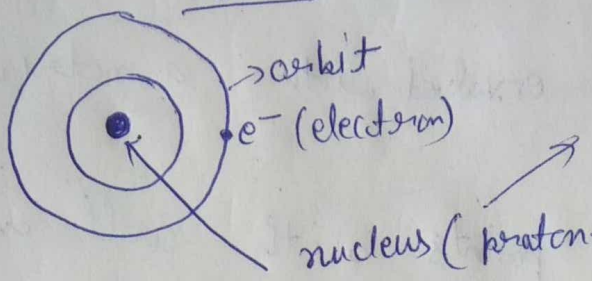
Lecture

Atom



discover by Rutherford α-particle exp.

nucleus contains positive charge (i.e. fundamental unit charge.

electron → -1.6×10^{-19} Coulomb

proton → $+1.6 \times 10^{-19}$ coulomb

Neutron → no charge

In Atom, no. of protons = no. of electrons

∴ Total charge any atom = 0

So atom is neutral.

Charge quantization:-

All electric charges come in integer multiples of a fundamental unit charge unit

i.e. $\boxed{Q = n|e|}$; $n = 0, \pm 1, \pm 2$

$|e| = 1.6 \times 10^{-19}$

Electron $n = -1$, ie. $q_e = -1.6 \times 10^{-19}$ C

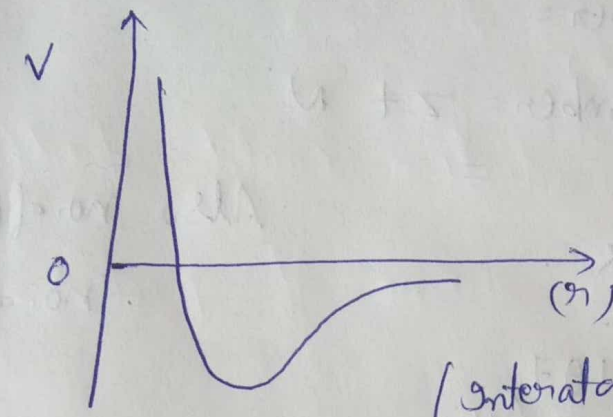
proton $n = +1$ i.e. $q_p = +1.6 \times 10^{-19}$ C

neutron $n = 0$ i.e. $q_n = 0$ C

Nucleus : $n = 2 = 1, 2, 3$

Note:- there is not fractional electric charge i.e. $\frac{1}{3}e$, $\frac{2}{3}e$, $\frac{1}{2}e$ not possible.

Neutrality of atoms:-

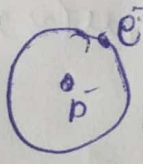


(interatomic potential)

∵ In atom,

no. of positive charge = no. of negative charge

$$\therefore \boxed{\Sigma(q) = 0} \Rightarrow \text{atom neutrality}$$



Hydrogen atom

$1e + 1p + 0n$

$\Sigma q = +1.6\times10^{-19}C - 1.6\times10^{-19} + 0$

$$\boxed{\Sigma q = 0}$$

There are some basic questions related to atomic nucleus:-

1. where does the extra mass come from?
2. what holds the proton together?
3. what are the constituents of a nucleus?

Z → atomic number = no. of protons

N → neutron number =

A → mass number = Z + N

=

Also no. of protons = no. of electrons

Notation = $^{A}_{Z}X$

For Gold $^{197}_{79}Au$

79 → proton , mass no = 197

79 → electron, ∴ N = 197 − 79

neutron = 118

Isotopes:-

atomic number is same but atomic mass (≈ mass no.) is not same.

e.g. **Carbon:-** $^{12}_{6}C$, $^{13}_{6}C$, $^{14}_{6}C$.

Hydrogen $^{1}_{1}H$, $^{2}_{1}H$, $^{3}_{1}H$

Experiment of chadwick:- (discovery of neutron):

It is seen that the nuclei of atoms contain, in addition to protons, neutral matter in multiples of a basic unit.

In 1932 , James chadwick observed emission of neutral ~~atoms~~ radiation when beryllium nuclei were bombarded with α-particles.

118

→ natural radiations consists of photons.

~~The only~~

Thus from conservation of energy and momentum, he was able to determine the mass of new particle, as very nearly the same of proton.)

$$m_n = 1.008664\,u = 1.67499 \times 10^{-27}\ kg$$

$$m_p = 1.007274\,u = 1.67262 \times 10^{-27}\ kg$$

$$m_e = 0.000554$$

$$1u = \frac{\text{mass of one } {}^{12}C \text{ atom}}{12}$$

$$= \frac{1.992647 \times 10^{-26}\ kg}{12}$$

$$1u = 1.660539 \times 10^{-27}\ kg$$

Note: (mass number > atomic mass)

elastic scattering:- Total Kinetic energy will be conserved + total momentum will be conserved. (i.e. α-particle experiment)

Inelastic scatting:- Total Kinetic energy will not be conserved +

total momentum conserved.

e.g. (Frank-Hertz experiment)

Experimental results of chadwick:-

(i) The bombarded gave rise to two kinds of species:

(i) proton and neutral radiation.

(ii) Neutral particles had great penetrating power (greater than x-rays)

(iii) The neutral radiation could further eject electrons from a no. of protons.

→ (neutron discovery)

Note:- Compton scatting is elastic scattering between photons & electrons.

~~Size of the Nucleus:-~~

Isobars:- Two nuclides with same A are called isobars.

e.g. $^{40}_{20}Ca$, $^{40}_{18}Ar$

Isotopes:- Two nuclides with the same A-Z are called isotopes.

e.g. $^{4}_{2}He$, $^{3}_{1}H$ etc.

both have 2 neutrons,

Size of the nucleus:—

$$r_{nucleus} \approx 10^{-19} \sim 10^{-15} \text{ m}$$

It has been found that a nucleus of mass number A has a radius—

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

$$R_0 \sim 1.2 \times 10^{-15} \text{ m}$$

$$M = M_0 A$$

$$V = V_0 A$$

Note → Nuclear density does not depends on atomic mass.

Mass - energy equivalance relation:—

$$E = mc^2$$

i.e. mass can be converted into energy.

speed of light → $c = 3 \times 10^8$ m/s—

Some properties:— (at highd speed ~ c)

① No material particles can move with a speed $v \geq c$.

(ii) therfor, $p \neq mv$, $E \neq \frac{1}{2}mv^2$

(iii) Inertia depends on the speed.

Newtonian case:— ($v << c$)

$$p = mv, \quad E = \frac{1}{2}mv^2$$

Einstein Case:—

$(v \approx c)$

then $m(v) = m_0 \dfrac{1}{\sqrt{(1 - v^2/c^2)}}$

m_0 ↓ rest mass

$$E = m(v)c^2$$

$$E^2 = p^2c^2 + m_0^2c^4$$

$$E(v) = \frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}}$$