Assignment 1
Numerical Problem on Quantum Mechanics

Q1. (a) Calculate the energy in electrons volt of photon of wavelength 1 Å.
(b) What is the momentum of this photon?

Q2. In an experiment tungsten cathode which has a threshold 2300 Å is irradiated by ultraviolet light of wavelength 1800 Å. Calculate –
(i) Maximum energy of emitted photo electrons and
(ii) Work function for tungsten.

Q3. Calculate the velocity of photo electron if the work function of the target material is 1.24 eV and the wavelength of incident light is 4.36×10^{-7}m. What retarding potential is necessary to stop the emission of these electrons.

Q4. Electrons with maximum energy are ejected from a metal surface by ultra violet radiation of wave length 1500 Å. Determine the work function of metal. The threshold wavelength of metal and the stopping potential difference required to stop the emission of electrons.

Q5. A photon of wavelength 3310 Å falls on photo cathode and eject an electron energy 3×10^{-19} joule. If the wavelength of incident photon is changed to 5000 Å. The energy of ejected electron is 0.972×10^{-19} joule. Calculate the value of plank's constant and threshold wavelength and work function for the photo cathode. ($c = 3 \times 10^8$ m/sec)

Q6. In Compton scattering the incident photons have wavelength 3×10^{-10}m. Calculate the wavelength of scattered radiation if they are viewed at angle of 60° to the direction of incidence.

Q7. X- Ray of 1.0 Å are scattered from a carbon block. Find the wavelength of the scattered beam in a direction making 90° with the incident beam. How much kinetic energy is imparted to the recoiling electron?

Q8. Find the energy of the neutron in unit of electron volt whose de-Broglie wave length is 1.0Å. (Given mass of the neutron = 1.674×10^{-27} kg. Planks constant 6.60×10^{-34} J.s)

Q9. An electron is confined to a box of length 10^{-9} m, calculate the minimum uncertainty in its velocity. Given mass of electron m = 9×10^{-31}kg & h = 6.6×10^{-34} j/sec.

Q10. Determine the size of hydrogen atoms using uncertainty principle. Give that potential energy of electron $V = \frac{-e^2}{4\pi\epsilon_0 a}$, where a is the distance of the electron from the nucleus.

Q11. Calculate the de-Broglie wavelength for
(a) A proton of kinetic energy 70 MeV
(b) A 100 g bullet moving at 900 m/s.

Q12. A particle of rest mass m_0 has kinetic energy 'k' which is not negligible in comparison to the rest mass energy mc^2. Prove that in this case the de Broglie wavelength is given by;

$$\lambda = \frac{hc}{\sqrt{k(k+2mc^2)}}$$

Q13. A photon of energy 3 keV collides elastically with an electron initially at rest. If the proton emerges at an angle of 60^0. Calculate
(a). KE of the recoiling electron
(b). The angle at which electron recoil.

Q14. Calculate the group velocity of light waves (λ = 5893 Å) through carbon di sulphide (μ=1.635). Given $\frac{d\mu}{d\lambda} = -1.89 \times 10^{-5}$ $Å^{-1}$.

Q16. Show that the phase velocity of de-Broglie waves associated with a moving particle of rest mass m_0 is given by; $v_p = c\sqrt{1+\left(\frac{(c\lambda m_0)^2}{h^2}\right)}$.

Q15. Find the probabilities of finding a particle trapped in a box of length L in the region from 0.45 L to 0.55 L fort he ground state and the first excited state.

Q17. Show that $\psi(x) = e^{ikx}$, where k is some finite constant, is acceptable eigen function. Also normalize it over the region -a>x<a.

Q18. The wavefunction for certain particle is; $\psi(x) = A\,cos^2x$ for $-\frac{\pi}{2} < x < \frac{\pi}{2}$. Find the value of A.

Q19. A microscope using photons is employed to locate an electron in an atom to within a distance of 0.2 Å. What is uncertainty in the momentum of the electron located in this way?

Q20. An excited atom has an average life time of 10^{-8} s. that is, during this period it emits a photon and returns to the ground state. What is the minimum uncertainty in the frequency of this photon?

Assignment: 2

Numerical Problems on Electro Dynamics

Q1. Calculate the radiation pressure at the surface of earth and sun assuming that solar constant has a value of 2 calcm^2 min at the surface of the earth and the radius of the sun is 7 x 10^8m and the average distance between earth and sun is 1.5 x 10^{11}m.

Q2. Derive Coulomb's law of electrostatics with the help of Maxwell's first equation.

Q3. A plane electromagnetic wave propagating along the X – direction has a wavelength 5.0 mm. The electric field is in the Y- direction and its maximum magnitude is 38 V/m. Find the time and space varying equation for the electric and magnetic fields.

Q4. Show that equation of continuity, $div.\mathbf{J} + \frac{\partial \rho}{\partial t} = 0$ is contained in Maxwell's equations.

Q5. A parallel plate capacitor made of two circular plates each of radius 10 cm and separated by 5 mm being charged by a steady current of 0.2 A.

(a) Calculate the capacitance and rate of change of potential difference between the plates.
(b) Obtain the displacement current across the plates.
(c) Is Kirchhoff's first rule valid at each plate of capacitor? Explain.

Q6. A laser emits a sinusoidal electromagnetic wave of wave length 10.6μ travelling in vacuum along x-axis the electric field of maximum magnitude 1.5 MV/m is parallel to the + z – axis. Write expression for E & B as a function of time and position.

Q7. A radio station radiates a sinusoidal wave with an average total power of 50 KW. Assuming that the transmitter radiates equally in all directions above the ground. Find the amplitude of E_{max} and B_{max} detected by a satellite at a distance of 100 km from the radio station transmitter antenna.

Q8. Calculate the skin depth δ and wave velocity at a frequency of 1.6MHz in aluminium for which $\sigma = 38.2$ MS/m and $\mu_r = 1$.

Q9. An electromagnetic wave of frequency f = 3.0 MHz passes from a vacuum into a non magnetic medium with permittivity μ. Calculate the increment in its wavelength.

Q10. A harmonic electromagnetic wave is free space is described by $E = E_0 \cos(kx - wt)$. Show that flux density or irradiance I is equal to $\frac{1}{2} c\epsilon_0 E_0^2$.

Q11. A 60 W monochromatic point source radiating equally in all direction in vacuum is Being monitored at a distance of 2.0 m. Calculate the amplitude of electric field, E at the detecting point.