13. In what terms wave functions are expressed to get their relationship with shapes of orbitals.

Ans. Wave functions are expressed in terms of spherical harmonics Y_l^m to derive relation with shapes of orbitals.

$$Y_l^m = \Theta_{l,m}\,\Phi_m$$

where

$$\Theta_{l,m} = \sqrt{\frac{(2l+1)}{2}\frac{\lfloor l-|m|}{\lfloor l+|m|}}\,P_l^m \cos\theta$$

$$\Phi_m = \frac{1}{\sqrt{2\pi}}e^{im\phi}$$

l stands for orbital angular momentum and m for magnetic quantum number.

14. Mention the number of radial nodes in 4*p*, 3*p* and 2*p* orbitals.

Ans. Number of radial nodes in 4*p*, 3*p* and 2*p* orbitals are 2, 1 and zero respectively.

15. What does principal quantum number *n* represent ?

Ans. Principle quantum number n represents main energy shell and energy of electron moving in a particular energy level. This tells average distance of an electron from nucleus.

16. How the possible orientations of the magnetic moment be determined from the orbital angular momentum of the electron ?

Ans. The value of obrbital angular momentum quantum number '*l*' can be 1, 2, 3, ... designated as *s*, *p*, *d*, *f* .... subshells respectively. The value of magnetic quantum number '*m*' ranges from $-l$ through 0 to $+l$ totalling $2l+1$. This each value of *m* represents a particular orbital.

17. Name the three quantum numbers of an electron which are yielded during the solution of Schrödinger wave equation.

Ans. The Schrödinger wave equation yielded three quantum number *i.e.*, Principal quantum number '*n*', orbital angular momentum quantum number '*l*' and magnetic quantum number '*m*'.

18. How many orientations are possible for *p* and *f*-orbitals ?

Ans. Number of orientations possible for *p* and *f* orbitals are 3 and 7 respectively.

9. What is ψ in the equation $H\psi = E\psi$.

Ans. ψ refers to amplitude of wave function.

10. Discuss how the allowed energies are exactly the same whether deduced by Schrödinger wave approach or Bohr model.

Ans. The energy calculated by Bohr model is $E_n = \frac{-2\pi^2 me^4}{(4\pi\varepsilon_0)^2 n^2 h^2}$ and it is similar to the energy of electron in hydrogen and hydrogen like atoms, *i.e.* $E_n = \frac{-2\pi^2 Z^2 \mu e^4}{(4\pi\varepsilon_0)^2 n^2 h^2}$. μ can be replaced by m_e since $m_n >> m_e$ in the relation $\mu = \frac{m_e m_n}{m_n}$.

11. Explain how ψ^2 is the measure of the probability of finding electron in the given volume.

Ans. Intensity of radiation is measured by square of the amplitude of the wave. Further intensity of radiation has direct relation to photon density. The existence of photons in the given volume is photon density. The existence of photons in the given volume is probability density since photons are small particles. Thus by analogy ψ^2 is probability density.

12. What are eigen functions and eigen values as used in Schrödinger wave equation ?

Ans. The eigen equation for Schrödinger wave equation is

$$\hat{H}\psi_n = E_n\psi_n \; [n = \text{quantum number} = 1, 2, 3 \ldots\ldots]$$

Here ψ_n are the Eigen functions and E_n are the eigen values.

5. Give the Schrödinger wave equation for hydrogen atom ?

Ans. Schrödinger wave equation for hydrogen atom :

$$\left(\frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}+\frac{\partial^2}{\partial z^2}\right)\psi+\frac{8\pi^2 m}{h^2}\left(E+\frac{e^2}{r}\right)\psi = 0$$

as for hydrogen atom, the nuclear charge is $+e$ and charge on the electron is $-e$.

$\therefore$ Potential energy of the electron, $V = -e^2/r$.

6. Mention the conditions which any acceptable wave function must satisfy.

Ans. The acceptable wave function ψ is single valued. This wave function and its first derivative with respect to its variables must be continuous. The wave function ψ should be finite.

7. What is de Broglie's equation ?

or

How are wavelength and momentum of particle related ?

Ans. $h = h/mu = h/p$

p = linear momentum of the particle.

8. What is significance of ψ and ψ^2 ?

Ans. ψ represents the amplitude of the wave whereas ψ^2 is measure of the probability of finding electron in the given volume.

1. Explain the Bohr postulate.

Ans. Energy is quantised so electron lose energy only in bundles when it jumps from one orbit to another. Stability of atom is ensured as the electron continues moving in a particular orbit associated with a particular definite amount of energy.

2. What is mathematical expression for Heisenberg's Uncertainty Principle ?

Ans. $(\Delta x)\,(\Delta p_x) \geq \frac{h}{4\pi}$

Δx = uncertainty with regard to position

(Δp_x) = uncertainty with regard to momentum

3. Can uncertainty principle be applied on stationary electron ?

Ans. No, uncertainty principle cannot be applied on stationary wave.

4. Write Schrödinger wave equation and mention the significance of terms associated in the equation.

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

ψ = amplitude function for the three coordinates x, y, z

E = Total energy

V = Potential energy

m = mass of the particle