelength.

② The energy of x-rays is inversly proportional to its wavelength. The wavelength is also inverly proportional to atomic number.

Q# What is M.M.IMP mosely law? Give its methametical form?

Mosely law:

The frequency of (X-rays) spectral lines of X-rays is directly proportional to the square of atomic number.

Mathematical form:

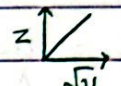
$$\sqrt{\nu} = a(z-b)$$

where;

ν = frequency of x-rays
a = proportionality constant
z = atomic number.
b = screening constant

Graph:

A straight line is formed between $\sqrt{\nu}$ and z.



Q# What is M.M.IMP the importance of Mosely law?

(1) He gave the correct arrangement of some elements such as K, Ar, Ni and Co, etc.

(2) He discover the atomic number of rare earth metal.

(3) He discovered some elements such as Tc (43), Pr (59), Rh (45).

De Broglie wave equation (Dual nature of matter):

According to De-Broglie "Every moving thing in universe have dual nature ie wave nature as well as particle nature."

Mathematically:

According to Einstein equation;

$$E = mc^2 \quad \ldots (i)$$

We know that;

$E = h\nu$ .... ii)

By comparing eq i and ii

$mc^2 = h\nu$

$mc^2 = \frac{hc}{\lambda}$ $\quad \because c = \nu\lambda$

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

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

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

changing "c" with "v"

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

2** Justify that electron have dual nature.

Calculation of wavelength for electron:

For electron:

$m = 9.108 \times 10^{-31}$ kg

$h = 6.63 \times 10^{-34}$ Js

$v = 2.188 \times 10^{6}$ ms^{-1}

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

$\lambda = \frac{6.63 \times 10^{-34}}{(9.108 \times 10^{-31})(2.188 \times 10^{6})}$

$\lambda = 0.33 \times 10^{-9}$ m

$\lambda = 0.33$ nm

The wavelength of electron is measureable.

Calculation of wavelength for proton:

If a proton is move with the velocity of speed of electron then the mass of proton is 1836 time heavier than the mass of electron. So its wavelength is 1836 time lesser than the electron.

This wavelength is also measureable.

Calculation of wavelength for stone:

For stone;

$m = 1g \rightarrow 10^{-3}$ kg

$v = 10 ms^{-1}$

$h = 6.63 \times 10^{-34}$ J.S

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

$\lambda = \frac{6.63 \times 10^{-34}}{(10^{-3})(10)}$

$\lambda = 6.626 \times 10^{-32}$ m

This wavelength cannot be measureable.

Heisenberg's uncertainity principle:

Statement:

It is impossible to measure

the momentum and position of electron accurately (at a same time) and simultaneously.

Equation:

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

where;

→ "Δx" is the uncertainity in position of electron.

→ "ΔP" is the uncertainity in the momentum of electron.

Both the uncertainity in position and momentum are inversly proportional to each other. If the uncertainity in position is decrease then the uncertainity in the momentum is increase.

Compton explaination:

To see the object we use ordinary light. The effect of light on macroscopic object is not prominant. To see the electron we use electron microscope. When we want to determine "the position and momentum of electron simultaneously"? If electrons are strike with atom. The position of electron within an atom can be determine but the momentum of electron has been changed or uncertainity in momentum is increased.

Concept of orbital:

According to Bohar atomic model electron revolves around the nucleus in orbit but according to Heisenberg uncertainity principle electrons revolves around the nucleus in wave.

To solve the position of electron three different scientist work on it. Schrodinger give an idea. There are some space around the nucleus where the probability of finding electron is maximum.

Q. What is the difference between orbit and orbital?

Orbit:	Orbital:
The path around the nucleus where an electron revolves is called orbit.	The volume of space around the nucleus where the probability of finding electron is maximum (90%) is called orbital.

- "$2n^2$" formula is used to find the number of electron in an orbit.
- Example:

  K, L, M, N.

- There are maximum two electrons are present in orbital.
- Example:

  P_x, P_y, P_z, etc.

Quantum Numbers:

Definition:

The set of numerical values which describe the location of electron is called quantum number. There are four types of numerical values;

→ Principle quantum number (n)
→ Azimuthal quantum number (l)
→ Magnetic quantum number (m)
→ Spin quantum number (s)

(1) Principle quantum number:

→ It is represented by "n".
→ The value of n is non-zero positive intiger.

→ $n = 1, 2, 3, 4, \ldots$

→ Principle quantum number represent the number of shell.

n	shell name
1	K
2	L
3	M
4	N

→ With the increase of value of shell the radius of shell also increase.

→ To determine the number of electron we use "$2n^2$" formula.

n	shell name	No. of electron
1	K	$2n^2 = 2(1)^2 \Rightarrow 2$
2	L	$2n^2 \Rightarrow 2(2)^2 \Rightarrow 2(4) \Rightarrow 8$
3	M	$2n^2 \Rightarrow 2(3)^2 \Rightarrow 2(9) \Rightarrow 18$
4	N	$2n^2 \Rightarrow 2(4)^2 \Rightarrow 2(16) \Rightarrow 32$

(2) Azimuthal quantum number:

→ When spectural lines are placed under high resolving spectrometer. The spectural lines are (placed) further divided into individual fine lines.

→ It is represented by "l".

→ The value of l is zero and positive intiger.

$l = 0, 1, 2, 3, 4, 5, \ldots\ldots (n-1)$

→ l represents the subshell.

→ To determine the number of electron we use the formula $2(2l+1)$

l	sub shell	sub shell name	No. of electron
0	s	spherical	2
1	p	Principle	16
2	d	diffused	10
3	f	fundamental	14

The relationship between "n"s "l"

n	l	sub shell
1	0	s can be written as 1s
2	0	s can be written as 2s
	1	p can be written as 2p
3	0	s can be written as 3s
	1	p can be written as 3p
	2	d can be written as 3d
4	0	s can be written as 4s
	1	p can be written as 4p
	2	d can be written as 4d
	3	f can be written as 4f

(3) Magnetic quantum number:

→ When spectural lines are placed under magnetic field. These spectural lines are further divided into fine lines which is explain magnetic quantum number.

→ It is represented by "m".

→ The value of m depend on the value of l.

$(l^{th}) \quad m = -l, \ldots -3, -2, -1, 0, 1, 2, 3, \ldots, l$

→ In an orbital maximum 2 electrons are accomodate.

→ If $l = 0$ then $m = 0$. So s orbital have only one orientation in space.

→ If $l = 1$ than $m = -1, 0, +1$. It shows that p orbital have three orientation in space ie; p_x, p_y, p_z

→ If $l = 2$ than $m = -2, -1, 0, 1, 2$. It shows that d-orbital have five orientations in space. ie; $d_{xy}, d_{yz}, d_{zx}, d_{x^2-y^2}, d_{z^2}$

The relationship between "n", "l" & "m"

n	l	m	orbital
1	0	0	s
	0	0	s
2	1	-1	p_x
		0	p_y
		+1	p_z
	0	0	s
3	1	-1	p_x
		0	p_y
		+1	p_z
		-2	d_{xy}
		-1	d_{yz}
	2	0	d_{zx}
		1	$d_{x^2-y^2}$
		2	d_{z^2}

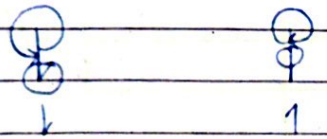
(4) Spin quantum number:

→ Alkali metal have only one electron in their valance shell. When the electron of alkali metal become

excited on heating. On (heating) dexcitation electron release some amount of energy. Pass the energy through high resolving spectrometer. A pair of lines are formed which is known as duplet lines. These duplet lines are explained by spin quantum number.

→ It is represented by "s"

→ It has two values i.e; $+\frac{1}{2}$ & $-\frac{1}{2}$



→ The electron have two type of spin one is clock wise which is represented by "↑" and other spin is anti clock wise which is represented by "↓"

→ Relationship between "n", "l", "m" and "s"

n	l	m	s
1	0	0	$+\frac{1}{2}, -\frac{1}{2}$
	0	0	$+\frac{1}{2}, -\frac{1}{2}$
2		-1	$+\frac{1}{2}, -\frac{1}{2}$
	1	0	$+\frac{1}{2}, -\frac{1}{2}$
		+1	$+\frac{1}{2}, -\frac{1}{2}$
	0	0	$+\frac{1}{2}, -\frac{1}{2}$
		-1	$+\frac{1}{2}, -\frac{1}{2}$
	1	0	$+\frac{1}{2}, -\frac{1}{2}$
3		+1	$+\frac{1}{2}, -\frac{1}{2}$
		-2	$+\frac{1}{2}, -\frac{1}{2}$
		-1	$+\frac{1}{2}, -\frac{1}{2}$
	2	0	$+\frac{1}{2}, -\frac{1}{2}$
		1	$+\frac{1}{2}, -\frac{1}{2}$
		2	$+\frac{1}{2}, -\frac{1}{2}$

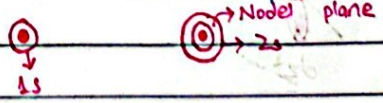
Shapes of orbital:

S-orbital:

→ The shape of s-orbital is spherical.

→ With the increase of the value of "n" the size of s-orbital increase.

→ Between two s-orbitals there are zero chance to find electron. This area is known as nodel plane.



Shapes of p-orbital:

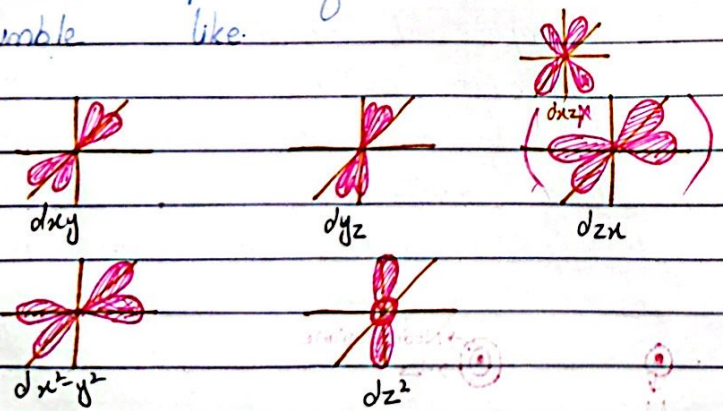
The magnetic quantum no. have three (orientation) values for p-orbital. It has three orientation in space which is along x-axis, y-axis and z-axis. It's shape is dumbal like.

With the increase of number of n the size of p-orbital increase.

Shapes of d-orbital:

There are five values for d-orbital of magnetic quantum number. It shows that d-orbital have five orientations in space which are d_{xy}, d_{yz}, d_{zx}, $d_{x^2-y^2}$, d_{z^2}.

The shape of d-orbital is double dumble like.



Electronic Configuration:

The arrangement of electron in different shell and sub-shell according to their energy is called electronic configuration.

Important point:

Maximum "two" electrons are accomodate in an orbital i.e; $s^2 p_x, p_y, \ldots$

Maximum number of electron in a shell can be calculated by "$2n^2$" formula.

Aufbau principle:

"Electrons are arranged according to their energy."

The energy of electron can be determine by $(n+l)$ rule.

Pauli's exclusion principle:

It is impossible for two electrons residing in the same orbital of poly electronic system having same four quantum number.

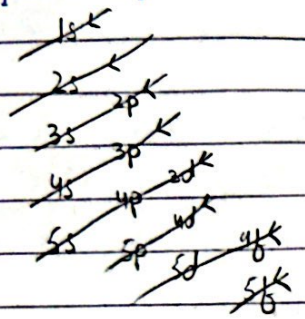
"OR"

Two electrons in same orbital should have opposite spin. (↑↓)

Hund's Rule:

If degenerate (same energy)

orbitals are available then electrons goes to seperate orbital with same spin rather than the same orbital with opposite spin.



Ch #06
Chemical Bonding

Chemical bonding:

The electrostatic force of attraction which is present between two atoms of a compound is called chemical bonding.

Cause of chemical bonding:

Reason to form chemical bonding:

Q# Why electron form chemical bond?

Atoms want stability and want to attain the noble gas electronic configuration by completing their octate and dipet rule. That's why atoms form chemical bond.

Q# Define octet rule and give two example?

Defination:

The ability of an atom to attain eight electrons in its/ their valance shell is called octet rule.

Example:

Mg-atom have two electron in their valance shell and lose two electrons to complete it's octet.