MBC- Mridul Bhaiya Classes

BY - MRIDUL BHAIYA

ATOMS NOTES

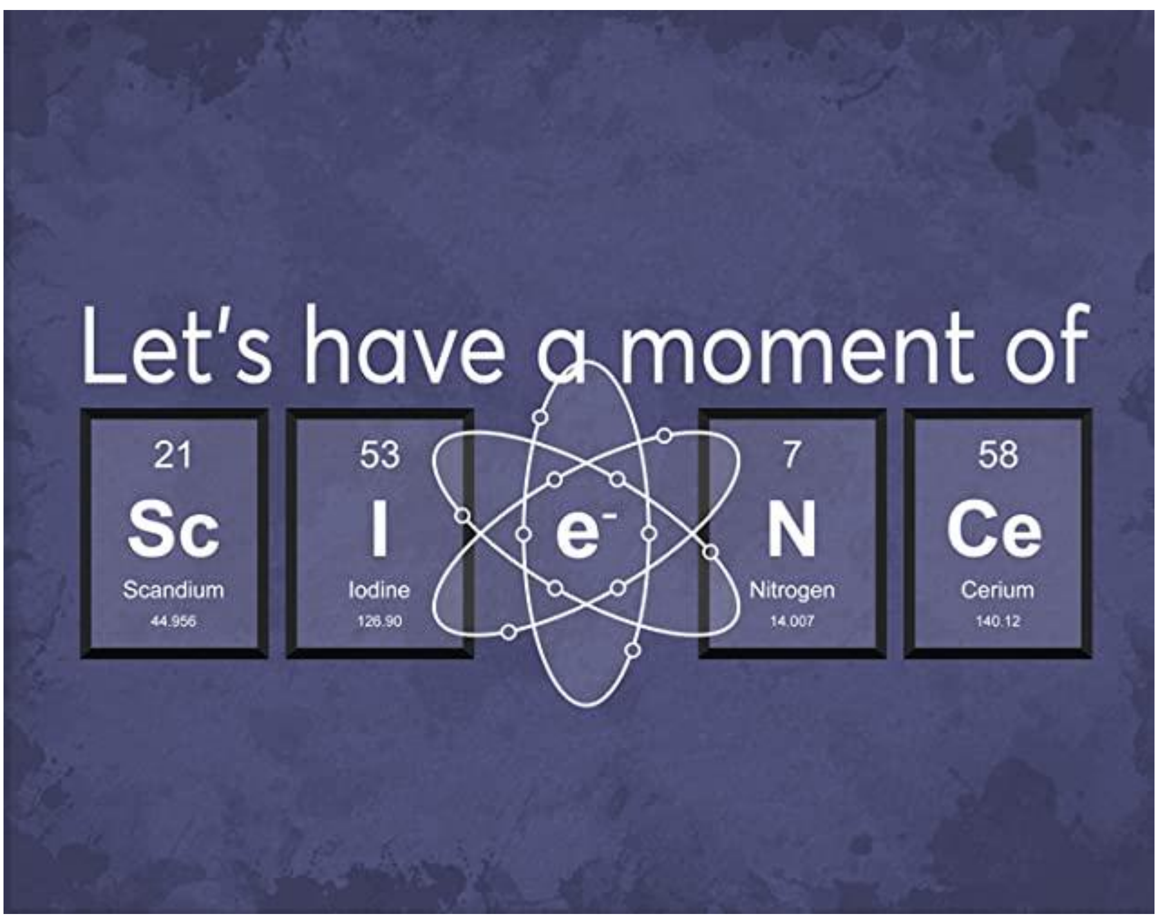
MBC – Mridul Bhaiya Classes

CLASS XII

PHYSICS NOTES

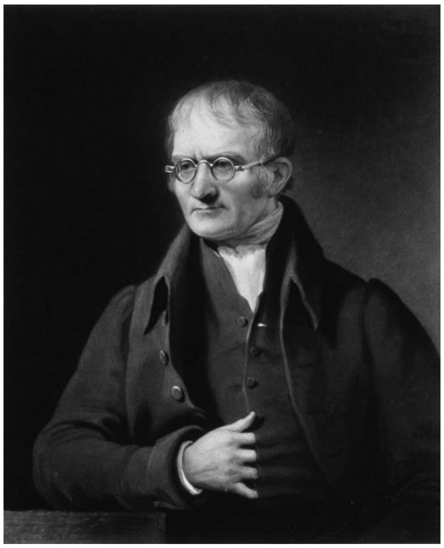
ATOMS

- ✓ Detailed notes
- ✓ PYQs with answers
- ✓ Graphics included

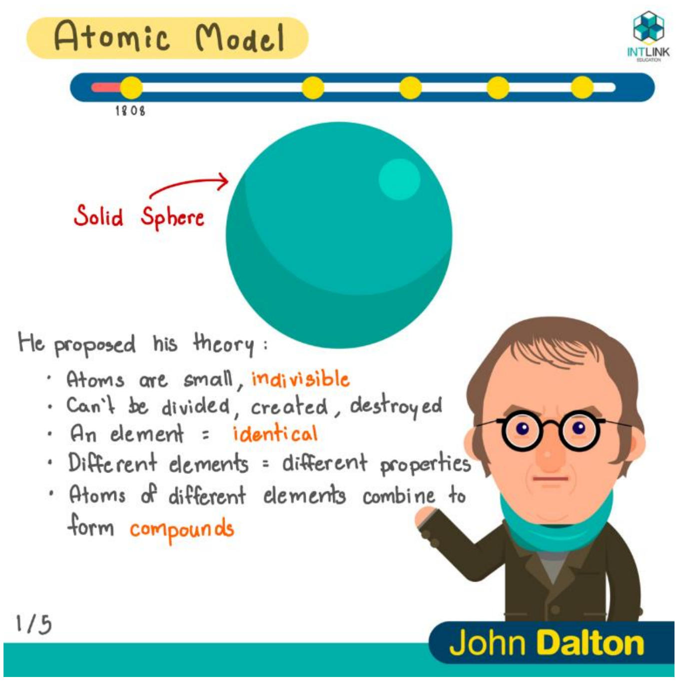


ATOMS

INTRODUCTION



JOHN DALTON



1808 : DALTON'S ATOMIC THEORY

All matter is comprised of tiny definite particles called ATOMS.

All atoms of a particular element share identical properties, including weight.

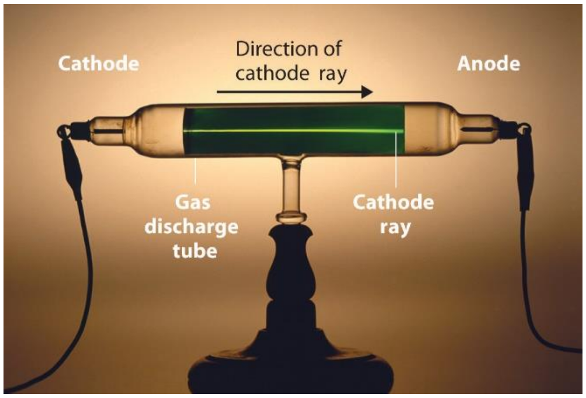
Atoms are indivisible and Indestructible.

FAILURE

The Indivisibility of an Atom was proved wrong : An atom can be further subdivided into protons, neutrons and electrons. However an atom is the smallest particle that takes part in chemical reactions.

According to Dalton, the atoms of same element are similar in all respects. However, atoms of some elements vary in their masses and densities these atoms of different masses are called Isotopes.

ELECTRIC DISCHARGE TUBE : 1897



DISCOVERED NEGATICE CHARGE

[CATHODE RAYS]

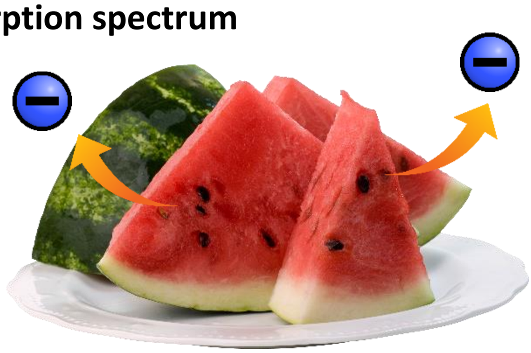
PLUM PUDDING MODEL : 1898

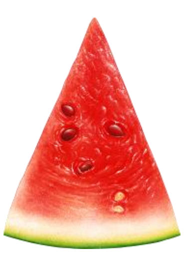
He compared atom with Watermelon

FAILURE

Could not explain the stability of atom

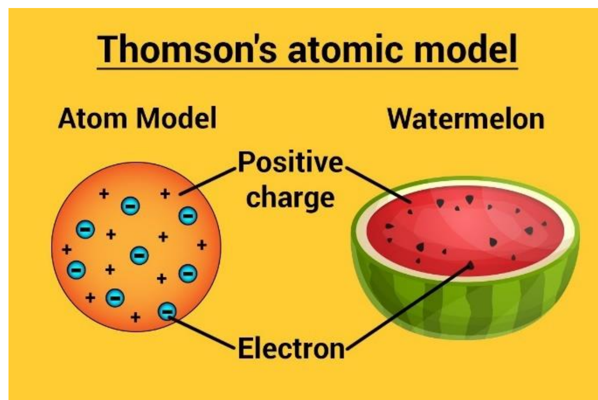
Could not explain the emission and absorption spectrum

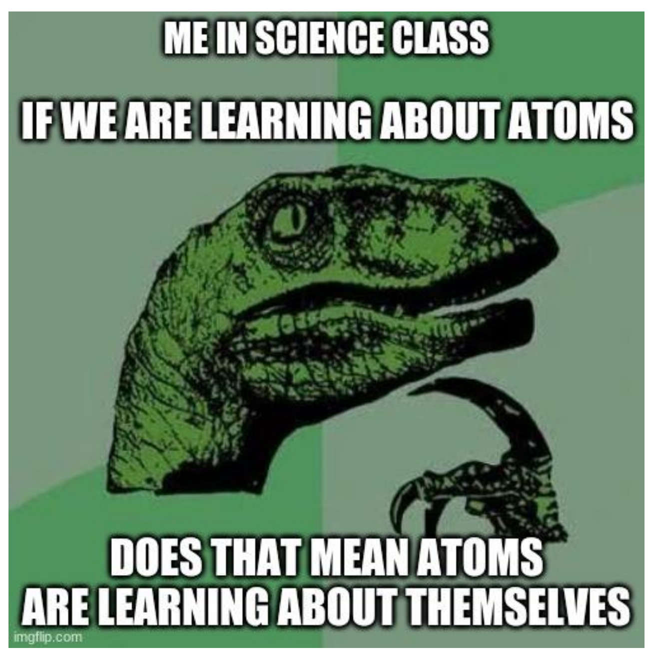


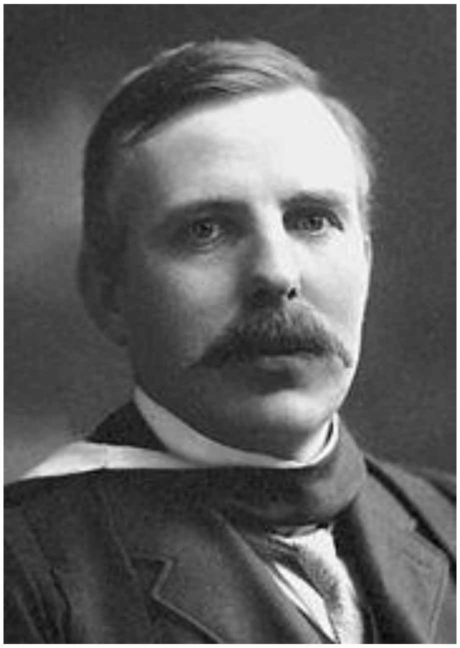


Also called **WATERMELON MODEL**

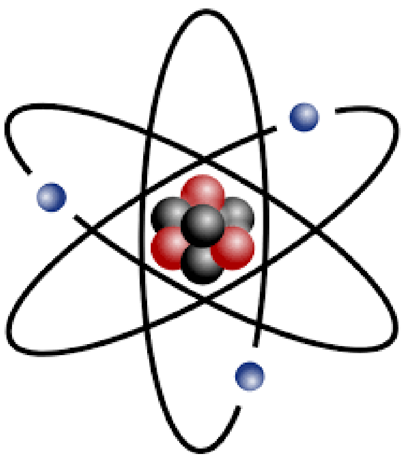
J.J THOMSON

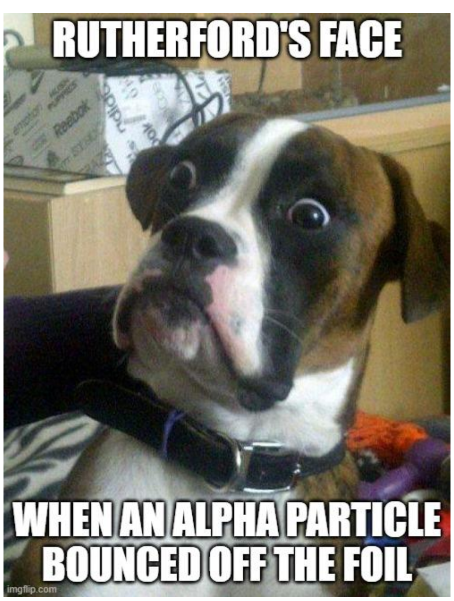




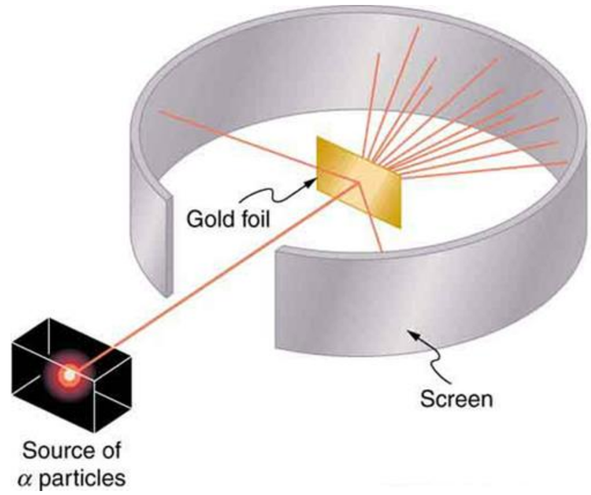


RUTHERFORD





1911 : ALPHA PARTICLE SCATTERING EXPERIMENT



OBSERVATIONS

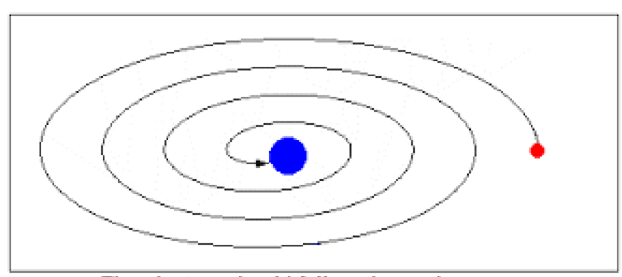
Positive charge is present at the center of atom and most of the space in atom is empty

Electrons revolve around the positive charge in circular orbit

Compared his model to Planetary Motion

FAILURE

According to electromagnetic wave theory accelerated charge particle emits E.M Wave and if it happens electron should loose their energy and will take a spiral path and ultimately collapse with the nucleus.



The electron should fall on the nucleus.

BOHR'S POSTULATES : 1913

BOHR'S FIRST POSTULATE

Electron in an atom coould revolve in certain stable orbits without the emission of radiant energy.

BOHR'S SECOND POSTULATE

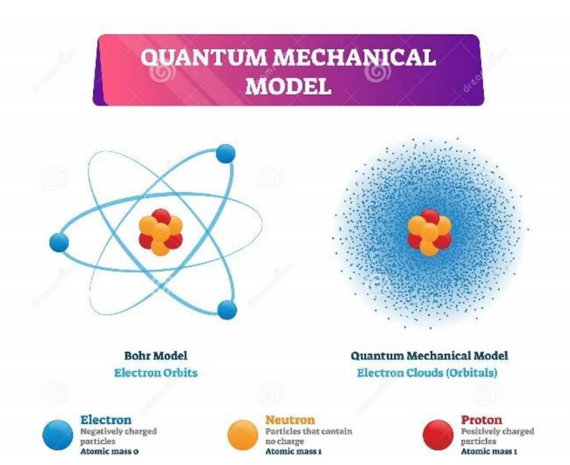
Electorn revolves around the nucleus only in those orbits for which the angular momentum is some integral multiple of $h/2\pi$.

BOHR'S SECOND POSTULATE

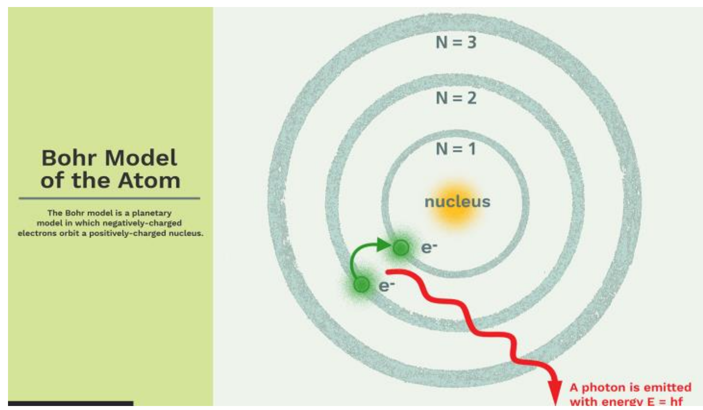
Energy of the orbits in which electrons are moving is fixed and when an electron makes a transition from upper orbit to lower orbit energy is released in the form of Photon.

LIMITATION

Bohr model is only applicable to Hydrogenic Atoms (single electron system)



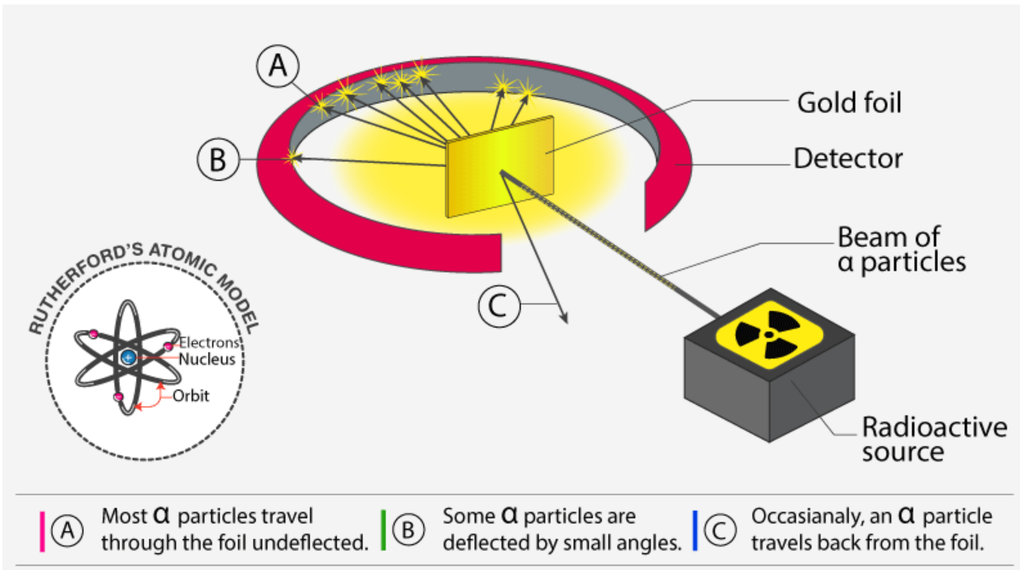
NEIL BOHR



QUANTUM MECHANICAL MODEL

ALSO KNOWN AS WAVE MECHANICAL MODEL
THIS IS NOT IN OUR SYLLABUS BUT WE HAVE ALREADY STUDIES THIS IN ATOMIC STRUCTURE OF CLASS 11TH CHEMISTRY

RUTHERFORD'S NUCLEAR MODEL OF ATOM (ALPHA PARTICLE SCATTERING)



In this experiment they directed a beam of 5.5 MeV α - particles emitted from a Bi_{83}^{214} radioactice source at a thin metal foil made of gold.

The beam was allowed to fall on a thin foil of gold of thickness 2.1×10^{-7} m.

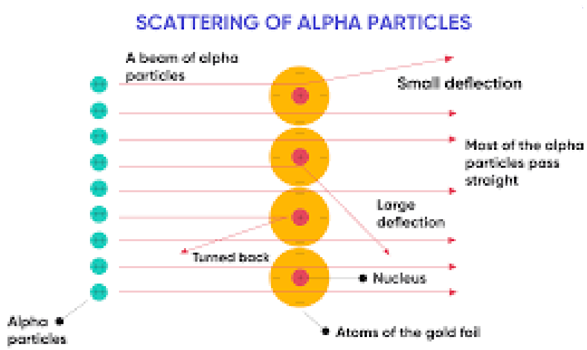
The scattered alpha-particles detector consisting of zinc sulphide screen and a microscope.

The scattered alpha particles on striking the screen produced brief light flashes or scintillation

OBSERVATION

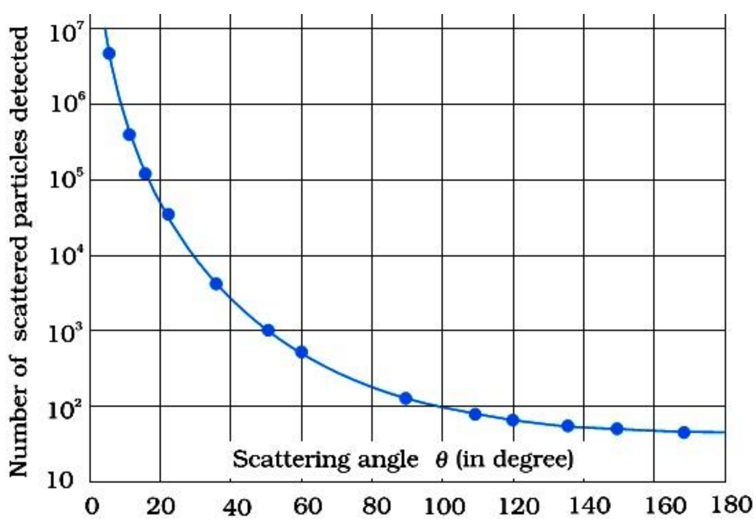
- Only about 0.14% of the incident α - particles scatter by more than 1°

- About 1 in 8000 deflect by more than 90°
- Very rare α - particles defect by 180°



CONCLUSIONS

- 180° Deflection can only be possible by a heavy mass having positive charge
- Very rare α - particles are deflected by 180° so it means this small heavy mass is very small in size
- Most of the α - particles goes without deflection that means most of the space is empty



Based on the above observation he concluded that atom is composed of heavy particles charge concentrated at the centre of atom, hence he discovered **nucleus.**

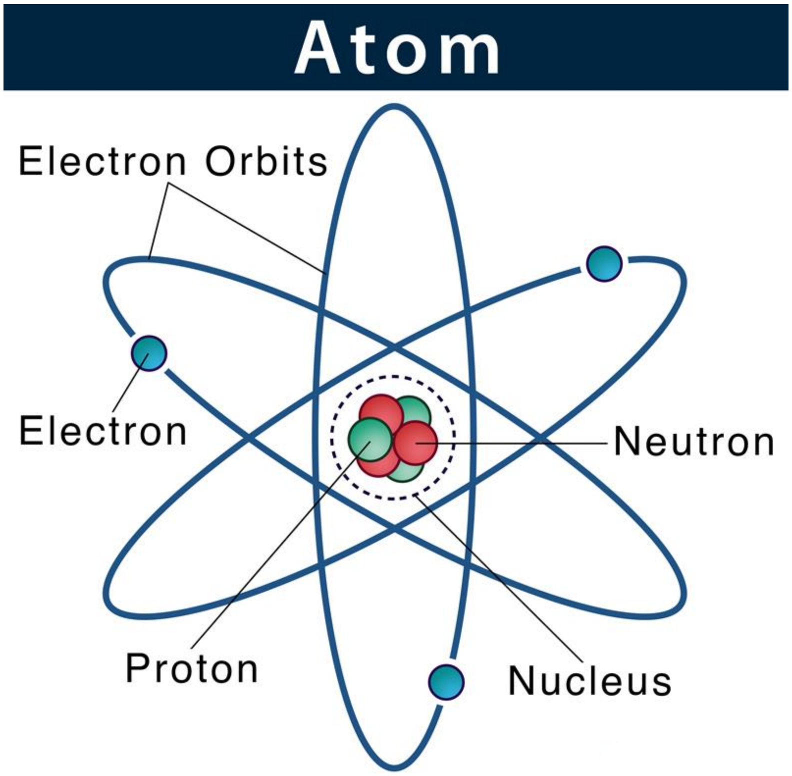
He concluded that electrons would be moving in orbits about the nucleus just as the planets do around the sun.

Size of nucleus is about 10^{-15}m to 10^{-14}m and the size of atom was known to be 10^{-10}m

Size of nucleus is much smaller than size of atom. Hence, most of the space in atom is empty.

Magnitude of force on α - particles by the nucleus is

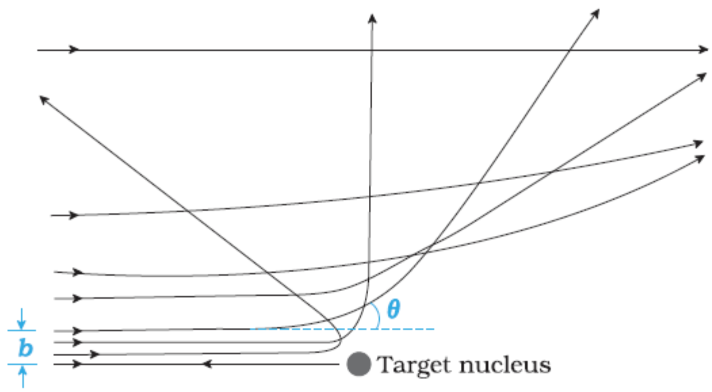
$F = 1/4\pi\epsilon_0 \times (2e)(Ze)/r^2$



ALPHA PARTICLE TRAJECTORY

Trajectory traced by α - particles depends on impact parameter, b of collision

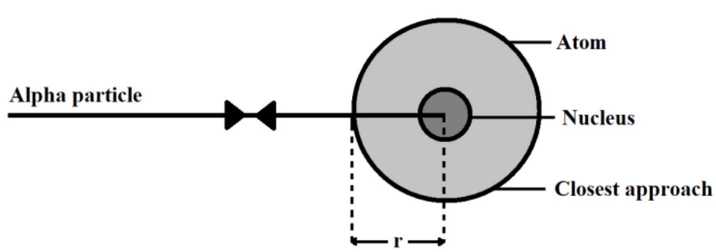
The impact parameter is the perpendicular distance of the initial velocity vector of the α - particles from the centre of the nucleus



In case of head on collision impact parameter is minimum and α - particles rebounds back

For a large impact parameter α - particles goes nearly undeviated

DISTANCE OF CLOSEST APPROACH



Definition : The distance of closest approach is the minimum distance of a stationary nucleus with a positivelu charged particle making head on collision from a point where its kinetic energy becomes zero.

To find the distance of closest approach we use law of conservation of energy

$T.E_i = T.E_f$

$K.E_i + \cancelto{0}{P.E_i} = \cancelto{0}{K.E_f} + P.E_f$

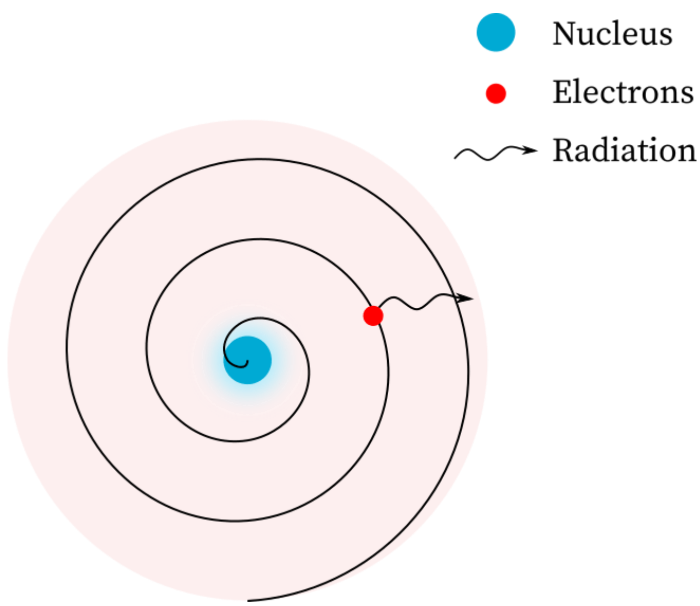
$KE = 1/4\pi\epsilon_0 \times (2e)(Ze)/d$

FAILURE OF RUTHERFORD MODEL

According to classical electromagnetic theory, an acceleration charged particles emits radiation in the form of electromagnetic waves.

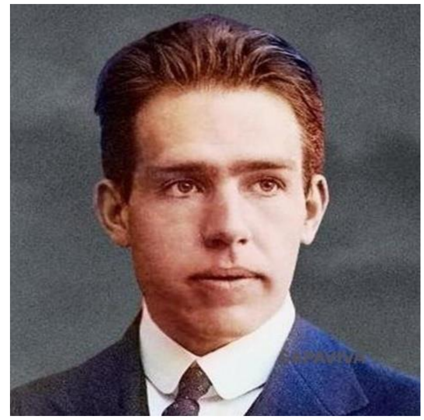
The energy of an acceleration electron should therefore, continously decrease, Hence atom can not be stable

According to classical electromagnetic theory, the frequency of the electronmagnetic waves emitted by the revolving electrons is equal to the frequency of revolution.



BOHR MODEL OF HYDROGEN ATOM

Niels Bohr Model (1885-1962) :



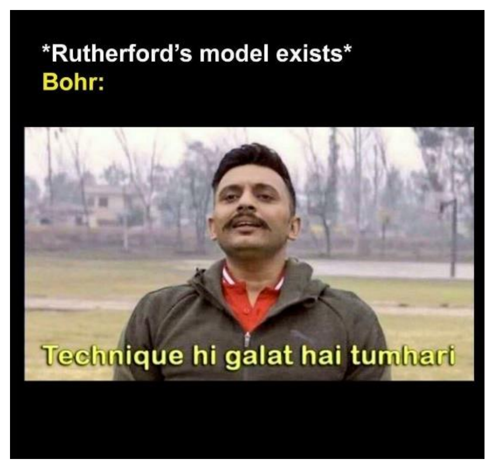
In 1913, he concluded that electromagnetic theory could not be applied to the atomic scale.

Bohr combined classical and early quantum concepts and gave three postulates.

BOHR FIRST POSTULATE :

It states that " Electron in an atom could revolve in certain stable orbits without the emission of radiant energy

According to this postulate, each atom has certain definite stable states in which it can exist



These are called **Stationary States of atom.**

BOHR SECOND POSTULATE :

Electrons revolve around the nucleus only in thode orbits for which the angular momentum is some integral multiple of h/2π where

h = 6.626×10^{-24} Js

Angular momentum (L) of the orbiting electron is quantised.

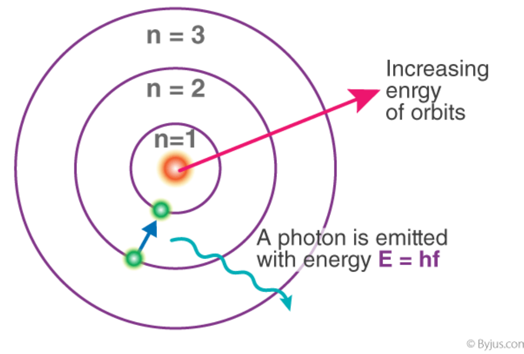
L = $\frac{nh}{2\pi}$

$m_e v r_n = \frac{nh}{2\pi}$

BOHR SECOND POSTULATE :

It states that on electron might make a transition from one of its specified non-radiating orbits to another of lower energy.

When electronic transition takes place, a photon is emitted having energy equal to the energy difference between initial and final states.

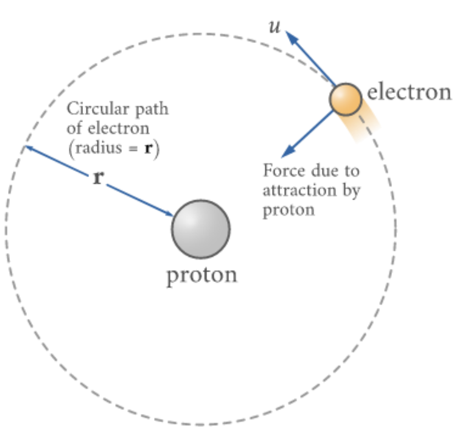


The frequency of emitted photon can be find out by the following

$h\nu = E_i - E_f$

VELOCITY OF ELECTRON

Velocity of Electron in nth Orbit : Electrons revolves around the nucleus in circular orbut and the required centripetal force is provided by electrostatic force between electron and the nucleus



$F_e = F_c$

$$\frac{1}{4\pi\varepsilon_0} \times \frac{Ze^2}{r_n^2}$$

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

$$\Rightarrow \quad v_n = \frac{2Ze^2}{4nh\varepsilon_0} = \frac{Ze^2}{2nh\varepsilon_0}$$

$$\Rightarrow \quad V_n = 2.18 \times 10^6 \frac{Z}{n} \text{ m/s}$$

RADIUS OF ORBITS

Radius of n^{th} Orbit : We know that

$L = m_e v r_n = \frac{nh}{2\pi}$

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

from previous we know that

$v_n = \frac{2Ze^2}{4nh\varepsilon_0}$

$\Rightarrow r_n = \frac{nh2nh\varepsilon_0}{2\pi mZe^2} = \frac{n^2\,h^2\varepsilon_0}{\pi mZe^2}$

$r_n = 0.529\,\frac{n^2}{Z}$ Å

ENERGY IN N^{TH} ORBIT

Kinetic Energy in n^{th} Orbit : We know that

K.E. = ½ mv^2

K.E. = ½ m $(\frac{Ze^2}{2nh\varepsilon_0})^2$

K.E. = ½ $mZ^2\,\frac{e^2}{4n^2h^2{\varepsilon_0}^2}$

$\Rightarrow$ K.E. = 13.6 $\frac{z^2}{n^2}$ eV

Potential Energy in n^{th} Orbit : We know that

$U = \frac{1}{4\pi\varepsilon_0}\,\frac{q_1q_2}{r}$

$U = -\frac{1}{4\pi\varepsilon_0}\frac{Ze^2}{r}$

$\Rightarrow U = -27.2\,\frac{z^2}{n^2}$ eV

Total Energy in n^{th} Orbit : We know that

T.E = U + K.E

$-27.2\,\frac{z^2}{n^2}$ eV + $13.6\,\frac{z^2}{n^2}$ eV

$\Rightarrow$ T.E = $-\,13.6\,\frac{z^2}{n^2}$ eV

Example : A 10kg Satellite circles earth once every 2h in an orbit having a radius of 8000km. Assuming that Bohr's angular momentum postulate applies to satellite just as it does to an electron in the hydrogen atom, find the quantum number of the orbit of the satellite.

Solution : $mv_nr_n = \frac{nh}{2\pi}$

$r_n = 8000 \times 10^3$ m

$T = 2 \times 60 \times 60$ s $= 2\pi r$

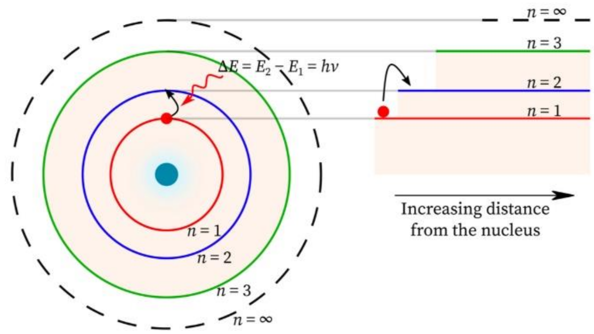
$v_n = \frac{2\pi 8000 \times 10^3}{2 \times 60 \times 60}$

put the values in eq^n

$10 \times \frac{2\pi 8000 \times 10^3}{2 \times 60 \times 60} \times 8000 \times 10^3 \text{ m} \times \frac{2\pi}{6.6 \times 10^{-24}} = n$

ENERGY LEVELS

The lowest state of the atom is called the ground state.



The energy is progressively larger in the outer orbits.

When electronic transitions takes place from higher orbit to lower orbit energy is released.

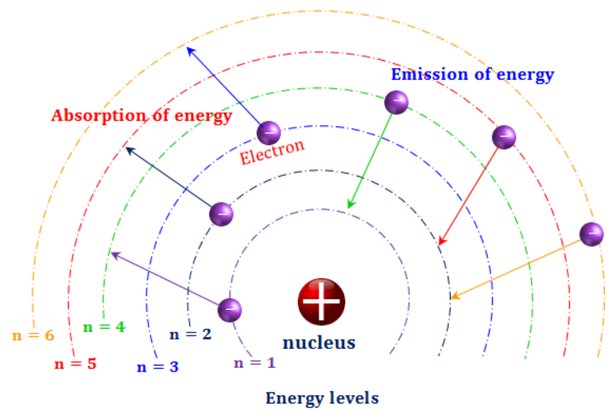
When electronic transition takes place from lower orbit to higher orbit energy is required.

We know that energy in nth orbit having atomic number Z is

$$- 13.6 \frac{z^2}{n^2} \text{ eV}$$

Ionization Energy : The minimum energy required to free electron from the ground state.

For example ionization energy of hydrogen atom is 13.6 eV



At room temperature most of the hydrogen atom are in ground state.

The energy required to shift an electron from lower state to higher state is called **Excitation Energy**

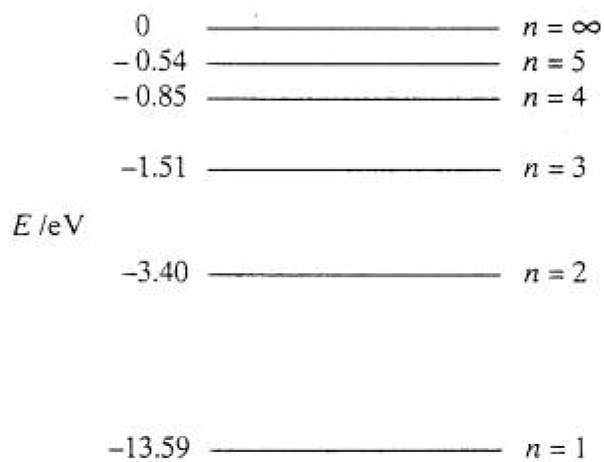
When electron shifted from ground state to n=2, it is said to be in first excited state, similarly when electron shifted from ground state to n=3, it is said to be in second excited state.

ENERGY LEVEL FOR HYDROGEN ATOM

We knoe that energy in n^{th} orbit having atomic number Z is

-13.6 $\frac{z^2}{n^2}$ eV

We know that for hydrogen atom Z = 1



ENERGY LEVEL FOR HYDROGEN LIKE ATOMS

we know that energy in n^{th} orbit having atomic number Z is

-13.6 $\frac{z^2}{n^2}$ eV

For n = 1

-13.6 (z^2) eV

For n = 2

-13.6/4 (z^2) eV

THE LINE SPECTRA OF THE HYDROGEN ATOM

According to Bohr's third postulate when an electron transition takes place from higher orbit to lower orbit energy is released in the form of photon.

Energy of photon released is given by the equation

$h\nu = E_{\text{higher orbit}} - E_{\text{lower orbit}}$

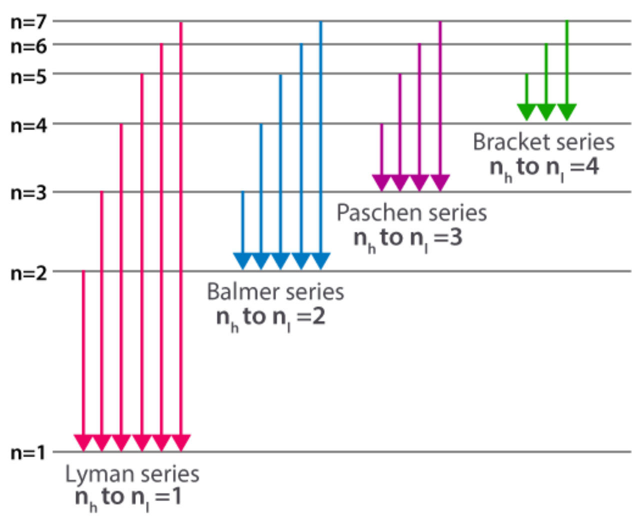
$$h\nu = \frac{me^4}{8\varepsilon_0^2 h^2}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$\nu = \frac{me^4}{8\varepsilon_0^2 h^3}\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

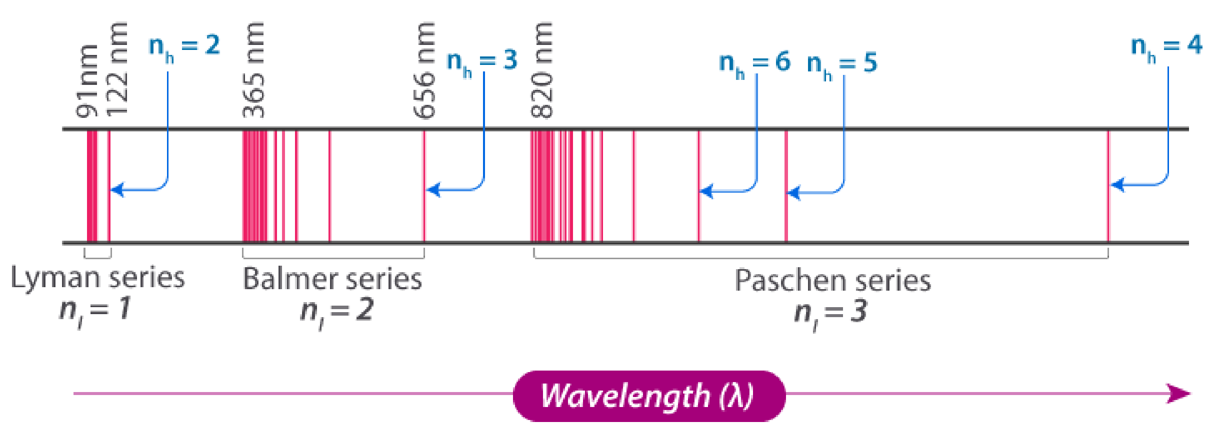
$$R = \frac{me^4}{8\varepsilon_0^2 h^3 c}$$ where R is Rydberg constant & $R = 1.097 \times 10^7\ m^{-1}$

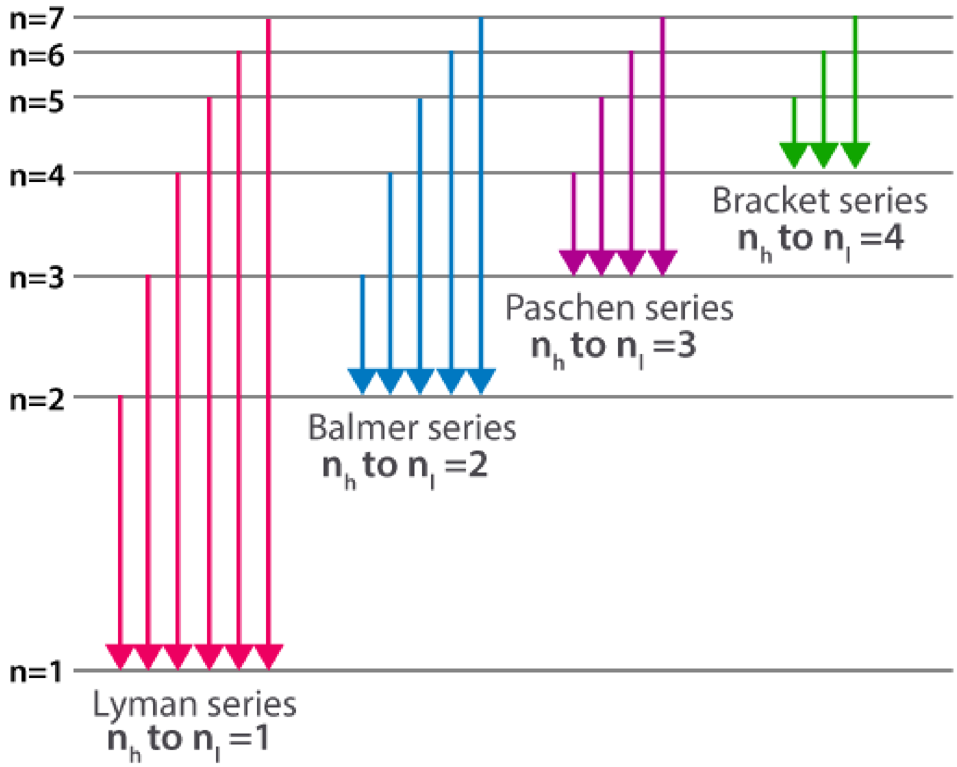
$$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

DIFFERENT SERIES



Lyman	Balmer	Paschen	Brackett	pfund
When electronic transition takes place from higher orbit to n = 1	When electronic transition takes place from higher orbit to n = 2	When electronic transition takes place from higher orbit to n = 3	When electronic transition takes place from higher orbit to n = 4	When electronic transition takes place from higher orbit to n = 5
When transition takes place from n = 2 to n = 1 then it is said to be first line of Lyman Series	When transition takes place from n = 3 to n = 2 then it is said to be first line of Balmer Series	When transition takes place from n = 4 to n = 3 then it is said to be first line of Paschen Series	When transition takes place from n = 5 to n = 4 then it is said to be first line of Brackett Series	When transition takes place from n = 6 to n = 5 then it is said to be first line of pfund Series
When transition takes place from n = ∞ to n = 1 then it is said to be series limit of Lyman Series	When transition takes place from n = ∞ to n = 2 then it is said to be series limit of Balmer Series	When transition takes place from n = ∞ to n = 3 then it is said to be series limit of Paschen Series	When transition takes place from n = ∞ to n = 4 then it is said to be series limit of Brackett Series	When transition takes place from n = ∞ to n = 5 then it is said to be series limit of pfund Series





LYMAN SERIES

1ST Line of Lyman

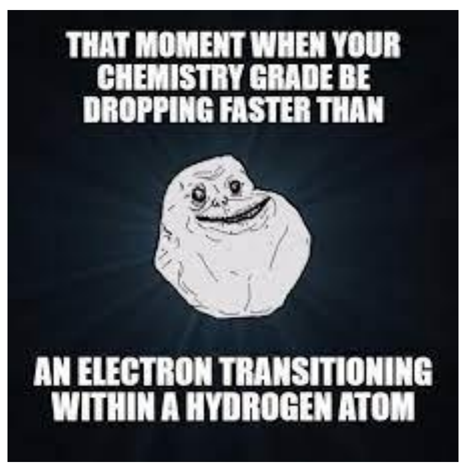
n = 2 to n = 1

$$\frac{1}{\lambda_{\text{1st line}}} = \mathrm{R}\left(\frac{1}{1} - \frac{1}{4}\right)$$

Series Limit

n = ∞ to n = 1

$$\frac{1}{\lambda_{\text{series limit}}} = \mathrm{R}\left(\frac{1}{1} - \frac{1}{\infty}\right)$$



BALMER SERIES

1ST Line of Balmer

n = 3 to n = 2

$$\frac{1}{\lambda_{\text{1st line}}} = R\left(\frac{1}{4} - \frac{1}{9}\right)$$

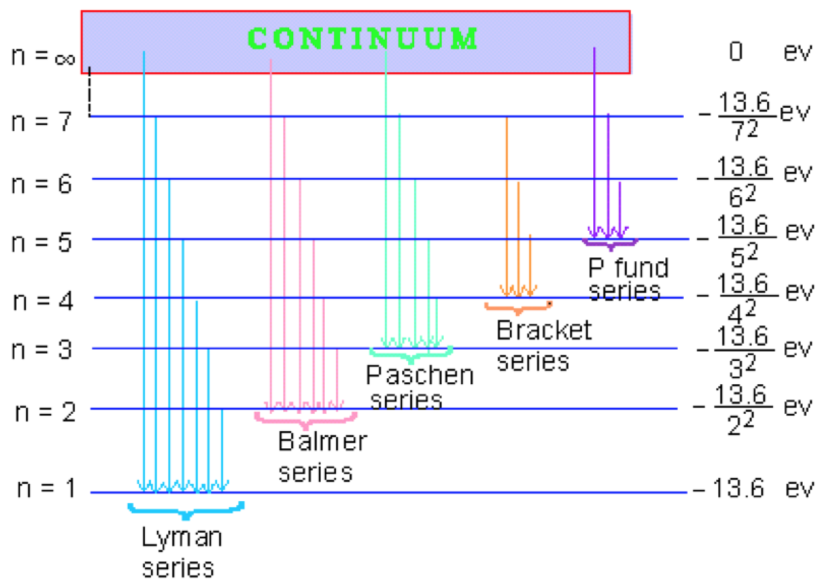
Series Limit

n = ∞ to n = 2

$$\frac{1}{\lambda_{\text{series limit}}} = R\left(\frac{1}{4} - \frac{1}{\infty}\right)$$

PASCHEN SERIES

1ST Line of Paschen



n = 4 to n = 3

$$\frac{1}{\lambda_{\text{1st line}}} = R\left(\frac{1}{9} - \frac{1}{16}\right)$$

Series Limit

n = ∞ to n = 3

$$\frac{1}{\lambda_{\text{series limit}}} = R\left(\frac{1}{9} - \frac{1}{\infty}\right)$$

BRACKETT SERIES

1ST Line of Brackett

n = 5 to n = 4

$$\frac{1}{\lambda_{\text{1st line}}} = R\left(\frac{1}{16} - \frac{1}{25}\right)$$

Series Limit

n = ∞ to n = 4

$$\frac{1}{\lambda_{\text{series limit}}} = R\left(\frac{1}{16} - \frac{1}{\infty}\right)$$

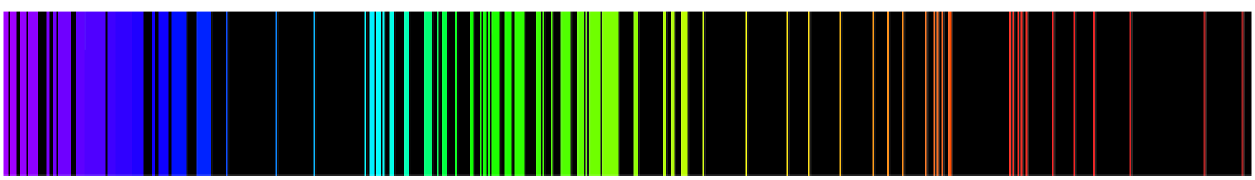
EMISSION SPECTRUM

The various lines in the atomic spectra are produced when electrons jump from higher energy state to a lower energy state and photons are emitted. These spectral lines are called **EMISSION LINES.**

When an atomic gas or vapour is excited at low pressure, usually by passing an electric current through it, the emitted radiation has a spectrum which contains certain specific wavelength only.

A spectrum of this kind is termed as emission line spectrum and it consists of bright lines on a dark background.

Study of emission line spectra of a material can therefore serve as a type of fingerprint for identification of the gas.

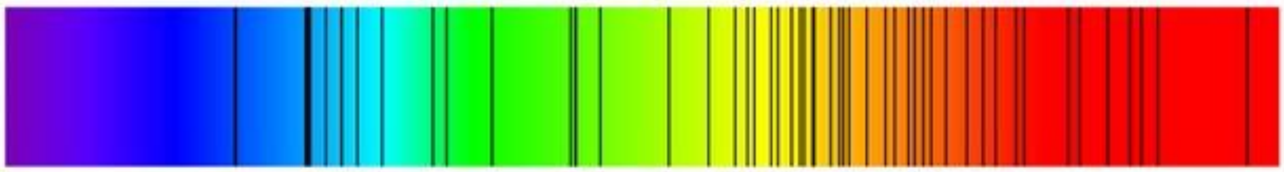


ABSORPTION SPECTRUM

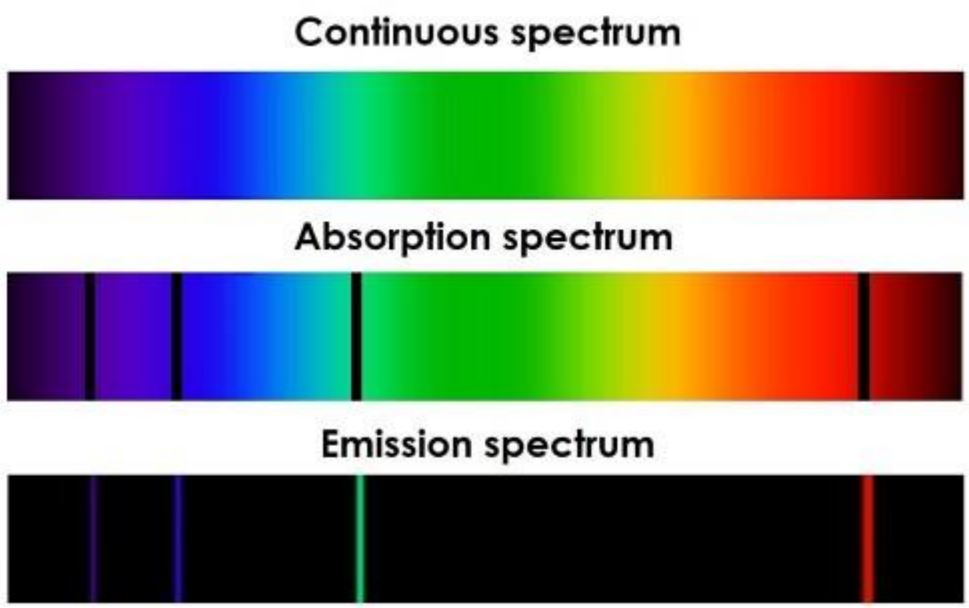
When an atom absorbs a photon that has precisey the same energy needed by the electron in a lower energy state to make transition to a higher energy state, the process is called **ABSORPTION**

If photons with a continous range of frequencies pass through a rarefied gas and then are analysed with a spectrometer, a series of dark spectral absorption lines appear in the continous spectrum. The dark lines indicate the frequencies that have been absorbed by the atoms of gas.

These absorbed wavelengths are named as absorption spectrum.



When you join absorption and emission spectrum you get continous spectrum.



Example : Using the Rydberg formula calculate the wavelength of the first four spectral lines in the lyman series of Hydrogen spectrum.

Solution : Try it yourself

BINDING ENERGY OF A STATE

Energy require to remove electron from a particlar quantum state is called BE of a that particular state.

e.g. BE of e^- of H-atom in n = 4 level is 0.85 eV

IONISATION ENERGY

The energy required to remove an electron from ground state of the atom is called its ionisation energy.

E.g Ionisation energy of H-atom = 13.6 eV

Ionisation energy of H-like atom = $(13.6)z^2$ eV

IONISATION POTENTIAL

The Potential difference through which an e^- must be accelerated to acquire this much energy (i.e. ionisation energy) is called Ionisation potential.

e.g. Ionisation Potential of H-atom = 13.6 volt

Ionisation potential = $\frac{Ionisation\ energy}{\mathrm{e}}$

EXCITATION ENERGY

The energy which must be provided the e^- of atom so that it may go to a higher energy level is called excitation energy of that particular excited state.

For equation for H-atom

Excitation energy of 1st excited state

$\Delta E_1 = E_2 - E_1$

$= (-3.4) - (-13.6)$

$= 10.2$ eV

Excitation energy of 2nd excited state

$\Delta E_2 = E_3 - E_1$

$= (-1.51) - (-13.6)$

$= 12.09$ eV

EXCITATION POTENTIAL

The Potential difference through which an e^- must be accelerated to acquire this much energy (i.e. excitation energy) is called excitation potential.

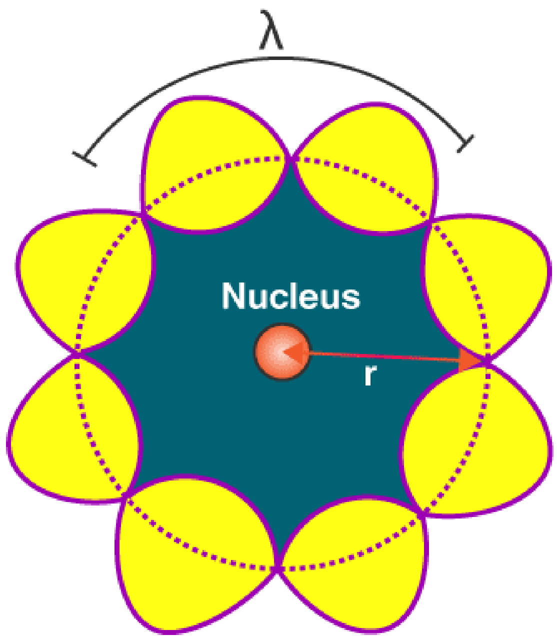
Excitation potential = $\frac{\text{Excitation } energy}{\text{e}}$

DE BROGLIE'S EXPLANATION OF BOHR'S SECOND POSTULATE OF QUANTISATION

An electron behaves as standing or stationary wave, which extends round the nucleuses in a circular orbit.

If the two ends of the electron wave meet to given a regular series of crests and troughs, the electron wave is said to be in phase

There is constructive interference of electron waves and the electron motion has a character of standing wave or non- energy radiation motion.



Quantization of Angular Momentum of Electron

Whatever be the path of the electron wave round the nucleus, it is necessary condition to get an electron wave in phase so that the circumference of the Bohr's orbit (= $2\pi r$) is equal to the whole number multiple to wavelength λ of electron wave

$2\pi r = n\lambda$ or $\lambda = \frac{2\pi r}{n}$

Now, according to de-Broglie

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

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

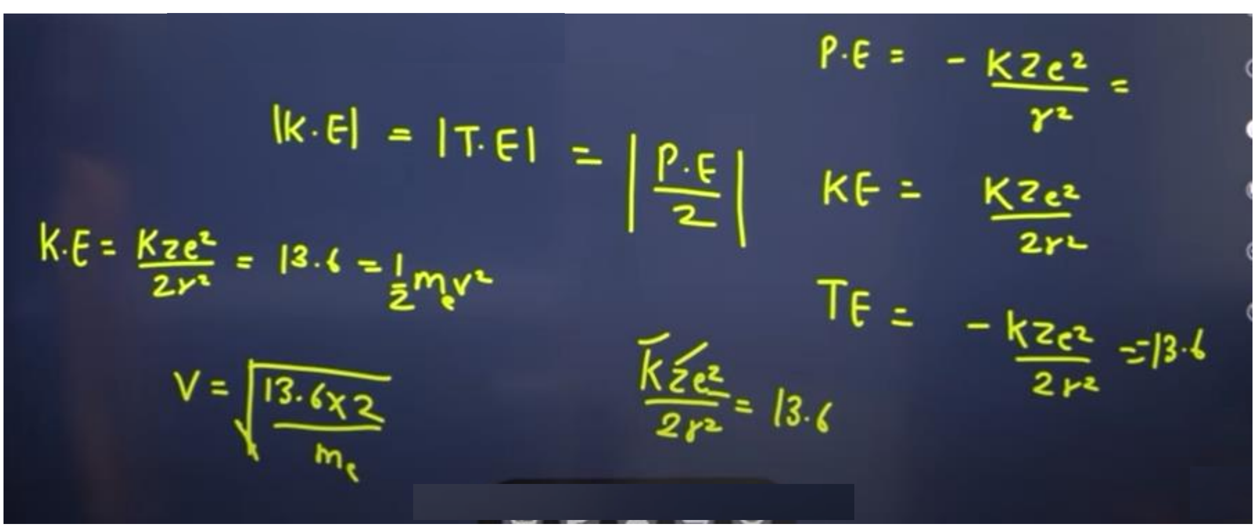
LIMITATION OF BOHR'S MODEL

The Bohr model is applicable to hydrogenic atoms. It cannot be extended even to mere electron atoms such as helium.

While the Bohr's model correctly predicts the frquencie of the light emitted by hydrogen atoms, the model is unable to explain the relative intensities of the frequencies in the spectrum. In emission spectrum of hydrogen, some of the visible frequencies have weak intensity, others strong.

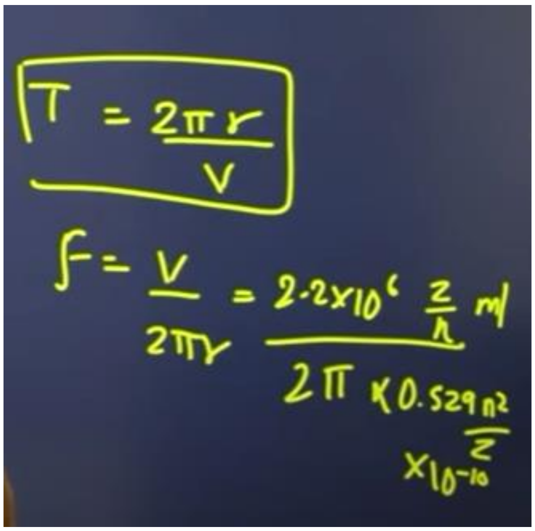
Example : It is found experimentally that 13.6 eV energy is required to separate a hydrogen atom into a proton and electron. Calculate the orbital radius and the velocity of the electron in a hydrogen atom.

Solution : |K.E.| = |T.E| = $\frac{|P.E|}{2}$



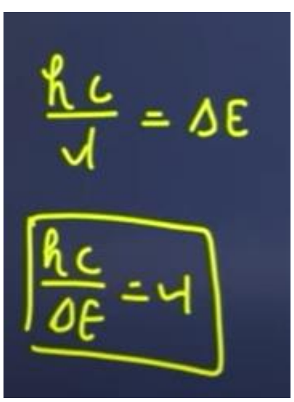
Example : According to the classiscal electromagnetic theory, calculate the initial frequency of the light emitted by the electron revolving around a proton in hydrogen atom.

Solution : $F = \frac{1}{T}$

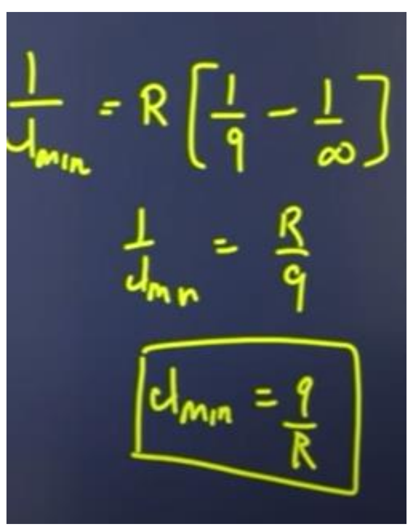


Example : What is the shortest wavelength present in the Paschen series of spectral lines?

Solution :



ΔE **is max for transition n = ∞ to n = 3**



This Chapter Ends here !! But not your work

Go to Practice Questions, Solve Dpps attend MCQs and revise the notes after some 2nd 4th and 7th day

To get 95+ you have to keep on revising what you studied.

[Remember Consistency and HardWork Gives Great Result]

NOTES MADE BY

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