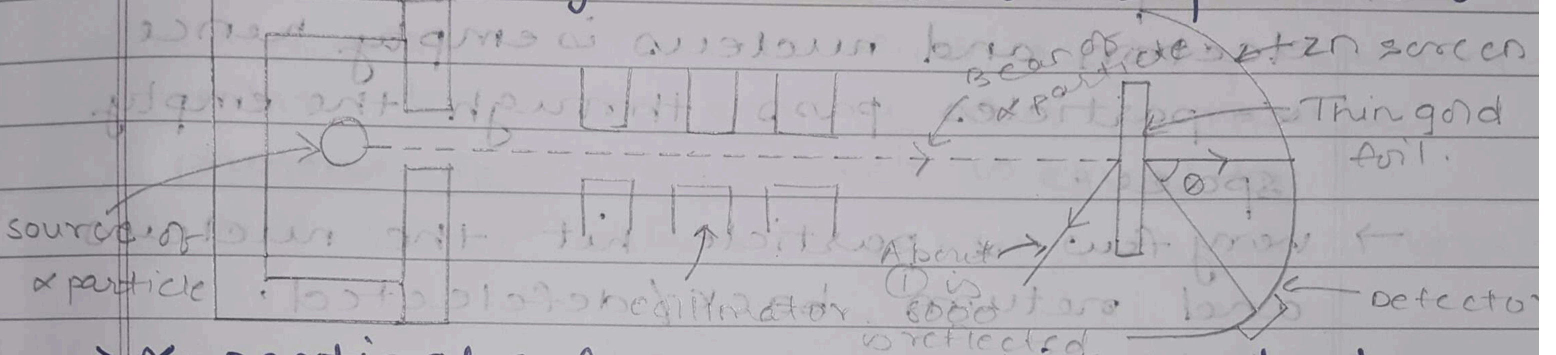
! Physics !

Structure of Atoms and Nuclei.

Q. Explain Thomson's atomic model.

According to this model an atom consist of positive charge sphere in which electrons are embaided. Atom is electrically neutral because it has equal +ve and -ve charge. It is also called as plum puding model.

Q. Describe Geiger- marsden's Experiment



→ α-particals from sources is made to fall on gold foil

→ They found that most of the α-particles passed through the foil and few were schattered by various angle.

→ only 0.14 % of α-particles were schattered more than 0.1°

→ About one particle out of 8000 were defeleted by more than 90°.

→ A few were deflected by an angle of 180°. This alpha particles are observed by microscope or detected which produced scintillation.

Q. Explain Rutherford's model of an atom or difficulties faced by Rutherford.

→ This model shows that entire positive charge and it's mass of an atom is concentrated in the nucleus

→ This electron revolves around the nucleus in circular orbit like a solar system.

→ The space between orbit of the electron and nucleus is empty hence α- particles pass through the empty space.

→ very few α-particle hit the nucleus and return back/defeleeted.

Limitations.

→ It could not explain stability of atom

→ It couldn't explain origin of atomic spectra (line septra).

Q. Postulates of Bohr's atomic model.

1st Postulate.

→ The electron revolves around the nucleus in circules orbit, which requires centripetal force which is provided by the electrostatic forces of attraction between electron and +ve charge nucleus.

centripetal Force = Electrostatic Force

CPF = ESF

$$\frac{m_e v^2}{r_n} = \frac{1}{4\pi\epsilon_0} \frac{Ze^2}{r_n^2}$$

2nd Postulate.

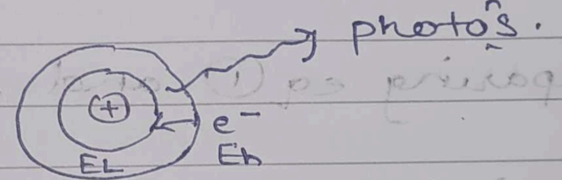
→ The radius of Bohr's orbit of an electron revolves around only in fixed orbit who's angular momentum is intergral multiple of $h/2\pi$

Angular momentum $(L_n) = \frac{nh}{2\pi}$.

where, h = plank constant.
n = princle quantum no.

3rd Prostulate.

→ when electrons jumps from higher to energy orbit to lower energy orbit. It radites photons of energy which is equal to difference between energy of two orbits.



$$E_H - E_L = h\nu$$

Q1 Derive an expression for radius of nth Bohr's orbit
show that radius of Bohr's orbit is proportional to square of principle of quantum no.

$$r \propto n^2.$$

1) According to Bohr's 2nd Postulate.

Angular momentum $(L) = \frac{h}{2\pi}$

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

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

squaring both sides.

$$v^2 = \frac{n^2h^2}{4\pi^2 m_e^2 r_n^2} \quad \text{--- (1)}$$

2) According to Bohr's I postulate.

CPF = ESF

$$\frac{m_e v^2}{\cancel{r_n}} = \frac{1}{4\pi\varepsilon_0} \frac{Ze^2}{r_n^{\cancel{2}}}$$

$$v^2 = \frac{Ze^2}{4\pi\varepsilon_0 m_e r_n} \quad \text{--- (2)}$$

comparing eq (1) and eq (2).

$$\frac{n^2h^2}{\cancel{4}\pi^{\cancel{2}} m_e^{\cancel{2}} r_n^{\cancel{2}}} = \frac{Ze^2}{\cancel{4\pi}\varepsilon_0 m_e \cancel{r_n}}$$

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

$$\varepsilon_0 h^2 n^2 = 2\pi m r e^2$$

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

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

where $\varepsilon_0, h, \pi, m, e$ = constant.

for hydrogen $Z=1$.

$$r_n = \left(\frac{\varepsilon_0 h^2}{\pi m e^2}\right) \times n^2.$$

$$r_n \propto n^2.$$

Hence; Radius of Bohr orbit is directly proportional to square of principle quantum no.

D2 Derive an expression for velocity of an electron in nth Bohr's orbit.

show that velocity of electron in an orbit is inversely proportional to principle quantum no.

$$V \propto \frac{1}{n}$$

1) According to Bohr's 2nd postulate.

$$\text{Angular momentum} = \frac{nh}{2\pi}.$$

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

$$v = \frac{nh}{2\pi m_e r_n}. \quad \text{--- (1)}$$

But, $r_n = \dfrac{\varepsilon_0 h^2 n^2}{Z\pi m_e e^2}.$

put in eq^n (1).

$$v = \frac{nh}{2\pi m_e}\left(\frac{\varepsilon_0 h^2 n^2}{2\pi m_e e^2}\right)$$

$$v = \frac{\cancel{n}\cancel{h}}{\cancel{2\pi}\cancel{m_e}} \cdot \frac{\cancel{2\pi}\cancel{m_e} e^2}{\varepsilon_0 h^{\cancel{2}} n^{\cancel{2}}}$$

$$v = \frac{Ze^2}{2\varepsilon_0 hn}$$

$$v = \left(\frac{Ze^2}{2\varepsilon_0 h}\right) \times \frac{1}{n}$$

where, e, ε_0, h = constant
for hydrogen at $Z = 1$:

$$v = \frac{e^2}{2\varepsilon_0 h} \times \frac{1}{n}.$$

$$v \propto \frac{1}{n}$$

Hence velocity of electron is inversely proportional to the principle quantum number.

Q3 show that maximum angular speed of an electron is inversely prop. to cube root of principle quantum no

$$\omega \propto \frac{1}{n^3}$$

$$\text{Angular momentum} = \frac{nh}{2\pi}$$

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

$$v = \frac{nh}{2\pi m_e r_n} \quad \text{--- (1)}$$

i) Acc. to Bohr's 1st postulate.

$$CPF = EST$$

$$\frac{m_e v^2}{r_n} = \frac{1}{4\pi\varepsilon_0} \frac{ze^2}{r_n^2}$$

$$v^2 = \frac{ze^2 \cancel{r_n}}{4\pi\varepsilon_0 m_e \cancel{r_n}}$$

$$v^2 = \frac{ze^2}{4\pi\varepsilon_0 m_e r_n} \quad \text{--- (2)}$$

÷ eqn (2) by eqn (1)

$$\frac{v^2}{v} = \frac{\frac{ze^2}{4\pi\varepsilon_0 m_e r_n}}{\frac{nh}{2\pi m_e r_n}}$$

$$\frac{v}{1} = \frac{ze^2}{\cancel{4\pi}_2 \varepsilon_0 \cancel{m_e r_n}} \times \frac{\cancel{2\pi m_e r_n}}{nh}$$

$$v = \frac{ze^2}{2\varepsilon_0 hn} \quad \text{--- (3)}$$

where ε_0, e, h = constant.
for hydrogen $z=1$.

$$V = \frac{ze^2}{2\varepsilon_0 h} \times \frac{1}{n}$$

$$V \propto \frac{1}{n} \text{ — speed}$$

But $V = \omega \times r$

$$\omega = \frac{V}{r} = \frac{\frac{ze^2}{2\varepsilon_0 hn}}{\frac{\varepsilon_0 h^2 n^2}{2\pi me^2}}$$

$$\omega = \frac{z^2 \pi me^4}{2\varepsilon_0^2 h^3 n^3}$$

where π, m, e, ε_0 = constant
hydrogen $z=1$.

$$\omega = \left(\frac{\pi me^4}{2\varepsilon_0 eh^3}\right) \frac{1}{n^3}.$$

$$\omega \propto \frac{1}{n^3}$$

Hence angular speed of the electron is inversely proportional to principle quantum no.

D4 Derive an expression for energy of an electron in the atom.
What is binding energy? Derive the expression for energy in the electron.

→ Binding energy: The maximum energy required to make electron ~~force~~ free from nucleus in called Binding Energy.

$$BE = -(T.E)$$
$$= (K.E + PE).$$

1) According to Bohr's 1st postulate.

$$CPF = ESF$$

$$\frac{mv^2}{r_n} = \frac{1}{4\pi\varepsilon_0} \frac{ze^2}{r^2 n}.$$

$$mv^2 = 1/4\pi\varepsilon_0 \quad ze^2/rn.$$

x mply both side by 1/2.

$$\frac{1}{2} mv^2 = \frac{1}{4\pi\varepsilon_0} \frac{ze^2}{rn} \times \frac{1}{2}$$

$$(K.E) = \frac{ze^2}{8\pi\varepsilon_0 r_n}.$$

Finding P.E.

P.E of e⁻ -ve charge no e⁻ × electron potential.

$$= P.E = -ze \times \left(\frac{1}{4}\pi\varepsilon_0 \times \frac{e}{m}\right)$$

$$P.E = -\frac{ze^2}{4\pi\varepsilon_0 r_n}$$

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multiple and ÷ Nr and Dr by 2.

$$P.E = \frac{-ze^2}{4\pi\varepsilon_0 r_n} \times \frac{2}{2}$$

$$P.E = \frac{-2ze^2}{8\pi\varepsilon_0 r_n} \quad (2)$$

Total Energy = K.E + P.E

$$TE\ (E_n) = \frac{ze^2}{8\pi\varepsilon_0 r_n} + \frac{-2ze^2}{8\pi\varepsilon_0 r_n}$$

$$(E_n) = \frac{ze^2}{8\pi\varepsilon_0 r_n} - \frac{2ze^2}{8\varepsilon_0 r_n}$$

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

But $r_n = \frac{\varepsilon_0 h^2 n^2}{z\pi me^2}$

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

$$E = \frac{-ze^2}{8\cancel{\pi}\varepsilon_0} \times \frac{z\cancel{\pi} m_e e^2}{\varepsilon_0 h^2 n^2}$$

$$E = \frac{-z^2 me^4}{8\varepsilon_0^2 h^2 n^2}$$ — Formula for energy.

where ε_0, h, m, e = constant.

$z = 1$ for hydrogen.

$$E_n = \left(\frac{-me^4}{8\,\varepsilon_0^2 h^2}\right) \times \frac{1}{n^2}.$$

$$E_n \propto \frac{1}{n^2}.$$

Here, hence energy of orbit can be obtain by.

$$E_n^2 = -\left(\frac{13.6}{n^2}\right) ev$$

D5 Derive an expression for wavelength of e^-.

Derive a formula for wavelength of lymn and Balmer series of spectral

we know that,

energy of e^- is,

$$E = -\frac{z^2 e^4 me}{8\,\varepsilon_0^2 h^2 n^2}.$$

For mth orbit [Higher orbit].

$$E_m = -\frac{z^2 e^4 me}{8\,\varepsilon_0^2 h^2 m^2}$$

For nth orbit [Lower orbit]

$$E_n = -\frac{z^2 e^4 me}{8\,\varepsilon_0^2 h^2 m^2}$$

According to Bohr's 3rd postulate.

$$\text{Energy} = E_m - E_n.$$

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

$$h\nu = \frac{-z^2 e^4 me}{8\,\varepsilon_0^2 h^2 m^2} + \frac{z^2 e^2 me}{8\,\varepsilon_0^2 h^2 n^2}.$$

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

$$h\nu = \frac{Z^2 e^4 m_e}{8 \varepsilon_0^2 h^2} \left[\frac{1}{n^2} - \frac{1}{m^2}\right]$$

For hydrogen atom $Z = 1$.

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

$$\frac{hc}{\lambda} = \frac{Z^2 e^4 m_e}{8 \varepsilon_0^2 h^2} \left(\frac{1}{n^2} - \frac{1}{m^2}\right)$$

$$\frac{1}{\lambda} = \frac{Z^2 e^4 m_e}{8 \varepsilon_0^2 h^3 c} \left(\frac{1}{n^2} - \frac{1}{m^2}\right)$$

where

$$\frac{e^4 m_e}{8 \varepsilon_0^2 h^3 c} = R_H \text{ [Rydberg constant]}$$

$$\frac{1}{\lambda} = R \left[\frac{1}{n^2} - \frac{1}{m^2}\right]$$

Define.

1) Nucleons: Protons and neutrons together are called as Nucleons.
2) Atomic number: The number of protons ~~and neutron~~ or electrons in an atom is called Atomic no.
3) Atomic mass No.: The total number of ~~protons~~ nucleons in a nucleus is called the atomic mass number.
4) Isotopes: Atoms having the same number of protons but different no. of neutrons are called Isotopes.
5) Isobars: Atoms having same atomic mass number are called Isobar.
6) Isotones: Atoms having same no. of neutrons but different value of atomic numbers are called Isotones.
7) symbolic form of element: An atom is represented as $_{Z}^{A}X$ where A is atomic mass number and Z is atomic no.
8) unified atomic mass unit: one u is equal to $1/12^{th}$ of the mass of a neutral carbon atom having atomic number 12.

Q what is nuclear force. write its properties.
→ It the force between nucleons.
→ It is a attractive force.
→ It keeps nucleons together and stable.

Properties:
→ It is a strong force.
→ It is independent of charge of the nucleons.

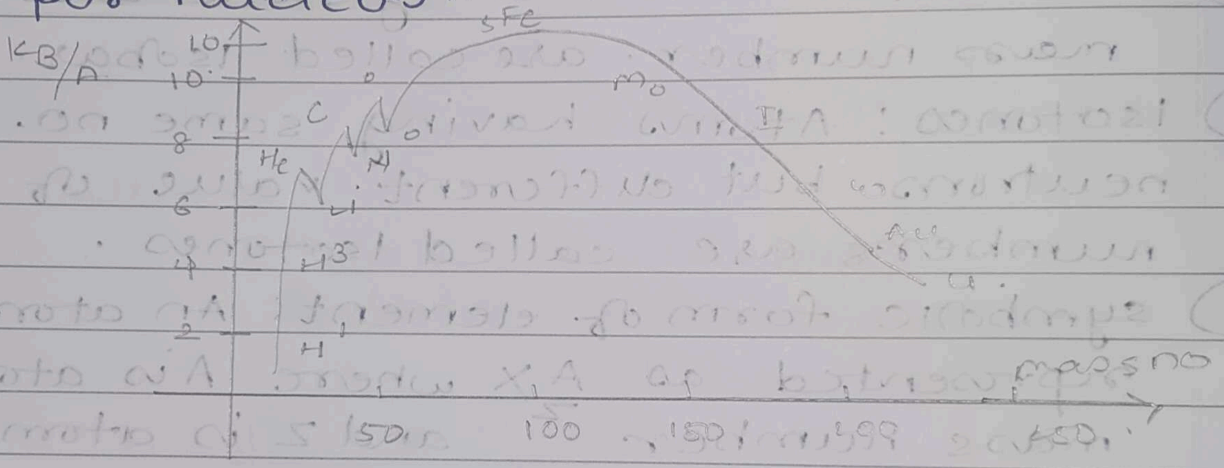
Q. What is mass defect.

→ The difference between total ~~mass~~ mass of neucleons and the actual mass of nucleons is called mass defect.

Formula = $\Delta m = [zmp + Nmn] - M$

Δm — mass defect; $[zmp + Nmn]$ — Total mass of nucleon.

Q. What is Binding energy per nuclons. Draw the plot of Binding energy per nucleus.



Binding energy per nucleon is the average energy which has to be supplied to nucleons to remove it form the neuclus make it free.

→ From the graph Duterium has minimum valve of EB/A. It is least stable.

→ Iron has maximum peak value that is captital A = 56 hence, it is most stable nuclei.

Define.

1) Parent Nucleus: unstable nucleus undergoes radioactive decay is called Parent nucleus.

2) Daughter Nucleus: Stable nucleus formed after the radioactive decay is called Daughter nucleus.

Q. What is Radioactive decay?

→ It is the change that occurs in parent nucleus which are unstable and get converted into most stable daughter nucleus by emitting of some particles is called Radioactive decay.

Radioactive decay is classified into 3 types.

α - decay.	β - decay	γ - decay
In this type of decay, the parent nucleus emits an alpha particles.	In this type of decay, the parent nucleus emits an beta particles.	In this ~~deca~~ type of decay gamma rays are emitted by the parent nucleus.

Q6 Derive an expression for radioactive decay law.

→ This law states that rate of disintegration is derectly proportional to number of radioactive nuclei present at that instant of time.

$$\frac{dN}{dt} \propto N.$$

$$\frac{dN}{dt} = -\lambda N.$$

$$\frac{dN}{N} = -\lambda dt \quad \text{--- (1)}$$

where, λ = decay constant or disintergation constant.

-ve sign indicates decrease in no. of nuclei.

Integrates eq (1).

$$\int \frac{dN}{N} = \int -\lambda dt$$

$$\int \frac{1}{N} dN = -\lambda \int dt$$

$$\log_e N = -\lambda t + C \quad \text{--- (2)}$$

Here, C = Integration constant.

At intitial condition.

$$t = 0 \qquad N = N_0$$

$$\therefore \log_e N_0 = -\lambda \times 0 + C$$

$$C = \log_e N_0.$$

$$\therefore \log_e N = -\lambda t + \log_e N_0.$$

$$\log_e N - \log_e N_0 = -\lambda t$$

$$\log_e \frac{N}{N_0} = -\lambda t.$$

In exponential form,

$$\frac{N}{N_0} = e^{-\lambda t}.$$

$$N = N_0 e^{-\lambda t}.$$