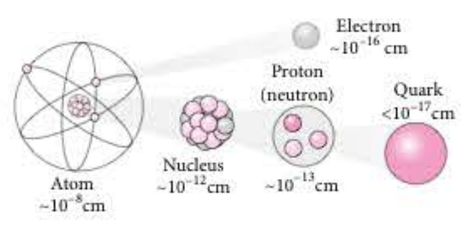
CONCEPT

MAP

STRUCTURE OF ATOM

Niels Henrik David Bohr (Niels Bohr), a Danish physicist who is generally regarded as one of the foremost physicists of the 20th century. He was the first to apply the quantum concept, to the problem of atomic and molecular structure. For that work he received the Nobel Prize in Physics in 1922. His manifold roles in the origins and development of quantum physics is his most important contribution.

FUNDAMENTAL PARTICLES



QUANTUM NUMBERS

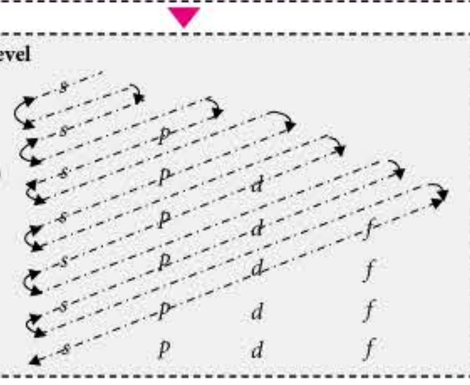
A set of four members which helps to determine the complete information about all the e^- in an atom.

Symbol	Quantum Numbers	Values	Role	
n	Principal	1, 2, 3,.....	Determines the energy (size).	
l	Angular	0, 1, 2, ... $n-1$	Special distribution of electron cloud and angular momentum.	
m_l	Magnetic	0, ±1, ±2, ... ±l	Determines the orientation in space.	
m_s	Spin	±1/2	Describes the electron spin (magnetic moment).	
l	0	1	2	3
Sub-shell	s	p	d	f
Orbital present	1	3	5	7

Rules for Assigning Electrons

- **Aufbau principle :** e^- occupy lowest energy orbital available.
- **Pauli exclusion principle :** Maximum 2 electrons per orbital must have opposite spins.
- **Hund's rule :** If two or more orbitals of equal energy are available, electrons will occupy them singly before filling in pairs.

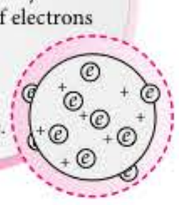
Energy Level



ATOMIC MODELS

Thomson's Model (1904)

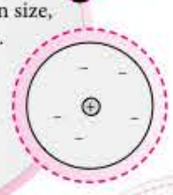
- Plum pudding model
- An atom was a sphere of positive electricity in which number of electrons were embedded, sufficient to neutralize the positive charge.



Rutherford's Model (1911)

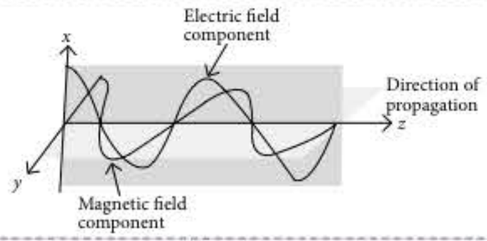
The atom consists of two parts :

- **Nucleus :** Very small in size, carries positive charge.
- **Extra-nuclear part, *i.e.*, orbit :** Space around the nucleus in which electrons were distributed.

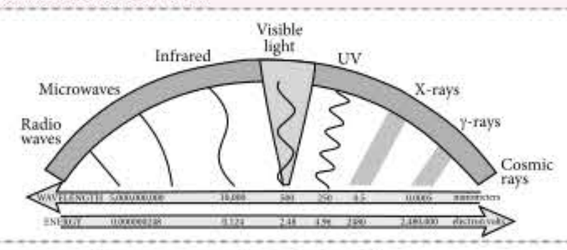


Electromagnetic Wave Theory

- James Maxwell (1870) suggested that when electrically charged particles move under acceleration, alternating electrical and magnetic fields are produced and transmitted. These fields are transmitted in the forms of waves, called electromagnetic waves or electromagnetic radiations.



- **Electromagnetic Spectrum :** The electromagnetic spectrum is a continuum of all electromagnetic waves arranged according to frequency and wavelength.
  Cosmic rays < γ-rays < X-rays < Ultra-violet rays < Visible < Infrared < Micro waves < Radio waves

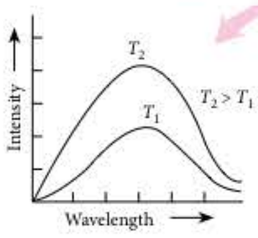


Particle Nature of Electromagnetic Radiations

- **Planck's Quantum Theory :** A body can emit or absorb energy only in terms of integral multiple of a quantum/photon.
  $E = nhv$;
  where, $n = 1, 2, 3,....$

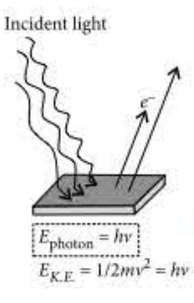
Black Body Radiation

If the substance being heated is a black body (which can emit and absorb all frequencies), the radiation emitted is called black body radiation.



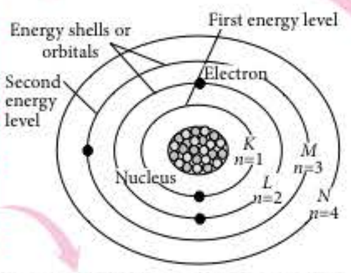
Photoelectric Effect

When radiations with frequency greater than a certain minimum frequency (v_0) strike the surface of a metal, the electrons are ejected from the surface of the metal. This phenomenon is called photoelectric effect.



Bohr's Model

- An atom consist of a small heavy positively charged nucleus.
- The electrons revolve only in those orbits which have a fixed value of energy.



- **For hydrogen like atoms :**

$$E_n = \frac{-1312\,Z^2}{n^2}\ \text{kJ mol}^{-1} = -13.6\,\frac{Z^2}{n^2}\ \text{eV/atom}$$

Radius : $r_n = 52.9\,\frac{n^2}{Z}$ pm

Velocity of electrons : $v_n = 2.188 \times 10^8\,\frac{Z}{n}\ \text{cm s}^{-1}$

Towards Quantum Mechanical Model

- **Dual nature of matter :** Every material particle in motion has dual nature (particle and wave nature).

de-Broglie wavelength, $\lambda = \frac{h}{mv} = \frac{h}{P}$

- **Heisenberg's uncertainty principle :** It is impossible to measure simultaneously the exact position and momentum of an electron.

$$\Delta x \times \Delta p \geq \frac{h}{4\pi}$$

Hydrogen Spectrum

According to Bohr's theory, an electron neither emits nor absorbs energy as long as it stays in a particular orbit.
However, an electron in an atom may jump from normal energy level, to some higher energy level. During each such jump, energy is emitted in the form of a photon (hv).

$E_2 - E_1 = hv = hc/\lambda$

Different excited electrons adopts different routes to return to various lower energy levels.

Lyman series	:	From $n = 2, 3, 4$ ..... to $n = 1$
Balmer series	:	From $n = 3, 4, 5$ ..... to $n = 2$
Paschen series	:	From $n = 4, 5, 6$ ..... to $n = 3$
Brackett series	:	From $n = 5, 6, 7$ ..... to $n = 4$
Pfund series	:	From $n = 6, 7, 8$ ..... to $n = 5$

Quantum Mechanical Model

- The electrons in an atom have only quantized values of energy.
- These quantized values of energy are obtained from the solution of Schrodinger wave equation.

$$\frac{d^2\Psi}{dx^2} + \frac{d^2\Psi}{dy^2} + \frac{d^2\Psi}{dz^2} + \frac{8\pi^2 m}{h^2}(E - V)\Psi = 0$$

By finding Ψ^2 at different points around the nucleus in an atom, we can predict the region of space around the nucleus within which the probability of finding the electron is maximum.