TUTORIAL SHEET (Unit -2)

(h=6.63 x10^{-34} J.s; e=1.6x10^{-19} C; m_0 =9.1 x10^{-31} kg; m_p=m_n =1.67x10^{-27} kg)

(i) de Broglie wavelength of a matter wave $\lambda = h/p$; $p = m.v$ where m =mass of the particle and v= velocity of the particle.
(ii) The energy of a particle of charge 'e' , accelerated through a potential difference 'V' is given by $E = eV = p^2/2m$ or $p = \sqrt{2meV}$ and $\lambda = h/\sqrt{2meV}$. This formula is valid when the particle is non-relativistic, i.e., travels with a velocity very much less than velocity of light, 'c'.
(iii)When the particle travels with velocities comparable to velocity of light it is called a relativistic particle and the energy, $E = \sqrt{E_0^2 + p^2c^2}$ where $E_0 = m_o c^2$ is the rest mass energy of the particle.
(iv) Group velocity $V_P - \lambda \frac{dV_P}{d\lambda} = V_g$,$V_g = d\omega/dk$ and phase velocity $v_p = c^2/v_g$

$V_P = \frac{\omega}{k}$ (v) Uncertainty Principle: $\Delta x . \Delta p_x \geq \frac{h}{4\pi}$, $\Delta E . \Delta t \geq \frac{h}{4\pi}$

(vi) $E_n = n^2h^2/(8mL^2)$. n=1,2,3,……… (vii) $\Psi_n (x) = \sqrt{\frac{2}{L}} \sin(n\pi x/L)$.
(viii) Probability density: P(x) =$\int_{x_1}^{x_2} \frac{2}{L} \left(\sin\left[\frac{n\pi x}{L}\right]\right)^2$ dx.

NUMERICAL PROBLEMS

1. Calculate the de Broglie wavelengths of a photon, an electron and a proton having an energy of 100 eV.
2. Calculate the group velocity and phase velocity for electrons of wavelength 1 Å.
3. Helium nucleus He_2^4 has a de Broglie wavelength of 0.45 pm. Find it's group velocity and phase velocity. What is the required potential difference to accelerate the Helium nucleus to this velocity?
4. The mass of a particle is 0.5MeV/c^2 and its energy is 100 eV. Calculate the group velocity. If the velocity can be determined to a precision of 1%, what is the uncertainty in determining its position?
5. An electron has a speed of 1.6 x10^5 m/s and it can be determined to an accuracy of .05%. Calculate the uncertainty in its position.
6. An electron and a photon have the same energy and the wavelength of photon is 10 times that of electron. Calculate the value of energy.
7. The phase velocity of ripples on liquid surface is $v_p = \sqrt{2\pi s/_{\lambda\rho}}$ where s is surface tension and ρ is density. Find the group velocity in terms of phase velocity.
8. The phase velocity of ocean waves is $v_p = \sqrt{g\lambda/_{2\pi}}$ where g acceleration due to gravity. Find the group velocity in terms of phase velocity.
9. For $\Psi (x) = A\, e^{ikx}$ in the region –a ≤ x ≤ a, find the normalization constant.

10. An electron is in the ground state in an infinite potential well of width 5Å. Calculate the excitation energy required to raise the electron to the third excited state.
11. A particle is confined to an infinite potential well of width 'L'. Calculate the probability of finding the particle for the following cases:
    (i) between x= 0 and x=L/2 in the ground state
    (ii) (ii) between x=0 and x=L/4 in the first excited state and
    (iii) (iii) between x=0.35 L and x=0.75 L in the second excited state.
12. The Eigen function of an electron in an infinite potential well has 5 antinodes. If the energy of the electron is 230 eV, calculate the width of the potential well.
13. If an electron having de Broglie wavelength 1.21Å is in the fifth excited state of an infinite potential well, what is the dimension of the potential well. Calculate the energy of the emitted photon when the particle transits to second excited state.
14. Calculate the lowest energy level for a neutron in a nucleus by treating it as if it were in an infinite potential well of width 10^{-14} m. Compare this with the lowest energy level for an electron in the same infinite potential well.