## Quantum numbers:

- To fully explain the motion of electron and to locate its correct address the following four quantum numbers are required.

### Principal quantum number (n):

- It is proposed by Bohr and denoted by 'n'.
- It represents the main energy level.
- It determines the size of the orbit and energy of the electron.
- It takes all positive and integral values from 1 to n.
- The maximum number of electrons in a main energy level is $2n^2$, and number of orbitals is $n^2$.
- If 'n' is the principal quantum number the energy of the electron in the principal quantum level is

  $E_n = -\frac{2\pi^2 e^4 m}{h^2}\frac{1}{n^2}$;  $E_n = -\frac{13.6}{n^2}$eV/atom

- As the value of 'n' increases, the energy of electron increases.
- The energy of electron in the ground state of hydrogen atom is – 13.6 eV/atom(or) $-2.176 \times 10^{-11}$ erg per atom(or) $-2.176 \times 10^{-18}$ joule per atom(or) –1312 kJ per mole (or) –313.6 kcal per mole.
- The energy of the electron in the second orbit of hydrogen atom is

  $= \frac{13.6}{2^2} = -3.4$ eV/atom

### Azimuthal quantum number (ℓ):

- It is also known as angular momentum quantum number or orbital quantum number (or) subsidiary quantum number.
- To express the quantized values of the orbital angular momentum, azimuthal quantum number was proposed.
- It is denoted by ℓ and takes values from 0 to n – 1.
- The number of values of 'ℓ' is equal to the value of n.
- It explains fine structure in H-spectrum.
- It determines the shape of orbitals.
- More fine lines in each main spectral line are seen.

  If n = 1, ℓ = 0 (s - sub-shell)

If n = 2, ℓ = 0, 1 (s, p sub-shells)

If n = 3, ℓ = 0, 1, 2 (s, p, d sub-shells)

If n = 4, ℓ = 0,1, 2, 3 (s, p, d, f - sub-shells)

- The orbital angular momentum of electron = $\frac{h}{2\pi}\sqrt{\ell(\ell+1)}$
- Azimuthal quantum number determines the shape of the orbital.
- The number of orbitals in a sub shell is (2ℓ + 1).
- The maximum number of electrons in a sub shell is 2(2ℓ + 1).

**Magnetic quantum number:**

- To explain Zeeman and Stark effects Lande proposed magnetic quantum number.
- It is denoted by m.
- It represents the sub-sub energy level or atomic orbital.
- It determines the orientation of orbital in space.
- When the atom is placed in an external magnetic field, the orbit changes its orientation.
- The number of orientations is given by the values of the magnetic quantum number m.
- m takes the values form –ℓ to +ℓ through 0. Total values of m for a given value of ℓ = (2ℓ + 1) values.
- A sub shell having azimuthal quantum number ℓ, can have (2ℓ + 1) space orientations.
- The number of orbitals in a subshell = (2ℓ + 1).
- If the changes in the axis in one direction are indicated by + m values, the changes in the axis in the opposite direction are indicated by – m.

**Spin quantum number (s):**

- In the fine spectrum of alkali metals pairs of widely separated lines are observed which are different from duplet, triplet, and quadruplets observed in the hydrogen spectrum.
- To recognize and identify these pairs of lines Goudsmit and Uhlenbeck proposed that an electron rotates or spins about its own axis.
- This results in the electron having spin angular momentum, which is also quantized.
- The electron may spin clockwise or anti clockwise. Therefore, the spin quantum number takes two values +1/2 and –1/2. Clockwise spin or parallel spin is given +1/2 or ↑ and anti-clockwise or anti parallel spin is given by –1/2 or ↓.