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- What is Electronics:

Electronics → Electron and Mechanics.

→ Study of the motion (or behaviour) of electron under the influence of various applied electric field.

- What is Electronics Engineering:

That branch of science and engineering which deals with the study of electronic devices and their utilization.

- What is Electronic Devices:

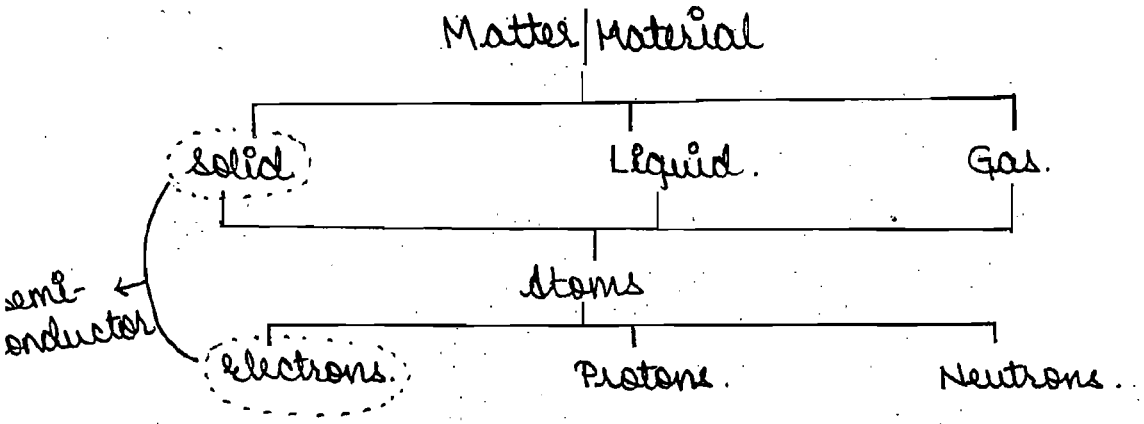
→ A device in which conduction takes place by the movement of electrons through vacuum, gas (air) or semiconductors.

→ In simple words we can say that, the device which controls the flow of electrons is known as electronic devices.

→ Table of content:

1. Semiconductor Physics.
2. Junctions.
3. Optoelectronic devices.
4. Bipolar Junction Transistor.
5. Field effect devices.
   - MOS capacitor.
   - MOSFET.
   - JFET.

Chapter → 1 : Semiconductor Physics



- Atomic Theories :

1. Dalton's Atomic theory :

Atom → Greek word → a- tomic.
↳ Non-divisible.

tom - cut
a- Not.

→ Everything is made up of some tiny indivisible structures known atom.

→ Atoms can neither be created nor destroyed.

→ Atoms of a particular element are identical in all respects including their physical and chemical properties but atoms of different element will differ in their properties.

→ Compounds are formed when atoms combine in definite ratio (fixed ratio).

eg: NaCl (1:1) $CaCl_2$ (1:2)

*/ Isotopes → same atomic no. but different atomic mass.

*/ Isobar → same atomic mass no. but different atomic no.

Eg: Isotopes: - $_1H^1$, $_1H^2$, $_1H^3$.

Isobars: $_{20}Ca^{40}$, $_{18}Ar^{40}$.

→ Dalton's theory failed as it failed to explain the existence of isotopes and isobars. (∵ he didn't know about sub-atomic particles)

Subatomic Particles

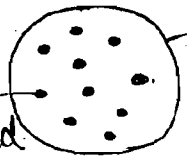
Electron	Proton	Neutron
→ Negatively charged particle.	→ Positively charged particle.	→ Neutral particle.
→ charge = -1.6×10^{-19} C.	→ charge = $+1.6 \times 10^{-19}$ C.	→ charge = 0
→ Mass = m_0 = 9.1×10^{-31} kg. (rest mass)	→ Mass = 1.672×10^{-27} kg.	→ Mass = 1.674×10^{-27} kg.

Magnitude of electronic charge = $q = 1.6 \times 10^{-19}$ C.

charge of electron = $-q$.

charge of proton = $+q$.

2. Thomson's atomic Model:



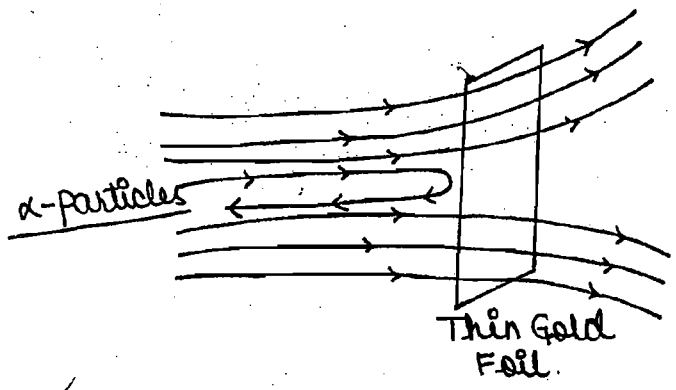
→ Positively charged sphere.

↓

Positive charge is uniformly distributed throughout atom.

Negatively charged electrons are embedded in such a number so that overall atom is electrically Neutral.

5. Rutherford's Nuclear Model of atom:



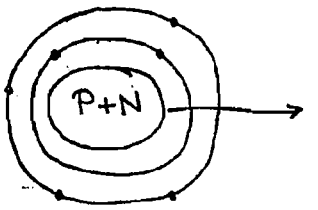
$y = fn(x)$

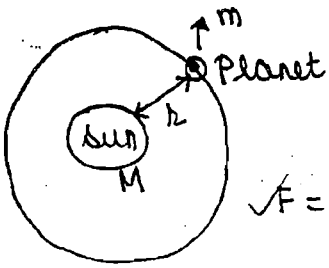
science = fn[Nature]

(dependent variable) (Independent variable)

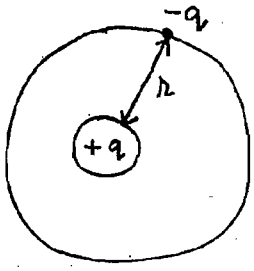
α-Particle:
2 Proton + 2 Neutron.
→ Mass = 4amu.
→ Charge = +2q.

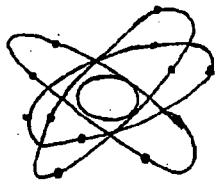
"Physics is the study of Nature."
— Dr. H.C. Verma.





$F = \frac{GMm}{r^2}$





$F = \frac{1}{4\pi\epsilon_0} \cdot \frac{(-q)(+q)}{r^2}$

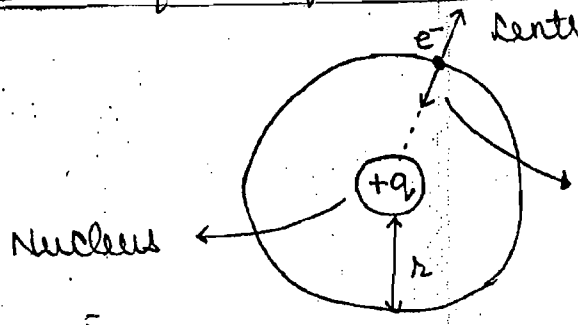
Coulombic force.
'OR'
Electrostatic force.

→ On the basis of α-particle scattering experiment, Rutherford proposed nuclear model of atom:

1. The +ve charge and most of the mass of atom is densely concentrated into a small region which is known as nucleus.
2. The nucleus is surrounded by electrons which moves around the nucleus in circular orbits as

the planets move around the sun. This model of atom resembles with solar system where ~~nucleus~~ nucleus plays the role of sun and electrons that of planets.

3. Electrons and nucleus are held together by <u>electrostatic force of attraction</u>.



Centrifugal force $= \frac{mv^2}{r}$;

m = mass of electron.

v = linear velocity of electron.

Centripetal force ↓ Electrostatic force of attraction.

→ As electron is not falling into the nucleus, so ~~not~~ net force on the electron in radial direction should be equal to zero.

i.e., centripetal force + centrifugal force = 0.

$$\Rightarrow -\frac{1}{4\pi\epsilon_0}\frac{q^2}{r^2} + \frac{mv^2}{r} = 0.$$

$$\Rightarrow \frac{mv^2}{r} = \frac{1}{4\pi\epsilon_0}\frac{q^2}{r^2}$$

$$\Rightarrow \boxed{mv^2 = \frac{1}{4\pi\epsilon_0}\cdot\frac{q^2}{r}} \quad \text{—(1).}$$

* +q ←— r —→ q

$$F_q = \frac{1}{4\pi\epsilon_0}\frac{(+q)(-q)}{r^2}$$

$$F_q = -\frac{1}{4\pi\epsilon_0}\cdot\frac{q^2}{r^2}$$

Now, let us calculate total energy of electron,

E = Kinetic energy + <u>Electrical Potential Energy</u>.

* (+q) ←— r —→ Potential $= \frac{1}{4\pi\epsilon_0}\frac{+q}{r}$.

Potential energy of electron

= (charge of electron) × (Potential at that point)

$$= (-q) \times \frac{1}{4\pi\epsilon_0} \times \frac{(+q)}{r} = \frac{-q^2}{4\pi\epsilon_0 r}.$$

So we know,

$$E = \frac{1}{2}mv^2 + \left(\frac{-q^2}{4\pi\epsilon_0 r}\right)$$

using equation (1),

$$E = \frac{1}{2}\cdot\frac{q^2}{4\pi\epsilon_0 r} - \frac{q^2}{4\pi\epsilon_0 r}$$

$$E = \frac{q^2}{4\pi\epsilon_0 r}\cdot\left[\frac{1}{2} - 1\right]$$

$$\boxed{E = \frac{-q^2}{8\pi\epsilon_0 r}} \rightarrow \text{Total energy of electron.}$$

$E \propto \frac{1}{r}$

$5 > 3$

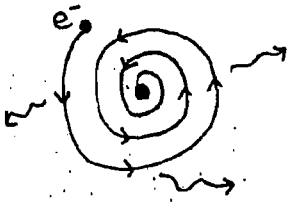
$-5 < -3$

→ Total energy of electron increases with increase in radius.

'OR'

The greater the distance of an electron from nucleus, higher is the it's total energy.

→ According to Maxwell's theory, a charged particle under acceleration must emit radiation.



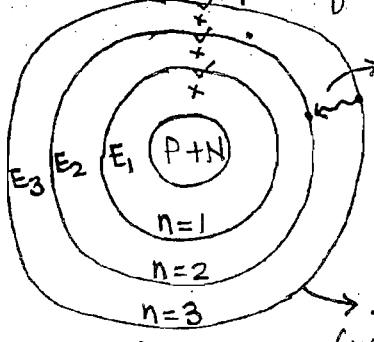
10 n sec

planets are neutral bodies.

→ Rutherford's model failed as it could not satisfy/explain Maxwell's theory.

4. Bohr's model for Hydrogen atom:

→ Bohr's model is based upon following postulates:



radiation = $\Delta E = E_3 - E_2$

(state)
(Energy state / e⁻ state)
Allowed energy state.

orbits → stationary states.
(when e⁻ is moving in these orbits then it's energy doesn't change with time)

It doesn't emits radiation.

1. The electron in Hydrogen atom can move around the nucleus in circular orbits / paths of fixed radius. These circular paths are known as orbits.

2. The electron can move only in those orbits for which it's angular momentum is an integral multiple of '$\frac{h}{2\pi}$'. (where, 'h' is planck's constant.)

Linear Momentum = mv.

Angular Momentum = (Moment of inertia) × (Angular velocity)

$= mr^2 \times \omega$

$= mr^2 \times \frac{v}{r}$

$= mvr$.

i.e., $\boxed{mvr = \frac{nh}{2\pi}}$, $n = 1, 2, 3, 4, \ldots$

3. The energy of an electron in the orbit doesnot change. But whenever an electron makes a transition from high energy state to low energy state then, energy is released in the form of radiations. Similarly when an electron makes a transition from low energy state to higher energy state then absorption of energy takes place.

The frequency of radiation (emission 'or' of absorption) is given as:

$$\nu = \frac{\Delta E}{h} = \frac{E_3 - E_2}{h}$$

ΔE = difference of energy b/w two orbits.

ν = frequency. (Hz).

h = Planck's constant

we have,

$$mvr = \frac{nh}{2\pi} \quad , \; n = 1, 2, 3, \ldots$$

$$\Rightarrow mv = \frac{nh}{2\pi r} \quad \text{—(1)}.$$

also,

$$\frac{mv^2}{r} = \frac{q^2}{4\pi\epsilon_0 r^2} \quad \text{—(2)}.$$

$$\Rightarrow mv^2 = \frac{q^2}{4\pi\epsilon_0 r} \Rightarrow r = \frac{q^2}{4\pi\epsilon_0 \cdot mv^2} \times \frac{m}{m}$$

$$\Rightarrow r = \frac{mq^2}{4\pi\epsilon_0 \cdot (mv)^2}$$

by eqn (1),

$$r = \frac{mq^2}{4\pi\epsilon_0} \cdot \frac{4\pi^2 r^2}{n^2 h^2}$$

$$r = \frac{\pi m q^2 r^2}{\epsilon_0 n^2 h^2} \Rightarrow \boxed{r = \frac{\epsilon_0 h^2}{\pi m q^2} \cdot n^2}$$

From above relation, 'r' is function of 'n'. Hence, electrons can occupy only certain fixed positions. Hence, above relation can be written as,

$$r = r_n$$

$$\boxed{r_n = \frac{\epsilon_0 h^2}{\pi m q^2} \cdot n^2} \rightarrow \text{Bohr's orbital radius.}$$

ϵ_0 = Permittivity of free space.

$\epsilon_0 = 8.854 \times 10^{-12}$ F/m.

$m = 9.1 \times 10^{-31}$ kg.

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

$q = 1.6 \times 10^{-19}$ C.

$r_n = 0.529 \times 10^{-10} n^2$.

$$\boxed{r_n = 0.529 n^2 \text{ Å}}$$