Engineering Physics (BAS101)
List of Important Questions

UNIT-1 : Quantum Mechanics

|| Short Answer Type Questions ||

1. Discuss in brief the failure or inadequacy of classical Mechanics?
2. Differentiate between classical mechanics and quantum mechanics with examples.
3. What is Planck's law of radiation?
4. What are matter waves?
5. What is de-Broglie wavelength ?
6. What is a wave packet?
7. Differentiate between phase velocity and group velocity?
8. Compare the de Broglie wavelengths of photon and electron having same linear momentum.
9. Compare the de Broglie wavelengths of electron and proton having same kinetic energy.
10. What is a wave function? Give Born interpretation of its physical significance.
11. What is normalized wave function? Show that $\Psi(x,t) = \Psi(x)\, e^{-i\omega t}$ is a stationary state wave function.
12. What is Compton effect? Why Compton shift is not observed for visible light.

|| Long Answer Type Questions ||

1. Giving hypothesis of Planck's law of radiation? Show that how does it explain spectrum of black body radiation.

2. What is Compton wavelength? Prove that Compton shift is given by $\Delta\lambda = \frac{h}{m_0 c}(1-\cos\phi)$ where symbols have their usual meanings.

Or

Explain Compton Effect and show that Compton shift depends only on the angle of scattering and is independent of wavelength of incident photo. Also mention its conclusions.

Or

Derive an expression for Compton shift. Explain why Compton shift is not observed with visible light. Why are both modified and the unmodified lines simultaneously present for non zero scattering angle.

3. Derive the expression for the direction of recoiled Compton electron. Show that the Compton electron can recoil only in the outward direction at an angle less than 90°.

4. A photon of frequency ν is scattered by an electron initially at rest. Prove that the maximum kinetic energy of the recoiled electron is given by $\frac{2h^2\nu^2}{m_0c^2\left[1+\left(2h\nu/m_0c^2\right)\right]}$.

5. What is de-Broglie wavelength of matter wave? Show that the wavelength associated with a particle of mass m and kinetic energy E is given by $\lambda = \frac{h}{\sqrt{2mE}}$

6. Show that de- Broglie wavelength of a particle of rest mass m_o, potential V and charge q is given as

$$\lambda = \frac{h}{\sqrt{2m_o qV\left(1+\frac{qV}{2m_o c^2}\right)}}$$

7. A particle has mass m_o has kinetic energy K. Show that its de Broglie wavelength is given as

$$\lambda = \frac{hc}{\sqrt{K(K+2m_o c^2}}$$

8. Describe Davisson and Germer's experiment to demonstrate the wave character or wave nature of electrons.

9. Deduce a relation between phase velocity and group velocity of a wave packet and show that these velocities are equal in a non-dispersive media.

OR

Obtain a relation between phase velocity and group velocity. What happens if the phase velocity is independent of frequency or wavelength ?

10. What is a wave packet? Show that the de-Broglie group velocity associated with wave packet is equal to the velocity of particle.

11. Distinguish between phase velocity (v_p) and group velociy(v_g) of a wave packet and show that $v_p.v_g = c^2$. where c is the speed of light.

12. Obtain time dependent and independent Schrödinger wave equations.

13. Find an expression for eigen-value (energy) and eigen function(wave function) for a particle trapped in a one dimensional box.

Or

Solve Schrodinger wave equation for a particle in one dimensional rigid box of side L and having potential energy (V) as follows:

$$V(x) = \infty \ for\ x < 0\ \&\ x > L$$
$$V(x) = 0 \ for\ 0 < x < L$$

|| Numerical Problems ||

1. X-rays of wavelength $2.00A^0$ are scattered from a block of carbon. The scattered X-rays are observed at an angle of 45^0 to the incident beam. Calculate the Compton shift and the wavelength of scattered X-rays at 45°. Also calculate the fraction of energy lost by photon in this collision.

2. X-rays of wavelength 10.0 pm are scattered from a carbon target
   a. Find the wavelength of X-rays scattered through 45^0
   b. Calculate the maximum wavelength present in the scattered X-rays
   c. Find maximum kinetic energy of recoiled electrons.

3. In Compton scattering, the energy of an incident X-ray photon in 150 keV and that of scattered photon is 130 keV. Determine the angle of scattering.

4. A beam of gamma-radiation having photon energy 510 keV is incident on a foil of aluminum. Calculate the wavelength of scattered radiation of scattered radiation at 90^0. Also the energy and direction of the emission of the corresponding electron.

5. An X ray photon is found to have its wavelength doubled on being scattered through 90^0. Find the Compton wavelength and energy of the incident photon.

6. A photon recoils back after striking an electron at rest. What is the change in wavelength of photon?

7. An X-ray photon collides with an electron at rest. It is scattered through 90^0. What is the frequency after collision if its initial frequency is 3×10^{19}Hz

8. Show that the minimum value of energy which a photon must have so that it may transfer half of its energy to an electron at rest is about 256 keV.

9. Calculate de Broglie wavelength associated with a proton moving with velocity equal to $1/20^{th}$ the speed of light.

10. Calculate the velocity and de Broglie wavelength of an alpha particle of energy 1 keV: Mass of alpha particle is 6.68×10^{-27} kg.

11. Calculate the de Broglie wavelength of neutron having kinetic energy of 12.8 MeV.

12. Calculate de-Broglie wavelength of an alpha particle accelerated through a potential difference of 200 volts.

13. What is the de-Broglie wavelength of an electron accelerated from rest through a potential difference of 100 volts?

14. Find the energy of an electron moving in one dimension in an infinitely high potential box of width 1 A^0.

15. A particle is in motion along a line between x=0 to x=L with zero potential energy. At points for which x < 0 and x >L, the potential energy is infinite. The wave function of particle in n^{th} state is given by $\psi_n = A\sin\frac{n\pi x}{L}$. Find expression for the normalized wave function.

16. Find the probability of finding a particle trapped in a box of length L in the region from 0.45 L to 0.55 L for ground state and first excited state.

17. The wave function of a certain particle is $\Psi = A\cos^2 x$ for $-\frac{\pi}{2} < x < \frac{\pi}{2}$, find the value of A and the probability of finding the particle between x= 0 and x = $\frac{\pi}{4}$