Wave nature of electron de-Broglie theory:

- de-Broglie proposed that the dual nature is associated with all the particles in motion and they are called matter waves.
- Electrons, protons, atoms and molecules which are treated as particles are associated with wave nature.
- Correlating Planck's equation E = hv and Einstein's equation E = mc^2, we can get wavelength of matter waves.

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

- de-Broglie applied this condition for the material particles in motion.
- The wavelength of a particle in motion is inversely proportional to its momentum.
- Smaller particles with very little mass have significant wavelength and bigger particles with large mass have negligible wavelengths.
- As electron has negligible mass, it has significant wavelength.
- The wave nature of electron was proved experimentally by Davisson and Germer in electron diffraction experiments.
- Hence electron exhibits both wave nature and particle nature.

Bohr's theory and de Broglie's concept:

- According to Bohr, electronic motion is permitted when the angular momentum is an integral multiple of h/2π.

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

- According to de Broglie, an electron behaves as a standing or stationary wave, which extends round the nucleus in a circular orbit.
- If the two ends of the electron wave meet, the electron wave is said to be in phase.
- In other words there is constructive interference of electron waves and the electron motion has a character of standing wave or non-energy radiating motion.
- For the electron wave in phase, the circumference of the Bohr's orbit should be an integral multiple of the wavelength of the electron wave.

- According to Bohr's quantum condition, $mvr = \frac{nh}{2\pi}$; $2\pi r = \frac{nh}{mv}$; $2\pi r = n\lambda$ ($\because \lambda = \frac{h}{mv}$)
- Thus, de-Broglie's theory and Bohr's theory are in agreement with each other.
- In case the circumference of the Bohr's orbit ($2\pi r$) is bigger or smaller than $n\lambda$, the electron wave is said to be out of phase.
- Then destructive interference of waves occurs causing radiation of energy.
- Such an orbit cannot exist.

Heisenberg's uncertainty principle:

- It is impossible to determine the exact position and velocity of the electron accurately and simultaneously.
- If the position is certain then the accurate determination of velocity is uncertain and vice-versa which is called Heisenberg's uncertainity principle.
- $\Delta x.\Delta p \geq \frac{h}{4\pi} or \Delta x.m\Delta V \geq \frac{h}{4\pi} or \Delta x.\Delta V \geq \frac{h}{4\pi m}$ If $\Delta x = 0$, Δv = infinity
- If $\Delta v = 0$, Δx = infinity
- Where Δx is uncertainity in position and Δp is the uncertainity in momentum.
- The radius of an atom is of the order of 10^{-10} m.
- Hence the uncertainty in the position of electron cannot be more than 10^{-10} m.

  When $\Delta x = 10^{-10}$ m.

  The uncertainty in velocity $\Delta v = \frac{h}{4\pi m\Delta x} = \frac{6.6x10^{-34}}{4x3.14x9.1x10^{-31}x10^{-10}} = 5.8x10^{5}ms^{-1}$
- Thus, the minimum uncertainty in its velocity cannot be less than 5.8×10^{5} m\sec
- The uncertainty is not of technical in nature, but it lies particle itself.

Schrodinger's wave equation:

- Schrodinger's wave theory is the basis for the modern quantum mechanical model of the atom.
- When the exact position of the electron cannot be determined we can predict the probability of finding the electron around the nucleus.
- This theory takes two facts into account.

  1) Wave nature of the electron

2) The knowledge about the position of an electron is based on its probability.

- It describes electron as a three-dimensional wave in the electric field of positively charged nucleus.
- Schrodinger's wave equation describes the wave motion of electron along X, Y and Z axes.

$$\frac{\partial^2\psi}{\partial x^2} + \frac{\partial^2\psi}{\partial y^2} + \frac{\partial^2\psi}{\partial z^2} + \frac{8\pi^2 m}{h^2}(E - U)\psi = 0$$

- In the above equation 'm' is the mass of electron, E is its energy, U is its potential energy, ψ is called wave function or amplitude of the electronic wave.
- The above equation indicates the variation of the value of ψ along x, y and z axes.
- Since, the probability of finding electron cannot be negative, ψ is replaced by ψ^2.
- ψ^2 is the probability function of the electron and it denotes the electron cloud density around the nucleus.
- The region or space around the nucleus where the probability of finding the electron is maximum (About 95%) is called an atomic orbital.
- The probability of finding the electron in the nucleus is zero.
- The probability of finding the electron in the radial space around the nucleus is called radial probability.
- The probability function of electron is called D function.
- Thus radial probability or electron probability function, $D = \pi r^2 dr.\psi^2$
- In hydrogen atom the probability of finding the electron is maximum at a distance 0.53 A^0 from the nucleus. The probability of electron at a distance of 1.3 A^0 is zero in H-atom.
- The plane in which the probability of finding the electron is zero is called node or nodal plane or nodal surface.