In this article, we will discuss atomic **models and quantum numbers**. This topic is important from the exam point of view. Questions were frequently asked about this topic.

Atomic Models:

To show the arrangement of fundamental particles in an atom various models were proposed, some important models are as follows:

Dalton's Atomic Theory:

The different assumptions of this theory are as follows;

- All matter are made up of atoms which are **indivisible and indestructible.**
- All the atoms of a given element have identical properties including identical mass.
- Atoms combine in small whole numbers to form **a compound.**
- Chemical reactions involve only the combination, separation or rearrangement of atoms.

Thomson's Atomic Model:

- Every atom consists of a uniformly positively charged sphere having a radius in the order of **10^{-10} m** in which the entire mass is uniformly distributed and negatively charges electrons are **embedded** randomly.
- Thomson uses the **cathode ray tube** to give its atomic model.
- This model is known as **the plum pudding model.**
- According to him, negative charge particles are distributed in the atom and to balance this negative charge some positive charge particles are also present in it.
- The atom as a whole is neutral.

Drawbacks of Thomson's Atomic Model:

- It could not explain the origin of **the spectral series** of hydrogen and other atoms.
- It could not explain significant angle scattering of alpha particles.

Rutherford's Atomic Model:

- He fired a beam of **the alpha** particle on a sheet of gold to give its model theory.
- The existence of the nucleus was proved by Rutherford in his alpha particle scattering experiment.
- The entire positive charge and the almost the entire mass of the atom are concentrated at its centre in a very tiny region of the order of **10^{-15}m**, called the nucleus.
- The negatively charged electrons revolve around the nucleus in different orbits.
- The total positive charge on the nucleus is equal to the total negative charge on the electron; therefore atom overall is neutral.

- A nucleus consists of positively charged **protons** and electrically neutral **neutrons.**

Limitations of Rutherford’s Atomic models:

- According to Maxwell's electromagnetic wave theory, an accelerated charged particle emits its energy in the form of electromagnetic waves. Therefore an electron must emit emits energy during its course of accelerated motion around the nucleus. Due to this the radius of its path will decrease gradually and ultimately it will fall into the nucleus.

Plank’s Quantum Theory:

Planck gave a new revolutionary theory of radiation known as **the quantum theory of radiation.**

According to this theory

Radiant energy is not emitted or absorbed continuously but discontinuously in the form of small packets of energy known as **photons (quanta).**

The amount of energy associated with a quantum of radiation is proportional to the frequency of radiation.

Energy = hv

Where h is Planck’s constant

Bohr’s Model:

- Bohr’s model is based on quantum physics i.e. quantization of energy
- This model is similar to **the planetary model** in which the electron revolves around the nucleus in the specific orbit
- Bohr’s model is considered the **primitive hydrogen atom model**
- Every orbit has a specific size and energy level.
- The smallest energy is found in the smallest orbit as **energy is related to the size of the orbit.**
- Electrons can move from one orbit to another by **emitting or absorbing energies** according to quantum mechanisms.

Heisenberg’s Uncertainty Principle:

- According to this theory, position and velocity or momentum cannot be measured in a single instant.
- Heisenberg principle does not apply to macroscopic objects

De-Broglie Concept:

- De Broglie states that an electron has dual nature i.e. wave nature and particle nature
- The wavelength (l) of an electron is inversely proportional to its momentum (p)

$l=h/p=h/mv$, where h is Planck's constant

Shell:

The electron has a definite energy characteristic of the orbit in which it is moving. These orbits or energy levels or shells therefore also known as **stationary orbits.**

n=1,2,3,4

Shell =K, L, M, N

The shell with n=1 is closest to the nucleus and an electron in this level has the lowest energy as it is closest to the positive charge of the nucleus.

Distribution of electrons in different orbits:

- It was suggested by **Bohr and Burry** and the rules that govern it are as follows:
- The maximum number of electrons present in a shell is given by the formula $2n^2$ where n=1,2,3 and 4 for K, L, M and N shots respectively.
- The maximum number of electrons accommodated in the outermost orbit is **8.**
- The shells are filled in a step-wise manner.

Electronic Configuration:

- It is the arrangement of electrons in various shells, subshells and orbitals in an atom.
- It is written as 2,8,8,18,32
- The maximum number of electrons in a shell is given by $\mathbf{2n^2}$

Filling or orbitals in Atoms:

The filling of electrons into orbitals of different atoms takes place according to the **Aufbau Principle, Pauli Exclusion Principle and Hund's rule of maximum multiplicity.**

According to **the Aufbau** principle in the ground state of an atom, an electron enters the orbital of lowest energy first and subsequent electrons enter in the order of increasing energies.

The lower the value of **(n+l)** for an orbital, the lower its energy.

here l is the azimuthal quantum number and n indicates the principal quantum number

If two orbitals have the same (n+l) value, the orbital with the lower value of **n has lower energy.**

Hund's rule of maximum multiplicity deals with the filling of electrons into the orbitals belonging to the same sub-shell. According to this rule, electron pairing will not take place in an orbital of the same energy until each orbital is first singly filled with parallel spin.

Quantum Numbers:

Each electron in an atom is characterised by a set of definite values of three quantum numbers n, l and m. In addition to these three numbers, fourth quantum number is also needed which specifies the spin of the electron.

Principal quantum number (n):

Determines the main energy level of the shell in which the electron is present.

The various values of n are 1, 2, 3 and 4 etc. also known as K, L, M and N etc. respectively, as the value of n increases the energy of the electron also increases.

Azimuthal quantum number (l) determines the sub-level or sub-shell(s, p, d and f) in a given principal energy level or shell to which an electron belongs.

Magnetic quantum number (m) gives information about the orientation of the orbitals.

Spin quantum number(s) describe the spin orientation of the electron; the electron can spin only in two ways, i.e. clockwise or anticlockwise.

Pauli Exclusion Principle:

It states that no two electrons in an atom can have the same set of four quantum numbers.