ATOMIC STRUCRURE

Long Answer Questions:

1. What are quantum numbers? Give their significance?

Ans. The various orbitals in an atom qualitatively distinguished by their size, shape and orientation. The atomic orbitals are precisely distinguished by the numbers known as quantum numbers. Each orbital is designated by three quantum numbers labelled as n, l and m.

There are four quantum numbers required for a complete explanation of electrons in an atom.

The quantum numbers are –

1) Principal quantum number (n)
2) Azimuthal quantum number (l)
3) Magnetic quantum number (m)
4) Spin quantum number (s)

1. Principal Quantum Number (n):

i. It was proposed by Neil's Bohr

ii. The value of n is 1,2,3,4..... (Or) K, L, M, N..... respectively

iii. As 'n' value increases, the size and energy of the orbit also increase.

Iv. The maximum number of electrons possible in an orbit = $2n^2$

v .The maximum number of orbitals possible in an orbit = 2n

vi. The maximum number of sublevels possible in an orbit =n

vii. The angular momentum of an electron in an orbit i.e. mvr = nh/2**π**

Significance: It indicates the size and energy of the orbit for hydrogen atom and hydrogen like species

2.**Azimuthal Quantum Number(L):**

I . It was proposed by Somerfield

ii. The values of l are 0, 1, 2,..... (n-1), a total of n values.

iii. The value of l represents various sub shells and l = 0,1,2,3 etc... are called s,p,d,f..... sub shells respectively

iv. It indicates the orbital angular momentum of electron. Orbital angular momentum of the electron is given by $\sqrt{l(l+1)}\frac{h}{2\pi}$

V. It represents the sub shell to which electron belongs.

Significance: It indicates the shape of orbitals S-spherical, P-dumb bell and d- double dumb bell.

3. **Magnetic Quantum Number (m):**

i. It was proposed by Lande

ii. The values of m are +l to -l including zero, a total of 2l+1 values

iii. The total number of m values indicates the total number of orbitals in the subshell. The number of orbitals in s, p, d and f sub shells is 1, 3, 5 and 7 respectively

iv. The number of oribitals in a sub shell =2l+1 and electrons = 2(2l+1)

Significance: It indicates the orientation of orbitals in space

4. **Spin Quantum Number(S):**

i. It was proposed by Goldsmith and Uhlenbeck

ii. The values of S in clock wise direction is represented by + 1/2 and anti clock wise, direction is represented by - 1/2

iii. An orbital can accommodate maximum of 2 electrons with opposite spin.

iv. The maximum number of electrons accommodated by s, p, d and f subshells is 2,6,10 and 14 respectively.

Significance: It indicates the direction of the spin of the electron

2. What are the main Postulates of Bohr's theory of hydrogen atom?Discus the importance of this model to explain various series of line spectra in hydrogen atom. Give its merits and demerits?

Ans. Postulates of Bohr's theory of hydrogen atom

(1) The electrons in the hydrogen atom revolves around the nucleus only in certain circular orbits associated with definite energy, called energy shells (or) energy levels. These are designated as numbers like 1,2,3,4, -------- etc (or) letters like K, L, M, N --------- etc.

(2) As long as the electron revolves in a particular orbit it can neither loose nor gain energy i.e energy of an electron in a particular orbit remains constant. Hence these orbits are called stationary orbits.

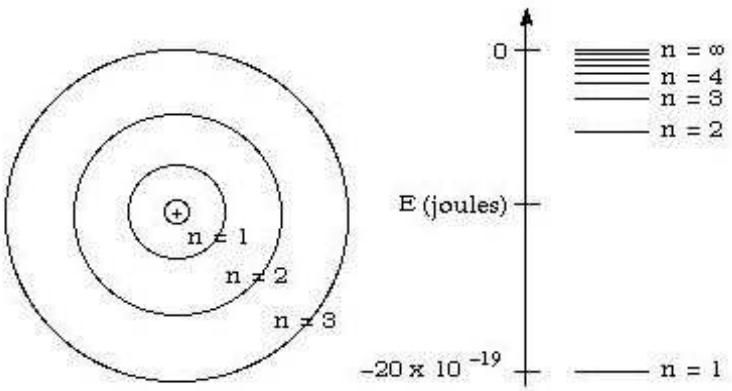
(3) Only those orbits are permitted in which the angular momentum of electrons is the whole number multiple of h/2**π**

The angular momentum of electron can be represented as

mvr=nh/2 where n = 1, 2, 3..... m = mass of electron, v = velocity of electron, r = radius of an orbit and h = Planck's constant

4) Electron may emit or absorbs energy when it changes from one level to another level. Electron moves from lower orbit to higher orbit by absorbing energy. If electron jumps from higher orbit to lower orbit then it emits energy.

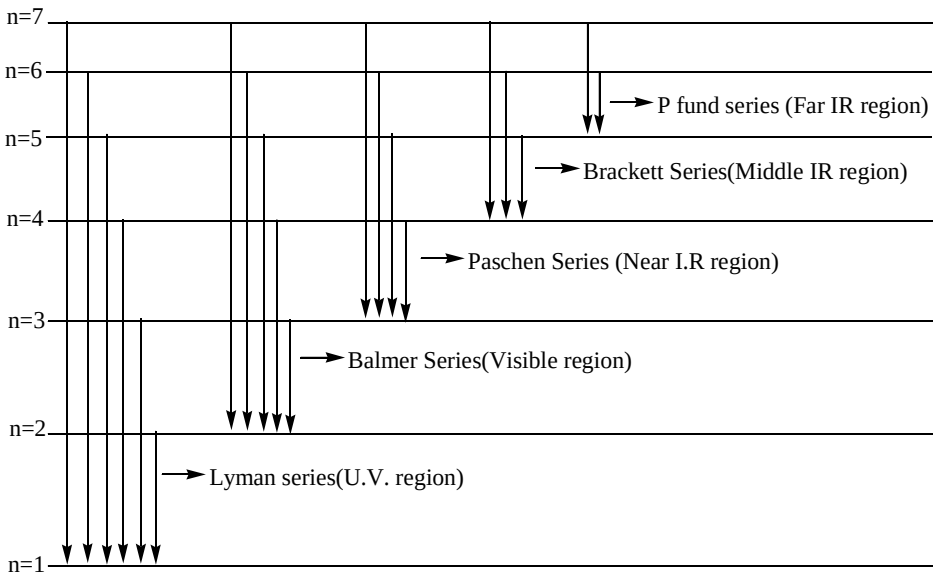
The energy emitted or absorbed is given by $\Delta E = E_2 - E_1 = h\nu$



The three orbits closest to the nucleus Energy levels

Bohr's Explanation of Hydrogen Spectrum:

Hydrogen atom has one proton and one electron in the ground state. By the absorption of energy, electron jumps from the ground state to the higher energy level and atom becomes unstable. In order to get the stability the electron should comes back to lower energy level with emission of energy. While de-excitation of electron, the electron directly comes to the first energy level (or) it may comes through the different intermediate levels. Since many atoms are involved, hence it produces large number of spectral lines in the hydrogen spectrum. The five series of spectral lines in the hydrogen emission spectrum are as shown below.



Merts of Bohr's Model:

1. Bohr's model explains the stability of the atom.
2. Bohr's theory successfully explains the atomic spectrum of hydrogen and one electron species such as He^{+}, Li^{2+} and Be^{3+} etc.
3. The experimentally determined frequencies of spectral lines are in close agreement with those calculated by Bohr's theory.

Limitations of Bohr's Model:

1. Bohr's theory fails to explain the spectra of multi electron atoms.
2. It could not explain the fine structure of atomic spectrum.
3. It does not explain the splitting of spectral lines into a group of finer lines under the influence of magnetic field (Zeeman Effect) and electric field (Stark effect).
4. Bohr's theory is not in agreement with Heisenberg's uncertainty principle.

3. State and explain the following with suitable examples.

a). Auf-bau principle b) Pauli's principle c) Hund's rule.

Ans.

Aufbau Principle:

It states that "In the ground state of the atoms, the orbitals are filled in order of their increasing energies". i.e. electrons first occupy the lowest energy orbital available to them and enter into higher energy orbitals only after the lower energy orbitals are filled.

The relative energy of an orbital is given by (n + *l*) value. As (n + *l*) value increases, the energy of orbital increases.

The orbital with the lowest (n + *l*) value is filled first. When two or more orbitals have the same (n + *l*) value, the one with the lowest 'n' value is preferred in filling.

Consider two orbitals 3d and 4s. The n + *l* value of 3d = 3 + 2 = 5 and of 4s = 4 + 0 = 4. Since 4s has lowest (n + *l*) value, it is filled first before filling taking place in 3d.

The order of increasing energy of atomic orbitals is:

1s < 2s < 2p < 3s < 3p < 4s < 3d < 4p < 5s < 4d < 5p < 6s < 4f < 5d < 6p < 7s and so on.

Pauli's Exclusion Principle:

Pauli's principle may be stated as "No two electrons in an atom can have the same set of values for all the four quantum numbers".

This means that two electrons in an orbital may have the same n, same *l* and same m but differ in spin quantum number. In an orbital if one electron has clockwise spin, the other has anticlockwise spin. It follows that an orbital can hold a maximum of two electrons with opposite spins.

For example helium atom has two electrons in its 1s orbital. Quantum numbers for

First electrons are n =1, *l* = 0, m = 0 and s = +1/2 and for second electrons are:

n =1, *l* = 0, m =0, s = –1/2.

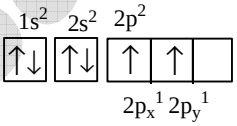
The two electrons have the same value for n, same value for *l* and same value for m but differ in s. The maximum capacity of a main energy shell is equal to $2n^2$ electrons and that of a sub-shell is equal to (4 *l* + 2).

Hund's Rule:

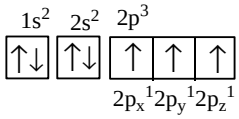
It states that "Pairing of electrons in the orbitals belonging to the same subshell (p, d or f) does not take place until each orbital belonging to that subshell has got one electron each i.e., all the orbitals are singly occupied".

Since there are 3, 5 and 7 orbitals in p, d and f - subshell, pairing in these subshells starts with 4th, 6th and 8th electron respectively.

The following examples explain Hund's rule of maximum multiplicity. **^{6}C:**



^{7}N :



Short Answer Questions

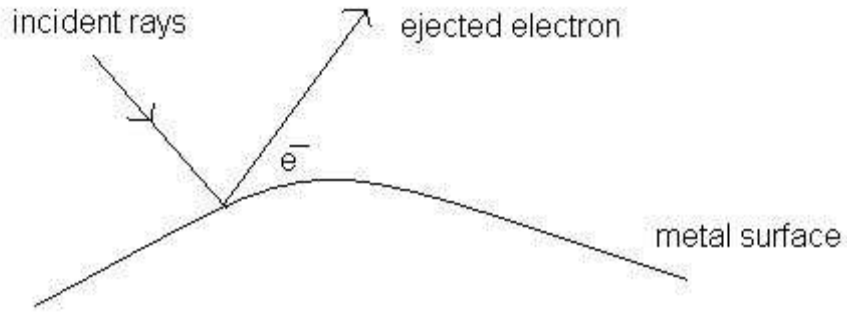
1. Explain the difference between emission and absorption spectra?

Ans.

Emission spectrum	Absorption spectrum
1). The spectra is formed when an electron Jumps from higher orbits to lower orbits	1). The spectra is formed when an electron jumps from lower orbits to higher orbits
2). It is formed due to emission of energy in	2). It is formed due to absorption of energy quanta in quanta
3). It contains bright lines on dark back ground	3). It contains dark lines on bright back ground
4). It is classified into continuous and discontinuous spectrum	4). It is not classified

2. Explain photo electric effect?

Ans. 1) When a beam of light (h) of suitable wave length is allowed to fall on, the surface of the metal. The electrons are emitted from the metal surface. This phenomenon is called photo electric effect. It is represented as follows.



i.e $h\nu = W_0 + K.E \rightarrow (1)$

Where $h\nu$ = energy of incident photon

W_0= work function

Kinetic energy K.E $= \frac{1}{2}mv^2$

the equation (1) is expressed as $h\nu = h\nu_0 + K.E \rightarrow (2)$ here $W_0 = h\nu_0$

$h\nu_0$ =the minimum energy required to break the force of attraction between nucleus and electron is called as Threshold energy. $h\nu = h\nu_0 + K.E$

$$K.E = h\nu - h\nu_0 = h(\nu - \nu_0) \quad \left[\therefore \nu = \frac{c}{\lambda}\right]$$

$$K.E = \frac{hc}{\lambda} - \frac{hc}{\lambda_0} = hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)$$

1) Except Li remaining alkali metals are used in photo electric cells. Due to low work function and low I.P value.

2) Caesium is more used in photo electric cell due to very low I.P value.

3. What is a nodal plane? How many nodal planes are possible for 2p- and 3d- orbitals?

Ans. The plane passing through the nucleus where the probability of finding the electron is zero is called nodal plane.

Number of nodal planes for orbit is equal to '*l*' where *l* is Azimuthal quantum number

i) For a 2p orbital 'l' is 1. $\therefore$ the number of nodal planes are one.

ii) for a 3d orbital l value is '2'. $\therefore$ the number of nodal planes are two.

Very Short Answer

1. What is a black body?

Ans. The ideal body which emits and absorbs radiations of all frequencies is called black body.

2. Which part of electromagnetic spectrum does Balmer series belong?

Ans. Visible region

3. What is an atomic orbital?

Ans. The region around the nucleus where the probability of finding an electron is maximum is called 'Orbital'.

4. When an electron is transferred in hydrogen atom from n = 4 orbit to n = 5 orbit, to which spectral series does this belong?

Ans. No spectral line is formed during this transition.

5. How many p electrons are present in sulphur atom?

Ans. Electronic configuration of 'S' (Z = 16) = $1s^2 2s^2 2p^6 3s^2 3p^4$

$\therefore$ No. of 'P' electrons = 10

6. The static electric charge on the oil drop is -3.2044×10^{-19} C. How many electrons are present on it?

Ans. -1.602×10^{-19} C means 1 electron

-3.204×10^{-19} C means

$$= \frac{-3.204\times10^{-19}}{-1.602\times10^{-19}} = 2 \text{ electrons.}$$